APPENDIX Z

Mine closure and rehabilitation strategy

Evolution MINING

EMM creating opportunities

Cowal Gold Operations Open Pit Continuation Project

Mine Closure and Rehabilitation Strategy

Prepared for Evolution Mining (Cowal) Pty Limited

May 2023

Cowal Gold Operations Open Pit Continuation Project

Mine Closure and Rehabilitation Strategy

Evolution Mining (Cowal) Pty Limited

J190417 RP#40

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Version	Date	Prepared by	Approved by	Comments
1	28 April 2023	Michael Frankcombe	Paul Freeman	Final for DPE SEARs review
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Executive Summary

ES1 Purpose

Evolution is seeking approval for continued open pit mining operations at CGO through the Open Pit Continuation Project (the Project).

This Mine Closure and Rehabilitation Strategy (Rehabilitation Strategy) forms part of the Project's Environmental Impact Statement (EIS). Consistent with the overarching SSD application requirements this rehabilitation strategy covers the final landform design, mine closure planning, rehabilitation planning, post mine land uses and proposed rehabilitation techniques for the Project.

This Rehabilitation Strategy covers the final landform design, mine closure planning, rehabilitation planning, post mine land uses and proposed rehabilitation techniques for the Project. Unlike a greenfield site where no development has previously occurred, the CGO is in its 17th year of operations and earthmoving involving hundreds of millions of tonnes of material in the form of WRE, IWL and the E42 open pit has already taken place.

These structures represent a mid-point in the development of the post-mine closure rehabilitation outcome. As a result, the rehabilitation strategies available for implementation on the Project are influenced by the approved mining activities carried out to date.

ES2 Rehabilitation Domains

The following rehabilitation domains have been developed for GCO and are shown in Figure 5.1:

- Domain B1 – Infrastructure area – Agriculture grazing
- Domain A1 – Infrastructure area – Native ecosystem
- Domain A2 – Integrated Waste Landform –Native ecosystem
- Domain A3 – Water management areas – Native ecosystem
- Domain A4 – WREs – Native ecosystem
- Domain F3 – Permanent water management areas
- Domain J5 – Active mining area (Open pit voids) – Final voids.

ES3 Rehabilitation stages

Rehabilitation staging and resulting completion criteria are used as the basis for assessing when rehabilitation of the project is complete. Indicators are measured against the criteria, and are set for the six phases of rehabilitation, consistent with the RMP guidelines as follows:

- Phase 1 – Decommissioning (ie removal of equipment and infrastructure)
- Phase 2 – Landform Establishment (ie land shaping)
- Phase 3 – Growth Medium Development (ie soil physical and chemical properties)
- Phase 4 – Ecosystem and Land Use Establishment (ie vegetation establishment)
- Phase 5 – Ecosystem and Land Use Sustainability (ie established vegetation is supporting post-mining land use)

- Phase 6 – Land Relinquishment.

The rehabilitation of the Project will follow this staging. The performance objectives and completion criteria vary for each stage and are detailed in Section 7. The general principle of the completion criteria is to measure success of the rehabilitation stage to ensure rehabilitation can trend towards completion.

ES4 Final land use objectives

The overall final land use objectives for the Project have not materially changed from the objectives presented and previously approved for CGO. The final land-uses and objectives are also detailed in the RMP.

The overarching objectives for the final landform design are for the site to achieve final landforms that incorporate natural design elements that are safe, stable and non-polluting. The final landforms will be aimed to be appropriate for the nominated final land uses and sympathetic with surrounding landforms. The final landform will incorporate sustainable vegetation communities appropriate for the nominated final land uses and will be consistent with the rehabilitation works undertaken on site to date.

The E42 pit and GR pit will merge into a single pit during the Project life. E46 will be backfilled and the E46 WRE subsequently established on the backfilled pit.

The slope design criteria of the Project's open pits have been developed in consideration of maintaining factors of safety appropriate for operating conditions and the long-term stability of the expanded LPB.

ES5 Final land use

The approved RMP required under Condition 2.4(c) of DA14/98 and Condition B24 of SSD 10367 outlines the approved conceptual final land use for CGO. The Project does not propose to change the currently approved final land use which will be:

- designed wherever possible to be compatible with regional landscape features
- progressively undertaken as a Run of Mine (ROM) operation wherever possible and left with untrimmed surface roughness to lower runoff coefficients and promote water absorption and storage
- revegetated with native and/or endemic vegetation communities, selected specifically for their suitability to the created elevation, aspect, substrate conditions and the overriding objective of re-establishing a greater extent of endemic vegetation within ML 1535 and ML 1971.

The overall final land use will be implemented in accordance with the approved Rehabilitation Management Plan, government guidelines, best practice rehabilitation techniques and agreed outcomes from stakeholders.

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1 Introduction

1.1 Background

Evolution Mining (Cowal) Pty Limited (Evolution) is the owner and operator of Cowal Gold Operations (CGO), an existing open pit and underground gold mine approximately 38 kilometres (km) north-east of West Wyalong, in the central west region of New South Wales (NSW).

CGO is located on the traditional lands of the Wiradjuri People and is immediately adjacent to the western shore of Lake Cowal, which is an ephemeral waterbody. The existing CGO mine is shown at a regional scale in Figure 1.1 and a local setting in Figure 1.2.

CGO was first approved in 1999, and open pit mining operations commenced in 2005. Underground mining operations were approved in 2021 and development works to enable underground mining are underway.

Evolution is seeking approval for continued open pit mining operations at CGO through the Open Pit Continuation Project (the Project).

This Mine Closure and Rehabilitation Strategy (Rehabilitation Strategy) forms part of the Project's Environmental Impact Statement (EIS). Consistent with the overarching SSD application requirements this rehabilitation strategy covers the final landform design, mine closure planning, rehabilitation planning, post mine land uses and proposed rehabilitation techniques for the Project.

1.2 Project overview

The Project will involve further development of the existing E42 Pit and the development of open pit mining of three adjacent orebodies, known as the 'E46', 'GR' and 'E41'. The three new open pits will be within the existing mining lease (ML 1535). No change to the approved ore processing rate of 9.8 Mt per annum is proposed.

A detailed description of the Project is contained in Chapter 4 of the EIS and a conceptual Project layout is shown in Figure 1.3. The Project comprises the following key components:

- the continued operation of activities as approved under DA14/98 and SSD 10367
- development of three new open satellite pits (the 'E46', 'GR' and 'E41' pits) to the north and south of the existing open pit, within the current approved mining lease
- extending the existing open pit to the east and south via a 'cutback' within the current approved mine lease
- extending open pit mining operations by approximately 10 years
- expansion of the IWL to accommodate life of mine tailings
- extension of the lake protection bund (LPB) system to provide continued separation and mutual protection between Lake Cowal and the mine
- backfilling of one of the new open satellite pits (E46) with waste rock and establishment of a new waste rock emplacement on the backfilled pit to minimise the additional area required for waste rock disposal
- expansion of the footprint of the existing WRE areas to accommodate additional waste rock
- development of additional topsoil and subsoil stockpiles to accommodate materials from pre-stripping, with materials to be reused during progressive mine rehabilitation

- upgrades to existing surface water drainage system, to assist with on-site water management and maximise on-site water conservation

- modification of internal site access and haul roads

- development of new water storages and relocation of some components of the surface water drainage system

- construction and operation of a secondary site access off Lake Cowal Road to the north of the existing ML

- modification and relocation of some existing auxiliary mining infrastructure.

Other than the changes to existing approved activities as set out above, all activities that are currently approved under the existing Ministerial development consents are intended to continue. The Project will not change existing ore processing rates or methods, tailings disposal methods, main site access, water supply sources or hours of operation. The Project will also retain the existing open pit mining workforce.

The Project will also not change the existing approved mine closure, rehabilitation or post mining land use objectives. The final land use objectives for the Project have been maintained largely consistent with previously approved land use objectives with native ecosystem areas and agricultural grazing achievable across the CGO mine site.

1.3 Site description

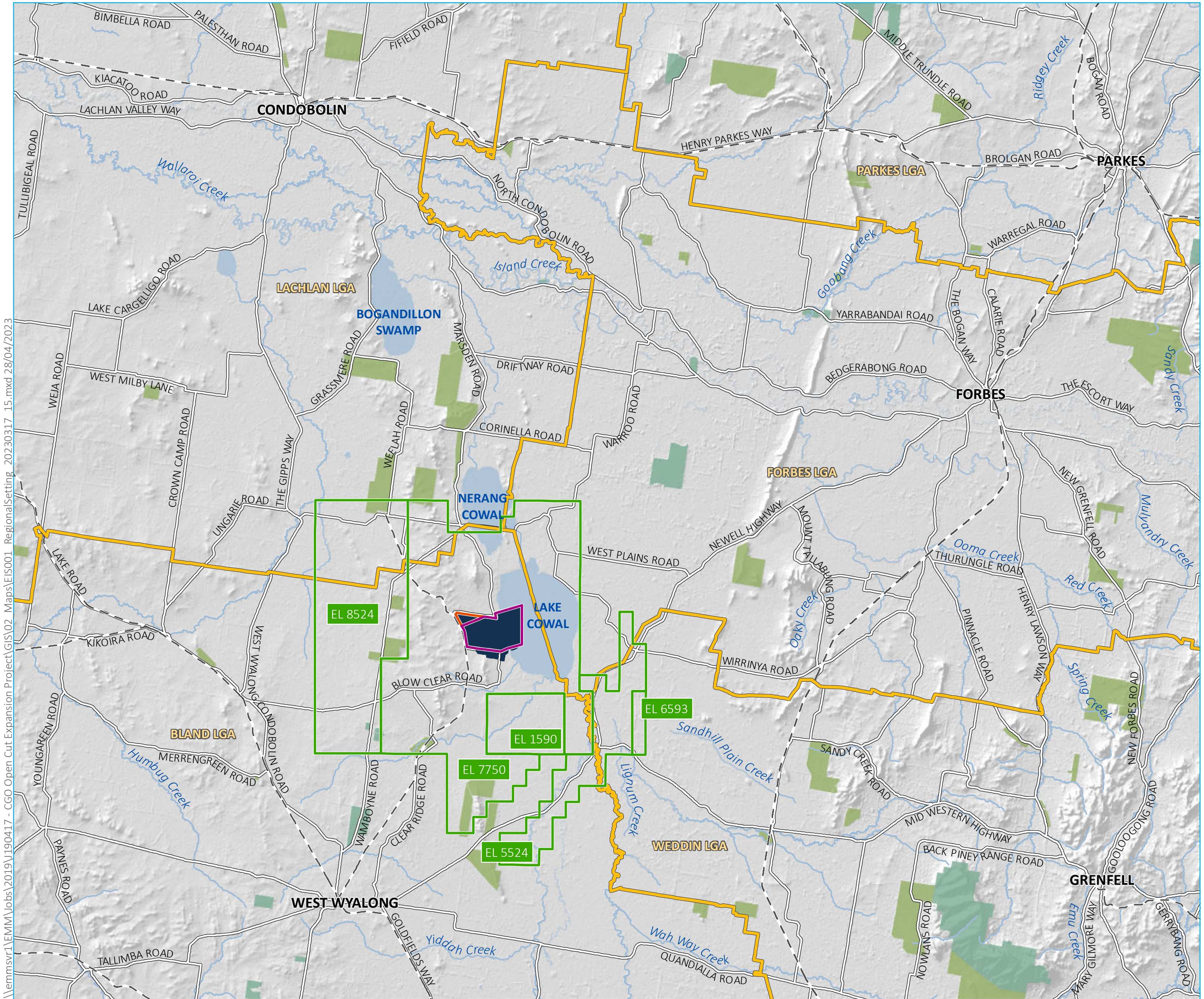
The site is in the Bland Shire local government area (LGA) and is wholly zoned RU1 Primary Production under the *Bland Shire Local Environmental Plan 2011*. Land adjacent to CGO is used primarily for pastoral activities, including cropping and grazing, which is typical of the broader Bland Shire region. The local area is sparsely populated, with residences relating to the large agricultural properties in the area. There are five Evolution owned and 22 privately owned residences within an 8 km radius of CGO.

The dominant local feature in the area where the Project will be located is the broad expanse of Lake Cowal, a natural, ephemeral freshwater lake. In a regional context the lake forms part of the Wilbertroy-Cowal Wetlands located on the Jemalong Plain (refer Figure 1.1).

Lake Cowal is the largest inland lake in NSW. When the lake is full, which on average is approximately 3 years in every 10, it supports a range of migratory birds and other fauna. When dry, the lakebed has been historically used for broad-acre cropping for grain crops, sunflowers as well as grazing.

The lake is situated entirely within privately-owned land and not protected under any reservation mechanism. Evolution does not allow its land within Lake Cowal to be used for agricultural activities when the lake is dry.

There are several state forests near CGO, the closest being the Lake View State Forest and Corringle State Forest which are 7 km north-east and east respectively. Other state forests in proximity to CGO include the state forests Euglo South, Nerang Cowal, Clear Ridge, Wyrra, Boxhall, Back Creek, Little Blow Clear, Blow Clear and Hiawatha. Evolution also manages existing and proposed biodiversity offset areas as well as remnant vegetation enhancement areas, which are all located within a 5 km radius of CGO, covering an approximate total area of 1,650 ha.



Source: EMM (2023); Evolution (2023); DFSI (2017); GA (2011); ASGC (2006)

0 10 20 km

GDA 1994 MGA Zone 55

N

KEY

- Project area
- Mining lease (ML1535)
- Mining lease (ML1791)
- Exploration licence (EL)
- Rail line
- Main road
- Named watercourse
- Named waterbody
- Local government area
- NPWS reserve
- State forest

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Regional setting

Evolution Mining
Cowal Gold Operations
Open Pit Continuation Project
Mine Closure and Rehabilitation Strategy
Figure 1.1

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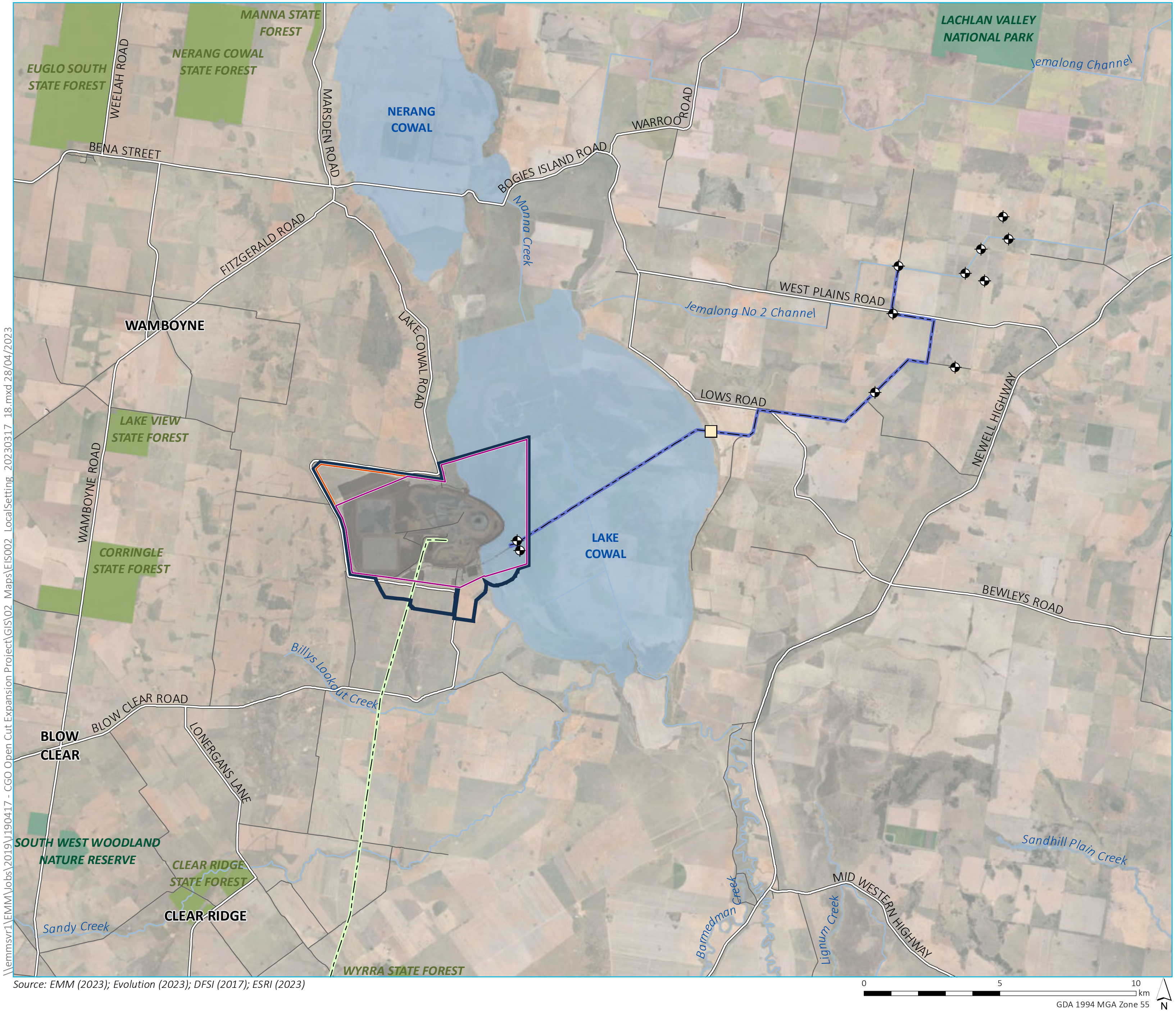

KEY

- Project area
- DA14/98 approved surface disturbance
- Mining lease (ML1535)
- Mining lease (ML1791)
- Eastern pump station
- Saline groundwater supply bore
- Water supply pipeline
- Electricity transmission line
- Major road
- Minor road
- Named watercourse
- Named waterbody
- NPWS reserve
- State forest

Source: EMM (2023); Evolution (2023); DFSI (2017); ESRI (2023)

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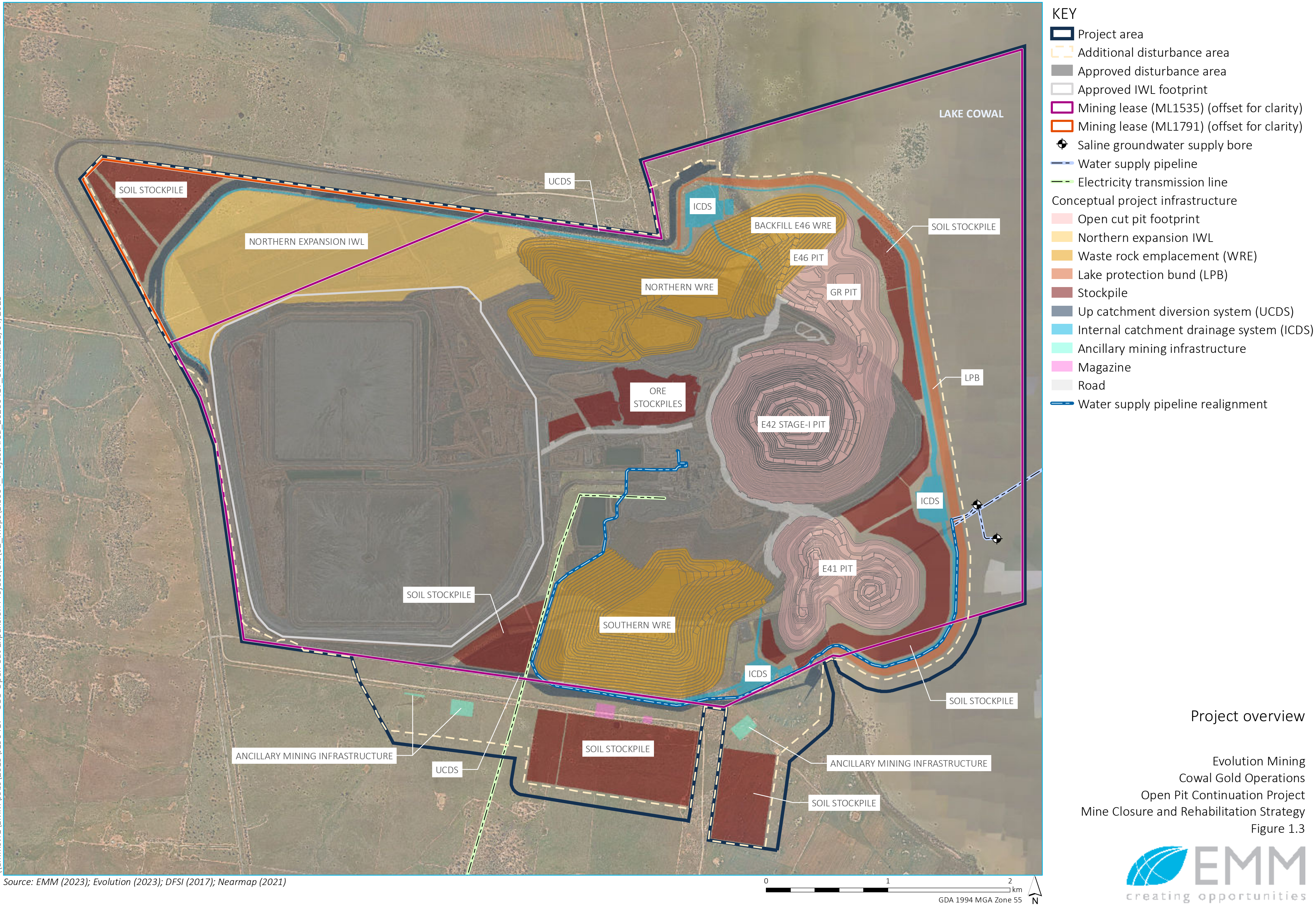
Local setting

Evolution Mining
Cowal Gold Operations
Open Pit Continuation Project
Mine Closure and Rehabilitation Strategy
Figure 1.2

EMM
creating opportunities



Source: EMM (2023); Evolution (2023); DFSI (2017); Nearmap (2021)

Project overview

Evolution Mining
Cowal Gold Operations
Open Pit Continuation Project
Mine Closure and Rehabilitation Strategy
Figure 1.3

EMM creating opportunities

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1.4 Purpose of this report

The purpose of this Rehabilitation Strategy is to address the relevant Secretary's Environmental Assessment Requirements (SEARs) for the Project that relate to mine rehabilitation and closure planning.

This Rehabilitation Strategy covers the final landform design, mine closure planning, rehabilitation planning, post mine land uses and proposed rehabilitation techniques for the Project. Unlike a greenfield site where no development has previously occurred, the CGO is in its 17th year of operations and earthmoving involving hundreds of millions of tonnes of material in the form of WRE, IWL and the E42 open pit has already taken place. These structures are individually massive and represent a mid-point in the development of the post-mine closure rehabilitation outcome. As a result, the rehabilitation strategies available for implementation on the Project are heavily influenced by the approved mining activities carried out to date.

1.4.1 Objectives of this strategy

The objectives of this rehabilitation strategy are to:

- confirm the overarching objectives for the final landform design and final land uses
- describe the proposed final land uses
- identify potential risks and impacts which could impact closure and rehabilitation management and success
- develop a suitable final landform
- describe the methods for establishing stable final landforms
- describe rehabilitation criteria and outlining the monitoring requirements that assess whether or not these criteria are being accomplished as the mine progresses.

1.4.2 Ongoing Rehabilitation Management Plans and Closure Plans

The Project will not significantly change the existing overall existing rehabilitation objectives and the proposed final land-uses for CGO from that currently approved.

The following rehabilitation objectives from the RMP (Evolution, 2022) are approved for the CGO and will be applied to the Project:

- The mine site as a whole is safe, stable and non-polluting;
- Final landforms are designed to incorporate micro-relief and integrate with surrounding natural landforms
- Constructed landforms are to generally drain to the final void
- To minimise long-term groundwater seepage zone
- Minimise visual impact of final landforms as far as is reasonable and feasible
- Decommission and remove surface infrastructure unless otherwise agreed with the RR
- Restore ecosystem function, including maintaining or establishing self-sustaining ecosystems
- Restore or maintain land capability as described in the EIS
- Paste backfill underground stopes so that they are safe and stable

- Surface subsidence is negligible in the long term
- Public safety is maintained
- Adverse socio-economic effects associated with mine closure are minimised.

This Rehabilitation Strategy has been prepared cognisant that should the Project be approved, the existing Rehabilitation Management Plan (RMP) will be amended and submitted to the Resources Regulator in accordance with the requirements under the Mining Act and Regulations applicable at the time. The RMP will be consistent with the rehabilitation and closure commitments described in this strategy and will provide more detail on rehabilitation scheduling and techniques.

As the mine progresses, knowledge of rehabilitation methods and techniques will be further developed and refined, and new approaches may be developed including technological advances. Refinements of the proposed rehabilitation approach, and methods, and schedule may be made to address these potential changes and included in the RMPs and the future detailed closure plans as they are developed and revised periodically.

1.5 Assessment approach

This strategy has been prepared in accordance with requirements of the NSW Department of Planning and Environment (DPE). These were set out in the SEARs issued on 10 June 2022.

The SEARs identify matters which must be addressed in the Environmental Impact Statement (EIS) and form its terms of reference. Table 1.1 lists individual requirements relevant to this strategy and where they are addressed in this report.

To inform the preparation of the SEARs for SSD-42917792, DPE invited other government agencies to recommend matters to be addressed in the EIS.

The Department of Regional NSW, Mining, Exploration and Geoscience (MEG) and Department of Regional NSW, Resources Regulator (RR) raised matters pertaining to rehabilitation and final landform. The matters and where they have been addressed in this Strategy are listed in Appendix A.

Table 1.1 SSD-42917792 rehabilitation related SEARs

Requirement	Section addressed
General Requirements: In particular, the EIS must include, but not necessarily be limited to the following: • a full description of the development including: – a rehabilitation strategy, including details of the progressive rehabilitation of the site during and following construction and decommissioning	This document. Progressive rehabilitation is addressed in Section 5.2
Key Issues The EIS must address the following specific issues: • Land and Soils – including: – an assessment of the likely impact of the development on landforms (topography), including the long-term geotechnical stability of any new landforms on site;	Sections 4.3 and 3.4.2 Appendix A – Erodibility Evaluation and Landform Evolution Modelling Program Soils and Land Impact Assessment (Minesoils 2023) (Appendix T of the EIS)
• **Closure, Rehabilitation and Final Landform –** including a Rehabilitation Strategy providing:	

Table 1.1 SSD-42917792 rehabilitation related SEARs

Requirement	Section addressed
– a detailed overview of the final land-use and final landform, rehabilitation objectives and closure criteria for the development, including the conceptual final landform design;	Chapter 3 and Chapter 4
– identification and discussion of opportunities for progressive rehabilitation throughout the mine life and to improve environmental outcomes for existing disturbed areas within the development site;	Section 5.2
– rehabilitation objectives, performance standards and completion criteria; and	Section 6 and 7
– decommissioning of surface infrastructure;	Section 5.1.2i

2 Statutory and strategic context

2.1 Legislation

2.1.1 Mining Act 1992

CGO operates within mining leases (ML1535 and ML1791) granted under the *Mining Act 1992* (the Mining Act). The Mining Amendment (Standard Conditions of Mining Leases – Rehabilitation) Regulation 2020 (the Mining Amendment Regulation) commenced on 2 July 2021. The Mining Amendment Regulation imposes new standard rehabilitation conditions for all mining lease holders in NSW through amendment of the Mining Regulation 2016. The transitional period that applied to GCO has finished, and the new standard rehabilitation conditions were introduced in July 2022. The new rehabilitation conditions as detailed in Table 2.1 replace existing rehabilitation and environmental management conditions on current leases.

Table 2.1 Standard rehabilitation conditions

Condition	Section addressed
5. The holder of a mining lease must rehabilitate land and water in the mining area that is disturbed by activities under the mining lease as soon as reasonably practicable after the disturbance occurs.	Chapter 3
6 (1). The holder of a mining lease must ensure that rehabilitation of the mining area achieves the final land use for the mining area.	Section 2.2 and Chapter 6
6 (2). The holder of the mining lease must ensure any planning approval has been obtained that is necessary to enable the holder to comply with subclause (1).	This reporting accompanies a Development Application
6 (3). The holder of the mining lease must identify and record any reasonably foreseeable hazard that presents a risk to the holder's ability to comply with subclause (1). Note— Clause 7 requires a rehabilitation risk assessment to be conducted whenever a hazard is identified under this subclause.	Chapter 6
6(4). In this clause – final land use for the mining area means the final landform and land uses to be achieved for the mining area – (a) as set out in the rehabilitation objectives statement and rehabilitation completion criteria statement, and (b) for a large mine – as spatially depicted in the final landform and rehabilitation plan, and (c) if the final land use for the mining area is required by a condition of development consent for activities under the mining lease – as stated in the condition. planning approval means – (a) a development consent within the meaning of the *Environmental Planning and Assessment Act 1979*, or (b) an approval under that Act, Division 5.1.	Noted
7 (1). The holder of a mining lease must conduct a risk assessment (a rehabilitation risk assessment) that – (a) identifies, assesses and evaluates the risks that need to be addressed to achieve the following in relation to the mining lease – (i) the rehabilitation objectives, and (ii) the rehabilitation completion criteria, and (iii) for large mines – the final land use as spatially depicted in the final landform and rehabilitation plan, and (b) identifies the measures that need to be implemented to eliminate, minimise or mitigate the risks.	Chapter 6
7 (2). The holder of the mining lease must implement the measures identified.	Noted

Table 2.1 Standard rehabilitation conditions

Condition	Section addressed
7 (3). The holder of a mining lease must conduct a rehabilitation risk assessment – (a) for a large mine – before preparing a rehabilitation management plan, and (b) for a small mine – before preparing the rehabilitation outcome documents for the mine, and (c) whenever a hazard is identified under clause 6(3) – as soon as reasonably practicable after it is identified, and (d) whenever given a written direction to do so by the Secretary.	
10 (1). The holder of a mining lease relating to a large mine must prepare a plan (a rehabilitation management plan) for the mining lease that includes the following – (a) a description of how the holder proposes to manage all aspects of the rehabilitation of the mining area, (b) a description of the steps and actions the holder proposes to take to comply with the conditions of the mining lease that relate to rehabilitation, (c) a summary of rehabilitation risk assessments conducted by the holder, (d) the risk control measures identified in the rehabilitation risk assessments, (e) the rehabilitation outcome documents for the mining lease, (f) a statement of the performance outcomes for the matters addressed by the rehabilitation outcome documents and the ways in which those outcomes are to be measured and monitored.	The existing RMP will be amended prior to commencement of Project operations
10 (2). If a rehabilitation outcome document has not been approved by the Secretary, the holder of the mining lease must include a proposed version of the document.	Noted
10 (3). A rehabilitation management plan is not required to be given to the Secretary for approval.	Noted
10 (4). The holder of the mining lease – (a) must implement the matters set out in the rehabilitation management plan, and (b) if the forward program specifies timeframes for the implementation of the matters – must implement the matters within those timeframes.	Noted
12 (1). The holder of a mining lease must prepare the following documents (the rehabilitation outcome documents) for the mining lease and give them to the Secretary for approval – (a) the rehabilitation objectives statement, which sets out the rehabilitation objectives required to achieve the final land use for the mining area, (b) the rehabilitation completion criteria statement, which sets out criteria, the completion of which will demonstrate the achievement of the rehabilitation objectives, (c) for a large mine, the final landform and rehabilitation plan, showing a spatial depiction of the final land use.	(a) Section 2.1 (b) Chapter 6 (c)Section 2.2
12 (2). If the final land use for the mining area is required by a condition of development consent for activities under the mining lease, the holder of the mining lease must ensure the rehabilitation outcome documents are consistent with that condition.	Noted
13 (1). The holder of a mining lease must prepare a program (a forward program) for the mining lease that includes the following – (a) a schedule of mining activities for the mining area for the next 3 years, (b) a summary of the spatial progression of rehabilitation through its various phases for the next 3 years, (c) a requirement that the rehabilitation of land and water disturbed by mining activities under the mining lease must occur as soon as reasonably practicable after the disturbance occurs.	To be included in the amended RMP following approval of the Project.

2.1.2 Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act* 1997 (POEO Act) establishes the State's environmental regulatory framework and includes licensing requirements for certain activities. The objectives of the POEO Act that relate to decommissioning and rehabilitation include '*...to protect, restore and enhance the environment, to reduce risks to human health and prevent degradation of the environment*'.

The POEO Act objectives have been used in the preparation of this strategy and are principally reflected in one of the overarching goals of the strategy; to minimise the risk of pollution occurring from the site during and following closure, decommissioning and rehabilitation.

2.2 Guidelines, Policies and Plans

This strategy has been prepared generally in accordance with relevant State and Commonwealth guidelines, policies and plans. The relevance and requirements of each of the guideline, policy and plan is discussed briefly in the following sections.

2.2.1 Guidelines

i Borehole Sealing Requirements on Land

The guideline for mineral exploration drilling; drilling and integrity of petroleum exploration and production wells (the drilling guideline) provides an overview of the process for rehabilitation of boreholes not licensed under the *Water Management Act 2000* or the *Water Act 1912*.

If any boreholes remain open at completion of the operational phase, Evolution will rehabilitate any remaining boreholes, having regard to the borehole sealing requirements in the drilling guideline.

ii Rehabilitation Plan Guidelines

The ESG3 – *Mining Operations Plan (MOP) Guidelines*, September 2013 (NSW Department of Trade and Investment – Division of Resources and Energy 2013) have been replaced by *Form and Way: Rehabilitation Management Plans for Large Mine*, September 2020 (the RMP guidelines) (Department of Regional NSW – Resources Regulator).

A RMP for the mining area must be prepared for large mines by the timeframe specified in the Regulation. It must incorporate the risk control measures identified in a rehabilitation risk assessment and be consistent with the site's project approvals. The RMP is to be amended over time to reflect any changes to the risk control measures identified in a rehabilitation risk assessment, as well as the approved rehabilitation objectives and completion criteria, and final landform and rehabilitation plan. The Secretary may also direct that the plan be updated. Once the rehabilitation objectives and completion criteria, and final landform and rehabilitation plan have been approved, leaseholders must implement the plan in accordance with the timeframes specified in the forward program. The plan will be a publicly available document and must be published (eg on the leaseholder's website) 14 days after it is prepared and after any amendment.

A rehabilitation risk assessment must be conducted by all leaseholders. This informs the preparation of annual forward programs. Large mines must undertake this assessment before preparing an RMP. The risk assessment must identify, assess and evaluate the risks to be addressed to achieve the proposed or approved rehabilitation objectives and rehabilitation completion criteria and the final land use depicted in the proposed or approved final landform and rehabilitation plan. The risk assessment must also identify the measures that need to be implemented to eliminate, minimise or mitigate the identified risks.

Rehabilitation objectives and completion criteria must be prepared by all leaseholders. For large mines, a final landform and rehabilitation plan is also required. Both must be submitted for approval by the Secretary by the timeframe specified in the Regulation.

This strategy has been prepared to address the various requirements of the closure and rehabilitation aspects of the RMP guidelines. Mining and final land-use domains have been identified as per the guidelines, as well as objectives and completion criteria for these domains. A detailed closure and rehabilitation risk assessment has been undertaken to inform the current approved RMP (Evolution 2022) and has informed the development of this rehabilitation strategy (refer Chapter 3) along with Project specific risk assessments that have been carried out throughout the Project design and assessment phase.

The CGO 's existing RMP will be reviewed and updated as required following Project approval.

iii Strategic Framework for Mine Closure

The *Strategic Framework for Mine Closure* (Australian and New Zealand Minerals and Energy Council and Minerals Council of Australia, 2000) (SFMC) was developed to promote nationally consistent mine closure management. The SFMC provides guidelines for the development of a mine closure plan to make sure that all stages of mine closure are conducted appropriately, including stakeholder engagement, development of mine closure methodology, financial planning, and implementation of mine closure. The SFMC also describes the expected standards for mine closure and relinquishment of the mine to a responsible authority. Whilst the objectives generally relate to mine closure, there are key elements that are relevant to rehabilitation of the project, in particular the allocation of appropriate resources and the establishment of rehabilitation criteria, which have been included in this strategy.

The main objectives of the SFMC are to:

- enable all stakeholders to have their interests considered during the mine closure process
- ensure the process of closure occurs in an orderly, cost-effective and timely manner
- ensure the cost of closure is adequately represented in company accounts and that the community is not left with a liability
- ensure there is clear accountability, and adequate resources, for the implementation of the closure plan
- establish a set of indicators which will demonstrate the successful completion of the closure process
- reach a point where the company has met agreed rehabilitation criteria to the satisfaction of the Responsible Authority.

iv Mine Rehabilitation - Leading Practice Sustainable Development Program for the Mining Industry

The aim of *Mine Rehabilitation – Leading Practice Sustainable Development Program for the Mining Industry* (NSW Department of Industry, Tourism and Resources, 2006) (MR Handbook) is to provide guidelines to promote 'leading practice' sustainable mine plan and rehabilitation design, considering environmental, economic, and social aspects to support on-going sustainability of a mining development. The MR Handbook recommends procedures and mitigation measures that should be considered during mine plan and rehabilitation design, including stakeholder consultation, material and handling, water balance, final landform design, soil (topsoil and subsoil) management, vegetation and fauna habitat re-establishment and rehabilitation, and agriculture / commercial forestry suitability. The MR Handbook also provides relevant mine development case studies supporting the recommended procedures and mitigation measures. Where relevant to the project, the above principals have been addressed in this strategy.

v Mine Closure and Completion - Leading Practice Sustainable Development Program for the Mining Industry

The aim of *Mine Closure and Completion – Leading Practice Sustainable Development Program for the Mining Industry* (NSW Department of Industry, Tourism and Resources, 2006) (MCC Handbook) is to provide guidelines to promote 'leading practice' sustainable mine closure and completion, minimising any long-term environmental, economic, and social impacts and resulting in a suitable final land form for an agreed land use. Specifically, the MCC Handbook provides that a progressive rehabilitation plan, which is a key principle of this strategy, should be developed for mine closure.

vi Policies

a NSW Wetlands Policy 2010

The NSW Wetlands Policy (DECCW 2010) aims to provide for the protection, ecologically sustainable use and management of NSW wetlands (Department of Environment, Climate Change and Water [DECCW], 2010). The policy provides a set of guiding principles that all government agencies will adopt, and all stakeholders can refer to when making decisions on wetland management and conservation.

The principles relevant to this strategy include:

- natural wetlands should not be destroyed or degraded
- degraded wetlands and their habitats should be rehabilitated and their ecological processes improved as far as is practicable
- the conservation and management of wetlands are most appropriately considered at the catchment scale.

Section 5.1.2vi of this strategy describes the rehabilitation of the LPB. In particular, the objectives of the rehabilitation program include habitat for wetland and terrestrial fauna species. This includes the design and reinstatement of the Lake Foreshore following construction of the expanded LPB in a manner consistent with the NSW Wetlands Policy.

b Policy and Guidelines for Fish Habitat Conservation and Management

The DPI's *Policy and Guidelines for Fish Habitat Conservation Management* (Update 2013) outlines the policies and guidelines aimed at maintaining and enhancing fish habitat for the benefit of native fish species, including threatened species, in marine, estuarine and freshwater environments. In relation to this strategy, the policy outlines key concepts for habitat rehabilitation. As described above, section 5.1.2vi of this strategy describes the rehabilitation concepts for reinstatement of the Lake Foreshore following construction of the expanded LPB in a manner consistent with this policy.

vii Plans

a Lachlan Long Term Water Plan

The Lachlan Long Term Water Plan (Part A and Part B) (Department of Planning, Industry and Environment 2020) contains ecological objectives and targets for priority environmental assets and ecosystem functions. Ecological objectives have been identified for native fish, native vegetation, waterbirds, frogs and functions such as river connectivity as they respond to flow. The objectives reflect the current scientific understanding of environmental outcomes that might be expected from implementation of the basin plan in the Lachlan catchment.

Broad outcomes underpinning the Lachlan Long Term Water Plan relevant to this strategy include biodiversity and native vegetation, water and aquatic ecosystems and land management. The rehabilitation methods and measures outlined in Sections 4 and 5 of this strategy are considered to be generally consistent with the objectives of this Plan.

2.3 Adoption of leading practices

The CGO is committed to adopting leading practices in the planning, construction, operation, closure and rehabilitation of the Project. This includes leading practice measures to avoid, minimise and/or mitigate potential environmental and social impacts. In relation to rehabilitation the leading practices adopted are:

- Adoption of a waste rock emplacement design that avoids structural drainage features and incorporates microrelief to increase the visual amenity of the landform.
- The use of topsoil/rock matrices to provide critical shear protection in sloping areas of the waste rock emplacements (WRE) and to minimise tunnel and gully formation on the rehabilitated landforms.
- Establishing a biodiversity post mining land-use on the waste rock emplacement that will help account for previous clearing for agricultural purposes and maximises the function and stability of the cover system.
- Scheduling the development of the waste rock emplacement so that it will be progressively rehabilitated over the life of the mine.

2.4 Rehabilitation undertaken to date

Rehabilitation of disturbed lands has been undertaken progressively and successfully at CGO throughout the mine's life. At the end of 2021, 109.6 ha of previously disturbed land within ML 1535 was under rehabilitation (ie either shaped and covered or rehabilitated and under maintenance (CGO 2021).

Areas currently under rehabilitation include:

- NWRE – north wall, continued post seeding monitoring of 47.9ha on all lower, mid and upper batters
- SWRE – internal wall, continued monitoring of 18 ha of stabilising rock armour placement
- SWRE – south wall, continued post seeding monitoring of 37.7ha on all lower, mid and upper batters.
- SWRE – south wall, ongoing monitoring of rock/topsoil trial plots following direct seeding in November 2011
- Perimeter Waste Rock Emplacement (PWRE) – continued monitoring of 6 ha of rehabilitation
- Temporary Isolation Bund and Lake Protection Bund – road and weed maintenance
- Bland Creek Palaeochannel Borefield water supply pipeline (rehabilitated and under maintenance).

The Project will re-disturb most previously rehabilitated areas, or areas under active rehabilitation, to accommodate the Project. Notwithstanding, the success and lessons learned from previous rehabilitation activities and investigations will be applied to the Project.

2.4.1 Rehabilitation trials

Significant rehabilitation trials have been undertaken over the life of the mine to inform and improve rehabilitation practices and outcomes.

Key findings of the rehabilitation investigations and trials conducted at the CGO to date include the following:

- The surface cover treatment/method most likely to stabilise final landform slopes and support long-term vegetation growth includes (DnA Environmental, 2022):
  - rock mulch and gypsum-treated topsoil cross-ripped along the contour of the slope (rock/soil matrix)
  - a light to medium application of native pasture hay or clean wheaten straw hay as an immediate protective soil cover, if vegetation establishment is not adequate.
- The annual exotic grass *Lolium rigidum* (Wimmera Ryegrass) present in the topsoil seed bank establishes rapidly in high abundance across rehabilitation areas, providing extensive vegetation cover and soil/surface protection, and a mulch/litter cover once it desists. As a result, hay mulch is only considered necessary in areas where *Lolium rigidum* (Wimmera Ryegrass) has not established.
- Direct seeding onto freshly topsoiled and deep ripped rocky surfaces has resulted in higher seedling densities compared with deep ripped grassland areas (DnA Environmental, 2022).
- Successful seedling establishment can be obtained in areas where a Wimmera Ryegrass cover crop has established by deep ripping prior to direct seeding (DnA Environmental, 2022).
- No obvious effects have been observed on the growth rates of the tubestock in the Northern Waste Rock Emplacement trial because of the different topsoil depths or mulch treatments (DnA Environmental, 2018b).
- The inclusion of rock mulch in the surface cover placed on CGO landform slopes provides resistance to erosion and reduces surface water flow velocities on landform slopes during high rainfall events (Gilbert and Associates, 2009).
- Primary waste rock is suitable for use as rock armour (or rock mulch) on landform slopes due to the material being typically non-saline and NAF (GEM, 2008; 2013; 2016). However, primary waste rock materials with higher reactive sulphide contents (greater than 0.5% sulphur) are likely to present a risk of developing saline conditions when oxidised and these materials should either be excluded from use as rock armour or blended with the lower sulphur material to dilute the reactive sulphides (GEM, 2008; 2013; 2016).
- Due to the expected salinity and sodicity of the oxide waste rock, this material is not suitable for armouring the batter slopes of the WRE or IWL (GEM, 2008; 2013; 2016).
- Due to the sodic and dispersive nature of the oxide waste rock material, gypsum needs to be spread on the surface of oxide waste rock material (i.e. in particular on the Southern Waste Rock Emplacement) prior to the application of the rehabilitation cover materials (e.g. rock mulch and gypsum-treated topsoil) to assist with stabilising the underlying substrate material (GEM, 2008; 2013; 2016; Barrick, 2014).
- Most stockpiled soil resources at the CGO are typically sodic and dispersive and therefore require treatment with gypsum to improve the soil structure and suitability for plant growth (Minesoils 2023).
- Various methods for treating or ameliorating soil at the CGO have been recommended by Minesoils (2023), including treating soil stockpiles with gypsum (or other relevant treatment material), treating strongly sodic and dispersive soil stocks with gypsum in a dedicated soil amelioration farm, treating soil when re-applied to rehabilitation areas and spreading gypsum on the surface of original soil profiles prior to soil stripping.

- Ameliorated soils are anticipated to improve revegetation outcomes for the CGO final landforms (due to improved soil properties for plant growth) and may increase the number and diversity of revegetation species able to be used in the CGO rehabilitation programme (i.e. additional species could be used that are typically less tolerant to deficient soils) (McKenzie Soil Management, 2013). Soil conditioning (with gypsum) and the application of surface cover treatments improves the effectiveness of revegetation techniques including direct seeding and tubestock planting (DnA Environmental, 2013a).

- The results from vegetation growth trials undertaken to date indicate that seedlings of select salt tolerant tree species continued to grow when planted in a substrate including CGO oxide and sulphide tailings (Barrick, 2013b). As a result, it is considered salt tolerant tree species would likely establish and develop when planted on the top surfaces of the TSFs/IWL.

  - the results from tree root growth assessments of six-year-old trees planted in substrates including topsoil, subsoil and oxide waste rock indicate (DnA Environmental, 2017);

  - the root systems of the younger sapling plants preferred to grow laterally on top of dense clay oxide waste rock layers, but were capable of growing down into crumbly oxide waste rock layers;

  - as the tree and root system matures, the stronger and larger roots were able to penetrate the dense clay oxide waste rock; and

  - the chemical characteristics of the oxide waste rock has not been observed to be a constraint to plant growth.

Formal rehabilitation monitoring as described in Section 7.2 has been undertaken at CGO since 2010 (DnA Environmental, 2022) using a combination of:

- Landscape Function Analysis (LFA) indicators (which includes measurement of soil erosion type and severity);

  - accredited soil analyses indicators; and

  - an assessment of ecosystem characteristics using an adaptation of methodologies derived by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Methodology for the Grassy Box Woodlands Benchmarking Project in Southern NSW Murray-Darling Basin (Gibbons, 2002) and the associated Biometric Model Rapidly quantifying reference conditions in modified landscapes (Gibbons et al., 2008).

LFA is one of three components of the EFA tool developed by the CSIRO that aims to measure the progression of revegetation/rehabilitation towards a self-sustaining ecosystem.

In accordance with the LFA methodology, the LFA monitoring results are to be used by CGO to assess whether rehabilitation areas are on a trajectory towards a self-sustaining landscape and to guide management intervention in accordance with the trigger, action and response plan in the CGO Rehabilitation Management Plan.

An annual rehabilitation report is prepared by DnA Environmental, and the rehabilitation performance is reported to agencies and the public in the Annual Reviews and Annual Rehabilitation Report.

3 Environmental risk management

The CGO maintains a rehabilitation risk assessment as a requirement of the RMP guidelines (refer Evolution 2022). Key rehabilitation and closure risks identified in the RMP risk assessment are detailed below along with their specific relevance to the Project.

3.1 Environmental geochemistry

A range of geochemical investigations have been conducted for CGO on the mine rock, surface material, waste rock (primary waste rock and oxide), low-grade ore (LGO), ore, and tailings. These have been summarised and expanded on in the recent 2023 geochemical investigation commissioned in support of the Project (GEM 2023, Appendix E of the EIS). The primary findings of the geochemical assessments for the waste rock, LGO and ore, and tailings are outlined below.

3.1.1 Waste Rock

The findings of the 2023 geochemical assessment (Appendix E.2 of the EIS) are generally consistent with the findings from the previous investigations, and are summarised as follows:

- The oxide waste rock is saline and sodic. Investigations also indicated a lack of reactive sulfide within the oxide waste rock samples, which precludes extensive acid generation. Due to a low acid neutralisation capacity (ANC) within the oxide waste rock, these samples have been classified as non-acid forming (NAF) to barren.

- Primary (fresh) waste rock is non- to slightly saline and non- to slightly sodic. In contrast to the oxide waste rock, primary waste rock was found to contain relatively high reactive sulfide; however, the primary waste rock also contains relatively high ANC, is typically NAF and may be acid consuming in some instances. Oxidation of reactive sulfide in the primary waste rock is therefore expected to be neutralised by the available ANC, which will limit acid generation, although there is a risk that drainage from this waste rock will become saline.

- One sample of the primary volcaniclastic waste rock from the E41 East deposit was classified as potentially acid forming (PAF), in contrast to the findings of the previous investigations.

- The waste rock is typically enriched with arsenic and antimony, with some samples found to be enriched with silver, cadmium and selenium. Leach testing identified molybdenum and selenium as potentially readily soluble under the prevailing near neutral to slightly alkaline pH conditions of the tests. However, sequential batch water extractions indicated that leaching of environmentally important elements from waste rock at CGO was unlikely to be of concern provided near neutral pH values were maintained.

i Rock Armour Suitability Geochemical Assessment (GEM 2008)

Specific to rehabilitation, GEM prepared a Rock Armour Suitability Geochemical Assessment for the Cowal Gold Mine (GEM, 2008) to assess the suitability of the CGO's oxide and primary waste rock for use as rock armouring on CGO landform slopes.

The main findings of the assessment indicated (GEM, 2008):

- the oxidised waste rock typically contains low sulphur and low acid neutralising capacity (ANC) and in terms of acid generation these materials are likely to be benign. However, a large proportion of the oxidised waste (70%) is likely to be saline.

- all of the primary waste rock types are typically non-saline.

- the primary waste rock contains reactive sulfides; however, due to their moderate to high ANC, all of the primary waste rock types are expected to be NAF.

Most of the waste rock samples assayed were found to be enriched in arsenic and some of the samples were found to be enriched in Cd, Pb, Sb and Zn (GEM, 2008). However, water extract testing showed that under the prevailing near-neutral pH condition these elements are not soluble and provided these pH conditions are maintained, element solubility and release from these materials is not expected to be a concern (GEM, 2008).

Based on these findings, the following recommendations were made (GEM, 2008):

- due to the expected salinity of the oxidised waste rock, this material is not suitable for armouring the batter slopes of the WRE and TSFs.

- the primary waste rock is typically non-saline and NAF and the majority of this material is expected to be suitable rock armour material. However, materials with higher reactive sulphide contents (greater than 0.5% sulphur) are likely to present a risk of developing saline conditions when oxidised and these materials should either be excluded from use as rock armour or blended with the lower sulphur material in order to dilute the reactive sulphides.

3.1.2 LGO and ore stockpiles

The LGO and ore characterisation in the 2023 geochemical assessment (Appendix E.2 of the EIS) is generally consistent with the previous investigations, with the exception that a number of PAF samples were identified within the E41 East deposit. The primary findings are:

- The LGO and ore is to be non-saline. Reactive sulfides are, however, present in the samples tested and although most samples are classified as NAF, a number of samples from the E41 East deposit are PAF or PAF low capacity (PAF-LC). In addition, although most LGO and ore is expected to have sufficient acid buffering capacity, the reactive sulfides may result in an increase in salinity following exposure on the surface of the LGO and ore stockpiles.

- The LGO and ore is enriched in arsenic and antimony, with some samples also enriched in silver, cadmium, copper, mercury, selenium and zinc. Leach testing found arsenic, molybdenum and selenium to be readily soluble.

3.1.3 Tailings

Previous and recent investigations into CGO tailings geochemical characteristics are summarised as follows:

- Geochemical investigations on tailings samples indicate that these are generally low in salinity and are non-sodic. The presence of reactive sulfides has been noted in a number of tailings samples; however, the presence of ANC within these samples is expected to limit acid generation and the majority of the tailings are classified as NAF.

- The 2023 geochemical study used ore and LGO samples as proxies for tailings and identified the potential occurrence of small quantities of PAF ore and PAF LGO in the E41 deposit, which may present the risk of acidifying on exposure.

- Elemental analyses conducted on the tailings samples predict high concentrations of arsenic, cadmium, lead, molybdenum, antimony and zinc. Kinetic leach column tests conducted on tailings samples identified the potential for an initial ‘flush’ of soluble copper and zinc from primary tailings. However, it was concluded that this release was most likely to be associated with residual cyanide in the tailings liquor/supernatant from the carbon-in-leach processing procedure and did not represent a long-term concern for water quality.

- Based on the similar geochemical characteristics of the ore between the previous and current investigations, it is predicted that the tailings will be enriched in Ag, As, Cd, Pb, Sb, Se and Zn. CGO's existing TSF water quality monitoring program will be amended to include the additional metals.

3.1.4 Key geochemical rehabilitation risk management measures

As a result of the geochemical assessments of waste rock conducted to date (GEM, 2008; 2009; 2013, 2016, 2018, 2020, 2023), the following will continue to be undertaken at CGO to manage any geochemical related risk to rehabilitation:

- testing of primary waste rock material is undertaken to assess sulphur content
- only benign primary waste rock is used as rock armouring for mine landform slopes
- the parameters As, Cd, Pb, Sb, Se and Zn are included in the CGO's surface water monitoring program.

3.2 Soils

3.2.1 Overview

The Project area consists of the Lake Cowal, Wah Wey, Marsden, Boxalls and Barmedman Soil Landscapes. A soil survey undertaken by Minesoils (2023, Appendix T of the EIS) found the Project area to contain four dominant soil mapping units as detailed below:

- **Soil Unit 1 Sodosols** – are dominant throughout the western half of the Project area. With a clear or abrupt textural B horizon and in which the major part of the upper 0.2 m of the B2 horizon (or the major part of the entire B2 horizon if it is less than 0.2 m thick) is sodic and not strongly acid. Topsoil consists of loam, sandy loam and clay loam texture with weak to moderate pedality, with occasional weakly structured A2 horizons. Subsoils contain a greater clay fraction and are consistently trend to moderately to extremely saline and strongly to very strongly alkaline with depth.

- **Soil Unit 2 Vertosols** – associated with the very gently undulating lower slopes and flats leading into Lake Cowal. Vertosols are soils with a clay field texture or 35 per cent or more clay throughout the solum except for thin, surface crusty horizons 30 mm or less thick. These soils were observed to exhibit a cracked surface condition and contained topsoils of well-structured clay loams through to heavy clay, overlying well-structured medium to heavy clay subsoils. Topsoils were generally non-saline and non-sodic at the surface trending to highly saline at depth, with instances of extreme salinity, and consistently strongly sodic. Alkalinity was also observed to increase with depth with topsoils displaying mildly alkaline or neutral properties and subsoils generally being strongly or very strong alkaline.

- S**oil Unit 3 Dermosols** – divided between two key areas: the first being within the Lake Cowal basin in the east of the Project area, and the second being an area in the south, closely associated with Soil Unit 1. This unit is characterised by Dermosols, which as defined as soils other than Vertosols, Hydrosols, Calcarosols and Ferrosols which have B2 horizons that have grade of pedality greater than weak throughout the major part of the horizon, and do not have clear or abrupt textural B horizon. Soils are generally non-sodic and non-sodic, with occasional exception (such as sodic soils at depth greater than 0.5m)

- **Soil Unit 4 Tenosols** – the least spatially extensive soil mapping unit and occupies two limited area in the south and the northwest of the Project area. This unit is characterised by Tenosols, which are soils that do not fit the requirements of any other soil orders. This soil unit consists of rocky, shallow soils with <0.5m depth to weathered parent material with moderate structural development in the sandy loam and loamy sand topsoils. Topsoils are non-saline and non-sodic, and slightly or moderately acidic. Subsoils are generally absent.

3.2.2 Soil physical and chemical limitations

Soil Unit 1 and Soil Unit 2 contain moderately suitable topsoils over subsoils which would typically be considered problematic for re-use in rehabilitation due to their saline and sodic characteristics. Nonetheless, due to the extensive presence of these soil types across the Project area, and a desire by CGO to reinstate deeper soil profiles depths, the subsoils of these unit can be recovered to establish an intermediate layer between overburden and topdressing on flat or very gently inclined areas of the post mining landform.

Soil that are sodic, saline or contain a greater clay fraction should be capped with a coarser textured material, which be beneficial to reset the soil profile in a way that mimics undisturbed soils and will constitute a control measure to limit the dispersion of sodic clays. Furthermore, this will increase the rehabilitated soil profiles infiltration, water holding capacity, seed germination and rootzone, and reduce the surface crusting common to sodic mine soils.

The application of gypsum to reduce the ESP of sodic topsoils and subsoils to <6% is a fundamental mitigation measure that will continue to be used of site to reduce the risk of tunnel, rill and gully erosion. The addition of organic matter from composted or biologically fermented organic matter can increase the humus content further reducing the impacts of sodicity. The use of non-water soluble, mineral based fertiliser inoculated with beneficial soil bacteria and mycorrhizae can reduce its erosion potential.

Soil Unit 3 represents a suitable soil for re-use in rehabilitation, generally meeting the desirable physical and chemical assessment parameters.

Soil Unit 4 has a coarser texture and poorer structure throughout the entire profile than would ordinarily be desirable for stripping and re-use. Nonetheless, given the non-dispersive and chemically stable nature of this soils type, stripping for re-use in rehabilitation as a topdressing over more chemically unstable materials is recommended.

3.2.3 Land and soil capability

Land and Soil Capability (LSC) of the Project area was assessed by Minesoils (2023) using the biophysical features of the land that are associated with various hazards are broadly soil, climate and landform and more specifically: slope, landform position, acidity, salinity, drainage, rockiness; and climate in accordance with OEH, 2012.

Minesoils (2023) determined the Project area (excluding approved disturbance areas) contains three LSC classes:

- LSC class 4: moderate capability land
- LSC class 6: low capability land
- LSC Class 7: very low capability land.

Class 4 land is the most spatially extensive class for the Project area and is generally associated with Soil Unit 1 and Soil Unit 2. This classification indicates moderate to high limitations for high-impact land uses that will restrict land management options for regular high-impact land uses such as cropping, high-intensity grazing and horticulture. These limitations can only be managed by specialised management practices with a high level of knowledge, expertise, inputs, investment and technology. The key limitations of this class within the Project area include water-logging and wind erosion.

Class 6 land is associated with Lake Cowal, immediately adjacent to Lake Cowal and more limited areas of land in the northwest and south of the Project area. This classification indicates very high limitations for high-impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation. The key limitations of this class within the Project area include water-logging, and soil depth.

Class 7 land is associated with limited areas of land in the north-west and south of the Project area. This land has severe limitations that restrict most land uses and generally cannot be overcome. On-site and off-site impacts of land management practices can be extremely severe if limitations are not managed. Key constraints consist of soil depth.

i Project impacts on Land and Soil Capability

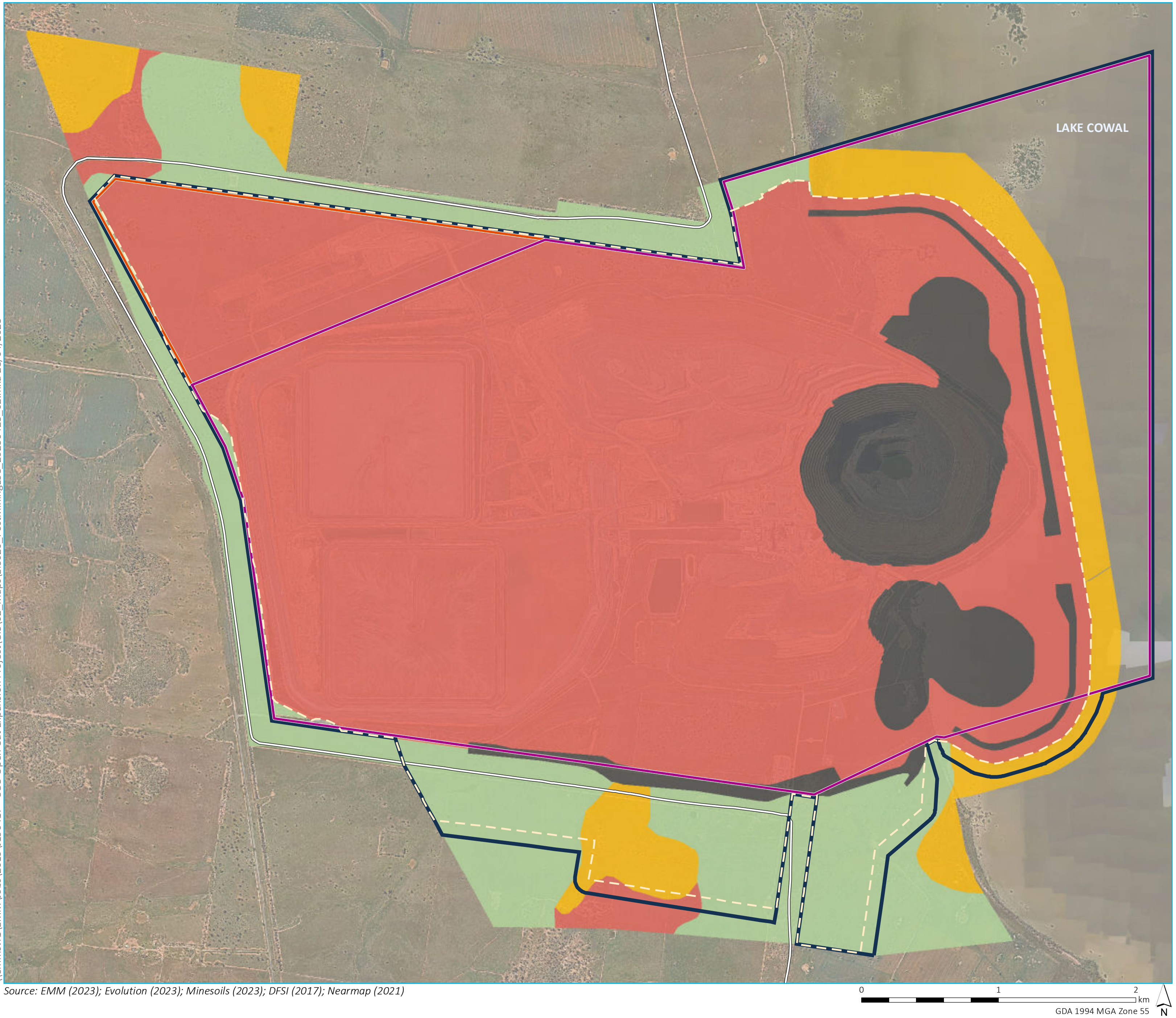
Due to the nature of the Project which will require major landform modification and soil stripping, impacts on all current LSC classes within the additional disturbance area will be high during operations.

The proposed post mining LSC for the additional disturbance area is based on the application of available soil materials on a rehabilitated landform to accommodate intended final land uses of native ecosystem and agriculture pasture. The proposed conceptual post-mining LSC is shown on Figure 3.1.

The final LSC of the additional disturbance area is expected to be as follows:

- LSC Class 4 – covering 199.3ha
- LSC Class 6 – covering 43.7 ha
- LSC Class 7 – covering 608.6 ha
- LSC Class 8 – covering 179.1 ha.

The final landform classification range of LSC 4 to LSC 7 are considered suitable for the post mining land uses and indicate land that has moderate to very high limitations. At best this means land management options are restricted for regular high-impact land uses such as cropping and high-intensity grazing and are best suited to grazing, nature conservation or forestry. Class 8 land is designated to final pit voids and water management areas. This is a default classification for land that represents no agricultural capability.



Source: EMM (2023); Evolution (2023); Minesoils (2023); DFSI (2017); Nearmap (2021)

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Post mining land and soil capability

Evolution Mining
Cowal Gold Operations
Open Pit Continuation Project
Mine Closure and Rehabilitation Strategy
Figure 3.1

EMM
creating opportunities

3.3 Geotechnical stability

Geotechnical assessments have been undertaken as part of the mine design process including for the Northern IWL expansion (AECOM 2023), LPB extension (SLR 2023) and pit designs (Mining One 2020) as summarised below. Regarding specifically the open pits, neither the pit designs or geotechnical models are static, and as additional data becomes available updates and development of the geotechnical model will occur and designs refined throughout the ongoing operation.

3.3.1 Open pit geotechnical stability

The E42 Stage I cutback and the new E41, E46 and GR open pits have been designed to operate in consideration of factors of safety appropriate for operating conditions at CGO and for the long-term stability of the extended LPB.

A number of geotechnical stability assessments have been carried out for the Project including slope stability, excavation stability associated with interactions between the underground development and expanded and new open pits, as well as surface infrastructure interactions (Mining One 2020). The key findings of these assessments are as follows:

- The E42 Stage I cutback pit design achieved the target factor of safety (FoS) acceptance criteria for the base case material parameters, adopted groundwater and stress conditions.
- Seismic assessment indicates that the PFS designs of the E41, GR and E46 pits are adequate in terms of FoS where dewatering recommendations are adopted.
- The underground development is not significantly impacted by the E42 Stage I cutback.

The Surface Subsidence Assessment (Beck 2023) (refer Appendix V of the EIS) assessed the potential for geotechnical interaction between the expansion of open pit mining and the underground mine, including forecasts for stress, strain and displacement. Beck (2023) found the forecast open pit mining-induced surface displacements and rockmass damage around the perimeter of the E41, E42, E46 & GR open pits would be classified as negligible.

Further to the above, neither the slope design or geotechnical models are static and, as additional data becomes available during the life of the Project, further refinement of the geotechnical model and designs will occur.

3.3.2 Northern IWL expansion

AECOM (2023) has carried out slope stability modelling of the proposed northern expansion IWL embankments with reference to the acceptable FoS for stability of tailings dam embankments outlined in ANCOLD 2019 including analysis of the maximum credible earthquake seismic event. The outcomes of this analysis indicate that the proposed embankment design meet the ANCOLD 2019 FoS stability guidelines for all assessed scenarios (AECOM 2023).

Multiple geotechnical investigations have been carried out by AECOM (2023) including:

- Evaluation of the IWL storage floor area to confirm consistent natural low permeability clay that meets the maximum equivalent permeability requirements and to characterise ground conditions below the natural clay liner.
- Characterisation and evaluation of embankment foundation conditions.

The outcomes of these assessments have been incorporated as relevant into the detailed design of the northern expansion of the IWL.

3.3.3 LPB extension

The extended LPB has been designed cognisant of the required flood protection, required slope stability and factor of safety (FoS) design criteria, geotechnical considerations and access considerations during the construction and operational phases of the Project.

3.4 Erosion and sediment control

3.4.1 Erosion hazard

A key risk to rehabilitated landforms is erosion particularly of landforms constructed from dispersive mine waste without natural bed rock capable of containing the depth of any gully or tunnel development as would occur on natural analogue landforms.

Detailed material characterisation, erosion hazard analysis, modelling, landform design and landform evolution modelling has been undertaken for the Project landforms (Landloch 2023, contained in Appendix B) as detailed in the following to:

- define target acceptable annual and peak erosion rates for the WRE and IWL landforms
- develop landform slope length and steepness design rules for the WRE and IWL landforms
- understand the erosion constraints of different materials and the surface cover requirements to achieve the target acceptable erosion rates
- avoid reliance on structural erosion controls where possible
- verify the landforms are stable and modify the landform design if required.

Detailed material characterisation and erosion modelling was undertaken by Landloch (2023) to develop slope gradient and slope design rules for the landform design process. A target annual average erosion rate of 2 t/ha/y and a peak erosion of rate of 5 t/ha/y was adopted on the basis that the soil landforms are considered high erosion risk (see Howard and Loch, 2019) due to their dispersive properties, the need to encapsulate PAF and saline wastes, and that there are no bedrock layers to limit the depth of any rills or gullies that may potentially form on the landforms.

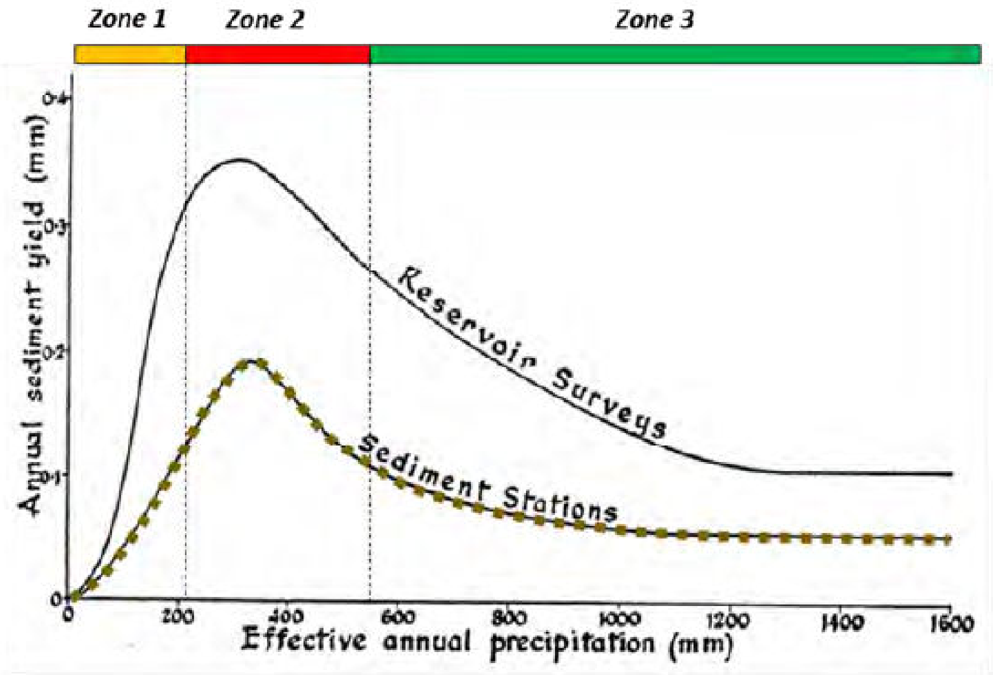
Once the landform designs had been developed, landscape evolution modelling was undertaken using SIBERIA to determine any locations requiring modification or additional erosion treatment to achieve tolerable erosion targets.

Data from natural catchment in the USA (Figure 3.2 - Kirby 1969) demonstrates that peak erosion rates occur in semi-arid environments (annual rainfall 300-450mm) like that experienced at CGO. This response is rationalised by the fact that low annual average rainfall volumes are insufficient to support significant vegetation covers, however storms of significant intensity still have a moderate likelihood of occurrence.

Applying the USA data to CGO implies that the expected vegetation cover may not provide adequate erosion control. However, monitoring of field trials on rehabilitated batter slopes covered with the CGO soil/rock matrix demonstrates that vegetative groundcover between 50-70% are achievable with between year variations driven primarily by annual rainfall totals (DnA Environmental, 2022).

Landloch (2023) considers a contributing factor for the appreciable vegetation growth at CGO could relate to the unique rainfall characteristics of the project area. Specifically, despite having a low average rainfall, typically less than 450mm, rain falls consistently across the year, with only small seasonal variations in the ~ 30 – 40mm per month rainfall. This low, but near uniform rainfall response can reasonably be expected to support onsite vegetation, maintain positive water balances, that would otherwise be much harder to achieve in comparable semi-arid regions that have an extended 'dry' season.

Although the uncertain risk that future climate change presents to the unique rainfall characteristics of the Project area is outside the scope of this strategy, the potential for a near-future that is increasingly dominated by extreme dry and wet periods may potentially impact the ability to rely on persistent vegetation growth for erosion stability and may require modification of the current rock/soil matrix method to provide better protection from overland flow critical shear protection.



Zone 1 : Low erosion potential due to low annual rainfall

Zone 2 : High erosion potential due to limiting annual rainfall needed to support significant vegetation cover

Zone 3 : Low erosion potential due to sufficient annual rainfall to support high vegetation cover

Figure 3.2 Relationship between annual rain and erosion (Kirby, 1969)

3.4.2 Landform evolution modelling outcomes

The landform evolution modelling undertaken by Landloch using SIBERIA indicates that with 70% vegetation cover levels combined with the use of the current rock/soil matrix system at least 99% of the landform surface in each of the three waste landforms can be considered stable in the long-term. Even after 500 years of simulation only 0.4% of the NWRE, 0.7% of the SWRE and 0.05% of the IWL of the landform surface is predicted to exceed the critical >0.3m erosion depth, which could expose encapsulated waste material and initiate gully erosion. Outcomes of the erosion modelling are shown in Figure 3.3, Figure 3.4 and Figure 3.5).

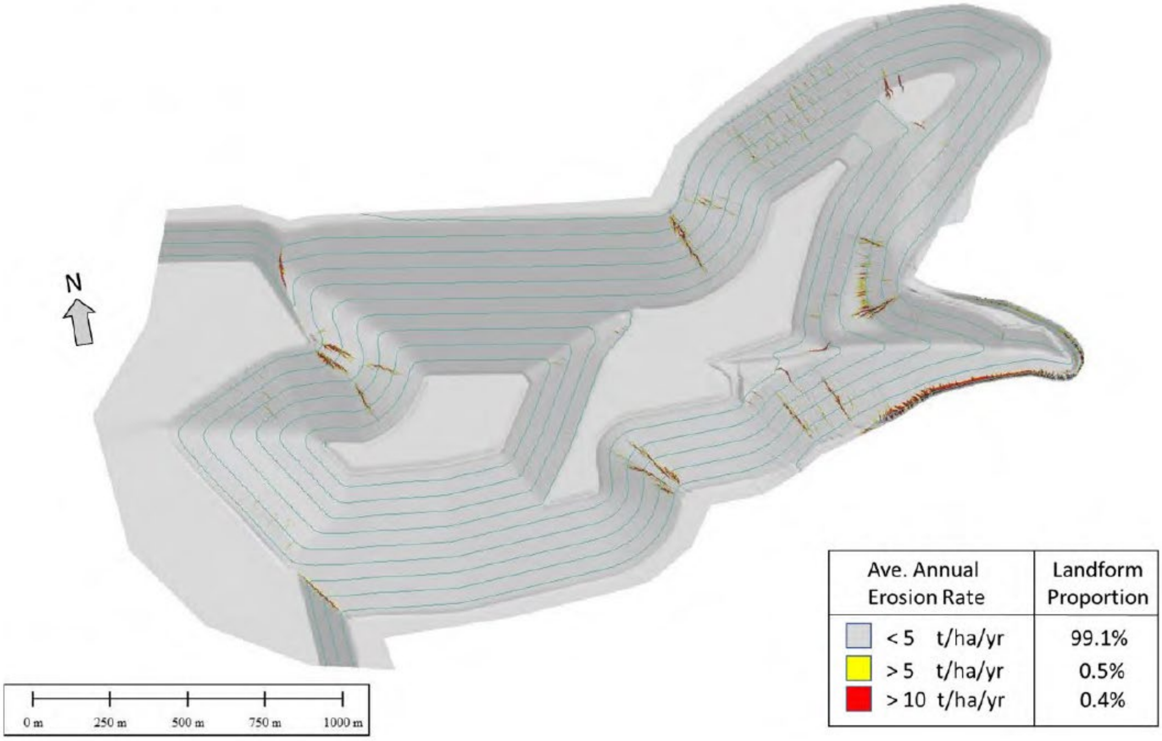


Figure 3.3 NWRE modelled annual erosion rates, 70% vegetation cover

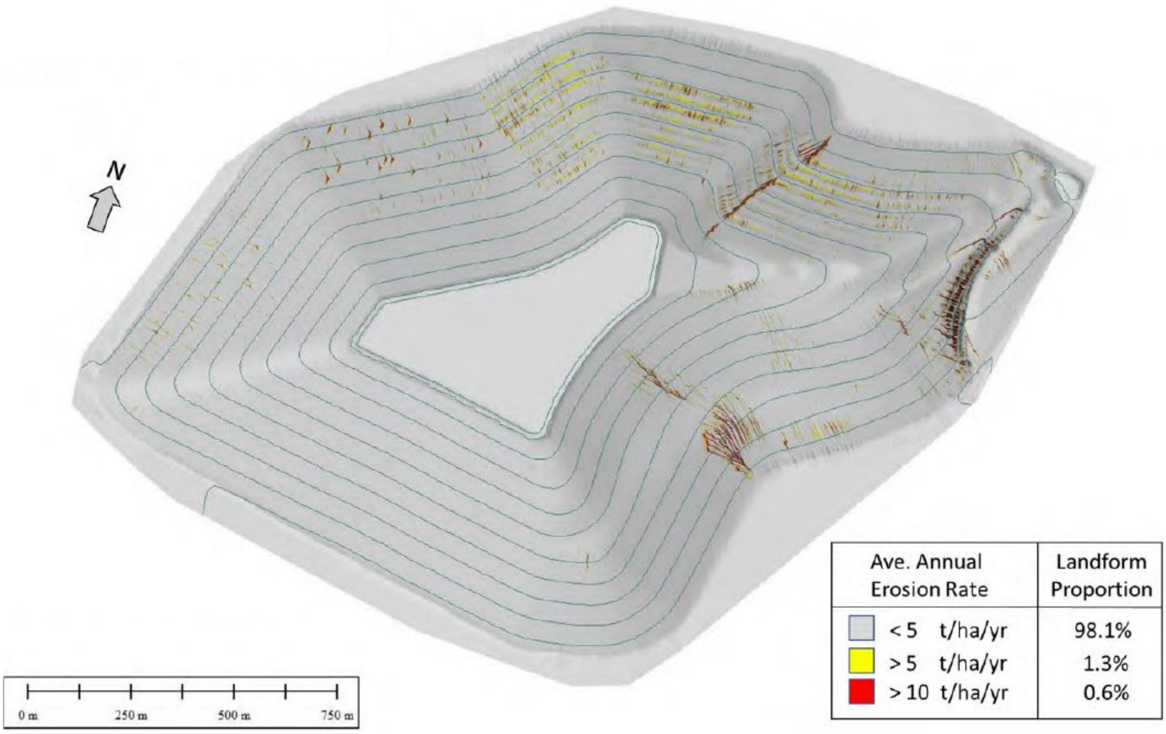


Figure 3.4 SWRE modelled annual erosion rates, 70% vegetation cover

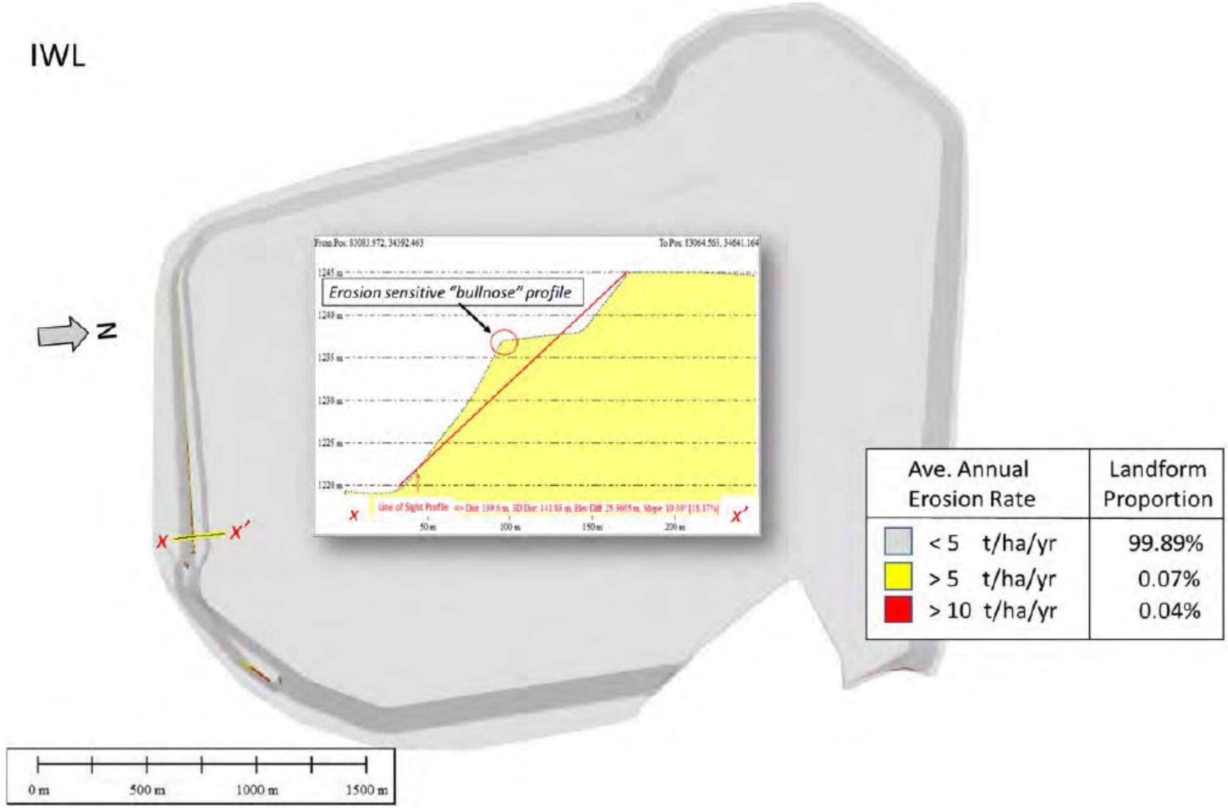


Figure 3.5 IWL modelled annual erosion rates, 70% vegetation cover

Landloch (2023) considers the erosion hazard areas are principally a function of topographic convergence (hillslope hollows) within the landform designs which concentrate flow and increase runoff shear stress. Remnant berm-batter structures on the SWRE are also identified as erosion hazard areas due to topographic convergence due to overtopping as a function of low points or sediment deposition within the berms from upslope erosion. The 'bull nose' hillslope profile arising from legacy benches on the southern batters of the IWL are identified as erosion hazard areas.

EMM considers that the portion of waste rock to soil in the bulk samples sent to Landloch laboratory may be lower than that on site, or the technique used by CGO to mix the topsoil and waste rock may be suboptimal resulting in reduces proportion of rock to soil and greater erosion rates.

Loch (2019 unpublished) states that three main methods are used on Australian mine site to create rock/soil matrices on landforms:

1. Placing layers of rock, then spreading topsoil over the rock and ripping the two layers to attempt to achieve proper mixing (this technique is used by CGO)

2. Placing rock and topsoil stockpiles separately at the top of the slope, then dozing then down together.

3. Physically mixing prior to placement.

Trials at a central Queensland coal mine and Telfer gold mine in Western Australia (Tiemann and Wealleans, 2015) found that mixing the rock and soil prior to pushing down the slope resulted in much better vegetation establishment and associated reduction in erosion.

3.4.3 Erosion and sediment control management and mitigation

The existing CGO Erosion and Sediment Control Plan will be updated to address the additional disturbance areas, new Project components and associated management and mitigation measures.

Landloch (2023) considers that there are three main options to mitigate high erosion hazards. The first option to mitigate the identified high erosion hazard areas is convergence elimination that requires landform reshaping modifications that act to reduce the angle of convergence curvature between connecting hillslopes and thereby reduce the volume of flowing through the less connected accumulating drainage pathways. An optimum (quantifiable) joining curvature potentially exists for each hillslope combination that constrains the accumulated volume and associated shear stress levels to that are less than the resisting shear strength of the drainage channel surface.

The second option involves increasing the shear stress resistance of the soil/rock matrix beyond that currently achieved by the existing soil/rock matrix system. This may feasibly be obtained by:

- increasing the D_{50} and D_{90} rock sizing; and/or
- altering the method of mixing to increase the proportion of rock in the soil/rock matrix using the mixing prior to placement method discussed in section 5.1.2viia below.

The third option is to construct rock-lined engineered channel in areas with convergent central drainage pathways. This approach is not recommended given the high erodible and dispersive nature of the materials upon which such rock drains would be constructed. Experience at CGO prior to adopting the soil/rock matrix method was severe tunnel and gully erosion under and adjacent rock drains constructed on the WRE (Loch, 2008).

3.5 Weed Control

Weeds have the potential to impact the productivity of rehabilitated grazing lands and compete with establishing native vegetation on native ecosystem rehabilitated lands. CGOs existing weed management programme is aimed at minimising the possibility of new weed incursion and controlling the spread of any existing noxious weeds on-site (including rehabilitation and biodiversity offset areas) and on all Evolution owned land.

Rehabilitation monitoring at the approved CGO also evaluates floristic diversity and documents the presence of exotic plant species in the rehabilitation areas. If present, weed incursion is recorded and control measures implemented where necessary.

3.6 Fauna

3.6.1 Habitat Enhancement

CGO's Vegetation Clearance Protocol as detailed in the approved Flora and Fauna Management Plan (Evolution, 2015) includes procedures where during the preliminary habitat assessment phase, trees are examined to identify roosting/nesting habitat resources that may be impacted by the vegetation clearance activities.
Where available, habitat features (ie hollows and logs) are salvaged for use in rehabilitation or habitat enhancement programmes within ML 1535 and/or within the Offset Areas and Remnant Vegetation Enhancement Programme (RVEP) areas.

3.6.2 Pest Control

Pest species can damage establishing vegetation or contribute to erosion in areas undergoing rehabilitation. CGO will continue to undertake pest control activities as detailed in the approved Land Management Plan (Evolution 2015a) including:

- regular property inspections to assess the status of pest populations on-site (including rehabilitation areas) and for all company-owned land
- mandatory pest control for declared pests (ie rabbits, feral pigs, wild dogs and foxes) in accordance with Pest Control Orders under the *Local Land Services Act, 2013,* and management of plague locust species including the Australian Plague Locust, Migratory Locust and the Spur-throated Locust
- inspections to assess the effectiveness of control measures implemented and review these if necessary.

3.7 Social

A Social Impact Assessment (SIA) has been undertaken by EMM (2023, Appendix M of the EIS) to assess the impacts of the Project on key social aspects (including amenity, community identity, economy, education, social infrastructure and the indigenous community) and to assess the potential impacts of closure of the Project. Future closure planning including relevant agency and community stakeholders will continue to inform the long-term land uses.

4 Final landform and land use

4.1 Final land use objectives

The overall final land use objectives for the Project have not materially changed from the objectives presented and previously approved for CGO. The final land-uses and objectives are also detailed in the RMP.

The overarching objectives for the final landform design are for the site to achieve final landforms that incorporate natural design elements that are safe, stable and non-polluting. The final landforms will be aimed to be appropriate for the nominated final land uses and sympathetic with surrounding landforms. The final landform will incorporate sustainable vegetation communities appropriate for the nominated final land uses and will be consistent with the rehabilitation works undertaken on site to date.

4.2 Final land use

The approved RMP required under Condition 2.4(c) of DA14/98 and Condition B24 of SSD 10367 outlines the approved conceptual final land use for CGO. The Project does not propose to change the currently approved final land use which will be:

- designed wherever possible to be compatible with regional landscape features
- progressively undertaken as a Run of Mine (ROM) operation wherever possible and left with untrimmed surface roughness to lower runoff coefficients and promote water absorption and storage
- revegetated with native and/or endemic vegetation communities, selected specifically for their suitability to the created elevation, aspect, substrate conditions and the overriding objective of re-establishing a greater extent of endemic vegetation within ML 1535 and ML 1971.

The predominant final land-use for the Project area will be native ecosystem, which is influenced by:

- constraints posed by the landforms, geochemistry, soils and climate
- current approved final land-uses and previous rehabilitation planning and works undertaken to date
- a desire by CGO to enhance biodiversity given the extent of past agricultural clearing
- biodiversity enhancement objectives proposed in various government strategic policy documents details in section 2.2.1vi

The exception is the proposed additional disturbance area to the south of ML 1535 which is currently used for agriculture. This portion of the Project area will be returned to agricultural land use.

A grazing final land-use for the WREs and IWL is not considered viable due to the erosion risk associated with potentially poorly managed grazing (over grazing, drought) and stock tracking. Overgrazing due to poor stock management, drought conditions and concentration of flow downslope and potential for gully development due to stock tracking could lead to unacceptable rates of erosion and exposure of encapsulated mine waste materials.

Also, the WREs and IWLs do not provide large and contiguous available areas of pasture and it is not possible to establish stock watering dams on the landforms due to the encapsulated wastes, potential for saline seepage and tunnel erosion risk associated with ponding water on dispersive soils.

KEY

- Proposed disturbance footprint (boundary offset for clarity)
- Mining lease (ML1535)
- Mining lease (ML1791)
- Major road
- Final landform contour (5 m)

Final rehabilitation domains

- Native ecosystem
- Agricultural – grazing
- Water management area
- Final void

Source: EMM (2023); Evolution (2023); DFSI (2017); Nearmap (2021)

0 1 2 km

GDA 1994 MGA Zone 55

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Final land form and land uses

Evolution Mining
Cowal Gold Operations
Open Pit Continuation Project
Rehabilitation Strategy
Figure 4.1

EMM creating opportunities

4.3 Post-mining landform design

4.3.1 Overview

Key features of the final landform include:

- final E41, GR and E42 voids
- backfilled E46 void and rehabilitated E46 WRE
- rehabilitated NWRE and SWRE
- rehabilitated IWL
- a woodland corridor between the rehabilitated NWRE and rehabilitated IWL
- areas surrounding the rehabilitated WREs and IWL associated with rehabilitated site infrastructure areas (ie the former process plant area and former soil stockpile areas)
- permanent water management features including the UCDS and low mounds associated with the ICDS
- permanent rehabilitated LPB to hydrologically separate the open pit development area and Lake Cowal during mining and post-mining.

Conceptual cross sections of the final landform of the Project are shown in Figure 4.2 and Figure 4.3.

4.3.2 Landform void options

There will three final voids at the end of the Project and one pit which will be completely backfilled. As a design option, consideration was given to the option of no final voids. This would require the excavation, haulage and emplacement of several billion cubic metres (m^3) of waste rock with a retention of excavator and haul truck mining fleets taking several years, and ultimately will result in extensive delays to rehabilitation of the site.

Backfilling of the voids to achieve a free-draining landform would result in:

- sterilisation of significant economically viable future gold resources
- several million m^3 of material mined from rehabilitated or partially rehabilitated WREs needed to fill the final E41 and E42/GR voids)
- potential re-disturbance of PAF materials encapsulated in WREs
- extension of rehabilitation efforts over several years and the ongoing excavation and rehandling of overburden would result in prolongation of potential air quality, noise impacts, additional Scope 1 greenhouse gas emissions
- delay in final mine site rehabilitation with no economic return.

The mine design option of backfilling the E42/GR and E41 final voids was not considered reasonable and feasible due to:

- longer term noise and dust generation impacts at the local area
- significant destruction of established rehabilitation

- delays in establishing the final landform and land use
- prolonged Scope 1 greenhouse gas emissions
- associated costs that significantly affects the Project's viability.

For these reasons, backfilling of all voids is not considered financially viable nor reasonable and feasible and would exclude the opportunity for the full extent of the gold resource being mined precluding future economic benefit.

4.3.3 Final Voids

The E42 pit and GR pit will merge into a single pit during the Project life. E46 will be backfilled and the E46 WRE subsequently established on the backfilled pit.

The slope design criteria of the Project's open pits have been developed in consideration of maintaining factors of safety appropriate for operating conditions and the long-term stability of the expanded LPB.
As noted in Section 3.3, the geotechnical modelling and analysis undertaken to determine suitable pit slope design criteria considered historical slope performance, and geotechnical data gained over previous and current studies for the existing and proposed pit for both surficial (soil/highly weathered rock) and hard rock material. The voids have been designed with geotechnically stable sides to economically access the ore body and minimise the generation of waste rock. The berm widths and slope angles will continue to be reviewed and monitored through ongoing geotechnical studies and data collection during mine development.

The final voids will be screened from public views on surrounding local roads and privately owned land by the IWL, expanded LPB and WREs and will be fenced upon completion of mining. Signposted warnings to the public will also be placed along the fence.

A typical conceptual cross-section south to north through the open pit areas and Northern WRE is shown in Figure 4.3 (refer cross section D).

i E42/GR Void

The E42 final void will be approximately -373m AHD in depth (approximately 582 metres below ground level (mbgl)) while the GR final void will be approximately 105 m AHD (100 mbgl). The combined E42 and GR final void will have an approximate area of 219 ha.

The final void water balance carried out as part of the Project's Surface Water Assessment (ATC Williams 2023, refer Appendix G of the EIS), a long term equilibrium level of approximately 110 mAHD within the E42 void (i.e. more than 90 m below the spill level) would be reached slowly over a period of approximately 700 years. Groundwater outflow was not simulated to occur – i.e. the final void would remain a groundwater sink.

The implications of climate change on the final void water balance was also considered in ATC Williams (2023). Climate change predictions have been derived for the CGO region using the Climate Futures Tool (CSIRO and BoM, 2015b). An assessment was performed for 2090 (i.e. approximately 50 years post Project life)[1] for the Murray Basin region of the continent which showed the mean annual change from the reference period to be -8.6% (i.e. a reduction) in rainfall and 19.4% (i.e. an increase) in evapotranspiration. The outcomes indicate that the E42 final void would reach a predicted equilibrium level of - 50 mAHD, more than 250 m below the spill level and would be contained. Equilibrium levels would be reached by approximately 400 years (ATC Williams 2023).

[1] No predictions are available beyond 2090 using the Climate Futures Tool.

The void water quality would reflect the influence of the high salinity in the groundwater. Given that the only outflow from the final void would be evaporation, salinity is predicted to increase trending to hyper-salinity in the very long term (ATC Williams 2023). Water quality in the final void at any given point in time would vary with depth as a result of mixing and stratification processes that would occur as a result of temperature and salinity differentials (ATC Williams 2023).

ii E41 void

The E41 final void will be approximately -16 m AHD (approximately 205 m below ground level (bgl)) and have a maximum extent of approximately 89 ha.

The final void water balance predictions indicate that the E41 final void would reach an equilibrium level of approximately 130 mRL which is more than 70 m below the spill level after approximately 140 years (ATC Williams 2023).

Climate change predications for the E41 final void balance indicate equilibrium levels within the E41 final void would still be reached in approximately 140 years, at a predicted level of 102 m AHD (ATC Williams 2023.

As for the E42/GR void, salinity in the E41 pit would increase trending to hyper-salinity in the very long term (ATC Williams 2023).

4.3.4 Waste Rock Emplacements

The erosion and landform evolution modelling (Appendix B) indicates that the existing CGO soil-rock matrix rehabilitation cover system is suitable for the proposed linear (1V:5H, 20%) profile batters of the WREs provided >50% vegetation cover can be maintained. Existing vegetation trials at CGO suggest that established vegetation cover levels in the order of 70% can be sustained based on average annual rainfall totals. Thus, providing confidence that the proposed linear batter design slopes of the WREs (20%) are justifiable (Landloch 2023).

Erosion hazard areas have been identified in the WRE designs primarily caused by localised enhancement of runoff volume, velocity, and shear stress in areas of significant topographic convergence (hillslope hollows). Though small in spatial extent (ie less than 1% of WRE total surface area), if not mitigated, a longer-term outcome within these areas is the development of erosion gullies that could extend into the encapsulated waste material (Landloch 2023). In line with recommendations outlined in Appendix B, identified erosion hazard areas will be reshaped where possible. In instances where reshaping is not possible, additional land surface protection, beyond the CGO soil-rock matrix cover system will be engineered and implemented.

Consistent with existing WRE design, the outer batters of the WREs are designed to have a final overall slope of around 11° and will be designed and built to meet the long-term goal of containing potentially saline seepage generated from waste rock emplacement areas during operation and post-closure. Development will involve surface preparation works to facilitate the direction of any permeating waters towards the open pits. Compacted oxide waste rock would continue to be used to construct the low permeability basal layer for the emplacement expansion area, so that any waters permeating through the expanded emplacement are intercepted by this layer and preferentially flow towards the open pits.

i Northern WRE and E46 WRE

An extension to the Northern WRE is required to store waste rock generated from the Project. While there will be no change to the approved maximum height of 308 m AHD, it will be expanded to the north. At its full extent, the Northern WRE final landform will integrate with the IWL at its western extent and the E46 WRE in the east. The E46 WRE will have a maximum height of 268 m AHD.

The expansion of the Northern WRE requires waste emplacement over some areas of existing rehabilitation. Any soil resources within the existing rehabilitation areas will be stripped and reused for future rehabilitation purposes.

Erosion and landform evolution modelling undertaken by Landloch (Landloch, 2023 Appendix B) has identified that the reverse grade berms used on the preliminary Northern WRE designs resulted in increased modelled erosion due to flow velocity increase when flows overtop the berms. The reverse grade berms will therefore not be included on the expanded Northern or E46 WREs. Perimeter bunds with an internal 10(h):1(v) gradient will be installed to prevent flow over the Northern and E46 WRE batter slopes.

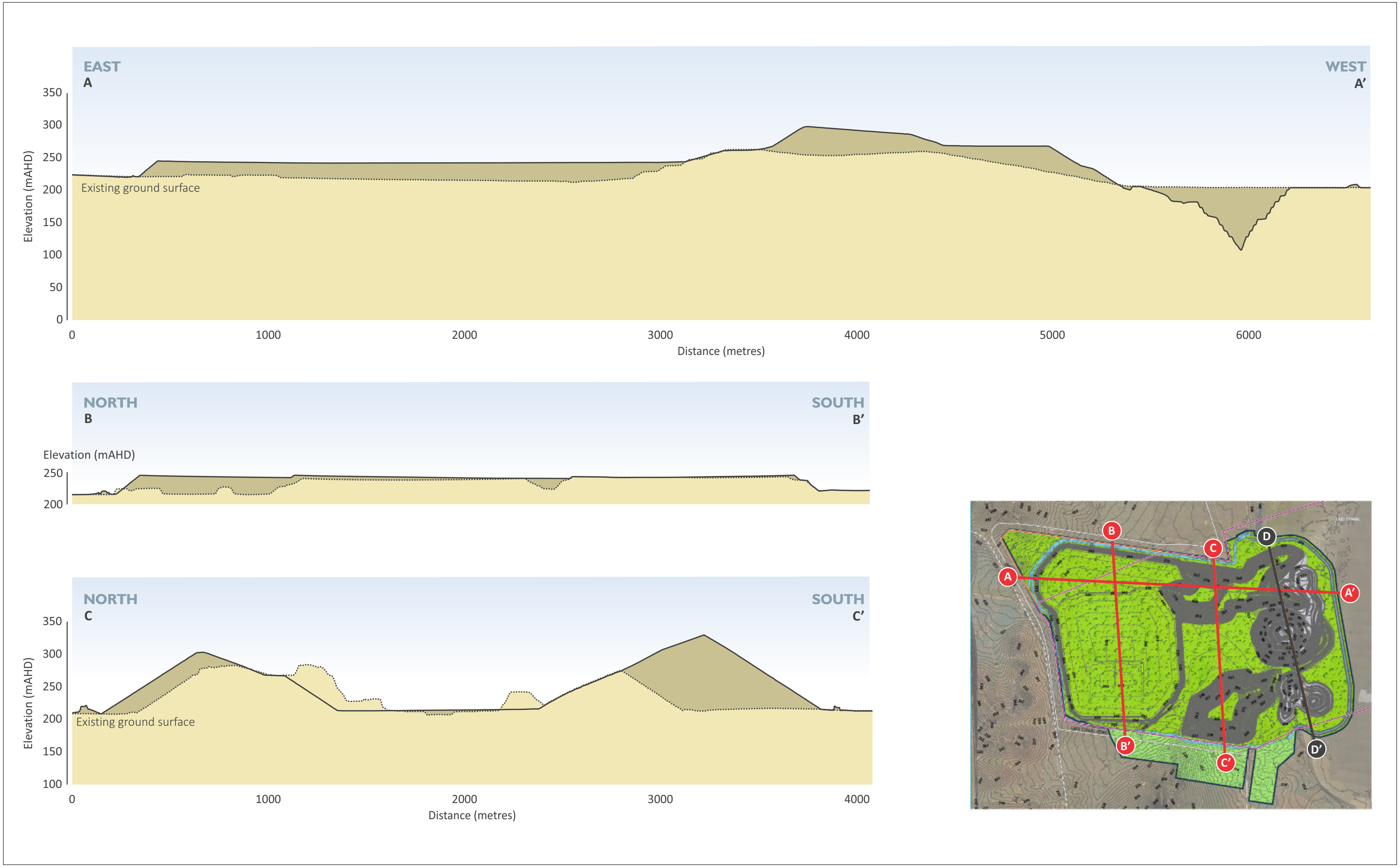
A typical conceptual cross-section through the Northern WRE and E46 WRE is shown in Figure 4.2 (refer cross section A) and through the Northern WRE and open pit areas in Figure 4.3 (refer cross section D).

ii Southern WRE

The Southern WRE will be expanded to accommodate the waste rock generated from the Project. The Southern WRE will also increase in height from the currently approved maximum height of 283 m AHD to a final maximum height of 308 m AHD.

The expansion of the Southern WRE requires waste emplacement over some areas of existing rehabilitation. Soil resources within the existing rehabilitation areas will be stripped and reused for future rehabilitation purposes. Any legacy landform features such as berms and bullnoses, identified by erosion and landform evolution modelling to increase erosion beyond acceptable rates will be removed or modified where possible (Landloch 2023). Where it is not possible, CGO will examine increasing the proportion of rock to soil in the rock/soil matrix to provide a higher level of critical shear.

A typical conceptual cross section south to north through the Southern WRE and Northern WRE is shown in Figure 4.3.



Existing and Final Landform cross sections A-A', B-B' and C'C'

Cowal Gold Operations Open Pit Continuation Project
Mine Closure and Rehabilitation Strategy
Figure 4.2

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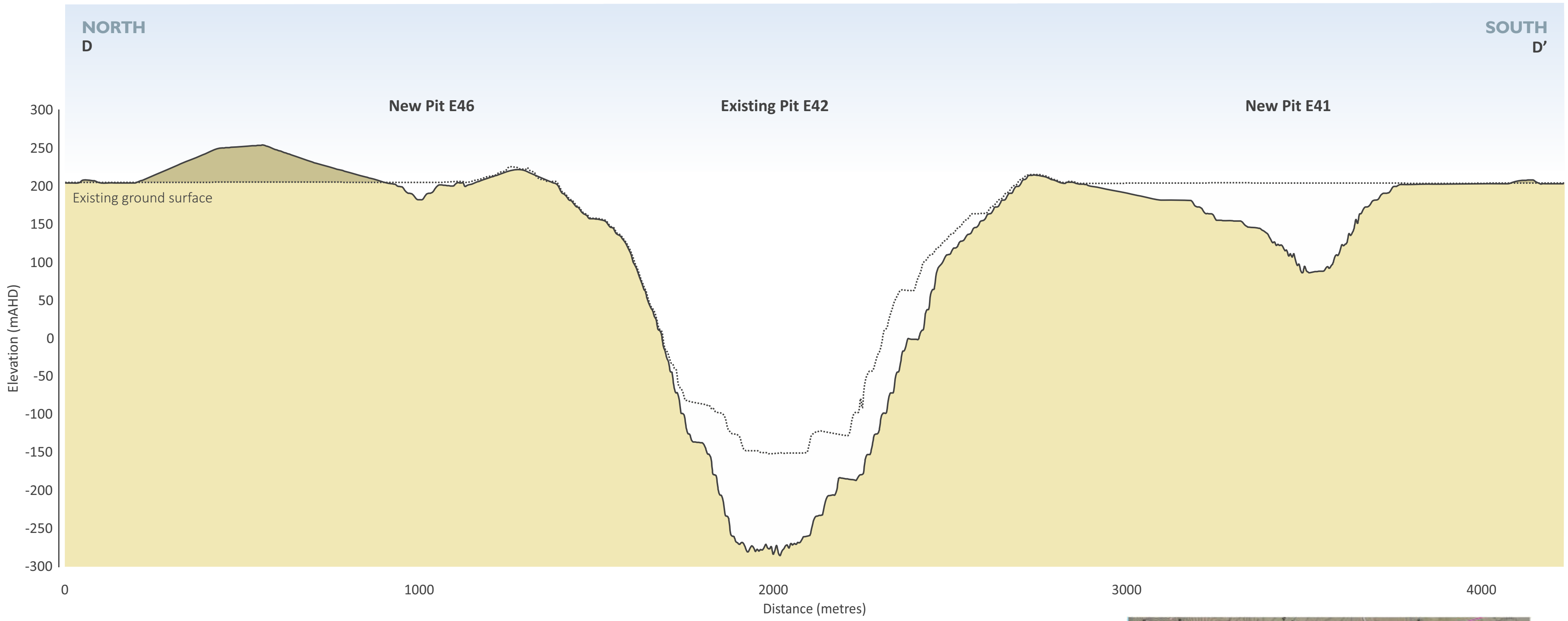


EMM creating opportunities

Existing and Final Landform cross section D-D'

Cowal Gold Operations Open Pit Continuation Project
Mine Closure and Rehabilitation Strategy

Figure 4.3

4.3.5 Integrated Waste Landform

The northern expansion of the IWL will create a new tailings deposition cell with capacity to store approximately 71.5 Mt of dry tailings. This will be sufficient to accommodate the approximately 66.3 Mt tailings storage capacity required to support the Project (AECOM 2023).

The northern expansion of the IWL will include a single downstream raised cell has been designed to meet 'Significant' consequence category requirement under ANCOLD 2019 guidelines. A new perimeter embankment will create an additional tailings storage cell adjacent to the northern wall of the IWL. The new embankment will resemble the existing IWL design including upstream clay facing keyed into the upstream toe and supported by a compacted rock fill shell.

The perimeter embankment design provides for upstream and downstream batter slopes of 1V:2H and 1V:4H, respectively. A typical embankment cross section is shown in Figure 4.4

The eastern portion of the embankment abuts the Northern WRE. The design includes a buffer of compacted rock fill between the Northern WRE and the northern expansion IWL embankment clay facing, as shown in Figure 4.5.

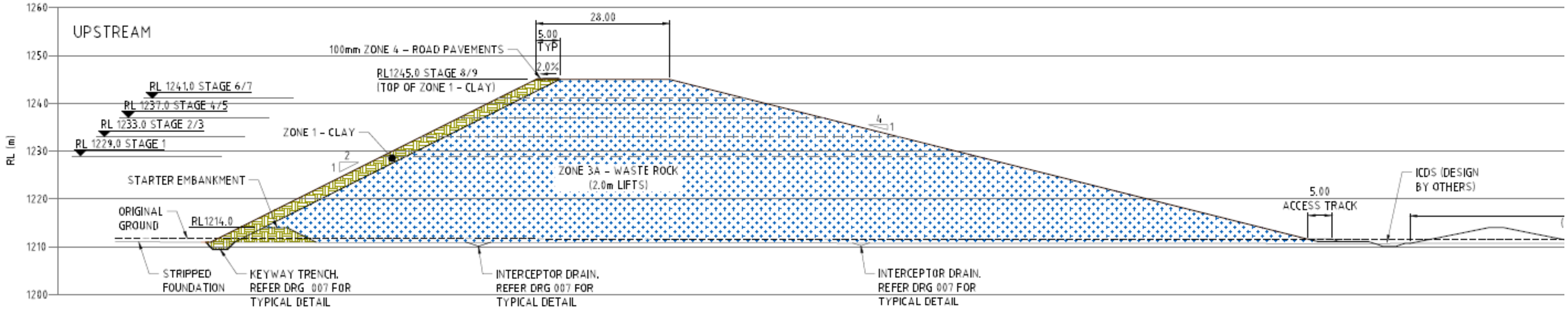


Figure 4.4 Northern expansion of IWL – typical embankment cross section

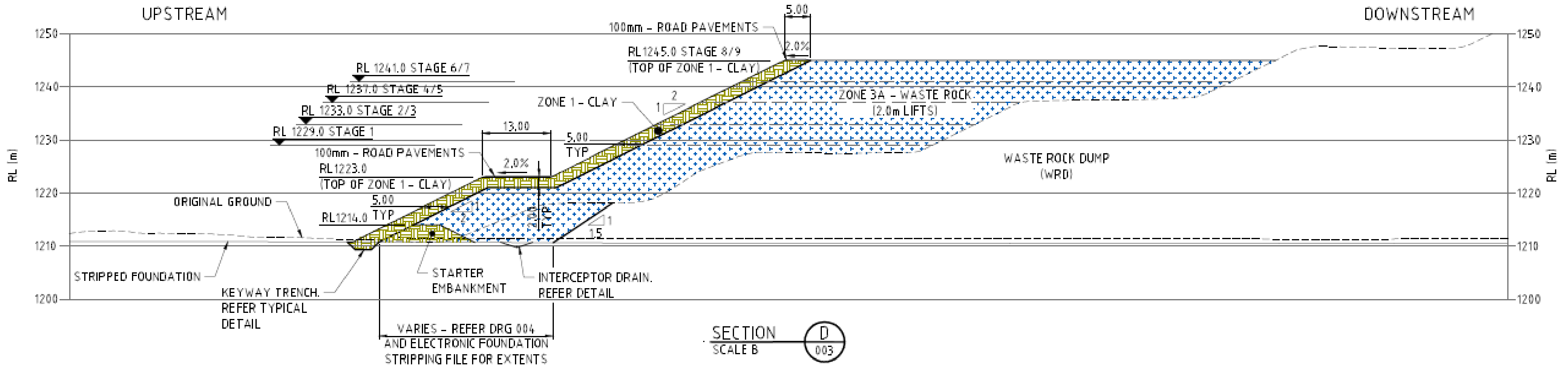


Figure 4.5 Northern expansion of IWL – typical embankment cross section adjacent to the Northern WRE

4.3.6 Lake Protection Bund

The extended LPB will be approximately 6.3 km long. The additional disturbance area of the expanded LPB and new mining areas within Lake Cowal will be approximately 367.4 ha representing a decrease in the lake surface area (at its spill level to Nerang Cowal) of approximately 1.7%.

The post mining landform objectives of the LPB will be to continue to provide mutual protection of CGO and Lake Cowal. The rehabilitation of the LPB will follow the objectives already set out in the RMP. Rock armouring the outer batter slope of the revised LPB Lake Protection Bund will aim to stabilise and maintain integrity of bund in the long-term.

Rehabilitation design and implementation for the proposed changes to the lake foreshore would have consideration to the NSW Wetlands Policy. Survey assessments would be undertaken from time to time in accordance with the RMP until permanent geotechnical stability is demonstrated.

The species selected to plant at the LPB Final Landform Design Concept will seek to establish riverine woodland and freshwater communities.

Following construction of the LPB and once water levels recede sufficiently, landscaping and reinstatement of the Lake Cowal foreshore will be carried out. The earthworks and landscaping, using primarily lakebed soils, will occur during the LPB construction if the lakebed is dry. Should the lakebed still be wet/semi-inundated then construction would be delayed until the conditions were suitable. From the toe of the LPB the landscaping will extend approximately 30 m horizontally into the lake.

Reinstatement of the lake foreshore around the extended LPB will generally follow the concepts approved in the existing Compensatory Wetland Management Plan and will include microvariations in slope and elevation to provide complex habitats for terrestrial and aquatic ecosystems.

Following the contouring of the new Lake Foreshore, rehabilitation will involve both active and passive rehabilitation techniques with the existing seedbank in the lakebed soils anticipated to provide natural revegetation of disturbed areas. The works will include placement of rock material and appropriate biomaterial to create water retaining elements.

5 Rehabilitation and closure planning

5.1 Domains

5.1.1 Overview

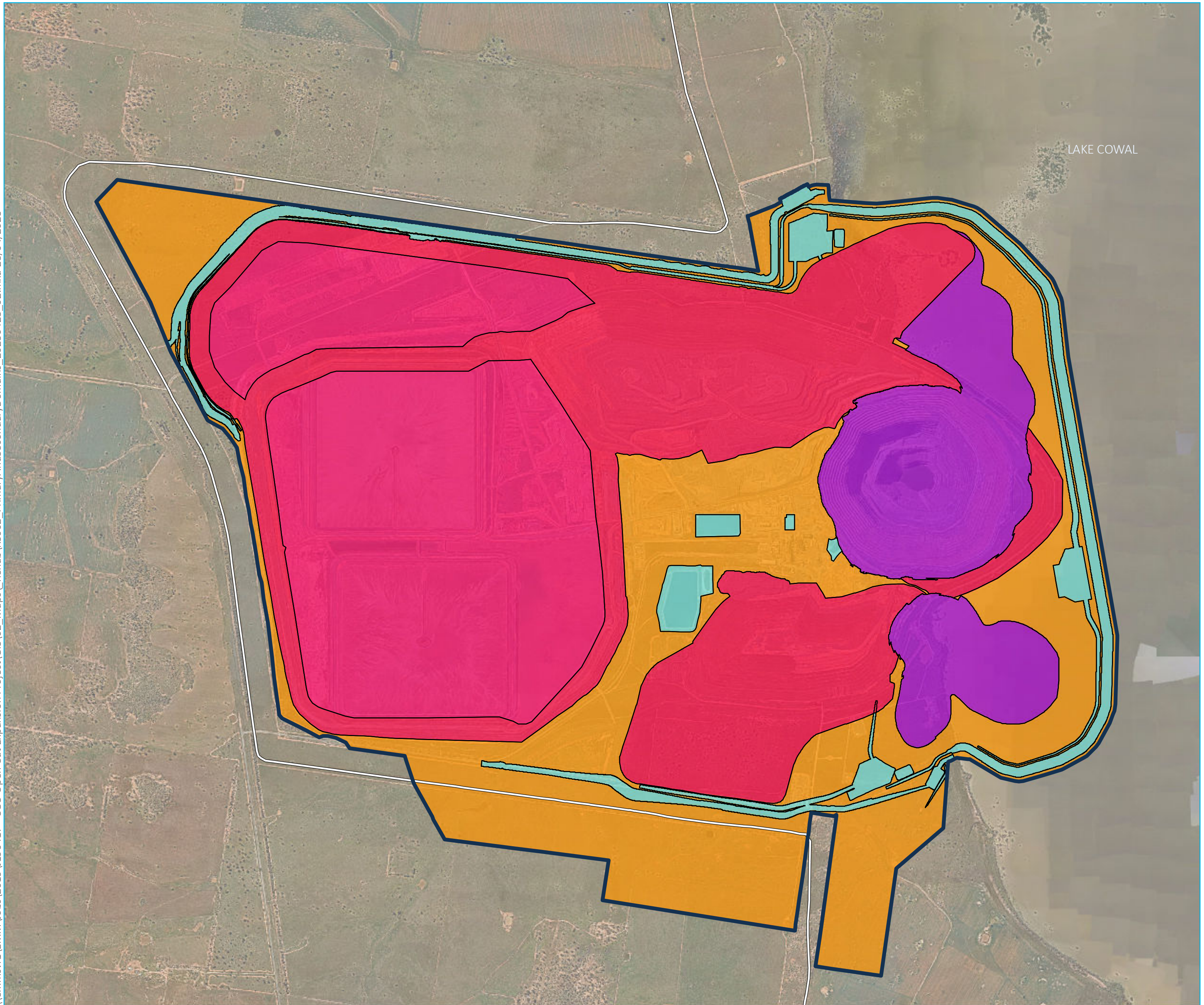
CGO's current RMP has four final land use domains and five mining domains assigned in accordance with the requirements of the RMP guidelines. Domain codes are in accordance with the *NSW Resources Regulator Mine Rehabilitation Portal Guideline* (RR 2021). Domains are defined to facilitate the identification of detailed closure implementation tasks to be undertaken in specific areas, to meet the final land use objectives that apply to those domains. Detailed descriptions of these domains are provided in the following sections.

Table 5.1 CGO final land use and mining domains

Final Land use Domains	
Code	**Final Land use Domain**
A	Native ecosystem
B	Agriculture grazing
F	Water management areas
J	Final voids
Mining Domains	
Code	**Mining Domain**
1	Infrastructure area
2	Tailings storage facility
3	Water management area
4	Overburden emplacement area
5	Active mining area (Open pit voids)

In summary, the following rehabilitation domains have been developed for GCO and are shown in Figure 5.1:

- Domain B1 – Infrastructure area – Agriculture grazing;
- Domain A1 – Infrastructure area – Native ecosystem
- Domain A2 – Integrated Waste Landform –Native ecosystem
- Domain A3 – Water management areas – Native ecosystem
- Domain A4 – WREs – Native ecosystem
- Domain F3 – Permanent water management areas
- Domain J5 – Active mining area (Open pit voids) – Final voids



KEY

Proposed disturbance footprint

Major road

Final mining domains

1. Infrastructure area

2. Tailings storage facility

3. Water management area

4. Overburden emplacement area

5. Active mining area (open pit voids)

Source: EMM (2023); Evolution (2023); DFSI (2017); Nearmap (2021)

0 1 2 km

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Final mining domains

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Figure 5.1

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5.1.2 Rehabilitation by domain

i Domain A1 – Infrastructure area –Native ecosystem

Domain A1 includes:

- Mine fleet workshop;
- Reagent and fuel storage areas
- Process plant and administration area
- Paste plant and associated conveyors
- Tailings deslimers and pipework
- Internal access roads and other roads
- Transmission line and substation
- Paste fill plant.

Some key infrastructure for the underground operations located in the E42 pit mine portals, vent fans, fuel storage and office facilities are included in the Active mining area (Open pit voids) mining domain (J5).

Post-operations, the rehabilitation objectives for the infrastructure areas are to:

- remove all infrastructure to ensure the site is safe and free of hazardous materials (unless an alternative arrangement is agreed by Evolution, the ultimate landholder and relevant regulatory authorities)
- establish vegetative communities (including scattered Eucalypt and other woodland species and native grassland species) that are endemic to the region.

ii Domain A2 – Integrated Waste Landform – Native ecosystem

As detailed in Section 3.3.5 the IWL will be extended to the north to allow for the storage of tailings resulting from the Project. The Project will not change the approved rehabilitation concepts for the IWL as outlined in the RMP with the following rehabilitation objectives maintained:

- to establish permanently stable landforms
- during operations, stabilise batters so that they provide minimal habitat value for bird life (ie rock mulch or pasture cover)
- post operations; cap and fill the decant towers and grout the underdrains
- post-operations, to establish vegetation communities (including Eucalypt and Riverine Woodland species and understorey species such as Rush sp. and pasture species) which are suited to the hydrological features and substrate materials of the top surface of the landform
- post-operations, to establish vegetation communities (including native and/or endemic Eucalypt Woodland, shrubland and grassland species) similar to those remnants in the surrounding landscape which are suited to the substrate materials and slope of the embankments
- to exclude grazing and agricultural production.

The following sub sections outline the rehabilitation strategy for the IWL as approved in the current RMP. The methods outlined may be subject to further investigations and/or trials and revised as required.

a IWL embankments

Erosion and landform evolution modelling considered the proposed CGO soil-rock matrix rehabilitation cover system is suitable for the proposed linear (1V:4H, 25%) profile batters of the IWL provided that >60% vegetation cover can be maintained (Landloch 2023). Existing vegetation trials at CGO indicate that established vegetation cover levels in the order of 70% can be sustained based on average annual rainfall totals. Thus, providing confidence that the proposed linear batter design slopes of the IWL (25%) are justifiable (Landloch 2023).
A small area of erosion hazard may result on the southern batters of the IWL arising from a legacy (existing southern TSF) 'bull nose hillslope' bench. This area will either be reshaped to remove the bull nose transition of and form a linear slope of 25% or shallower or alternatively an alternative sized soil-rock matrix of this area may be designed and applied (Landloch 2023).

b IWL Rehabilitation Cover System

As outlined in the RMP, the final surface of the IWL will include an upper and lower catchment area. Each area will form a low, internally draining landform, with drainage effected by controlled placement of cover materials and several shallow swales. The contained catchments will minimise surface water runoff from the top surface down the embankments.
The rehabilitation cover system materials for the top surface will include a capillary break layer of rock, and layers of gypsum-treated subsoil and topsoil. The rehabilitation methods for the IWL embankments will include spreading gypsum treated topsoil over the surface of the embankment, cross-ripping along the contour of the slope and then revegetating with native and/or endemic woodland, shrubland and grassland species suited to slope and elevated positions similar to those remnants in the surrounding landscape.

c Revegetation

Like the revegetation approach for the WREs, revegetation of the IWL will include selecting species suited to the hydrological features and substrate materials of the landform and will be based on results of rehabilitation investigations and trials in consultation with regulatory authorities.

Revegetation will consider the results of hydrological modelling predictions for the IWL (i.e. plant species will be selected that are suited to the hydrological conditions of the storages such as inundated areas, dry areas and swales).

Rehabilitation trials will continue to be undertaken to determine the most suitable revegetation species for the top surface and embankments of the IWL. A description of the rehabilitation trials that will be undertaken for the Project is provided in section 7.2.2.

iii Domain A3 – Water management areas - Native ecosystem

The rehabilitation objectives for the operational water storages are to either decommission the infrastructure or retain the infrastructure for local landholder use. Decommissioning of the operational water storages will be undertaken to the satisfaction of the Resources Regulator and EPA in consultation with DPE Water. Alternatively, the operational water storages may be retained for local landholder use upon agreement by Evolution and in consultation with the regulatory authorities.

The rehabilitation objectives for the Bland Creek Palaeochannel Borefield, Eastern Saline Borefield and associated pump stations and pipelines are to either dismantle and decommission (i.e. plug and cap) the bores and associated pump stations, or agree to an alternative use with local water users. These objectives will be reviewed during the life of the Project in consultation with CEMCC.

iv Domain A4 – Waste Rock Emplacements - Native ecosystem

Domain A4 includes the Northern, Southern and E46 WREs. The Project will not change the existing rehabilitation objectives of WREs which includes a native ecosystem post mine land-use with the establishment of native Eucalypt woodland, shrub and grassland communities and the exclusion of stock.

The approved rehabilitation objectives for the WREs as outlined in the RMP are to:

- stabilise batter slopes with rock armour (primary waste rock/soil matrix) to control surface water runoff downslope and reduce erosion potential
- provide a stable plant growth medium able to support long-term vegetation growth including native and/or endemic Eucalypt woodland, shrubland and grassland species suited to slope and elevated positions similar to those remnants in the surrounding landscape;
- exclude grazing and agricultural production.

The following sub sections outline the rehabilitation strategy for the WREs as approved in the current RMP. The methods outlined may be subject to further investigations and/or trials and revised as required.

a Top of emplacement rehabilitation

Drainage on the top surfaces of the WRE will be managed via a series of small shallow basins (depressions), a rehabilitation cover system (including gypsum-treated subsoil and topsoil) that absorbs rainfall and comprises woodland vegetation. The use of depressions is aimed at maximising internal drainage without creating permanent ponding during normal and heavy rainfall events.

Containment of runoff on the top of the WREs will also be maximised, via the use of perimeter bunds that have an internal 10(h):1(v) batter grade to ensure any runoff that ponds on surface is well away from the edges of the WRE where it could potentially cause tunnel erosion.

A layer of gypsum and then primary waste rock may be placed over oxide waste rock areas on the top surface to assist with stabilising the sodic and dispersive characteristics of the oxide waste rock.

b Rehabilitation Cover System – Batters

The rehabilitation cover system for the WRE batters remains unchanged from the current RMP and includes:

- unoxidised (primary) rock mulch
- low salinity and gypsum-treated topsoil.

The rock mulch and topsoil layers are cross-ripped with approximately 10 tonnes per hectare (t/ha) gypsum to reduce dispersion and form a binary rock/soil matrix, followed by seeding with native and/or endemic Eucalypt Woodland and shrub species during suitable seasonal conditions. This approach significantly reduces the potential for tunnel erosion and the rock/soil interface if just rock alone is used (pers.com. Dr Rob Loch).

To stabilise areas where an adequate vegetation cover has yet not established, a layer of locally harvested seed-bearing native pasture hay (or clean wheaten hay) is spread to provide soil protection and soil stability for vegetation establishment. Cross-ripping along the contour is undertaken to encourage infiltration and enhance vegetation establishment. The unoxidised (primary) rock mulch used in the cover system is sourced from development of the open pit and includes suitable non-saline material.

Results of rehabilitation investigations and trials will continue to inform and refine CGO rehabilitation methods including rehabilitation materials and revegetation species.

c Revegetation

The revegetation approach for the Project's WREs remains unchanged from currently approved. Revegetation aims to re-establish native and/or endemic Eucalypt Woodland, shrub and grassland communities similar to those remnants which persist on similar landforms in the regional landscape (e.g. Wamboyne Mountain, Fellmans Hill and Billy's Lookout). Suitability of revegetation species include consideration of the physiographic and hydrological features of the landform and performance relative to both stability and surface rehabilitation materials.

Revegetation species considered suitable for revegetation of the CGO WRE have been developed by DnA Environmental (2016) with assistance from Diversity Native Seeds (a local native seed supplier). These species are associated with woodlands on low ridges and hills in the local landscape.

Results of ongoing rehabilitation trials and monitoring will continue to be used to refine the revegetation species suited to the cover system materials for the waste rock emplacement batters.

v Domain B1 – Southern infrastructure area – Agriculture

The Project proposes to establish a new final land use domain in the Project area to the south of ML1535. Evolution currently leases these portions of the Project area to local agricultural producers for grazing and cropping purposes. In recognition of the existing agricultural values of these areas, the rehabilitation objectives of this domain will be to maintain/restore the existing Class 4 land and soil capability (refer Section 5.2.3) of these areas post mining to enable sustained agricultural land use.

vi Domain F3 – Permanent water management areas

The permanent water management structures for the Project comprise:

- UCDS
- components of the ICDS, including the existing low mounds associated with the permanent catchment divide)
- the LPB.

The rehabilitation objective for the permanent water management structures is to create stable systems (ie with acceptably low risk of environmental harm to Lake Cowal). The permanent water management structures have a native ecosystem final land use consisting of riverine woodland and freshwater communities where appropriate.

The following sub sections outline the rehabilitation strategy for the Project's permanent water management structures. The methods outlined may be subject to further investigations and/or trials and revised as required.

a Lake Protection Bund

The LPB will be constructed provide continued separation and mutual protection between Lake Cowal and the mine and to hydrologically isolate CGO from Lake Cowal during mining and post-mining.

Rehabilitation of the lake side section of the LPB will be an iterative process and revegetation species will be selected in consideration of:

- rehabilitation monitoring of the existing LPB and foreshore
- Lake Cowal's hydrological regime (wetting and drying cycles
- species occurring in relevant reference sites (including lake and slope woodland communities

- species performance during revegetation trials
- suitability to substrate conditions.

Subject to these parameters, species may be selected from the following vegetative suites:

- fringing lake vegetation on foreshore batters (i.e. Eucalypt dominated woodland including River Red Gum)
- freshwater habitats.

A conceptual typical cross section of the re-instated (15-20 years in the future) Lake Cowal foreshore at the foot of the extended LPB is presented in Figure 5.2.

b UCDS and ICDS

The UCDS is used to divert clean water from the north and south of the mine around disturbed areas. Post closure, the UCDS will remain to facilitate permanent drainage of adjacent areas upslope of the site to Lake Cowal and the low mounds associated with the ICDS will remain to contain runoff generated within the site catchment.

CGO will continue to implement measures to prevent land degradation (ie erosion, salinity, and loss of soil structure and nutrients) and rehabilitate previously degraded land or land affected by land disturbing activities.

As per the existing UCDS, the realigned UCDS will be constructed to simulate natural drainage features in the region and includes a low flow drainage path within a wider floodplain. The expanded UCDS would be designed and profiled such that peak flow velocities and bed shear stresses generated during the design event would not result in significant[1] erosion or geomorphic instability. The expanded UCDS would have been in operation for approximately 18 years at the end of the Project life. This again allows time for "proving" the stability of the UCDS. Any unforeseen instability would lead to remedial works which would result in an improvement in the durability of the UCDS.

vii Domain J5 – Active mining area (Open pit voids) – Final voids

For the final voids, the Project will not change the currently approved rehabilitation objectives for this mining domain as outlined in the RMP, which are to create habitat opportunities for waterbirds at the approximate level at which void water will reach equilibrium, where feasible; and leave the void surrounds safe (for humans and stray stock).

The LPB will be constructed around the perimeter of the final voids which will be planted with an initial cover crop (to assist in stabilising the bund following construction) and will be seeded with native and/or endemic Eucalypt woodland species. The final voids will be screened from public views on Lake Cowal Road and private land holdings by the IWL, WREs and LPB and will be fenced upon completion of mining. Signposted warnings to the public will also be placed along the fence.

a E42 and GR final voids

The E42 final void will be approximately -373m AHD in depth (approximately 582 metres below ground level (mbgl)) while the GR final void will be approximately 105 m AHD (100 mbgl). The combined E42 and GR final void will have an approximate area of 219 ha.

[1] The design intent in regard to erosion and geomorphic instability is that the scale and magnitude of erosion and/or geomorphic instability within the constructed expanded UCDS would be consistent with expected erosion and geomorphic instability likely to occur in the drainage features as they existed in the CGO area prior to all mine related disturbance.

The final void water balance carried out as part of the Project's Surface Water Assessment (ATC Williams 2023, refer Appendix G of the EIS), a long term equilibrium level of approximately 110 mAHD within the E42 void (i.e. more than 90 m below the spill level) would be reached slowly over a period of approximately 700 years. Groundwater outflow was not simulated to occur – i.e. the final void would remain a groundwater sink.

It is expected that the benches constructed within the sodic soils in the upper margins of the E42 void will be removed following the cessation of mining to minimise the risk of tunnel and gully erosion, treated with gypsum to reduce dispersion, and then stabilised with a combination of rock/soil matrix and seeding with a hydraulically applied growth medium which is a combination of a biotic growth medium and heavy duty hydro-mulch to facilitate vegetation establishment and provide erosion protection.

It is noted that the Project's proposed cut back of the E42 pit and earthwork to link the E42 pit with the GR pit will remove some of the existing areas of erosion in the upper dispersive soils resulting in minimal modification expected to be required to the final void landform of E42 during the rehabilitation phase.

The underground portals are at 77 m AHD and 127 m AHD respectively. All portals will be sealed in accordance with the requirements of the Resources Regulator.

b E41 final void

The E41 final void will be approximately -16 m AHD (approximately 205 m below ground level (bgl)) and have a maximum extent of approximately 89 ha.

The final void water balance predictions indicate that the E41 final void would reach an equilibrium level of approximately 130 mRL which is more than 70 m below the spill level after approximately 140 years (ATC Williams 2023).

Conceptual cross section of re-instatement of Lake Cowal Foreshore

Cowal Gold Operations Open Pit Continuation Project
Mine Closure and Rehabilitation Strategy
Figure 5.2

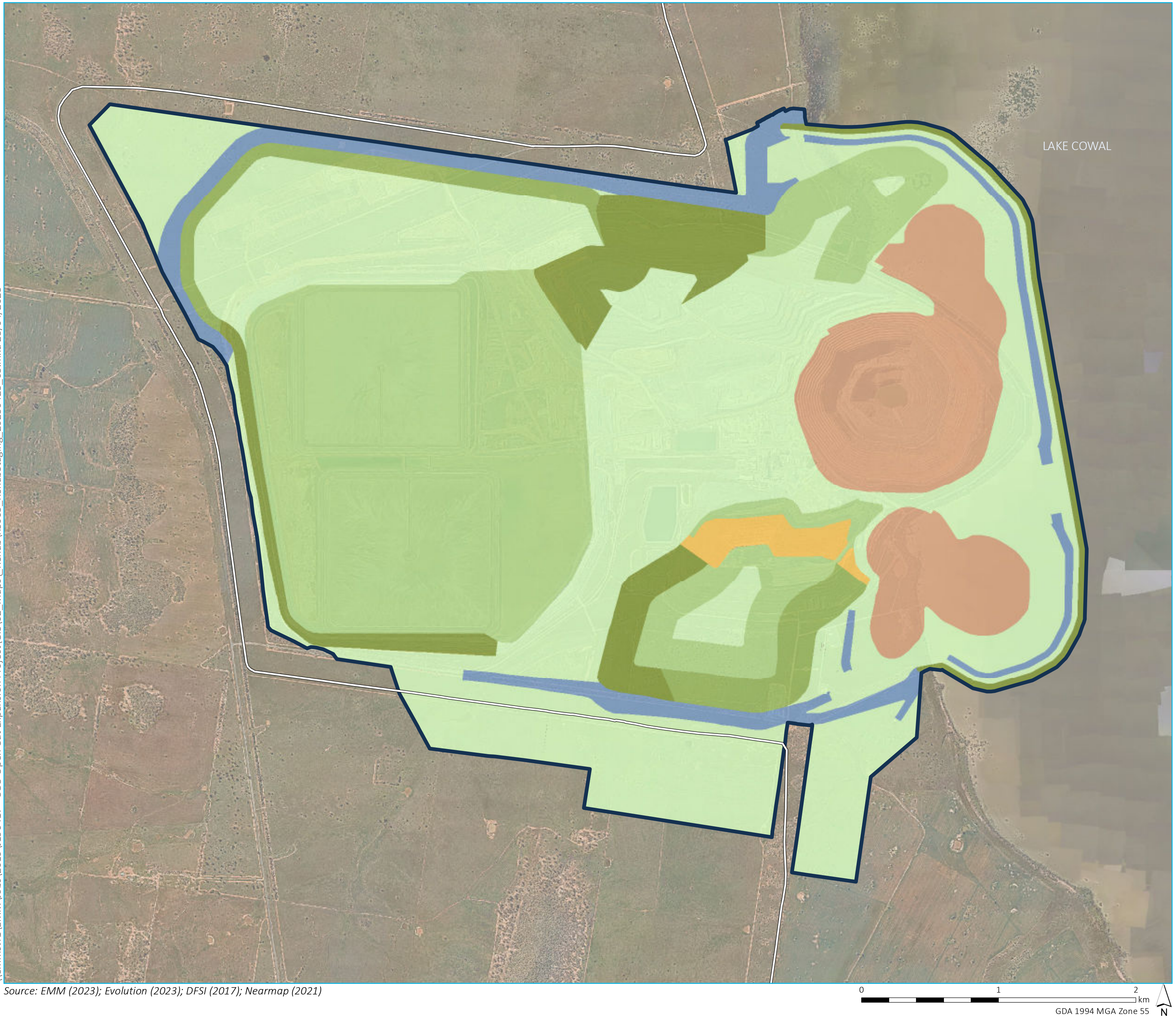
EMM
creating opportunities

5.2 Progressive rehabilitation

The bulk of rehabilitation works will occur toward the end of project life following the cessation of waste haulage and emplacement from the pit and processing of ore and generation of tailings however, progressive rehabilitation of areas to be disturbed by the Project will be undertaken where it is possible to do so throughout the Project life. An indicative schedule of rehabilitation is summarised in Table 5.2, while a conceptual progress of rehabilitation planned to occur over the life of the Project is illustrated in Figure 5.3.

Table 5.2 Rehabilitation progress

Project year	Approximate rehabilitation area (cumulative ha)
Year 4	227
Year 8	322
Year 13	1058
Final	**2253**
Pit voids	304
Water management	154



Source: EMM (2023); Evolution (2023); DFSI (2017); Nearmap (2021)

KEY

- Proposed disturbance footprint
- Major road

Rehabilitation stages

- Existing seeded area
- Year 4
- Year 8
- Year 13
- Final
- Pit void
- Water management

Progressive mine rehabilitation

Evolution Mining
Cowal Gold Operations
Open Pit Continuation Project
Mine Closure and Rehabilitation Strategy
Figure 5.3

EMM creating opportunities

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6 Rehabilitation methods for closure

6.1 Soil management

6.1.1 Soil Stripping Procedures and Soil Stockpile Management

Minesoils (2023) determined that structural and textural properties of soils, along with dispersion potential, sodicity and acidity/alkalinity are the most common and significant limiting factors in determining depth of soil suitability for re-use within the Project area.

Soil Unit 1 and Soil Unit 2 contain moderately suitable topsoils over subsoils which would typically be considered problematic for re-use in rehabilitation due to their saline and sodic characteristics. Nonetheless, due to the extensive presence of these soil types across the additional disturbance area, and based on previous site experience and an appetite by site managers to reinstate deeper soil profiles depths, the subsoils of this unit can be recovered in order to establish an intermediate layer between overburden and topdressing on flat or very gently inclined areas of the post mining landform.

Soils that are sodic, saline or contain a greater clay fraction should be capped with a coarser textured material, which will be beneficial to reset the soil profile in a way that mimics undisturbed soils and will constitute a control measure to limit the dispersion of sodic clays. Furthermore, this will increase the rehabilitated soil profiles infiltration, water holding capacity, seed germination and rootzone, and reduce the surface crusting common to sodic soils.

Further mitigation options include the application of gypsum, lime (for non-alkaline soils) and/or organic matter such as compost and the use of mineral based, biologically inoculated fertilisers, which can increase the humus content further reducing the impacts of sodicity. Further, any ameliorated sodic soils should be prioritised to be placed on flatter landforms to reduce the risks of rill, gully and tunnel erosion on slopes.

Soil Unit 3 represents a suitable soil for re-use in rehabilitation, generally meeting the desirable physical and chemical assessment parameters. Soil Unit 4 has a coarser texture and poorer structure throughout the entire profile than would ordinarily be desirable for stripping and re-use. Nonetheless, given the non-dispersive and chemically stable nature of this soil type, stripping for re-use in rehabilitation as a topdressing over more chemically unstable materials is recommended.

Topsoil materials should otherwise be stockpiled separately to subsoils. Topsoil stockpiles will be seeded to protect the surface from erosion and minimise weed germination. Subsoil stockpiles will also be seeded, but where the subsoil is deleterious to grass establishment, the stockpiles will be protected from erosion using a soil stabilising polymer or some other appropriate form of surface cover.

6.1.2 Soil resources

Minesoils (2023) used a combination of field assessment and laboratory data to determine the depth of soil suitable for recovery and re-use for rehabilitation purposes. The recommended stripping depth for each soil type will subject to disturbance requirements. The depth of soil salvaged should be as deep as excavations or surface disturbance required, or to a depth where parent material is encountered.

Visual observations will be undertaken by CGO environmental personnel during stripping activities to determine if greater depths of desirable salvageable soil material (such as that of Soil Unit 3 or Soil Unit 4) can be recovered.

Topsoil and subsoil depths will be recorded in GIS and rehabilitated with target species to build up the seedbank over the years of stockpiling.

CGO provide Minesoils details of the available soil and rock matrix resources the proposed restrip area to allow modelling of the total soil resources in the project area.

The soils resources contained within the existing and approved disturbance area are summarised as the following;

- 3,720,000 m^3 of topsoil
- 3,400,000 m^3 of subsoil
- 122.4 ha of soil rock matrix.

Recommended stripping depths for the additional disturbance area have been included in Table 6.1, along with soil resources of the approved disturbance area, to model calculations for a soil bank volume scenario.

The soil bank volume modelling indicates approximately 17,242,800 m^3 of suitable soil is available for rehabilitation. This consist of 6,123,500 m3 of topsoil materials and 11,119,300 m^3 of subsoil materials.

It is important to note that Minesoils excluded the soil rock matrix area from the soil bank volume as this area will be conceptually applied over an equivalent area of the final landform, as outlined in the soil balance.

Table 6.1 Soil stripping depths and soil volume (Minesoils, 2023)

Area	Soil Unit	Soil Layer	Area (ha)	Stripping Depth (m)	Soil Volume (m^3)
Additional Disturbance Area	1	Topsoil	250.9	0.00 – 0.20	501,800
		Subsoil		0.20 – 1.00	2,007,200
	2	Topsoil	468.4	0.00 – 0.20	936,800
		Subsoil		0.20 – 1.00	3,747,200
	3	Topsoil	280.7	0.00 – 0.30	842,100
		Subsoil		0.30 – 1.00	1,964,900
	4	Topsoil	30.7	0.00 – 0.40	122,800
		Subsoil		NA	0
Existing and Approved Disturbance Area	Topsoil resources				3,720,000
	Subsoil resources				3,400,000
	Soil Rock Matrix				NA
Total Volume (m^3)					**17,242,800**

6.1.3 Soil respreading depths

The re-spread soil depths to ensure the objectives of the final land use domains and their associated LSC classes of the entire CGO site are achieved have been modelled for the purpose of a soil balance scenario and shown in Table 6.2.

Respread depths for Domains A and B are based on current site practice and include up to 300 mm topsoil and 500 mm subsoil, however, Minesoils nominates an average respread subsoil depth of 400 mm for Domain A to allow for slopes where less subsoil material will be placed. These respread depths are considered sufficient to achieve intended post mining land uses. Domains F and J (ie water management areas and final voids) will not be subject to soil rehabilitation.

While most of the currently rehabilitated or partially rehabilitated areas of the CGO site will be re-disturbed as part of the Project, a rehabilitated area on the northern face of the southern WRE within the existing and approved disturbance area will not be subject to re-disturbance. This area covers 31.1 ha. For the soil balance calculations, this area has been removed from the Domain A areas requiring soil bank resources.

Additionally, for the purpose of the soil balance modelling, the soil rock matrix area that covers 122.4 ha has also been removed from the Domain A area requiring soil bank resources, as it is assumed this area will be allocated to an equivalent area.

Therefore, the total area of Domain A (2,180.1 ha) subject to the soil balance is 2,026.6 ha. The total volume of material required to meet the final land use and LSC objectives is calculated to be 15,742,200m^3. This consist of 6,663,300 m^3 of topsoil materials and 9,078,900 m^3 of subsoil materials.

Table 6.2 Soil spreading depths and required volume (Minesoils, 2023)

Domain	Name	Project Disturbance Area (ha)	Topsoil Respread Depth (m)	Subsoil Respread Depth (m)	Required Soil Volume (m^3)
A	Native Ecosystem	2,026.6	0.3	0.4	14,186,200
B	Agricultural - Grazing	194.5	0.3	0.5	1,556,000
Total Volume (m^3)			6,663,300	9,078,900	15,742,200

6.2 Soil balance

Based on a soil bank of 17,242,800 m^3, the soil balance results in an overall net surplus of 1,500,600 m^3, consisting of a deficit of 539,800 m^3 of topsoil and a surplus of 2,040,400 m^3 of subsoils, as shown in Table 6.3. Based on this outcome, rehabilitation efforts will require a minimal deviation from current site practice with reduced topsoil respread depths and corresponding increases in subsoil depths where suitable.
This is considered a negligible impact to the final land use outcomes of the rehabilitated landform. An option to increase the available topsoil resources would be to harvest organic material and convert it to an organic growth medium using composting or via biological fermentation and mix that with the available topsoil resources.

Table 6.3 Soil balance (Minesoils, 2023)

	Soil Bank Volume (m^3)	Required Soil Volume (m^3)	Balance (m^3)
Topsoil	6,123,500	6,663,300	- 539,800
Subsoil	11,119,300	9,078,900	+ 2,040,400
Total Volume	17,242,800	15,742,200	+ 1,500,600

6.2.1 Stripped soil management

The following soil handling techniques are used by CGO to prevent excessive soil deterioration and dispersion. Final soil handling methods will be included in the revised Rehabilitation Management Plan for the site and may include alternate methods to manage soil deterioration.

- prior to stripping of soil, appropriate sediment controls are installed to prevent off-site loss of soil sediments

- desirable soil materials are stripped to maximum excavation depths, subject to further investigation as required
- where conditions allow, soil is stripped in a slightly moist condition to minimise structural decline
- excessive advance clearing and soil removal is kept to a minimum to reduce dust generation and potential impacts on fauna species. However, this is to be balanced with clearing a large enough area to aid flexibility in the scheduling of stripping activities to enable works to occur in favourable conditions and outside of fauna breeding periods
- soil is grade or pushed into windrows with graders or dozers for later collection by open bowl scrapers or for loading into rear dump trucks by front-end loaders. This minimises compression effects of the heavy equipment that is often necessary for economical transport of soil material;
- soil transported by dump trucks is generally placed directly onto rehabilitation areas where possible or into stockpiles. Soil transported by scrapers is used to form stockpiles formed by other equipment (e.g. dozer) to avoid tracking over previously laid soil resulting in compaction of the stockpile.

Where feasible, soil is transferred directly from stripping to re-spreading operations, eliminating the need for stockpiling. However, mine scheduling dictates that soil storage will be necessary on occasion for extended periods. Where stockpiling is required, the following mitigation measures are adopted:

- the height of soil stockpiles is limited to 3m and ripped in order to promote infiltration and minimise erosion until vegetation is established, and to prevent anaerobic zones forming
- stockpiles are preferentially located away from heavily trafficked or active mining areas, watercourses and are placed on areas of flat topography or along the contour to minimise erosion
- where necessary, a flow diversion bank or catch drain is placed up-slope of a stockpile to direct surface water flows away. All stockpiles shall remain in a free-draining location to avoid long term soil saturation
- stockpiles are seeded as soon as possible. An annual cover crop species that produce sterile florets or seeds may be sown. A rapid growing and healthy annual pasture sward is used to provide sufficient competition to minimise the emergence of undesirable weed species. Final rehabilitation target pasture or native grass species should be established on stockpiles to build up a desirable species seed bank in the topsoil
- soils are stockpiled separately according to source, nature and history, and characterisation, and records maintained
- a register of available soil is maintained to ensure adequate materials are available for planned rehabilitation activities when the time comes. As stockpiles are constructed, added to or drawn upon, relocated, or removed the register is updated to provide a current account of stockpiled soil materials. The register is updated periodically and reviewed annually in association with annual reporting processes
- inspections of stockpiled soils are undertaken to inform ongoing management of the resource and to assist in limiting potential degradation of soil quality while held in storage
- prior to re-spreading stockpiled topsoil onto the disturbance area, an assessment of weed infestation on stockpiles is undertaken to determine if individual stockpiles require herbicide application

The revised RMP will consider where additional assessment of previously utilised soil resources, that are currently used on rehabilitated lands, will be required to inform management controls prior to re-use.

6.2.2 Soil spreading and amelioration

The following re-spreading and seedbank preparation techniques will continue to be undertaken to prevent excessive soil deterioration and dispersion. Final soil management measures will be included in the revised RMP.

- following ground preparation and growth medium development works, revegetation activities will commence as soon as possible
- soils to be placed in a rehabilitation area are identified for use based on the soil quality and vegetation history, with consideration to the planned final land use of the rehabilitation area, and with consideration to the mine plan and operational factors
- subsoil will be spread and ameliorated with gypsum as required
- topsoil will be spread, ameliorated with fertiliser, gypsum (where required) and seeded in one consecutive operation, to reduce the potential for topsoil loss to wind and water erosion. Thorough seedbed preparation will be undertaken to ensure optimum establishment and growth of vegetation
- topsoiled areas will be scarified on the contour (apart from rock/soil matrix areas) (after topsoil spreading) to create a ‘key between the soil and material below. Best results will be obtained by ripping immediately prior to sowing
- soil management documentation is maintained that includes confirmation that topsoil stockpiles have been scalped, topsoil has been placed at the appropriate depth and ameliorants have been applied at the correct rate
- The need for maintenance fertilising will be assessed during regular rehabilitation monitoring programs, particularly in agricultural final land use areas where grazing is occurring or planned to occur.

6.3 Vegetation establishment

6.3.1 Species selection

Revegetation of the final landforms will include endemic vegetation communities, selected specifically for their suitability to the created elevation, substrate conditions and the overriding objective of re-establishing a greater extent of endemic vegetation within the Project area.

Lists of species potentially considered suitable for use as tubestock and in a native seed mix for the CGO’s rehabilitation programme have been developed by DnA Environmental in conjunction with Diversity Native Seeds to consider the common local endemic vegetation species present in the landscape surrounding the CGO (DnA Environmental, 2022).

The revegetation approaches for disturbed areas will continue to be informed by the results of the rehabilitation investigations, trials (Section 7.2) and rehabilitation monitoring results. Based on these results, the CGO rehabilitation programme (including revegetation species lists for each rehabilitation domain) will be refined in consultation with relevant regulatory agencies.

6.3.2 Seed Collection

As a component of the Vegetation Clearance Protocol, during the preliminary habitat assessment phase, trees may be examined for their provision of seed to be used in the rehabilitation programme.

Where available, seed would be collected at the time of vegetation clearance activities and habitat features (i.e. hollows and logs) would be salvaged for use in rehabilitation or habitat enhancement programmes within ML 1535 and/or within the CGO's offset areas and RVEP areas.

CGO will prepare a seed supply and planting implementation strategy for the CGO's rehabilitation programme within the Project area and for implementation of the CGO's offset strategy. The strategy will include implementation plans/programmes for:

- seed collection/harvesting and seed processing and storage
- seed propagation
- site preparation and planting
- maintenance (including supplementary plantings and weed and pest control).

The strategy will include an assessment of the potential risks associated with the seed supply and planting implementation programme.

6.3.3 Revegetation methods

Revegetation at the CGO uses a combination of direct seeding and tubestock planting. These methods will continue to be applied for the Project.

6.4 Fauna and habitat enhancement measures

As detailed in the RMP, where practicable, vegetation clearance operations will be managed to maximise the re-use of cleared vegetative material and habitat resources/features. Habitat resources/features such as logs and hollows will be clearly marked (with flagging tape or similar) for salvage/relocation in the CGO's rehabilitation programme (or for use within the CGO's offset enhancement areas or remnant vegetation enhancement programme areas).

Vegetative material unsuitable for the rehabilitation programme or for habitat enhancement will be mulched and stockpiled.

6.5 Erosion and sediment control

The key erosion risks for the project are:

- highly erodible dispersible subsoils and topsoils
- low annual average rainfall to establish and sustain vegetation cover
- long slope length
- areas of flow convergence due to landform design or legacy erosion control measure (reverse grade berms).

Erosion and sediment control management and mitigation measures are described in the approved CGO Erosion and Sediment Control Plan which will be revised for the Project. As detailed in Section 5.2.4, the erosion risk on the WRE's and IWL is mitigated by the use of rock/topsoil matrices combined with vegetative soil surface cover. The rock provides a high degree of overland flow critical shear protection, until the vegetation cover establishes. The rock/soil matrix also reduces runoff by encouraging infiltration into the rock/soil layer which also aids the establishment of vegetation.

Most of the disturbed areas within the project will report to Type D/F sediment basins such that any eroded sediments will be contained (up to and including the design storm event). Contained turbid water is re-used on site.

The sediment basins will be maintained on site until 70% soil surface cover has been achieved on the rehabilitated surfaces and/or runoff meets the nominated water quality criteria.

Dispersive soils are managed in accordance with the methodologies described in sections 3.2.2 and 3.4.2 that including gypsum treatment to reduce exchangeable sodium and exchangeable magnesium levels and the use of rock/soil matrices on slopes.

Progressive rehabilitation of disturbed areas is undertaken to reduce the area and duration of exposure.

Interim rehabilitation measures that are implemented to minimise the area exposed for dust generation include the topsoiling and establishment of a cover crop on landforms/areas and on long-term soil stockpiles to minimise area exposed for dust generation.

The rock component of the rock/soil matrices is applied as soon as practicable following the completion of landform shaping to minimise the potential for windblown dust from the surface waste rock and to reduce the potential for soil erosion from rainfall.

Following re-profiling works and rock mulch and topsoil application, native pasture hay (or clean wheaten hay) applied on areas where the initial cover crop has not yet established to assist with stabilising and minimising the loss of topsoil resources.

6.6 Post-closure maintenance

6.6.1 Rehabilitation monitoring

Rehabilitation monitoring will continue to be undertaken using analogue sites and Landscape Function Analysis (LFA) to assess rehabilitation progress and success as detailed in the RMP. Annual rehabilitation reports will continue to be prepared and submitted to the Resources Regulator via their portal. A GIS database will be maintained for rehabilitated areas and stockpile locations. Rehabilitation actions arising from monitoring will be documented along with remediation actions.

Data obtained from the analogue sites provides a range of values from replicated examples of similar vegetation communities. Rehabilitation areas are compared to reference sites that best represent the final land use, vegetation community and management conditions they will be subjected to.

This approach allows the recognition of the dynamic nature of ecosystems therefore rehabilitation sites are monitored simultaneously to the reference sites over time to account for changes in:

- seasonal variations
- climatic conditions
- management practices
- unexpected disturbance events such bushfire.

To demonstrate rehabilitate success or succession toward rehabilitation success, specific indicators have been developed to equal values obtained from the reference site under the same set of conditions or demonstrate a positive trend towards target values.

Rehabilitation monitoring informs areas requiring maintenance and identify and address deviations from the expected outcomes. Rehabilitated areas are assessed against performance indicators (Section 7) and regularly inspected (at least on an annual basis) for the following aspects:

- evidence of any erosion or sedimentation
- success of initial establishment cover
- natural regeneration of improved pasture
- weed infestation (primarily noxious weeds, but also where rehabilitation areas are dominated by other weeds)
- integrity of diversion drains, waterways and sediment control structures
- general stability of the rehabilitation areas.

Where rehabilitation criteria have not been met, maintenance works will be undertaken in accordance with the RMP.

6.6.2 Weed management

The presence of weed species has the potential to have a major impact on revegetation outcomes. Additionally, any significant weed species within the surrounding land has the potential to impact on the success of the rehabilitated areas. Weed management will be an important component of rehabilitation activities.

The spread of declared noxious weeds (and other invasive weeds that could impact revegetation success and/or plants that are undesirable to grazing stock) will be managed across the project area through a series of control measures, including:

- herbicide spraying or scalping weeds
- post-mining use of rehabilitated areas as a working grazing farm, with associated management practices
- rehabilitation inspections to identify potential weed infestations.

6.6.3 Access

Access tracks may be required to facilitate the revegetation and ongoing maintenance of the rehabilitated Project area. These tracks will be kept to a practical minimum and will be designated prior to the completion of the Project.

6.6.4 Public safety

Controls will be implemented to minimise the potential for impacts on public safety. This may include maintenance of fencing and warning signs around areas that have the potential to cause harm and that are accessible to the public, including bunding and fencing of the void as described in section 4.4.1.

6.6.5 Rehabilitation resources

A RMP has been developed to provide a structured and documented process for managing and improving rehabilitation activities at the mine. The plan serves as a process map for interdepartmental administration of rehabilitation activities within the mine planning and implementation process. This RMP will be updated as required to adopt the specific management requirements arising from this Rehabilitation strategy.

CGO Environmental personnel will continue to implement the RMP for the life of the Project.

Earth moving operations will be performed by machinery operators with experience and skill in the operation of the relevant machinery (bulldozers, loaders, excavators etc). Project supervisors will be responsible for compliance with the requirements of the RMP and its future revision.

7 Performance indicators and completion criteria

7.1 Rehabilitation criteria and reporting

Rehabilitation completion criteria are used as the basis for assessing when rehabilitation of the project is complete. Indicators are measured against the criteria, and are set for the six phases of rehabilitation, consistent with the RMP guidelines as follows:

- Phase 1 – Decommissioning (ie removal of equipment and infrastructure)
- Phase 2 – Landform Establishment (ie land shaping)
- Phase 3 – Growth Medium Development (ie soil physical and chemical properties)
- Phase 4 – Ecosystem and Land Use Establishment (ie vegetation establishment)
- Phase 5 – Ecosystem and Land Use Sustainability (ie established vegetation is supporting post-mining land use)
- Phase 6 – Land Relinquishment.

7.1.1 Existing CGO performance indicators and completion criteria

The rehabilitation criteria need to demonstrate that the rehabilitation objective has been achieved. Qualitative and quantitative rehabilitation performance indicators and completion criteria have been developed by DnA Environmental (2022) to assess rehabilitation performance at the CGO.

The rehabilitation criteria for the Project have been developed with the current knowledge of rehabilitation practices and success at CGO and in similar project environments. They consist of a set of objectives; rehabilitation criteria and evidence that criteria have been met using LFA and agricultural productivity measures or the like.

Aspects to be monitored and reported include final landform shape and surface covers, vegetation establishment and sustainability, removal of infrastructure and treatment of soil contamination. Criteria will be reviewed with each RMP renewal provided to the Resources Regulator.

Whether rehabilitation criteria have been met depends on the trending of measurements over time compared to pre-mining or analogue site conditions. DnA Environmental has identified an upper and lower range of criteria values based on monitoring data collected across selected analogue sites. It is important to note that these upper and lower criteria values are dynamic and change each year based on the monitoring results from the analogue sites. This is undertaken to reflect the seasonal and climatic conditions at the time of monitoring.

Table 7.1 Rehabilitation performance indicators and completion criteria

Rehabilitation Phase	Aspect or Ecosystem Component	Completion Criteria	Performance Indicators
Landform establishment and stability	Landform slope, gradient	Landform suitable for final land use and generally compatible with surrounding topography	Slope
	Active erosion	Areas of active erosion are limited	Number of rills/gullies
			Cross-sectional area of rills/gullies
Growth medium development	Soil chemical, physical properties and amelioration	Soil properties are suitable for the establishment and maintenance of selected vegetation species	pH
			EC
			Organic Matter
			Phosphorous
			Nitrate
			Cation Exchange Capacity
			Exchangeable Sodium Percentage
Ecosystem and Land Use Establishment	LFA Landform Stability and Landscape Organisation indices	Landform is stable and performing as designed	LFA Stability
			LFA Landscape Organisation
	Vegetation diversity	Vegetation contains a diversity of species comparable to that of the local remnant vegetation	Diversity of shrubs and juvenile trees
			Total species richness
			Native species richness
			Exotic species richness
	Vegetation density	Vegetation contains a density of species comparable to that of the local remnant vegetation	Density of shrubs and juvenile trees
	Ecosystem composition	The vegetation is comprised by a range of growth forms comparable to that of the local remnant vegetation	Trees
			Shrubs
			Sub-shrubs
			Herbs
			Grasses
			Reeds
			Ferns
			Aquatic
			Parasite

Table 7.1 Rehabilitation performance indicators and completion criteria

Rehabilitation Phase	Aspect or Ecosystem Component	Completion Criteria	Performance Indicators
Ecosystem and Land Use Development	LFA Landform Function and Ecological Performance indices	Landform is ecologically functional and indicative of a landscape on a trajectory towards a self-sustaining ecosystem	LFA Infiltration
			LFA Nutrient Cycling
	Protective ground cover	Ground layer contains protective ground cover and habitat structure comparable with the local remnant vegetation	Litter cover
			Annual plants
			Cryptogam cover
			Rock
			Log
			Bare ground
			Perennial plant cover (< 0.5 m)
			Total Ground Cover
	Ground cover diversity	Vegetation contains a diversity of species per square meter comparable to that of the local remnant vegetation	Native understorey abundance
			Exotic understorey abundance
	Native ground cover abundance	Native ground cover abundance is comparable to that of the local remnant vegetation	Percent ground cover provided by native vegetation <0.5 m tall
Ecosystem and Land Use Development (Cont.)	Ecosystem growth and natural recruitment	The vegetation is maturing and/or natural recruitment is occurring at rates similar to those of the local remnant vegetation	Shrubs and juvenile trees 0 - 0.5 m in height
			Shrubs and juvenile trees 0.5 – 1 m in height
			Shrubs and juvenile trees 1 - 1.5 m in height
			Shrubs and juvenile trees 1.5 – 2 m in height
			Shrubs and juvenile trees >2 m in height
	Ecosystem structure	The vegetation is developing in structure and complexity comparable to that of the local remnant vegetation	Foliage cover 0.5 – 2 m
			Foliage cover 2 – 4 m
			Foliage cover 4 – 6 m
			Foliage cover >6 m
	Tree diversity	Vegetation contains a diversity of maturing tree and shrubs species comparable to that of the local remnant vegetation	Tree diversity
	Tree density		Tree density

Table 7.1 Rehabilitation performance indicators and completion criteria

Rehabilitation Phase	Aspect or Ecosystem Component	Completion Criteria	Performance Indicators
		Vegetation contains a density of maturing tree and shrubs species comparable to that of the local remnant vegetation	Average diameter at breast height (dbh)
	Ecosystem health	The vegetation is in a condition comparable to that of the local remnant vegetation	Live trees
			Healthy trees
			Medium health
			Advanced dieback
			Dead Trees
			Mistletoe
			Flowers/fruit: Trees
			Hollows: Trees

7.1.2 Domain specific performance indicators and completion criteria

Indicative rehabilitation criteria and final land use objectives for each of the final land use domains are provided in Table 7.2 to Table 7.5. Some of these include alternative options that are still subject to consultation and agreement (e.g. decommissioning water management infrastructure or retaining for future use post-mining), the performance indicator will be to undertake the relevant consultation to determine the final rehabilitation and land use objective. The relevant completion criteria will then be updated in future RMPs once the final land use is agreed for these domains.

Table 7.2 Rehabilitation objectives, performance indicators and indicative completion criteria for Domains A1 and A3

Rehabilitation Phase	Objective	Performance Indicator	Completion Criteria	Justification/validation methods
Decommissioning	All infrastructure will be dismantled, decommissioned and removed to ensure the site is safe and free of hazardous materials. (unless an alternative use is agreed)	Workshop, storage, process plant and administration buildings removed.	Complete removal of buildings.	Statement provided Demolition records from certified contractor
		Hazardous materials removed.	Hazardous materials (including process chemicals) removed to appropriate standards.	Contamination Remediation Report prepared by Land Contamination Consultant.
		Cyanide areas decontaminated and decommissioned.	Cyanide areas decontaminated and decommissioned to appropriate standards.	Contamination Remediation Report prepared by Land Contamination Consultant.
		Undertake consultation to confirm any alternative use for non-permanent water management infrastructure (i.e. contained water storages) post-mining.	Consultation complete. Decision made regarding whether water management infrastructure is retained for alternative use or if infrastructure is to be decommissioned.	Consultation records/statement
Growth Medium Establishment	All areas where infrastructure has been removed will be ripped, contoured (if necessary) and topsoiled.	Infrastructure removed. Topsoil stocks available. Gypsum applied to topsoil (if necessary).	Growth medium established for all former infrastructure areas where infrastructure is not retained.	Rehabilitation monitoring reports and GIS records
Ecosystem and Land Use Establishment	Establish vegetative communities (including scattered Eucalypt woodland species and native pasture species) which are endemic to the region and/or suited to the substrate materials.	Refer to Ecosystem and Land Use Establishment performance indicators in Table 13 Evolution, 2018a	Refer to Ecosystem and Land Use Establishment completion criteria in Table 13 Evolution, 2018a.	Rehabilitation monitoring reports and GIS records Suitably qualified specialist ecological reports (where required)
	Vegetative communities (including scattered Eucalypt woodland species and native pasture species) are self-sustaining and suited to agreed post-mining land use.	Refer to Ecosystem and Land Use Development performance indicators in Table 13 Evolution, 2018a.	Refer to Ecosystem and Land Use Development completion criteria in Table 13 Evolution, 2018a.	Rehabilitation monitoring reports and GIS records Suitably qualified specialist ecological reports (where required)

Table 7.3 Rehabilitation objectives, performance indicators and indicative completion criteria for Domain A2

Rehabilitation Phase	Objective	Performance Indicator	Completion Criteria	Justification/validation methods
Decommissioning	IWL infrastructure to be removed.	A plan for decommissioning the IWL has been developed.	Pipelines, pumps and related tailings infrastructure removed.	Statement provided Demolition records from certified contractor
Landform Establishment	Establish permanently stable landforms.	TSF/IWL outer batter slopes constructed in accordance with design criteria.	TSF/IWL outer batters constructed as designed.	Landform Evolution modelling on final landform
		Assessment of the integrity of the TSF/IWL walls.	Agreement/sign-off from the DSC.	Engineering report
Growth Medium Establishment	During operations, stabilise embankments so that they provide minimal habitat value for bird life (i.e. pasture cover).	Erosion monitoring undertaken.	No active erosion on outer batter slopes.	Rehabilitation monitoring reports and before and after photos
		Benign primary waste rock mulch (rock mulch) sized approximately < 300 mm available for use.	Rock mulch size and depth is effective in stabilising outer batters of the TSFs/IWL.	Rehabilitation monitoring reports and before and after photos
		Complete soil resource materials balance.	Sufficient soil available to meet cover system depth requirements.	Independent specialist reports
		Soil analysis undertaken to confirm appropriate gypsum application rate.	Soil analysis complete and gypsum applied at appropriate application rate.	Rehabilitation monitoring reports Independent specialist reports
Ecosystem and Land Use Establishment	During operations, stabilise embankments so that they provide minimal habitat value for bird life (i.e. pasture cover).	Refer to Ecosystem and Land Use Establishment performance indicators for 'Grassland Ecosystem Range 2017' in Table 13 Evolution, 2018a.	Refer to Ecosystem and Land Use Establishment completion criteria for 'Grassland Ecosystem Range 2017' in Table 13 Evolution, 2018a.	Rehabilitation monitoring reports/ecological monitoring reports

Table 7.3 Rehabilitation objectives, performance indicators and indicative completion criteria for Domain A2

Rehabilitation Phase	Objective	Performance Indicator	Completion Criteria	Justification/validation methods
Ecosystem and Land Use Sustainability	**Top Surface of IWL** Post-operations, establish vegetative communities (including Eucalypt and Riverine woodland species and understorey species such as Rush sp. and pasture species) on the top surface of the IWL which are suited to the hydrological features and substrate materials of the top surface of the landform.	Rehabilitation trials have identified vegetation species suited to the IWL top surface.	Rehabilitation monitoring demonstrates vegetation established on top surface of the IWL is suited to the landform and is on a trajectory towards a self-sustaining ecosystem.	Rehabilitation monitoring reports and GIS records Suitably qualified specialist ecological reports (where required) Before and after photos
	Outer Embankments of IWL Post-operations, establish vegetative communities (including native and/or endemic Eucalypt Woodland, shrubland and grassland species) similar to those remnants in the surrounding landscape which are suited to the substrate materials and the slope of the embankments.	Refer to Ecosystem and Land Use Development performance indicators for 'Slopes Ecosystem Range 2017' in Table 13 Evolution, 2018a.	Refer to Ecosystem and Land Use Development completion criteria for 'Slopes Ecosystem Range 2017' in Table 13 Evolution, 2018a.	Rehabilitation monitoring reports and GIS records Suitably qualified specialist ecological reports (where required) Before and after photos
	Exclude grazing and agricultural production.	Fence IWL.	IWL fenced, and grazing and agricultural production excluded.	Statement provided and before/after photos

Table 7.4 Rehabilitation objectives, performance indicators and indicative completion criteria for Domain A4

Rehabilitation Phase	Objective	Performance Indicator	Completion Criteria	Justification/Source
Landform Establishment	Stabilise batter slopes with rock armour (benign primary waste rock mulch) to control surface water runoff downslope and reduce erosion potential in the long-term.	Refer to Landform Establishment and Stability performance indicators for 'Slopes Ecosystem Range 2017' in Table 13 Evolution, 2018a.	Refer to Landform Establishment and Stability completion criteria for 'Slopes Ecosystem Range 2017' in Table 13 Evolution, 2018a.	Cowal Gold Operations Processing Rate Modification Environmental Assessment (Evolution, 2018a)
	Top surfaces of WRE constructed to include a series of small shallow basins (depressions) to maximise internal drainage.	Shallow basins constructed on waste rock emplacement top surfaces.	Drainage of top surfaces of WRE is managed by shallow basins.	Cowal Gold Operations Processing Rate Modification Environmental Assessment (Evolution, 2018a)
	A bund around the perimeter of top surface of WRE will be constructed to minimise surface water runoff from the top surface down the batters.	Perimeter bund constructed.	The top surface of WRE forms a contained catchment and the perimeter bund minimises surface water runoff from the top surface down the batters.	Cowal Gold Operations Processing Rate Modification Environmental Assessment (Evolution, 2018a)
Growth Medium Development	Provide a stable plant growth medium on the outer batters and top surfaces of the WRE able to support long-term vegetation growth.	Refer to Growth Medium Development performance indicators for 'Slopes Ecosystem Range 2017' in Table 13 Evolution, 2018a.	Refer to Growth Medium Development completion criteria for 'Slopes Ecosystem Range 2017' in Table 13 Evolution, 2018a.	Cowal Gold Operations Processing Rate Modification Environmental Assessment (Evolution, 2018a)
Ecosystem and Land Use Establishment	**Top Surfaces of Waste Rock Emplacements** Post-operations, establish vegetative communities (including Eucalypt woodland species) on the top surfaces of the WRE which are suited to the substrate materials and is comparable to local remnant ecological communities located on hill top areas in the surrounding landscape.	Refer to Ecosystem and Land Use Establishment performance indicators for 'Hill Ecosystem Range 2017' in Table 13 Evolution, 2018a.	Refer to Ecosystem and Land Use Establishment completion criteria for 'Hill Ecosystem Range 2017' in Table 13 Evolution, 2018a.	Cowal Gold Operations Processing Rate Modification Environmental Assessment (Evolution, 2018a)
	Outer Batters of Waste Rock Emplacements Post-operations, establish vegetative communities (including Eucalypt woodland species) on the outer batters of the WRE which are suited to the substrate materials and is comparable to local remnant ecological communities on rocky slopes in the surrounding landscape.	Refer to Ecosystem and Land Use Establishment performance indicators for 'Slopes Ecosystem Range 2017' in Table 13 Evolution, 2018a.	Refer to Ecosystem and Land Use Establishment completion criteria for 'Slopes Ecosystem Range 2017' in Table 13 Evolution, 2018a.	Cowal Gold Operations Processing Rate Modification Environmental Assessment (Evolution, 2018a)

Table 7.4 Rehabilitation objectives, performance indicators and indicative completion criteria for Domain A4

Rehabilitation Phase	Objective	Performance Indicator	Completion Criteria	Justification/Source
Ecosystem and Land Use Sustainability	**Top Surfaces of Waste Rock Emplacements** Ecosystem is on a trajectory towards self-sustaining and is comparable to local remnant ecological communities on hill top areas in the surrounding landscape.	Refer to Ecosystem and Land Use Development performance indicators for 'Hill Ecosystem Range 2017' in Table 13 Evolution, 2018a.	Refer to Ecosystem and Land Use Development completion criteria for 'Hill Ecosystem Range 2017' in Table 13 Evolution, 2018a.	Cowal Gold Operations Processing Rate Modification Environmental Assessment (Evolution, 2018a)
Ecosystem and Land Use Sustainability (continued)	**Outer Batters of Waste Rock Emplacements** Ecosystem is on a trajectory towards self-sustaining and is comparable to local remnant ecological communities on rocky slopes in the surrounding landscape.	Refer to Ecosystem and Land Use Development performance indicators for 'Slopes Ecosystem Range 2017' in Table 13 Evolution, 2018a.	Refer to Ecosystem and Land Use Development completion criteria for 'Slopes Ecosystem Range 2017' in Table 13 Evolution, 2018a.	Cowal Gold Operations Processing Rate Modification Environmental Assessment (Evolution, 2018a)
	Exclude grazing and agricultural production from WRE.	Fence WRE.	Waste rock emplacements fenced and grazing and agricultural production excluded.	Cowal Gold Operations Processing Rate Modification Environmental Assessment (Evolution, 2018a)

Table 7.5 Rehabilitation objectives, performance indicators and completion criteria for Domain B1

Rehabilitation Phase	Objective	Performance Indicator	Completion Criteria	Justification/validation
Land Use Establishment	Select and establish species for revegetation and based on rehabilitation monitoring and trial results. Suitability determined for the end use Erosion is minimised and land drains to the final voids	Provide a stable plant growth medium on the outer batters and top surfaces of the WRE able to support long-term vegetation growth. Cover crop established Suitable drainage and erosion controls implemented for the agricultural areas	Suitability for agricultural use determined Erosion minimised	This assessment RMP requirements
Land Use Sustainability		Offsite run-off is minimised	Soil stability determined	RMP requirements This assessment

Table 7.6 Rehabilitation objectives, performance indicators and indicative completion criteria for Domain F3

Rehabilitation Phase	Objective	Performance Indicator	Completion Criteria	Justification/validation methods
UCDS/ICDS				
Ecosystem and Land Use Sustainability	Permanent drainage of adjacent areas upslope of the CGO to Lake Cowal will be facilitated by the UCDS.	UCDS constructed.	UCDS facilitates permanent drainage of adjacent areas upslope of the CGO to Lake Cowal.	Approved RMP Cowal Gold Operations Processing Rate Modification Environmental Assessment (Evolution, 2018a)
	The UCDS will include constructed features that simulate endemic drainage features including low flow and overbank zones, meanders, pool/riffle sequences and riparian vegetation to stabilise the channel.	Low flow and overbank zones, meanders, pool/riffle sequences constructed and riparian vegetation established.	The UCDS constructed features simulate endemic drainage features and riparian vegetation is present and stabilises the upper banks of the channel.	Approved RMP Cowal Gold Operations Processing Rate Modification Environmental Assessment (Evolution, 2018a)
	Runoff generated within the site will be contained by low mounds associated with the ICDS.	Low mounds constructed.	Runoff generated within the site is contained.	Approved RMP Cowal Gold Operations Processing Rate Modification Environmental Assessment (Evolution, 2018a)
LPB				
Landform Establishment	Continued mutual protection of CGO and Lake Cowal	Long term stability of the LPB determined	Stabilisation works complete.	As built design report.
Growth Medium Development	Provide a plant growth medium on LPB to support long-term vegetation growth.	Undertake growth medium works on the LPB is possible during construction	Growth medium works complete	Rehabilitation monitoring reports and GIS records Before and after photos
Ecosystem and Land Use Establishment	Select and establish species for revegetation of the New Lake Foreshore from vegetative suites as described in Section 5.3.6 and based on rehabilitation monitoring and trial results.	Appropriate species planted at LPB Reinstatement of the lake foreshore around the extended LPB generally following the concepts approved in the existing Compensatory Wetland Management Plan.	Planting program undertaken and completed	Rehabilitation monitoring reports and GIS records Before and after photos RMP requirements

Table 7.6 Rehabilitation objectives, performance indicators and indicative completion criteria for Domain F3

Rehabilitation Phase	Objective	Performance Indicator	Completion Criteria	Justification/validation methods
Ecosystem and Land Use Sustainability	Ecosystem is on a trajectory towards self-sustaining.	Revegetation undertaken in accordance with the RMP	Suitable trend to growth materialises	Rehabilitation monitoring reports and GIS records Before and after photos

Table 7.7 Rehabilitation objectives, performance indicators and completion criteria for Domain J5

Rehabilitation Phase	Objective	Performance Indicator	Completion Criteria	Justification/validation methods
Decommissioning	Leave the void surrounds safe (for humans and stray stock).	Safety measures implemented in area surrounding final voids.	Perimeter bund constructed, is stable and vegetated with long-term cover crop. Voids fenced and warning signs posted along the fence. Portals sealed and underground infrastructure removed	Statement provided and before/after photos Engineering report/statement photos etc.

7.2 Rehabilitation monitoring and research

7.2.1 Rehabilitation monitoring

The rehabilitation monitoring methodology used CGO has been independently developed to assess the performance of the CGO's rehabilitation areas (and to assess regeneration [and revegetation] performance within the existing CGO's Offset and RVEP Areas).

The rehabilitation monitoring methodology was developed by DnA Environmental in 2011 that includes a combination of:

- LFA indicators (which includes measurement of soil erosion type and severity)
- accredited soil analyses indicators
- an assessment of ecosystem characteristics using an adaptation of methodologies derived by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Methodology for the Grassy Box Woodlands Benchmarking Project in Southern NSW Murray-Darling Basin (Gibbons, 2002) and the associated Biometric Model Rapidly quantifying reference conditions in modified landscapes (Gibbons et al., 2008).

The methodology includes qualitative performance indicators and completion criteria and quantitative performance indicators and completion criteria developed from relevant analogue sites representative of the CGO final landforms and long-term land use strategy.

A summary of the monitoring methodology components currently used on site, and will continue to be used, is provided below.

i Landscape Function Analysis

LFA is one of three components of the EFA tool developed by the CSIRO that aims to measure the progression of revegetation/rehabilitation towards a self-sustaining ecosystem.
LFA indices can be used to demonstrate that an area is on a trajectory towards a self-sustaining landscape, that is, the landscape contains processes operating to maintain the biogeochemical 'engine-room' of a landscape (Tongway and Hindley, 2004). The EFA methodology is described in detail in *Assessing Rehabilitation Success Version 1.1* (Tongway, 2001), *Landscape Function Analysis: Procedures for Monitoring and Assessing Landscapes with Special Reference to Minesites and Rangelands Version 3.1* (Tongway and Hindley, 2004), *and Landscape Function Analysis Field Procedures* (Tongway, 2008).
In accordance with the LFA methodology, the LFA monitoring results will be used to assess whether rehabilitation areas are on a trajectory towards a self-sustaining landscape. Relevant LFA performance indicators and completion criteria are detailed in Section 7.1.1.

ii Soil analyses

Soil samples are taken using a core sampler within a monitoring quadrat at each rehabilitation monitoring site. At least 12 cores are taken at each site and soil samples sent to a National Association of Testing Authorities (NATA) accredited laboratory for analysis.

Soil samples are analysed for the following parameters: pH, electrical conductivity, available calcium, magnesium, potassium, ammonia, sulphur, organic matter, exchangeable sodium, calcium, magnesium, potassium, hydrogen, aluminium, cation exchange capacity, available and extractable phosphorus, micronutrients (zinc, manganese, iron, copper, boron) and total carbon and nitrogen. Exchangeable sodium percentages are also calculated as a measure of sodicity or dispersion.

iii Ecological assessment

In addition to LFA, various biodiversity components are assessed to monitor the successional phases/changes of plant development and to identify the requirements for ameliorative measures and guide adaptive management. The rapid ecological assessment provides quantitative data that measures changes in:

- floristic diversity including species area curves and growth forms (using full floristic sampling)
- ground cover diversity and abundance
- vegetation structure and habitat characteristics (including ground cover, cryptogams, logs, rocks, litter, projected foliage cover at various height increments)
- understorey density and growth (including established shrubs, direct seeding and tubestock plantings and tree regeneration)
- overstorey characteristics including tree density, health and survival
- other habitat attributes such as the presence of hollows, mistletoe and the production of buds, flowers and fruit.

Permanent transects and photo-points have been established to record changes in these attributes over time. These ecological assessment components will be described in detail in the annual rehabilitation monitoring report.
The monitoring methodology described above may be revised (in consultation with relevant regulatory authorities) should an alternative method be required to adequately assess rehabilitation performance.

iv Monitoring quadrats

The monitoring methodology components described above are undertaken within 20 m x 50 m monitoring quadrats established at each rehabilitation monitoring site and reference site. An LFA transect is established along the 20 m downslope boundary of the quadrat. Vegetation monitoring is undertaken within 1 m x 1 m sub-quadrats at 5 m intervals along the 50 m transect which runs perpendicular to the LFA transect.

The transect and quadrat boundary points are marked with pegs (and flagging tape) and global positioning system details recorded at each peg to ensure the location of the quadrat and transects is consistent over time.

Permanent photo-points have been established at the monitoring quadrats to monitor the changes that occur over time. The methodology for photographic monitoring is consistent with the NSW National Parks and Wildlife Service (2003) *Conservation Management Note 9 – Photographic Monitoring*. Photos are taken annually during spring and during a similar time of day (for consistence of light conditions).

After each photographic monitoring event, the photographs are compared to the photographs from the previous monitoring periods. The following elements will be noted:

- plant establishment
- the status of weeds
- natural regeneration of species
- presence of habitat features (e.g. logs, litter, rocks).

A review of aerial photography may also be used to show enhancement of vegetation connectivity.

v Analogue sites

In 2011 DnA Environmental identified four broad vegetation community types as representative of the CGO final landforms:

- lake – woodlands occurring within the lake and lake foreshores (relevant to the LPB])
- slopes – woodlands occurring on flat to gently undulating slopes (relevant to lower slopes of the WREs)
- hills – woodlands occurring on low ridges, hills and elevated land (relevant to upper slopes and top surfaces of the WREs)
- grasslands – cleared native grasslands, predominantly occurring on flat to gently undulating slopes (relevant to infrastructure areas and slopes of the IWL [during operations]).

Analogue sites relevant to each of the four broad vegetation communities listed above were established in the landscape surrounding the CGO in 2010 and include the following:

- RLake 01 and RLake 02 – woodlands occurring within the lake and lake foreshores
- RSlope 01 and RSlope 02 – woodlands occurring on flat to gently undulating slopes
- RHill 02, RHill 03 and RHill 06 – woodlands occurring on low ridges, hills and elevated land
- RGrass 01 and RGrass 03 – cleared native grasslands, predominantly occurring on flat to gently undulating slopes.

These are shown in Figure 7.1.

7.2.2 Rehabilitation trials and research

Rehabilitation will continue to be an iterative process, whereby the results of the revegetation trials and monitoring will be used to provide feedback into the most appropriate species, revegetation and propagation methods, and substrate suitability for the rehabilitation of the CGO components.

Many of the rehabilitation practices currently used on site are a function of previous research and rehabilitation trials: Key examples include:

- The use of topsoil and rock matrices to provide erosion protection, reduce runoff and maximise native plant establishment; and
- The use of native pasture hay for erosion protection and moisture retention.

Ongoing rehabilitation trials and research will be an extension of the trials undertaken to date and will include:

- Material Amelioration – Continued investigation into the chemical and physical properties of soil resources and the optimum rates of gypsum application to improve suitability for plant growth and use on rehabilitation areas.
- Rehabilitation Media – Continued monitoring of the effectiveness of various applications associated with the rock mulch, topsoil and hay cover materials stabilising landform slopes (ie controlling erosion) and providing a suitable medium for revegetation.
- Revegetation – Ongoing trials and research to determine the most appropriate revegetation species suited to substrate materials of the CGO's final landforms including:

- Implementation of new vegetation growth trials to investigate revegetation species suited to the top surface rehabilitation materials of CGO final landforms, including the TIWL and WREs, to refine revegetation objectives
- Investigations and implementation of a trial to determine the most effective methods for direct seeding rehabilitation areas following the establishment of the initial Wimmera Ryegrass cover crop
- Implementation of research and a revegetation trial to investigate revegetation methods and species suited to the final slopes and rehabilitation media of the IWL embankments.

• Soil/rock matrix application and mixing – trialling the soil/rock matrix application and mixing techniques detailed in section 3.4.2 to determine which methods provides the greatest level of erosion protection and vegetation establishment

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Attachment A

Agency requirements

A.1 Department of Regional NSW, Mining, Exploration and Geoscience (MEG) and Department of Regional NSW, Resources Regulator (RR) Agency Requirements

Table A.1 MEG assessment requirements for SSD-42917792

Requirement	Section addressed
8. Rehabilitation and final landform The proponent must supply an analysis of the proposed rehabilitation and final landform including: rehabilitation methodology, objectives and outcomes, including life-of-mine tailings management strategy conceptual final landform design (including any voids) accounting for mine design, engineering feasibility, economic feasibility and balance of environmental and social outcomes post-mining land use and barriers or limitations to effective rehabilitation.	Sections 4.1, 5.1.2, 5.1.2ii and 2.4 Sections 3, 4 and 6

Table A.2 Resources Regulator assessment requirements SSD-42917792

Requirement	Section addressed
Post-mining land use Identification and assessment of post-mining land use options;	Section 4.2
Identification and justification of the preferred post-mining land use outcome(s), including a discussion of how the final land use(s) are aligned with relevant local and regional strategic land use objectives;	Sections 2.2, 4.1 and 4.2
Identification of how the rehabilitation of the project will relate to the rehabilitation strategies of neighbouring mines within the region, with a particular emphasis on the coordination of rehabilitation activities along common boundary areas;	Not applicable as there are no neighbouring mines.
Rehabilitation objectives and domains Inclusion of a set of project rehabilitation objectives and completion criteria that clearly define the outcomes required to achieve the post-mining land use for each domain. Completion criteria should be specific, measurable, achievable, realistic and time-bound. If necessary, objective criteria may be presented as ranges;	Sections 6 and 7
Rehabilitation methodology Details regarding the rehabilitation methods for disturbed areas and expected time frames for each stage of the rehabilitation process.	Sections 5.1.2 and 5.2
Mine layout and scheduling, including maximising opportunities for progressive final rehabilitation. The final rehabilitation schedule should be mapped against key production milestone (i.e. ROM tonnes) of the mine layout sequence before being translated to indicative timeframes through the mine life. The mine plan should maximise opportunities for progressive rehabilitation;	Section 5.2

Table A.2 Resources Regulator assessment requirements SSD-42917792

Requirement	Section addressed
Conceptual final landform design Inclusion of a drawing at an appropriate scale identifying key attributes of the final landform, including final landform contours and the location of the proposed final land use(s)	Figure 4.1, Figure 4.2, Figure 4.3,
Monitoring and research Outlining the monitoring programs that will be implemented to assess how rehabilitation is trending towards the nominated land use objectives and completion criteria	Section 7
Details of the process for triggering intervention and adaptive management measures to address potential adverse results as well as continuously improve rehabilitation practices;	RMP Table 12
Outlining any proposed rehabilitation research programs and trials, including their objectives. This should include details of how the outcomes of research are considered as part of the ongoing review and improvement of rehabilitation practices;	Section 7.2.2
Post-closure maintenance Description of how post-rehabilitation areas will be actively managed and maintained in accordance with the intended land use(s) in order to demonstrate progress toward meeting the rehabilitation objectives and completion criteria in a timely manner;	Section 6.6
Barriers or limitations to effective rehabilitation	
Identification and description of those aspects of the site or operations that may present barriers or limitations to effective rehabilitation, including:	
evaluation of the likely effectiveness of the proposed rehabilitation techniques against the rehabilitation objectives and completion criteria	Section 2.4
an assessment and life of mine management strategy of the potential for geochemical constraints to rehabilitation (e.g. acid rock drainage, spontaneous combustion etc.), particularly associated with the management of overburden/interburden and reject material;	Section 3.1 Note given that this is not a coal mining proposal, spontaneous combustion is not a risk for this project.
the process that will be implemented throughout the mine life to identify and appropriately manage geochemical risks that may affect the ability to achieve sustainable rehabilitation outcomes;	Section 3.1
a life of mines tailings management strategy, which details measures to be implemented to avoid the exposure of tailings materials that may cause environmental risk, as well as promote geotechnical stability of the rehabilitated landform; and	Sections 5.1.2ii
existing and surrounding landforms (showing contours and slopes) and how similar characteristics can be incorporated into the post-mining final landform design. This should include an evaluation of how key geomorphological characteristics evident in stable landforms with the natural landscape can be adapted to the materials and other constraints associated with the site.	Sections 4.3 and 3.4.2, Figure 4.1

Table A.2 Resources Regulator assessment requirements SSD-42917792

Requirement	Section addressed
Where a void is proposed to remain as part of the final landform include:	
A constraints and opportunities analysis of final void options, including backfilling, to justify that the proposed design is the most feasible and environmentally sustainable option to minimise the sterilisation of land post-mining;	Section 4.2
A preliminary geotechnical assessment to identify the likely long term stability risks associated with the proposed remaining high wall(s) and low wall(s) along with associated measures that will be required to minimise potential risks to public safety; and	Section 4.3
outcomes of the surface and groundwater assessments in relation to the likely final water level in the void. This should include an assessment of the potential for fill and spill along with measures required to be implemented to minimise associated impacts to the environment and downstream water users.	Section 4.3.3
Where the mine includes underground workings:	
Determine (with reference to the groundwater assessment) the likelihood and associated impacts of groundwater accumulating and subsequently discharging (e.g. acid or neutral mine drainage) from underground workings post cessation of mining; and	Section 2.3.1
Consideration of the likely controls required to either prevent or mitigate against these risks as part of the closure plan for the site.	Section 2.3.1
Consideration of the controls likely to be required to either prevent or mitigate against rehabilitation risks as part of the closure plan for the site;	Section 2.4
Where an ecological land use is proposed, demonstrate how the revegetation strategy (e.g. seed mix, habitat features, corridor width etc) has been developed in consideration of the target vegetation community(s);	Section 6.3
Where the intended use is agriculture, demonstrate that the landscape, vegetation and soil will be returned to a condition capable of supporting this; and	N/A
Consider any relevant government policies	Section 2.2

Attachment B

Erodibility Evaluation and Landform Evolution Modelling Program

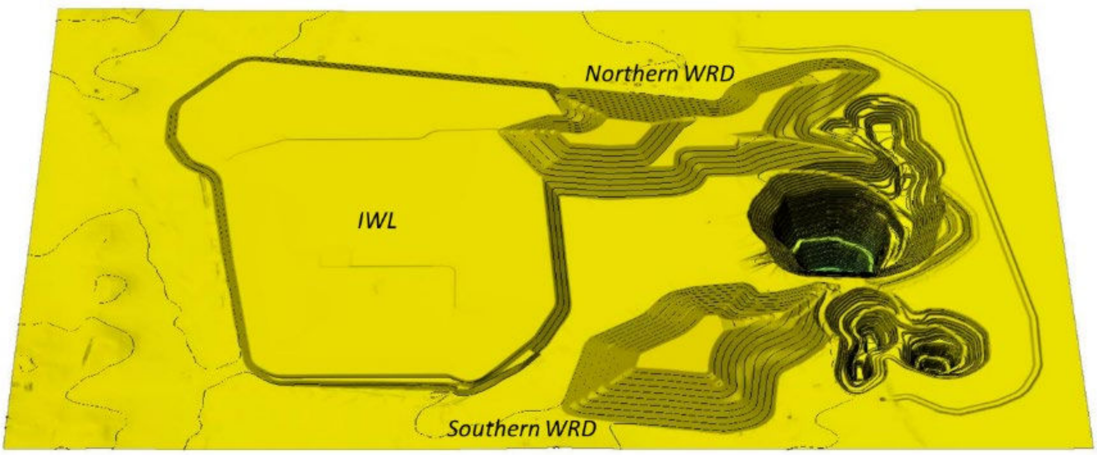
EMM
creating opportunities

COWAL GOLD OPERATIONS
OPEN PIT CONTINUATION PROJECT (OPC)

Erodibility Evaluation and Landform Evolution Modelling Program

Northern Waste Rock Dump (WRD) extension
Southern WRD extension
Final Integrated Waste Landform (IWL)

April 2023



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Project Number: 3407.21a

Report Title: Cowal Gold Operations Open Pit Continuation Project (OPC) – Erodibility Evaluation and Landform Evolution Modelling Program.

Client: EMM Consulting Pty Ltd

Review History

Version	Prepared by	Reviewed by	Date
Draft A	Simon Buchanan Scott Wooldridge	Deborah Heggs	25/10/2022
Draft B	Simon Buchanan	Isaac Kelder	27/10/2022
Draft C	**Simon Buchanan**	**EMM / CGO**	**1/11/2022**
Final	**Scott Wooldridge**	**Simon Buchanan**	**11/04/2023**

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1 INTRODUCTION

The proposed Open Pit Continuation Project (the OPC Project) at Cowal Gold Operations (CGO; the Mine) includes expansion of its three existing waste enclosure landforms, namely the (i) Northern Waste Rock Dump (WRD), (ii) Southern WRD, and (iii) Integrated Waste Landform (IWL). The Northern and Southern WRDs are both proposed to increase in height and footprint to accommodate additional waste rock spoil. The IWL will be expanded to the north to accommodate additional tailings storage.

EMM Consulting Pty Ltd (EMM) on behalf of Evolution (Cowal) has engaged Landloch to provide targeted technical support for the OPC Project to evaluate the long-term erosional stability of the three expanded landforms.

The erodibility of soil capping material on the constructed landforms at CGO is a fundamental determinant for predicting their long-term erosional performance. In recent years, a soil-rock matrix cover system has been adopted as the primary capping and growth media (Appendix A). Trials on site have demonstrated that the use of a soil-rock cover improves resistance to rill and gully initiation (Gilbert and Associates, 2009).

To evaluate the long-term erosional stability of the three landforms, Landloch have undertaken erodibility testing of the soil-rock matrix used for rehabilitation. The landforms are to be revegetated with endemic vegetation that is consistent with the surrounding landscape, which is expected to provide additional protection from erosive processes. Modelling was conducted to identify the minimum vegetation cover levels required for the given batter geometries to achieve erosional stability. Landform evolution modelling was conducted for the 3-D rehabilitation designs to evaluate the impact of changing landform shape on long-term erosion, and to identify where additional refinement of the rehabilitation designs may be required.

1.1 Project Description

Evolution Mining (Cowal) Pty Limited (Evolution) is the owner and operator of CGO, located approximately 38 kilometres north-east of West Wyalong, NSW. The existing CGO mine is located immediately adjacent to the ephemeral waterbody known as Lake Cowal. When full, Lake Cowal is recognised as the largest inland lake in NSW.

CGO is an open pit and underground gold mining operation. The open pit mining operations commenced in 2005. Underground mining operations were approved on 30 September 2021 and are projected to commence in 2023.

Operations at CGO are regulated by two Ministerial development consents, for 'surface' operations (i.e., open pit mining and associated infrastructure) and 'underground' operations. Development Consent DA 14/98 covers 'surface' operations, and Development Consent SSD 10367 covers 'underground' operations.

Evolution seeks to continue open pit mining operations at CGO by way of the OPC Project. This will involve further development of the existing E42 Pit and the development of three new open pits adjacent to E42. It is anticipated that this development will allow continued mining operations until the end of 2042.

CGO currently has two mining leases (ML), ML1535 and ML 1791, covering approximately 29 km^2. The general arrangement of the Mine (Figure B1) including the primary (operational) and secondary (post-mining land use) domains (Figure B2) are provided in Appendix B. The proposed expansion footprint of the Northern and Southern WRDs are wholly contained within ML 1535, whilst the northern expansion of the IWL will straddle both ML 1535 and ML 1791.

1.2 Scope of Work

The scope of work is as follows:

i. Determine the erodibility characteristics of the proposed soil-rock matrix using simulated rain, overland flows and settling columns.
ii. Derive erodibility parameters for input into the WEPP runoff/erosion model.
iii. Undertake long-term erosion modelling on representative slopes and slope conditions for the materials and use outcomes to determine erosionally stable batter geometries.
iv. Calibrate the SIBERIA model and conduct landform evolution modelling on the 3-D rehabilitation designs.

2 SITE SETTING

2.1 Climate

The Mine is situated in a warm semi-arid climate zone. Summer temperatures range between an average minimum of 15 °C and an average maximum of 33 °C (Table 1). In the winter months, temperatures range between an average minimum of 3 °C with a maximum of 16 °C (Bureau of Meteorology, 2022).

Table 1: Summary of mean temperature statistics (1895 – 2020) at Lake Cowal, Station 073054 (Bureau of Meteorology).

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max. °C	32.9	31.9	28.7	23.7	18.7	14.9	14.1	16.0	19.6	23.5	27.3	30.7
Min. °C	17.6	17.5	14.5	10.0	6.8	4.2	3.0	3.9	6.2	9.4	12.6	15.4

Annual rainfall at Lake Cowal is low, typically less than 450 mm. Rain falls throughout the year, with small seasonal variations in monthly rainfall (Figure 1).

Rainfall erosivity is a measure of the ability of rainfall to cause erosion. The annual rainfall erosivity factor (R-factor) is based on the two most important rainstorm characteristics that determine erosivity: rainfall depth and a measure of peak intensity. These variables characterise the influence of climate on the average rate of soil loss. Annual R-factor values vary between 600 MJ.mm/ha/h/y in the driest parts of western NSW to over 10,000 MJ.mm/ha/h/y on the far north coast of NSW.

The annual rainfall erosivity factor (R-factor) calculated for the site is 687 MJ.mm/ha.h.y with rainfall erosivity ratings ranging from *low-moderate* in the warmer summer months to *very low* in the cooler winter and spring months.

In summary, the rainfall characteristics of the area indicate a low likelihood (i.e., low encounter rate) of the intense rainfall-runoff events that frequently occur on the eastern coastline of Australia.

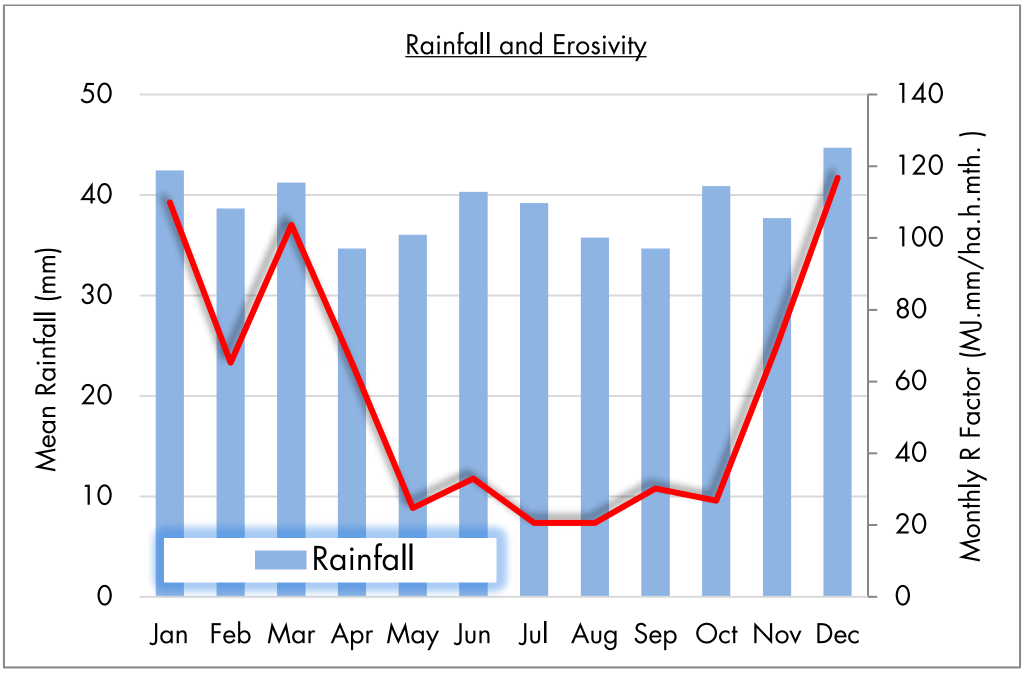


Figure 1: Monthly rainfall and erosivity (R-factor) for CGO Mine.

2.2 Topography

The topographic relief (m) and associated slope gradient (%) across the CGO mine site resulting from the proposed OPC project is displayed in Figures 2 and 3 respectively. The uniform linear batter slope gradient (max.) for the Northern WRD (20%), Southern WRD (20%) and IWL (25%) are a dominant feature.

Two exceptions are noteworthy (Figure 3):

i. the legacy berm-batter features on the lower north-facing slopes of the Southern WRD, arising from the existing Southern WRD landform footprint, and
ii. a legacy bench feature on the southern batters of the IWL arising from the existing Southern TSF.

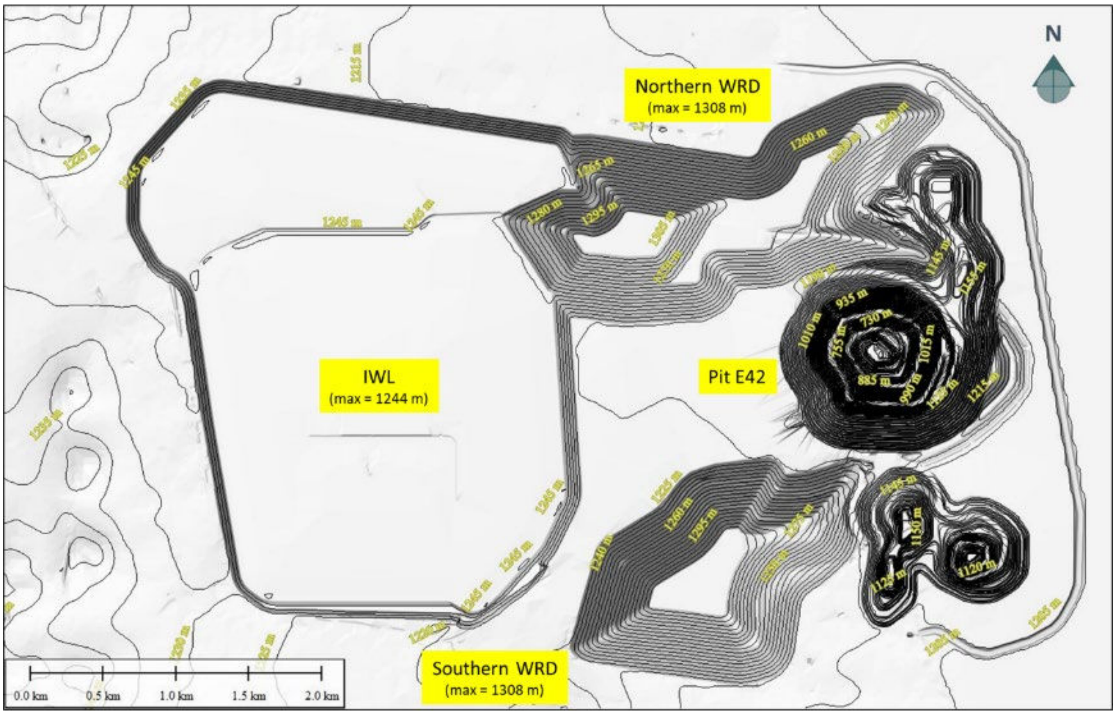


Figure 2: Topographic relief (m) across the proposed CGO Mine expansion.

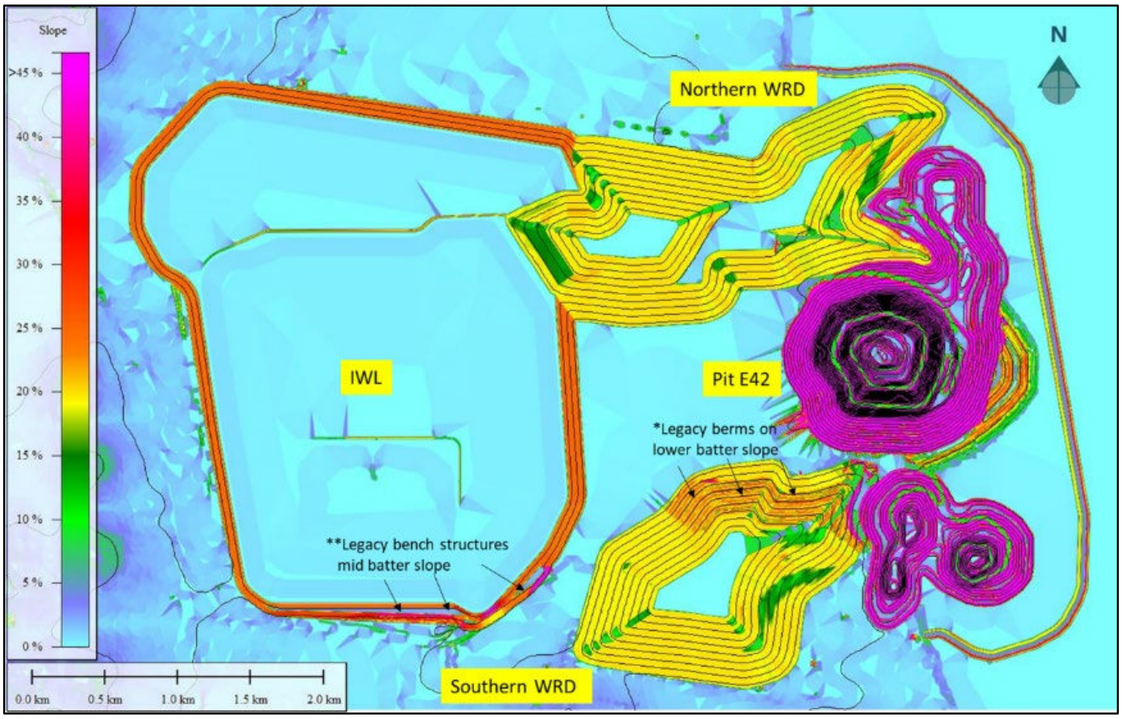


Figure 3: Landform slope gradients (%) for the proposed CGO Mine expansion.

2.3 Waste Materials

2.3.1 Waste Rock (Spoil)

The Cowal gold mineralisation is hosted within a sequence of Ordovician volcaniclastic rocks (informally named the Lake Cowal Volcanic Complex). The 'Primary' waste rock is defined as the fresh (unweathered) mined volcanic waste rock from the pit and underground operation. The Primary waste rock is overlain by an 'Oxide' waste rock that is defined as the weathered rock and hard oxidised volcanic/saprolitic material mined from the pit.

Geochemical assessments of the waste rock (e.g., GeoEnvironmental Management (GEM), 2008; 2009; 2016) has found that:

- Oxide waste rock is typically saline and sodic. Due to the low reactive sulphide content and low acid neutralising capacity (ANC), this material is expected to be non-acid forming (NAF); and
- Primary waste rock is typically non-saline, non-sodic to slightly sodic and NAF. Data on the durability and weathering rates of primary waste rock has not been reviewed or evaluated in this scope of works.

The oxide waste rock spoil is highly erosion prone. It will be encapsulated into the WRDs and IWL, and be capped with a growth media that supports vegetation.

2.3.2 Tailings

Previous investigations have identified an elevated risk of tailings from the open-pit operations being saline and developing saline conditions within the Tailings Storage Facility ((TSF) GEM, 2009). CGO's TSF rehabilitation design includes a cover to avoid development of a salt pan layer.

It is understood the function of the TSF is intended to change to an IWL that contains both tailings and waste rock. Geochemical data on the IWL wastes has not been reviewed in this program but considering it will contain both tailings and waste rock, it is expected salinity and sodicity hazards will remain. As such, it is assumed that a cover will still be required as the underlying materials are potential hostile.

2.4 Stockpiled Soil and Growth Media Resources

Past stripping and stockpiling of both topsoil and subsoil resources at CGO has been actively managed to ensure a sufficient volume of suitable material is retained for cover and rehabilitation purposes (e.g., WRD's and IWL).

2.4.1 Topsoil

Most stockpiled topsoil resources at CGO reflect the red duplex soils dominating the ML area. The soils include sandy clay loam, clay loam, and medium heavy clay textures that are prone to hard-setting (McKenzie Soil Management, 2013). These soils are dispersive (where non-saline), have variable pH, are occasionally phosphorus deficient, range from non-saline to strongly saline, and are sodic (McKenzie Soil Management, 2013).

2.4.2 Subsoil

The stockpiled subsoil resources have a light medium clay texture and are extremely hard when dry (McKenzie Soil Management, 2013). Materials are dispersive, strongly saline, strongly sodic, phosphorus deficient, and have variable pH ranging from neutral to strongly alkaline (McKenzie Soil Management, 2013).

2.5 Soil-Rock Matrix

Existing trials at the site indicate that the severity of erosion on batters is reduced when vegetation is established in a soil-rock matrix cover layer, compared to cover layers consisting of solely topsoil or subsoil materials.

Erosion prone spoil material is overlain by a soil-rock matrix cover layer to provide a surface that is less prone to erosion. This is generally followed by a layer of growth media to support vegetation. The soil-rock matrix is manufactured by blending primary waste rock with recovered topsoil materials (Photographs 1 and 2).

Typically, the soil-rock matrix cover system comprises a mixture of the following materials and quantities:

- 300 mm deep rock mulch underlay of benign (primary) competent rock (approximately <300 mm in size);
- 300 mm deep overlay of low salinity and gypsum-treated topsoil; and
- Gypsum applied at approximately 10 t/ha gypsum;

Further detail of how the soil-rock matrix layer is created is provided in Appendix A.

Photograph 1: Topsoil (brown material top left) has been placed above the (grey) rock mulch underlay in preparation for spreading (Photo courtesy of Donna Johnston, DnA Environmental).

Photograph 2: CGO soil-rock matrix cover system with mounding formed by cross ripping (Photo courtesy of Donna Johnston, DnA Environmental).

2.6 Post-Mining Land Uses

The dominant land use type prior to the commencement of mining was livestock grazing on native and improved pastures, on cleared and semi-cleared farmland. As detailed in CGO's Rehabilitation Management Plan (Evolution 2022), it is planned that upon relinquishment of the Mine's leases the rehabilitated land will be in transition towards the establishment and/or maintenance of sustainable endemic woodland, shrub and grassland communities similar to that remnant in the regional landscape. .

The rehabilitated final waste landforms, mining voids and other mine disturbance areas are designated to be enclosed with stock exclusion fencing, with the aim of protecting revegetation and natural regeneration, and to maintain the long-term stability of the engineered landforms.

The primary revegetation objective for the final landforms is the establishment of endemic eucalypt woodland, shrub and grassland communities suitable for the slope and elevation. For the lower slopes this includes communities dominated by *Eucalyptus populnea, E. macrocarpa*, *Callitris glaucophylla* and *Alectryon oleifolius*. On the steeper slopes and elevated lands, it includes *E. dwyeri, Acacia doratoxylon, C. endlicheri and E. sideroxylon*.

Agricultural production consistent with pre-mining activities in the form of managed grazing by livestock, will be the dominant land use for the remaining portions of the Lease.

3 EROSION MODELS

Two erosion models were selected to deliver the rehabilitated landform design for CGO, the Water Erosion Prediction Project (WEPP) runoff/erosion model (Flanagan and Livingston 1995) and the SIBERIA landform evolution model (Willgoose *et al.,* 1989). The two models have extremely different structures and functions and are used for different purposes.

3.1 Water Erosion Prediction Project

The Water Erosion Prediction Project (WEPP) runoff/erosion model (Flanagan & Livingston, 1995) was used to evaluate the landform designs. The WEPP model effectively considers runoff and erosion on 2-D batter slopes. It was developed by the United States Department of Agriculture (USDA) to predict runoff, erosion, and deposition for hillslopes and watersheds. It is a simulation model with a daily input time step, and internal calculations use sub-daily rainfall data (storm data) when predicting runoff and erosion for days on which rainfall occurs.

As a primary planning tool, WEPP has several advantages, including the ability to:

- Derive accurate erodibility parameters from laboratory erosion studies;
- Consider site-specific climate (typically using a 100-year synthetic file based on local data);
- Rapidly assess a wide range of slope gradients, profile shapes, slope lengths, materials (soils), and surface vegetation cover;
- Provide erosion and runoff predictions at a range of time scales, from long term averages, daily data, or averages for specified periods or seasons; and
- Provide predictions of erosion rates at 100 points along a slope length, rather than simply averaging erosion over the entire slope length.

3.2 SIBERIA

The SIBERIA landform evolution model is a 3-D topographic model that predicts the long-term development of channels and hillslopes in a catchment based on runoff, erosion, and deposition. The location and speed with which rills and gullies develop is controlled by a channelisation function. SIBERIA does not input actual rainfall or material erodibility parameters. Rather, the input parameters that define this channelisation function is related to both runoff and soil erodibility (Willgoose *et al.,* 1989) and must be derived for each test material at each project site. SIBERIA solves for two variables:

1. Elevation, from which slope geometries are determined; and
2. An indicator function that determines where channels exist.

Channel growth is governed by a 'stream power' activation threshold that is dependent on discharge and slope gradient. When the activation threshold is exceeded, a channel is predicted to develop. In this way, it is possible for a modelled surface to initially have no gullies, and for channels to develop when the activation threshold is exceeded over time.

The model is equally applicable to any climatic regime as its input parameters are derived by calibration to runoff and erosion data. Input parameters can be derived from output of the WEPP model using methods developed by Landloch in consultation with the developers of SIBERIA.

SIBERIA has been successfully applied to explain aspects of geomorphology of natural landforms (Willgoose, 1994) and has been extensively used in the context of mining and subjected to extensive validation. In general, the validation work indicates that provided the model is adequately calibrated, SIBERIA predictions of landform development appear to be reasonable (Hancock *et al.,* 2000; Hancock *et al.,* 2002; Hancock *et al.,* 2003). In addition, Hancock (2004) notes that rates of erosion predicted by SIBERIA for a catchment in the Northern Territory compared favourably with estimates of erosion derived using the Caesium-137 method. As the two methods used completely independent input information, the agreement is particularly significant.

The SIBERIA model has been widely used for assessment of the development of constructed landforms on a range of mine sites across Australia and overseas (Willgoose, 1995; Willgoose & Riley, 1993; Boggs *et al.,* 2000; Hancock *et al.,* 2003; Hancock & Willgoose 2004; Hancock 2004; Mengler *et al.,* 2004; Hancock & Turley, 2006).

4 TOLERABLE SOIL LOSS CRITERIA

The concept of 'tolerable soil loss' is based on work by the US Department of Agriculture (Wischmeier & Smith, 1978) and relates to the "maximum average annual soil loss that will permit current productivity to be sustained indefinitely". This study used runoff and erosion modelling to identify landform options that would erode at rates low enough to provide long-term stability. Essentially, the landforms are planned to be consistent with tolerable soil loss rates.

A soil loss target of 11.2 t/ha/y, averaged over an area of interest, is often cited as a tolerable soil loss rate. However, that value was derived by soil conservation agencies in the United States of America (USA) for deep, fertile cultivated soils, and has little relevance to most rehabilitated mine sites. Using similar criteria to those applied for cropping land, a lower soil loss tolerance value of 4.5 t/ha/y was developed by USA agencies for erosion of rangeland soils and shallow cultivated soils (Wright & Siddoway, 1982).

Low tolerance values are relevant to rangeland and mine site situations, as not only are the soils shallower and more susceptible to fertility decline, but the lack of regular tillage or disturbance means that any rills or points of scour that form are more likely to extend and develop into gullies over time if not stabilised. These are typically of concern for mine site landforms where there is no bedrock layer at depth that can limit long-term deepening of rill features.

A key priority is setting a tolerable erosion criterion that prevents the development of highly eroded slopes and landforms. For disturbed lands and engineered landform batters with suitable climate conditions and growth media qualities, to support well vegetated slopes that passively stabilise rills, Landloch commonly applies a 'tolerable soil loss rate' screening level criteria of:

- (100-yr) mean average erosion rate for the whole slope of 5 t/ha/y; and
- (100-yr) mean maximum rate at any one point on the slope of 10 t/ha/y.

However, for slopes considered to have an elevated erosion hazard, the 'tolerable soil loss rate' criterion is reduced to levels that further deter rill/gully development, i.e., to a mean maximum rate of 5 t/ha/y at any one point on the slope

Examples of factors considered when determining whether slopes have a high erosion hazard include, but are not limited to:

- The material underlying the surface is limiting for plant growth (e.g., acidic, saline, dispersive) and likely to be more erodible than the surface layer if exposed;
- Establishment of vigorous and sustainable vegetation is considered challenging or unachievable;
- Climate conditions and soil fertility/productivity are such that it is unlikely vegetation will stabilise rills that form;
- The overall landform height exceeds 50 m; and
- There is potential for eroded sediment to impact on sensitive receptors.

For this assessment, the batters of waste landforms are considered to have an elevated erosion hazard due to the underlying materials being dispersive and saline,, and relief of WRDs commonly exceed 50 m. The 'tolerable soil loss rate' screening level criteria applied to this assessment are:

- (100-yr) mean erosion rate of 5 t/ha/y for the whole slope; and at any one point along the slope.

5 EVALUATION OF SLOPES - WEPP EROSION SIMULATIONS

5.1 Erodibility testing

Landloch received two soil-rock mixes for testing. These were sampled from the surface of a rehabilitated batter slope at two layers: Soil-Rock Matrix Upper Layer (Photograph 1), and Soil-Rock Matrix Lower Layer (Photograph 2).

Laboratory data on the soil-rock matrix materials received for testing is provided in Appendix C, with key features detailed below:

5.1.1 Soil-Rock Matrix Upper Layer

This material was collected from the upper portion of the soil-rock matrix at a depth of 0–0.15 m. General characteristics include:

- Hard-setting red duplex soil, fine sandy clay loam to medium heavy clay loam with coarse fragment content approximately 5–25 %;
- Mildly alkaline ($pH_{1:5}$ ~7.9);
- Salt levels are moderate (EC <0.4 dS/m) with moderate levels of chloride-based salts (chloride <450 mg/kg); and
- Dispersive and sodic

5.1.2 Soil-Rock Matrix Lower Layer

This material was collected from the lower portion of the soil-rock matrix at a depth of 0.15–0.3 m. General characteristics were similar to the Upper Layer; except:

- Higher coarse fragment content of 30–50%;

- More strongly alkaline ($pH_{1:5}$ ~8.3);
- More elevated salt levels (EC >1.3–1.5 dS/m; and chloride > 1500 mg/kg); and
- Sodic but non-dispersive, reflective of their high salinity.

Due to the way the soil-rock matrix is created (Appendix A) the differences between the Upper and Lower layers are likely due to cross ripping that results in spoil materials being mixed in with the soil-rock matrix. The proportion of spoil to soil-rock matrix will be greater in the Lower layer and results in the increased alkalinity and salinity levels.

Photograph 1: Bulk sample of Soil-Rock Matrix Upper Layer.

Photograph 2: Bulk sample of Soil-Rock Matrix Lower Layer.

5.2 Derivation of WEPP Soil Input Parameters

Measurements were made using simulated rain and overland flows to enable derivation of erodibility parameters for the WEPP runoff/erosion model.

Rainfall simulation and overland flow tests were performed on all materials to derive erodibility parameters for use as site-specific input data for erosion modelling. These parameters are used to predict changes in erosion processes and rates in response to changes in runoff, slope length, and land management. The key parameters of materials considered in erosion modelling are described below:

- *Critical shear* - a threshold value above which there is a rapid increase in soil detachment per unit increase in flow shear stress.
- *Interrill erodibility* - a measure of sediment delivery rate to rills by the combination of raindrop impacts and shallow overland flow.
- *Rill erodibility* - a measure of soil susceptibility to detachment by concentrated flow. It is the increase in soil detachment per unit increase in effective shear stress of the flow.
- *Effective hydraulic conductivity* – directly influences runoff rate. Runoff occurs once the rainfall intensity exceeds infiltration rate.
- *Surface roughness* – relates to the micro-relief of the ground surface and any surface detention of rainfall excess by long-lasting relief (e.g., crests and trough) formed by tillage or ripping.
- *Rill spacing* – The area between vegetative surface cover canopies is defined as the potential rill area. The WEPP model is sensitive to cross-slope rill spacing, as

more widely spaced rills give greater concentration of flow and increase the potential for the estimated concentrated flow velocity to exceed the critical shear stress of the soil. The lower and upper boundary constraints on cross-slope rill spacing are 0.5 m for well vegetated slopes and 5 m for slopes with a little to no vegetative cover.

- *Soil analytical data* on particle size analysis, settling velocity distribution, and cation exchange capacity.

5.2.1 Rainfall Simulation

Landloch's in-house rainfall simulator applies simulated rain with a kinetic energy equivalent to that of natural rainfall at intensities >40 mm/h (Loch, *et al.*, 2001). As the simulated rain is used to derive infiltration and interrill erosion parameters, the actual intensity applied does not affect the parameters obtained, provided it is sufficient to cause runoff, and has appropriate kinetic energy.

Triplicate plots 0.75 m square and 0.2 m deep were packed, compacted, and subjected to multiple wetting/drying cycles so the sample to be tested was consistent with soil that had consolidated naturally under rainfall.

The plots were set at 20% gradient and simulated rain was applied for a period sufficient for the samples to reach steady infiltration/runoff rates. Runoff generated by simulated rain was sampled at regular intervals, and sediment concentrations were measured gravimetrically. At the conclusion of the application of simulated rain, samples of the rain-wet surface were taken for measurement of sediment settling velocity distributions using an automated settling column (Loch, 2001).

Rainwater was used in all measurements to avoid any potential impacts of water quality on infiltration and on the disaggregation of sediment to finer sizes.

Photographs of example rainfall simulation test plots are provided in Appendix D.

5.2.2 Overland Flows

Studies of rill erodibility used flumes 2 m long and 0.4 m wide. For all materials, three flumes were run, set at various gradients to ensure a wide range of hydraulic shear stress (i.e., flow tractive force) was applied. In all cases, samples were packed, compacted, and subjected to multiple wetting/drying cycles so the sample tested was consistent with soil that had consolidated naturally under rainfall. For each flume, a range of flow tractive forces were also applied, and sediment concentration measurements were made at these different tractive forces. Photographs of sample test flumes are provided in Appendix D.

5.2.3 WEPP Soil Parameters

The materials used for testing comprised the two soil-rock matrix materials (Upper Layer and Lower Layer) that were mixed in equal proportions to produce one material for use in testing. The key parameters of materials considered in erosion modelling are provided in Table 2.

Table 2: Key input parameters of materials considered in erosion modelling, based on laboratory data for the bulk samples of materials used in erodibility testing.

Parameter	Unit	Soil-Rock Mix Details
Texture	-	Clay loam/Rock
Rock percentage	%	29.5
Hydraulic conductivity 50% Cover 70% Cover 90% Cover	mm/hr	 20 31 42
Critical shear stress	Pa	5.7
Interrill erodibility	Kg.s/m^4	0.57 x10^6
Rill erodibility	s/m	2.9 x 10^{-3}
Surface roughness	cm	5

5.3 WEPP Climate Parameters

All simulations used a 100-year climate file based on data from nearby weather stations. Data from three stations were used to prepare the climate file in erosion modelling for this project and summary details of the stations are provided in Table 3.

Table 3: Summary details of weather station data used to prepare the climate file for erosion modelling.

Station Name	Station ID	Locality to site	Commencing	Effective years	Data
Lake Cowal	50022	7.3 km S	Jan 1900	64.7	Daily
Burcher Post Office	50010	17.9 km NW	Jul 1937	67.7	Daily
Condobolin Soil Conservation	50102	65.1 km N	Jul 1957	17.5	Sub-daily

A 100-year climate sequence was generated from these daily and sub-daily statistics using CLIGEN version 5.1 (Yu 2002). The resultant climate sequence has sub-daily rainfall properties consistent with Lake Cowal and Burcher Post Office and daily, monthly, and annual climate statistics.

The average annual rainfall for Lake Cowal and Burcher Post Office is 458.9 mm and 458.6 mm respectively. This compares well with the CLIGEN sequence which has a similar average annual rainfall or 458.5 mm. Average monthly rainfall for Lake Cowal, Burcher Post Office and CLIGEN are shown in Figure 4. The data show good agreement between the observed and CLIGEN monthly rainfall values. The magnitudes of the observed and CLIGEN daily events are compared against the Annual Exceedance Probability (AEP) for that event, assuming each event has a 24 hour storm duration. Figure 5 shows good agreement between the observed data and the data within the CLIGEN sequence.

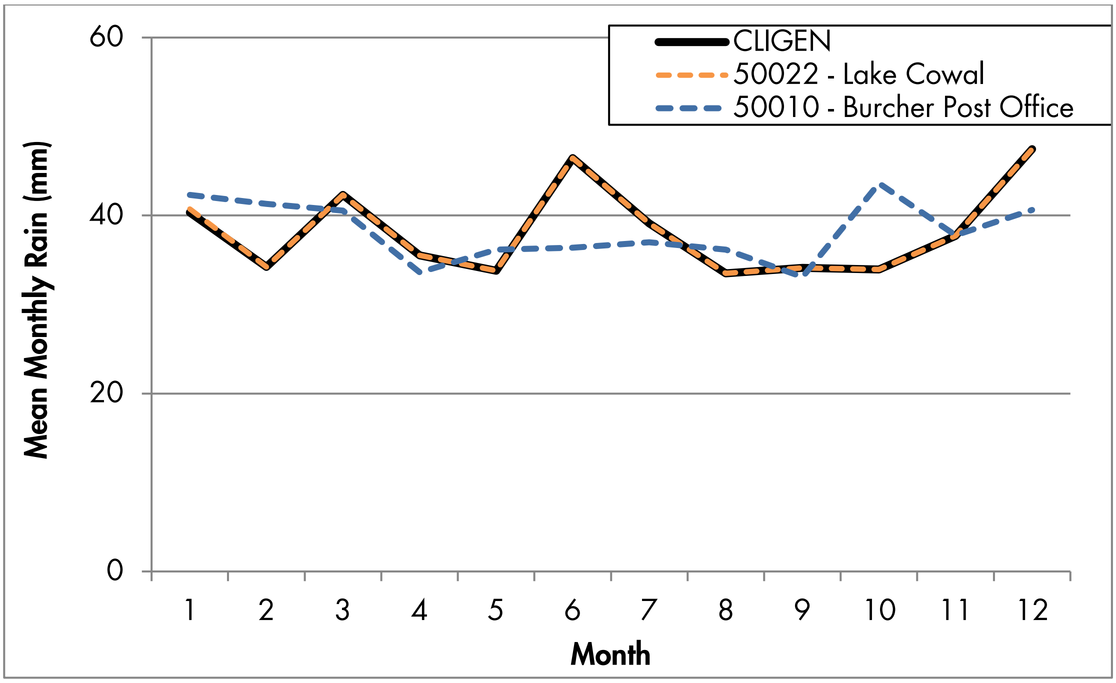


Figure 4: Observed monthly rainfall for Lake Cowal, Burcher Post Office, and average monthly rainfall values for the CLIGEN sequence.

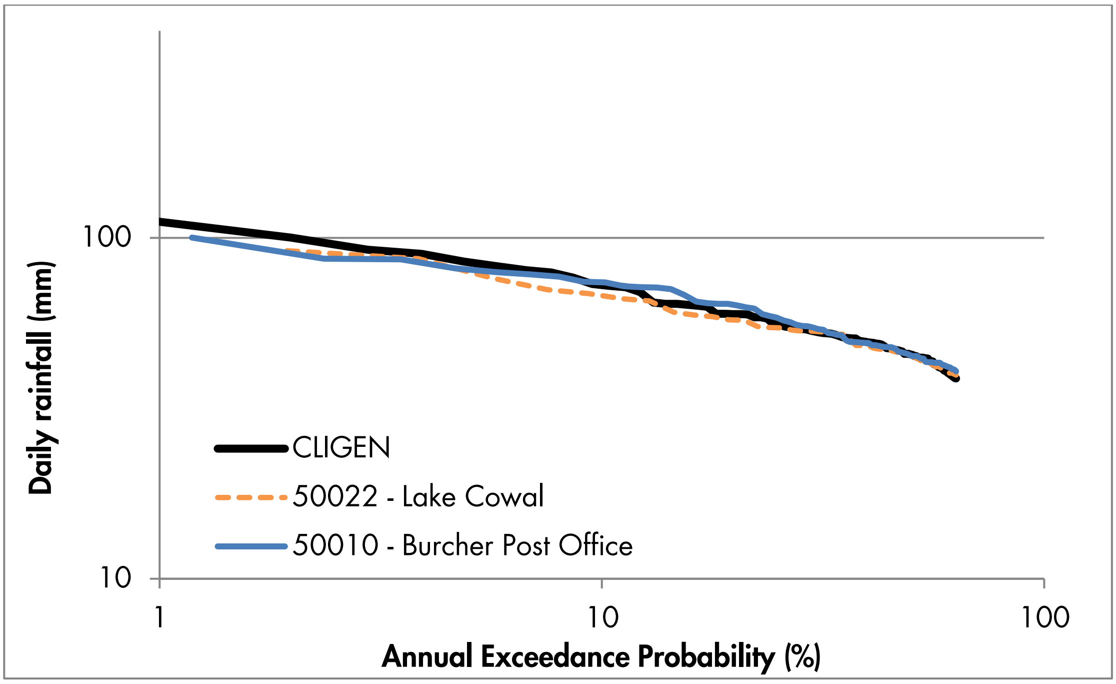


Figure 5: Daily rainfall verse annual exceedance probability for observed rainfall (data drill) and the CLIGEN sequence.

5.4 WEPP Input Slopes

The established batter slope design criteria for the three CGO waste emplacements (as modified DA 14/98) are summarised in Figure 6. In addition to modelling the erosion response of the current criteria, the sensitivity of the findings to a 30 m increase in maximum vertical relief was also considered. Therefore, the adopted modelling strategy was to focus initial attention on the raised 30 m scenarios, the rationale being that if the 'tolerable' erosion criteria is satisfied at the higher vertical relief (i.e., longer slope lengths) then the lower relief batters (of equivalent slope angle but lower slope length) would also satisfy the criteria. The WEPP model input profiles of initial interest were a 1V:4H (25%) slope with 120 m vertical relief, and a 1V:5H (20%) slope with 60 m vertical relief (Figure 7). The upper portion of the hillslope profiles were assumed to be hydrologically contained, in the sense that no rainfall run-on from the top surfaces of the landform were considered. This is consistent with a landform design that includes an effective top perimeter bund.

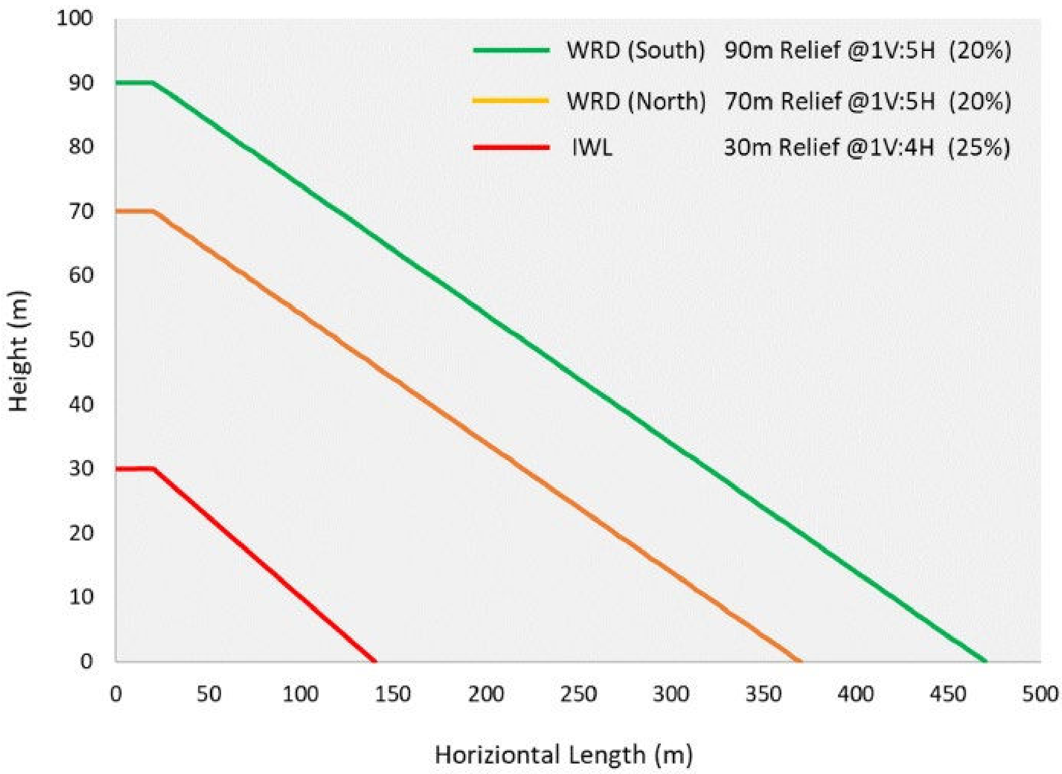


Figure 6: Conceptual representation of the DA (14/98) approved batter slope 'design' profiles for the CGO waste enclosure landforms.

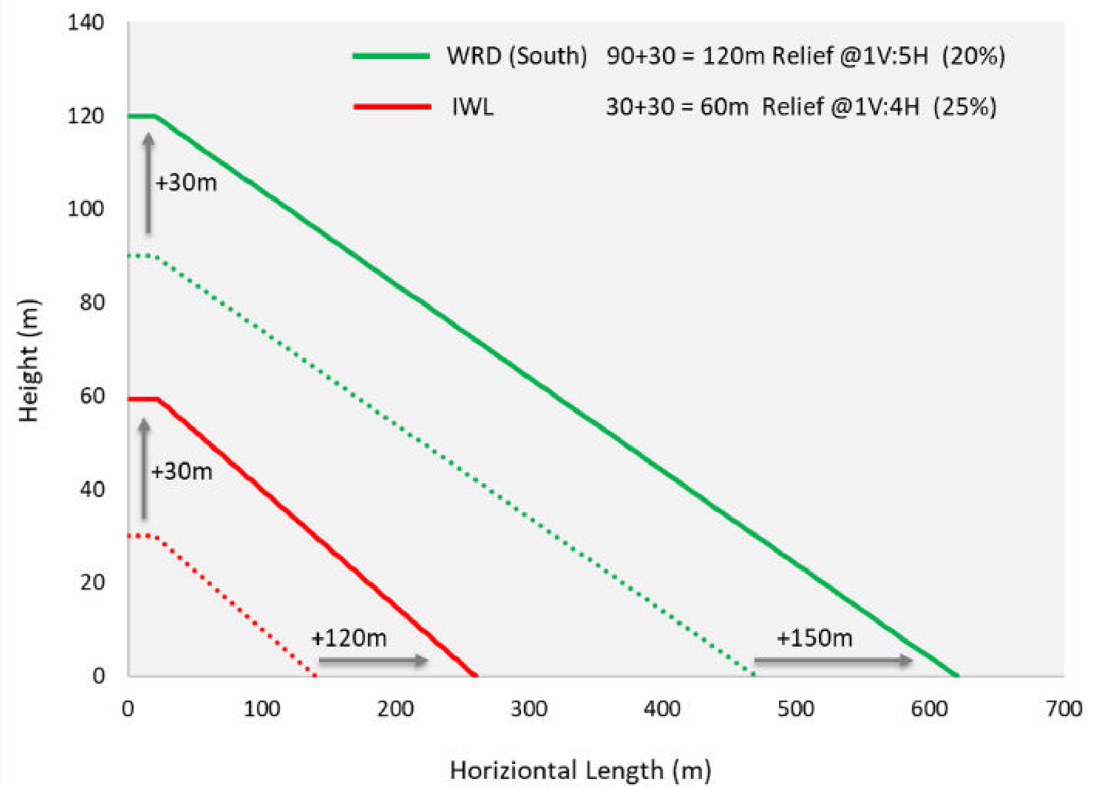


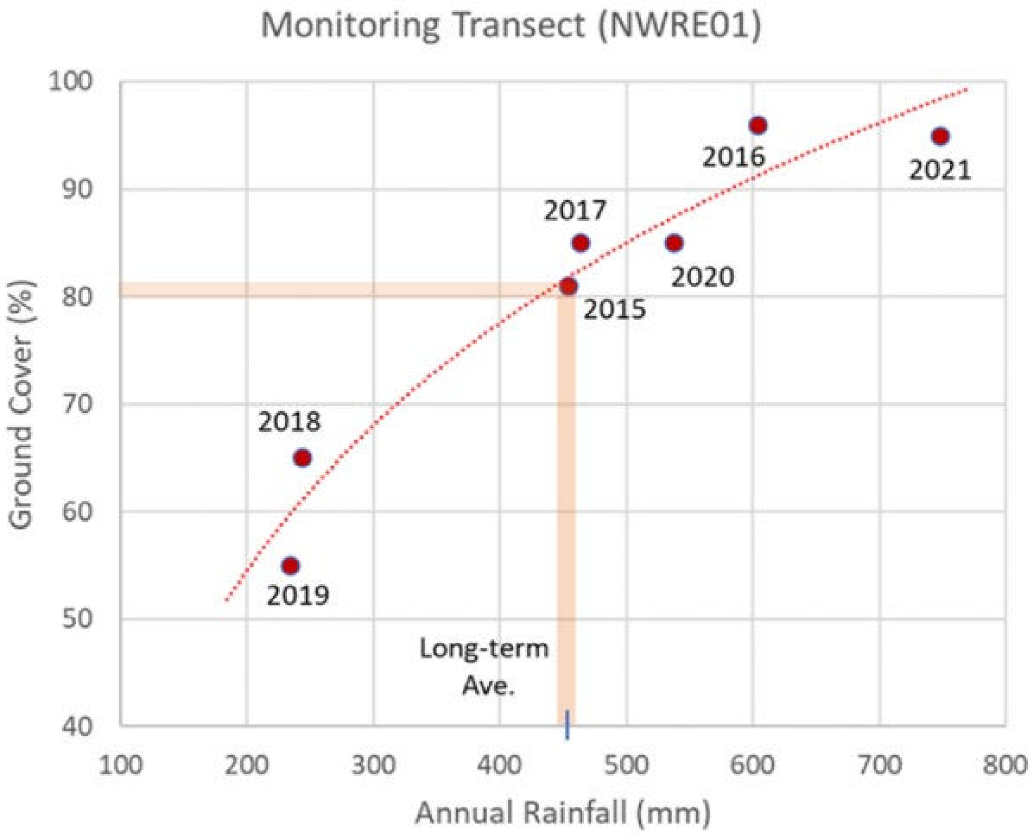
Figure 7: Graphic representation of the WEPP model input slopes.

5.5 Cover Levels

Field trials on the existing Northern WRD have been undertaken since 2015/16 to investigate the suitability of the soil-rock matrix cover system to support vegetation growth. Vegetation monitoring results for the NWRE01 transect site (DnA Environmental, 2021) provides persuasive evidence that ground cover (%) is strongly correlated with annual rainfall totals (Figure 8). In summary:

- Below average rainfall supports ground cover levels ~55–70%.
- Average rainfall years supports ground cover levels ~70–80%; and,
- Above average rainfall years support ground cover levels ~80–>90%.

In terms of modelling strategy, a conservative approach was adopted with a focus on average and below-average rainfall responses, associated with expected 50%, 60%, and 70% vegetation cover levels.



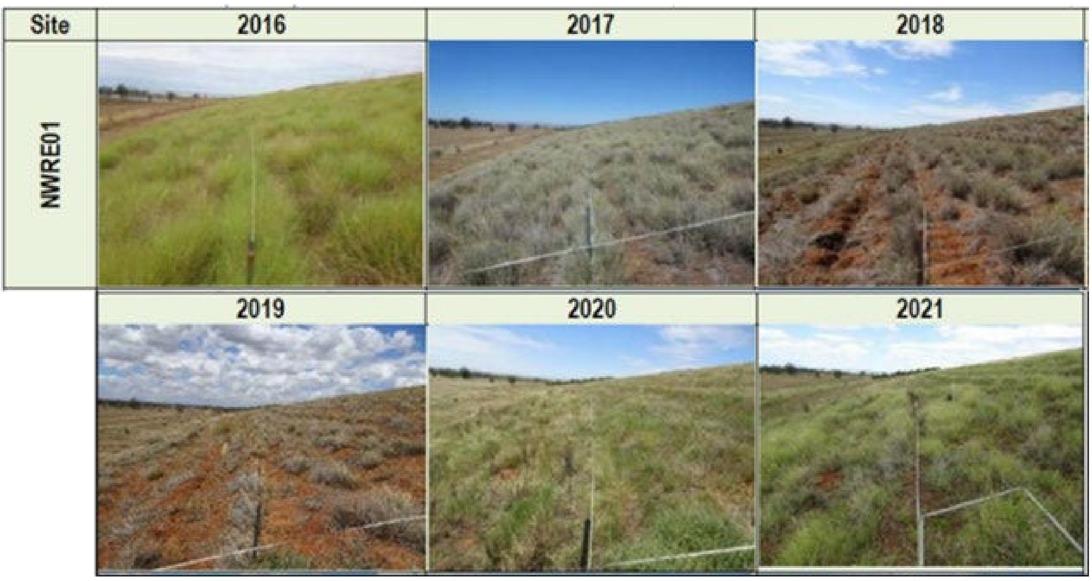


Figure 8: Temporal changes in ground cover (%) recorded at monitoring transect site NWRE01, CGO (DnA Environmental, 2021).

5.6 Results of WEPP Simulations

Findings from the WEPP modelling are summarised below. A key feature of the results for both the WRD and IWL batter slopes is the conditional importance of vegetation surface cover levels for the erosion rate of the soil-rock matrix cover layer. Vegetation cover interacts by reducing raindrop impact, increasing infiltration, and increasing critical flow shear stress for rill development (Flanagan & Livingston, 1995).

5.6.1 WRD Batter Slope (1V:5H)

Figure 9 provides graphical representation of the 100-year average erosion rate along the representative (generalised) 20% WRD batter slope. Though the modelled 120 m vertical relief is 30 m or 50 m higher than currently approved limits for the Northern and Southern WRD (respectively), soil loss remains 'tolerable' provided vegetative surface cover is >50%.

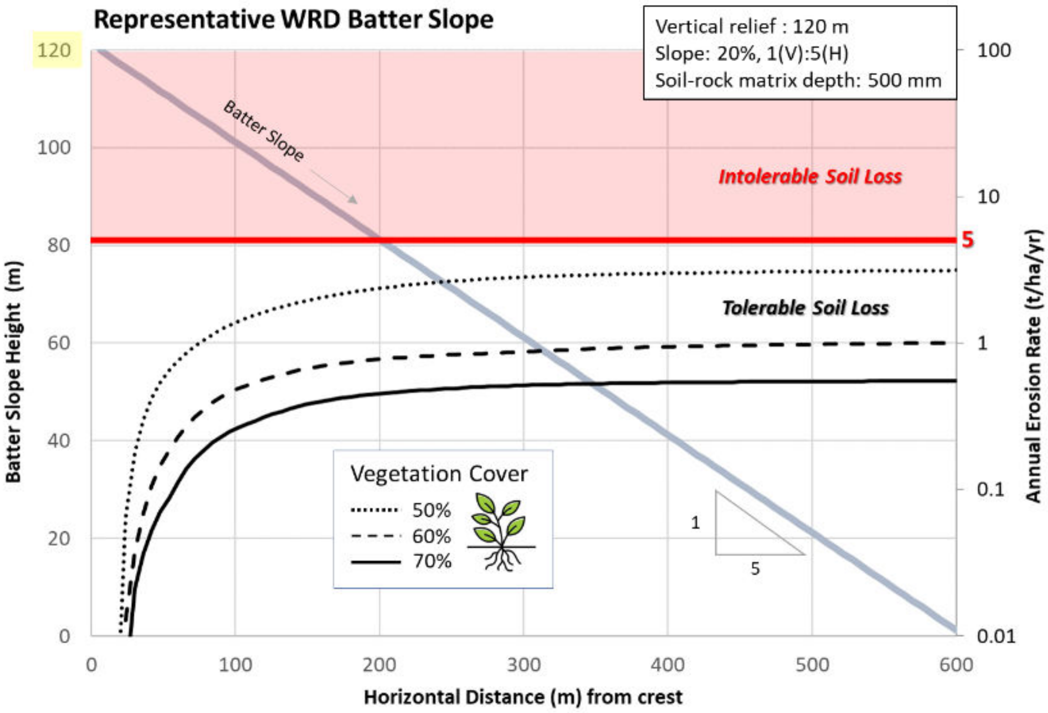


Figure 9: Predicted rates of erosion along the representative 20% WRD batter slope profile with modelled vertical relief of 120 m.

5.6.2 IWL Batter Slope (1V:4H)

Figure 10 provides graphical representation of the 100-year average erosion rate along the generalised 25% IWL batter slope. The modelled 60 m vertical relief is 30 m higher than currently approved. In this case, soil loss rates exceed the 'tolerable' limit at distances >100 m (of 240 m total) from the crest if vegetation cover levels are <50%. However, soil loss rates remain 'tolerable' along the entire slope provided vegetation cover levels are >60%.

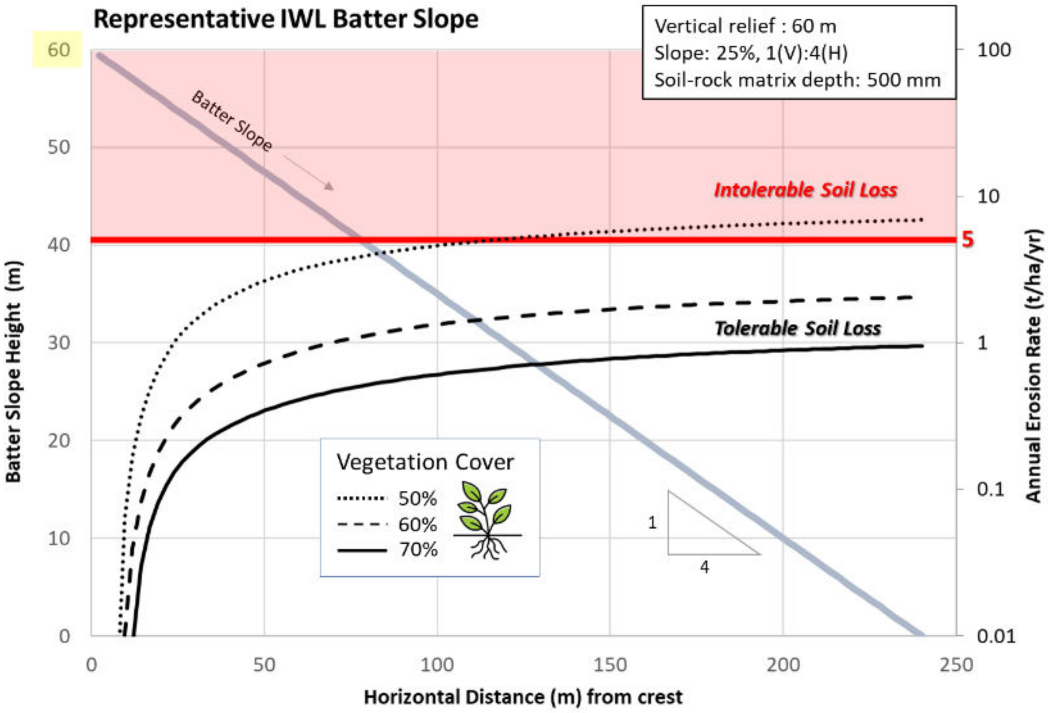


Figure 10: Predicted rates of erosion along the representative 25% IWL batter slope profile with modelled vertical relief of 60 m.

For the currently approved IWL 30 m vertical relief slope soil loss rates exceed the 'tolerable' soils limits at distances beyond ~100 m (of 120 m total) from the crest when vegetation cover levels are <50% (Figure 11). The exceedance occurs at the lower portion of the batter. At vegetation cover levels of 60% or greater soil loss rates remain 'tolerable' along the entire slope.

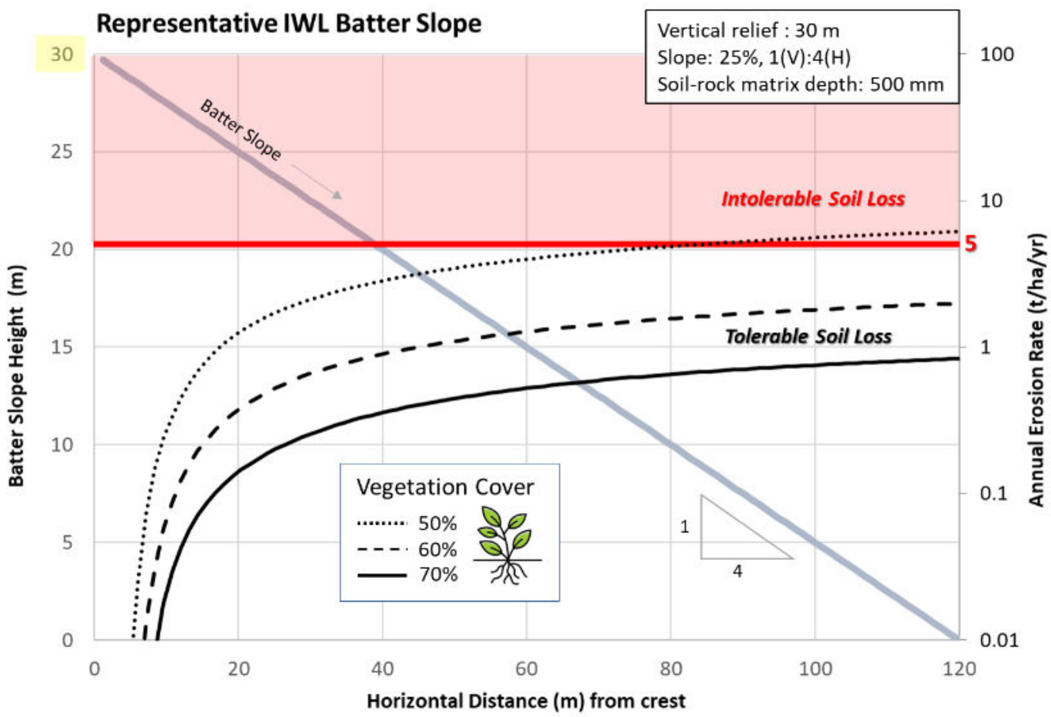


Figure 11: Predicted rates of erosion along the generalised 25% IWL batter slope with modelled vertical relief of 30 m.

5.7 Summary of WEPP Modelling Outcomes

The key findings from the linear hillslope parameterisation from the WEPP model:

i. Acceptable soil loss thresholds are (100-yr) mean erosion rate of 5 t/ha/y for the whole slope; and at any one point along the slope

ii. The CGO soil-matrix rehabilitation cover system is suitable for the proposed 1V:5H (20%) linear batters of the Northern and Southern WRDs provided that >50% vegetation cover is maintained.

iii. The CGO soil-matrix rehabilitation cover system is suitable for the proposed1V:4H (25%) linear batters of the IWL provided that >60% vegetation cover is maintained.

6 LANDFORM EVOLUTION MODELLING - SIBERIA

Beyond the linear hillslope scenario modelled by WEPP, it is beneficial to also consider the full suite of interacting topographic and hydrologic controls that can occur across the integrated 3-D landform. Most importantly, how topographic convergence (hillslope hollows) within the integrated landscape can act to funnel multiple hillslope flow paths over greater widths of slope into "erosive hazard areas" that experience localised increases in flow velocities and runoff shear stress.

The SIBERIA landform evolution model is conceptualised to account for such topographic complexity, and spatially quantifies the extent to which these convergent "erosive hazard areas" magnify erosion rates (and associated rill/gully depths) beyond the typical hillslope erosion response. For the CGO waste landforms, the "typical" (spatially dominant) hillslope response is the -standard linear batter response. With regards to SIBERIA outputs presented henceforth, this linear hillslope batter response condition can be associated with the expected median (50th percentile) response. The sophistication of SIBERIA lies in its ability to track the spatial evolution of variable topographic-driven responses through time, such as the difference between the 50th percentile hillslope response and the more extreme >99th percentile erosion responses resulting from concentrated flow areas.

An overview of the methods adopted to parameterise and then run SIBERIA for the three CGO waste landforms follows below. The developed modelling framework assumes that the entire surface of three landforms is capped by the soil-rock matrix cover system and supports a long-term average vegetation cover of 70% (based on average rainfall years supporting ground cover levels ~70 – 80% - Section 5.5)

6.1 SIBERIA Parameters

Input parameters for the soil-rock matrix material were developed from Landloch's laboratory-based assessments of infiltration and erodibility and are given in Table 4. These parameters are specific to the soil-rock mix at CGO and cannot be used to represent the erodibility of different materials at CGO, or at sites other than CGO.

Where practicable, the key fluvial transport model parameters for SIBERIA – (viz., β_1 and m_1) would be derived by fitting the SIBERIA model equations to time series data of runoff and erosion. However, in most instances, sufficiently long series of these paired data are not available for the landforms of interest. Therefore, Landloch has developed an alternative approach for developing the required SIBERIA input parameters. The general approach is to:

a) Make measurements of runoff and erosion on materials using laboratory-based flumes to derive calibrated WEPP runoff/erosion model parameters.
b) Run the WEPP model for batter geometries consistent with the geometries used in the landform design under consideration. Generate data sets of runoff and erosion for batter geometries and materials of interest using long (100-yr) site specific climate sequences that contain a wide range of rainfall events, including rare and extreme events.
c) Analyse the WEPP runoff and erosion model output and fit to the SIBERIA model equations to derive values for β_1 and m_1.

Table 4: SIBERIA parameters for the soil-rock matrix.

Material	Vegetation Cover	β_1	m_1
Soil-rock matrix	70%	0.000083	1.238

6.2 Model Settings

A digital elevation model (DEM) of the proposed CGO landform was provided to Landloch (file name: EIS_E46BF_FINAL LANDFORM_V3.dxf). Due to SIBERIA file size constraints, the landform was split to consider the three waste landforms individually. This allowed each landform to be run with a grid cell resolution of 1.5 x 1.5 m.

For the present application, SIBERIA assumes the 3-D landform (i.e., spatial topography and depth profile) is fashioned from a single homologous input material. In this way, the 3-D landform is given the erosive and structural properties of the cover material to be assessed. The intent is to evaluate the performance of the selected cover material over time, across the total surface of the landform input. This means however, that the direct impact of the (known) higher erodibility of the encapsulated waste material below ~0.3 m (see Appendix A) is not explicitly modelled. Therefore, whilst the predicted erosion depths for the surface capping materials are considered reliable, erosion depths >0.3 m are assumed to be inaccurate once the encapsulated spoil material is encountered. Simulated erosion depths >0.3 m, however, can reasonably be assumed to trigger unstable gully development when the underling materials have lower critical shear strengths than the capping materials.

The modelling assumption that the 3-D landform is constructed from a single homologous input material also means that SIBERIA model results will be less accurate at areas of the Mine where the surface cover is different to the model input cover material being analysed. Example areas include where the Northern WRD and Southern WRD landforms merge with existing pit walls. This needs to be considered when interpreting SIBERIA outputs.

The modelling also assumes no maintenance to the landform, i.e., rill and gullies are not repaired. In such situations the modelling could be considered to represent a 'worst case scenario'.

The following SIBERIA outputs were produced:

- Statistics for depth of erosion 50th (median) and 99th percentiles for each simulated period of 100, 300, and 500 years;
- Visual outputs for the three waste landforms that show:
    - average erosion rate; and
    - evolution of the landforms due to erosion and deposition after 500 years.

6.3 SIBERIA Modelling Outcomes

Overall, the SIBERIA erosion modelling indicates that with 70% vegetation cover levels the overwhelming majority (at least 99%) of the landform surface in each of the three waste landforms can be considered stable in the long-term. Indeed, even after 500 years of simulation, only 0.4% (Northern WRD), 0.7% (Southern WRD) and 0.05% (IWL) of the landform surface is predicted to exceed the critical >0.3 m erosion depth, which would likely expose the encapsulated waste material, and initiate unstable gully erosion (Figure 12). Whilst, small in spatial area coverage, these unstable "erosion hazard areas" still warrant remedial action. Spatial mapping, including explanation of their likely cause, is considered separately for each landform.

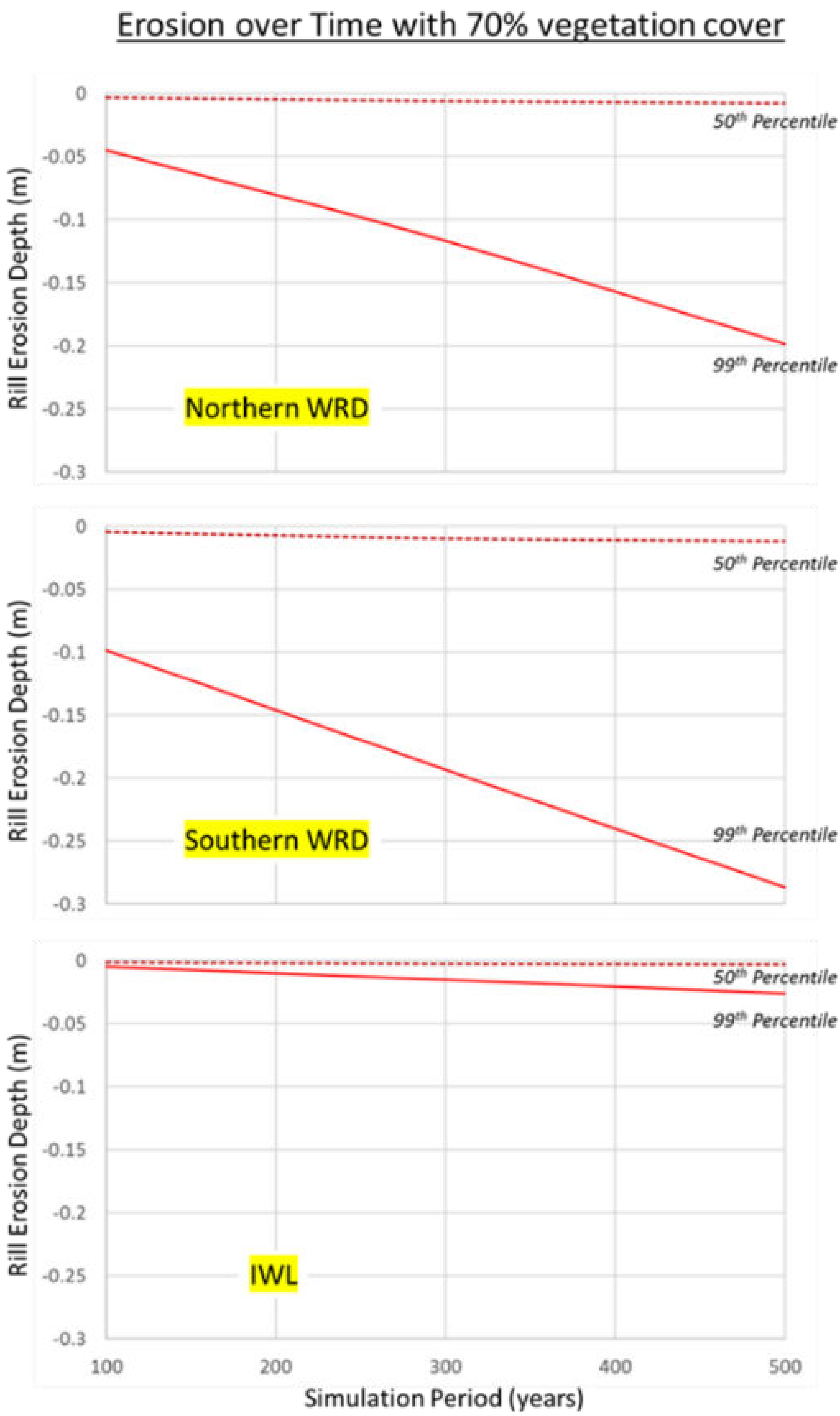


Figure 12: Simulated median (50th Percentile) and 99th Percentile erosion depth over time for each waste landform.

6.3.1 Northern WRD Simulations

Results for the Northern WRD simulations conducted with the soil-rock matrix and 70% vegetative cover model parameters applied to the surface, are provided in Figures 13, 14, and Appendix G (Figure G1).

The key findings for proposed Northern WRD are:

- Approximately 99% of the landform surface achieves acceptable levels of stability to erosion (average annual erosion <5 t/ha/yr) (Figure 13);
- Approximately 1% of the landform surface can be considered long-term "erosion hazard areas" (average annual erosion >5-10 t/ha/yr) being driven by the effects of topographic convergence (hillslope hollows) (Figure 13, Figure G1); and
- At year 500, approximately 0.45% of the landform surface is predicted to exceed the critical >0.3 m erosion depth, which would likely expose the encapsulated waste material, and initiate unstable gully erosion (Figure 14).

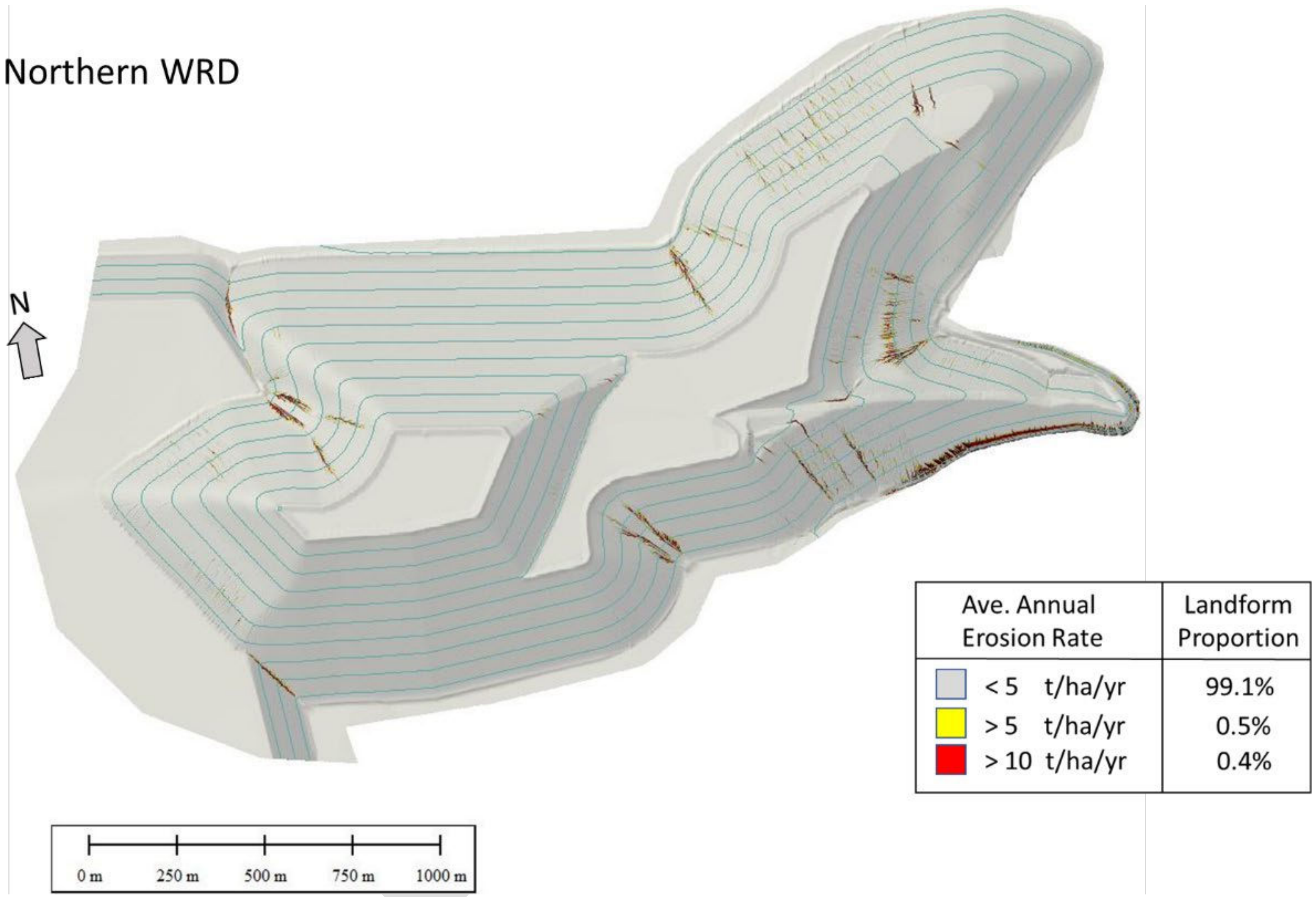


Figure 13: Average annual erosion rates – CGO Northern WRD soil-rock matrix growth media supporting 70% vegetative cover.

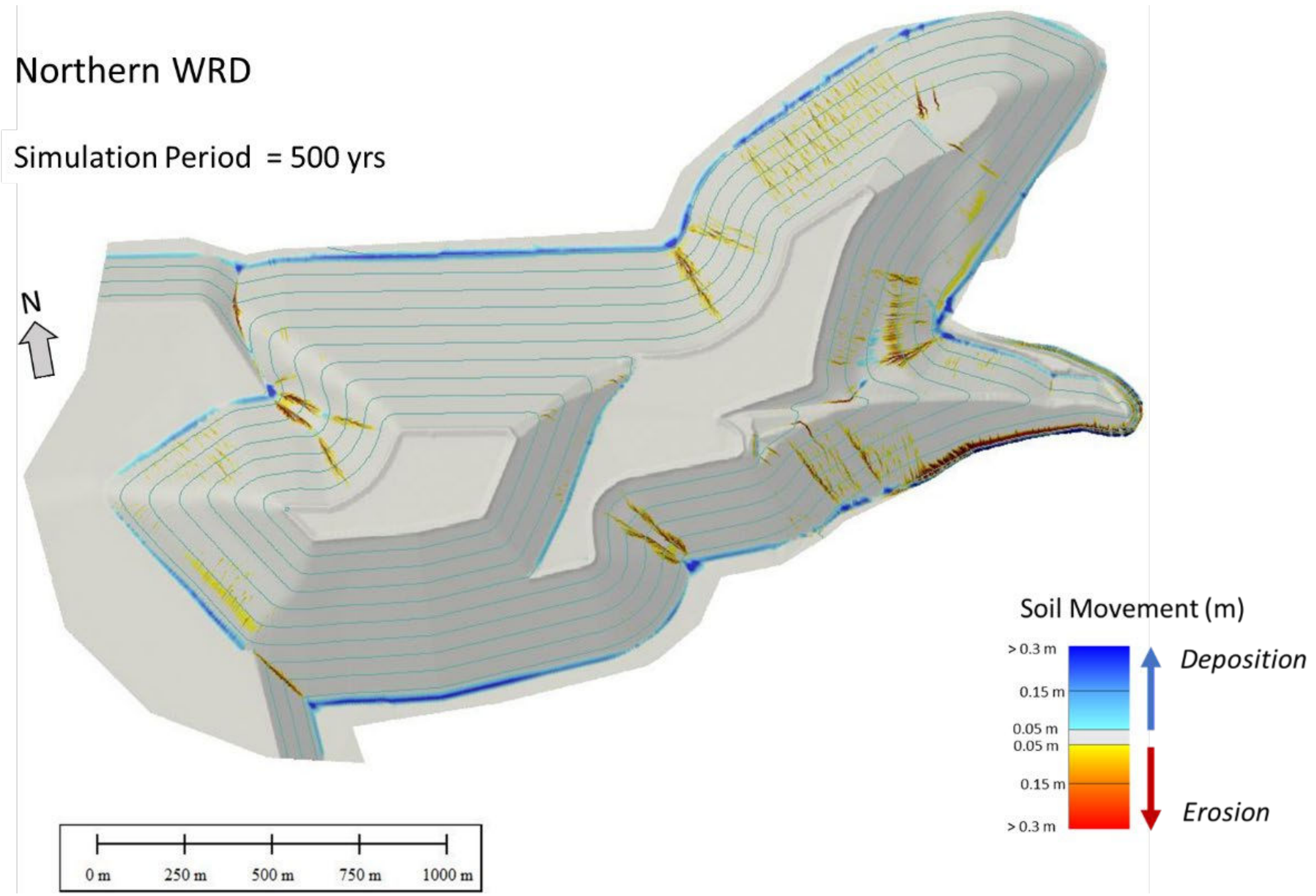


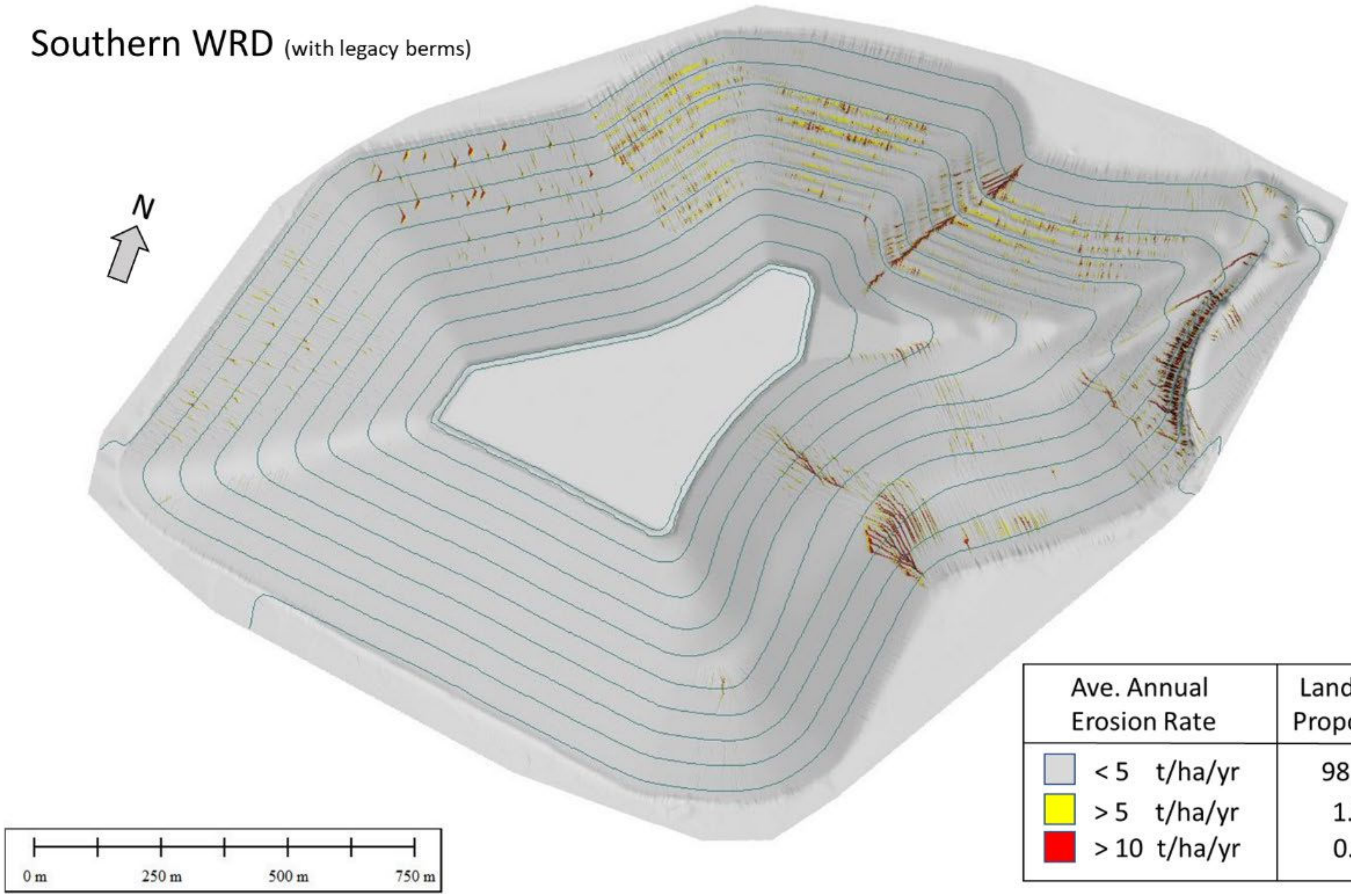
Figure 14: Erosion and deposition areas at 500 years - CGO Northern WRD soil-rock matrix growth media supporting 70% vegetative cover.

6.3.2 Southern WRD Simulations

Results for the Southern WRD simulations conducted with the soil-rock matrix and 70% vegetative cover model parameters applied to the surface are provided in Figures 15, 16, and Appendix G (Figure G2).

The key findings for the proposed Southern WRD are:

- Approximately 98% of the landform surface achieves acceptable levels of stability to erosion (average annual erosion <5 t/ha/yr) (Figure 15);
- Approximately 2% of the landform surface can be considered long-term "erosion hazard areas" (average annual erosion >5-10 t/ha/yr) being driven by the effects of topographic convergence (hillslope hollows) and the erosive consequences of legacy berms on the lower north-facing slopes (Figure 15, Figures G2, G3); and
- At year 500, approximately ~0.7% of the landform surface is predicted to exceed the critical >0.3 m erosion depth, which would likely expose the encapsulated waste material, and initiate unstable gully erosion (Figure 16).



Ave. Annual Erosion Rate	Landform Proportion
< 5 t/ha/yr	98.1%
> 5 t/ha/yr	1.3%
> 10 t/ha/yr	0.6%

Figure 15: Average annual erosion rates – CGO Southern WRD soil-rock matrix growth media supporting 70% vegetative cover.

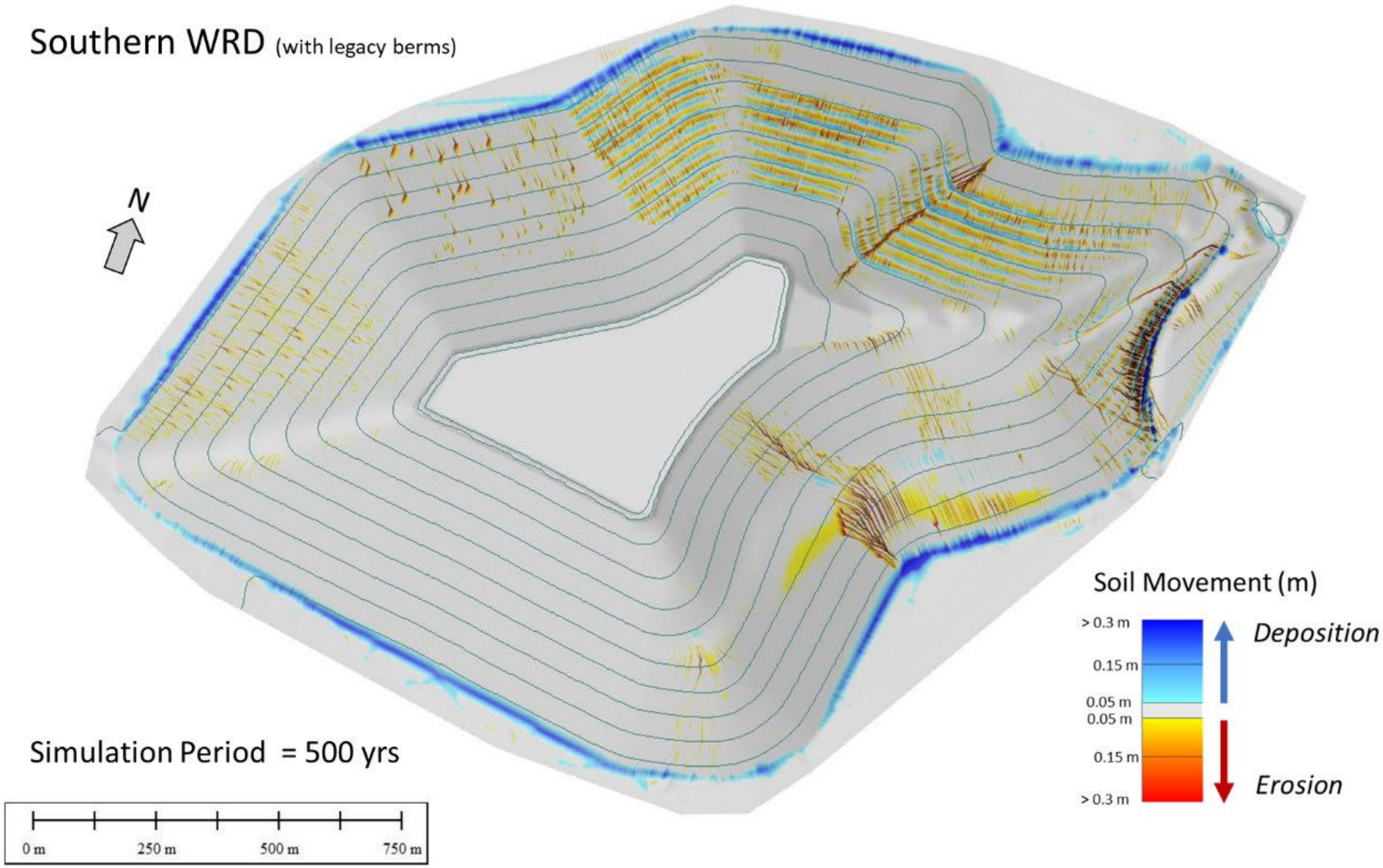


Figure 15: Erosion and deposition areas at 500 years - CGO Southern WRD soil-rock matrix growth media supporting 70% vegetative cover.

6.3.3 IWL Simulations

Results for the IWL simulations conducted with the soil-rock matrix and 70% vegetative cover model parameters applied to the surface, are provided in Figure 17 and 18.

The key findings for the proposed IWL are:

- Approximately 99.9% of the landform surface achieves acceptable levels of stability to erosion (average annual erosion >5-10 t/ha/yr) (Figure 17);
- Approximately 0.1% of the landform surface can be considered long-term "erosion hazard areas" (average annual erosion >5-10 t/ha/yr) being driven by the effects of topographic convergence (hillslope hollows) and the confined to the legacy benches on the southern batters of the IWL (Figure 17); and
- At year 500, approximately ~0.06% of the landform surface is predicted to exceed the critical >0.3 m erosion depth, which would likely expose the encapsulated waste material, and initiate unstable gully erosion (Figure 18).

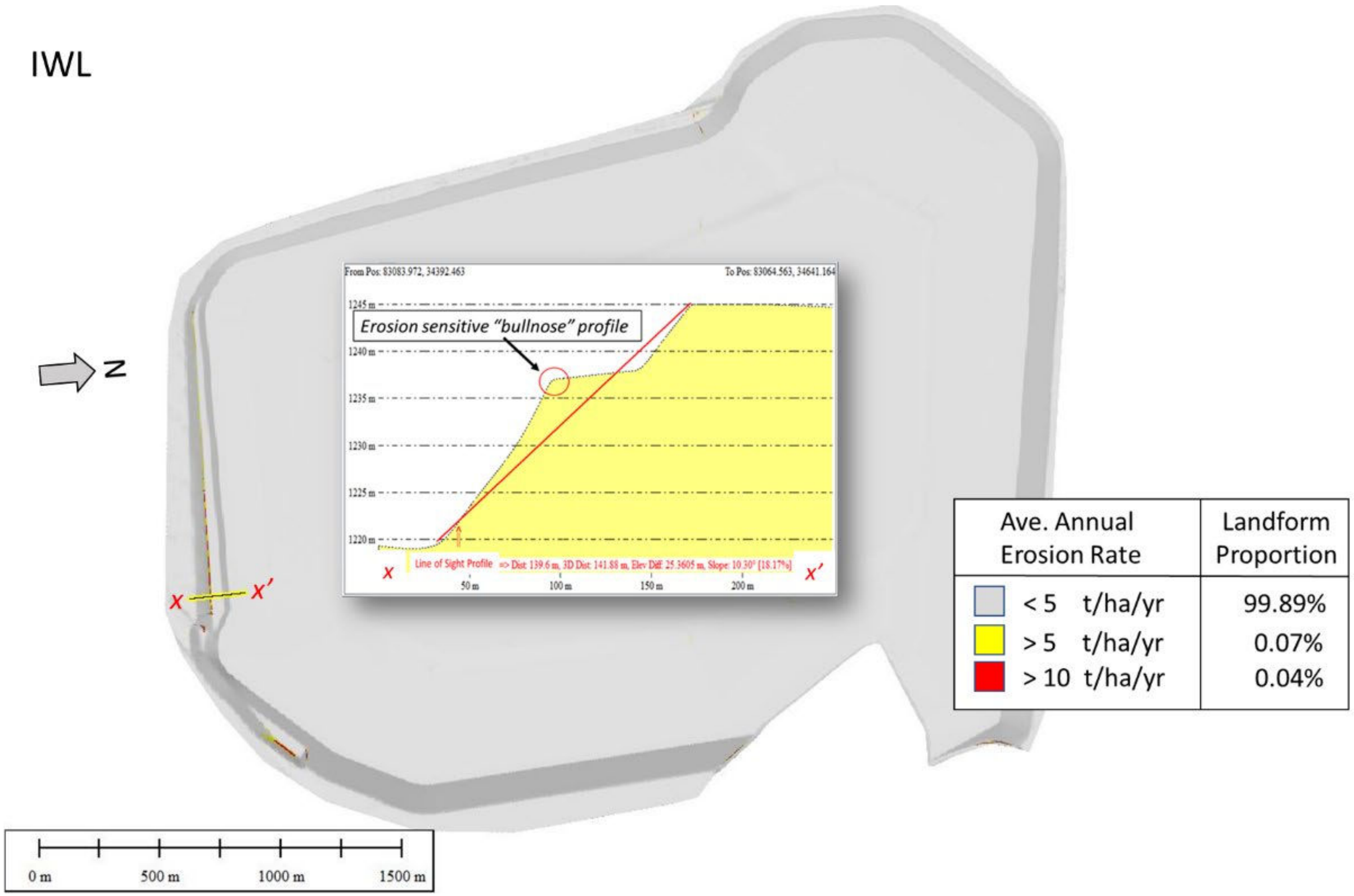


Figure 17: Average annual erosion rates – CGO IWL soil-rock matrix growth media supporting 70% vegetative cover.

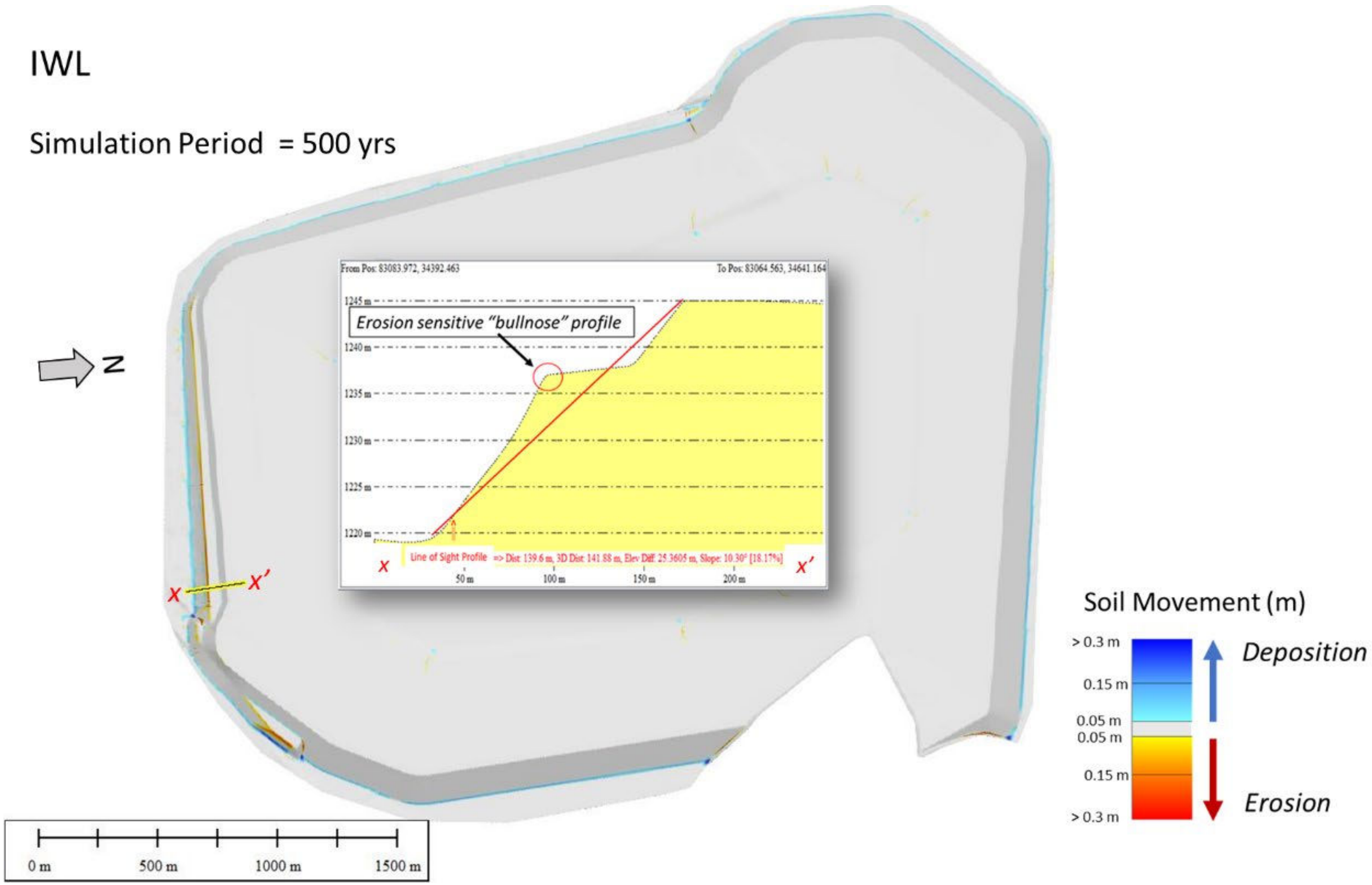


Figure 18: Erosion and deposition areas at 500 years - CGO Southern WRD soil-rock matrix growth media supporting 70% vegetative cove

6.4 Summary of SIBERIA Modelling Outcomes

Based on the model parameter combination arising from the CGO soil-rock matrix capping system and 70% vegetative cover levels, the key findings from SIBERIA are:

i. The greater part of the landform designs for the Northern WRD (99%), Southern WRD (98%), and IWL (99.9%) perform well, with tolerable rates of erosion across most of the surface (average annual erosion <5 t/ha/yr);
ii. The much smaller (balancing) part of the landform designs for the Northern WRD (1%), Southern WRD (2%), and IWL (0.1%) can be considered long-term "erosion hazard areas" (average annual erosion >5-10 t/ha/yr);
iii. As a consequence of the "erosion hazard areas", approximately 0.4% (Northern WRD), 0.7% (Southern WRD) and 0.05% (IWL) of the land surface is predicted to exceed the critical >0.3 m erosion depth within 500 years;
iv. The "erosion hazard areas" are principally the result of topographic convergence (hillslope hollows) within the landform designs, which become focal areas of elevated flow discharges and associated runoff shear stress;
v. Remnant berm-batter structures on the Southern WRD are also identified as "erosion hazard areas" due to topographic convergence, most likely the consequence of existing erosive damage (see Discussion for details); and
vi. The erosion-prone bullnose hillslope profile arising from legacy benches on the southern batters of the IWL are identified as "erosion hazard areas".

7 DISCUSSION

The highly erodible and dispersive oxide waste rock (spoil) encapsulated within the three expanded waste landforms of the CGO OPC project dictates that the applied land surface soil capping layer be sufficiently resistant to erosion, such that the long-term likelihood of surface exposure of the encapsulated waste spoil is reduced to near zero. In response to this challenge, CGO has developed a soil-rock matrix capping system (see Appendix A) which keys competent soil and rock onto the batters of the waste landforms to enhance critical shear protection against the initiation of damaging rill and gully erosion.

The highly erodible, dispersive, and tunnel-prone waste rock spoil materials present a challenge to rehabilitation for the three expanded waste landforms arising from the CGO OPC. This is especially true when a key rehabilitation objective is to design landforms that remain stable to accelerated in the long-term. In response to this challenge, CGO has developed a soil-rock matrix capping system (see Appendix A) which keys competent soil and rock onto the batters of the waste landforms to enhance critical shear protection against the initiation of damaging rill and gully erosion.

Landloch's outlined *Erodibility Evaluation and Landform Evolution Modelling Program* has: (i) experimentally tested the erosion resistance properties of this soil-rock matrix cover system, and (ii) then quantitatively modelled/simulated its likely long-term stability on four representative batter slopes of the expanded Northern and Southern WRDs and IWL.

7.1 Importance of Vegetation Cover

The findings highlight the conditional importance of adequate levels of vegetation cover in addition to the soil-rock matrix cover system in order to ensure stability of the landforms in the long-term. Indeed, by itself, the soil-rock matrix cover systems is insufficient to ensure stability. For example, in addition to the soil-rock matrix cover system a minimum vegetation groundcover of 50% is required for the WRD with a 20% linear batter slope profile, and a minimum of 60% is required for the IWL batter with a 25% linear slope profile. It follows that it is essential for CGO to understand/measure the likelihood of achieving these minimum vegetation cover requirements to be confident that the CGO waste landforms will remain stable in the long-term.

Generally, semi-arid environments (viz. annual rainfall 300–450 mm) like that experienced at CGO (Lake Cowal) are likely candidate locations for high rates of erosion. For example, data from natural catchments in the USA (Appendix F) indicate that peak erosion rates occur in semi-arid environments. This response is rationalised by the fact that: *low* annual average rainfall volumes are insufficient to support significant vegetation covers, yet individual storms of significant intensity (i.e., erosion generating rainfall events) still have a moderate likelihood of occurrence.

Simple extrapolation of the USA data to the CGO mine site underscores the potential risk that realised vegetation groundcover in the long-term may not provide adequate erosion control. Encouragingly, however, field trials on the rehabilitated batter slopes capped with the CGO soil-rock matrix cover system indicate that groundcover between 50–70% are achievable; with between-year variations driven primarily by annual rainfall totals (Figure 6; DnA Environmental, 2018).

A contributing factor for the notable vegetation growth at CGO could relate to the unique rainfall characteristics at Lake Cowal. Specifically, despite having a low average rainfall, typically less than 450 mm, rain falls consistently across the year, with only small seasonal variations in the ~30–40 mm per month rainfall (Figure 1). This low, but near uniform rainfall response can reasonably be expected to assist the onsite vegetation to maintain positive daily water balances, that would otherwise be much harder to achieve in comparable semi-arid regions that have an extended 'dry' season. Though the uncertain risk that future climate change presents to the unique rainfall characteristics at Lake Cowal exist outside the scope of this present report, it is recommended that it be given further consideration by CGO. The potential for a near-future that is increasingly dominated by extreme dry (and wet) periods would be disadvantageous for persistent vegetation growth, and by inference stable landforms at CGO in the long-term.

Because of the fundamental importance of maintaining vegetation covers >50–60% to ensure the long-term stability of the CGO waste landforms, some consideration must also be given to the identified elevated salinity (i.e., beyond desirable levels) that were found to exist within the soil-rock matrix material, particularly the lower layer (see Appendix C). Highly saline materials can be challenging to successfully revegetate. Onsite rehabilitation monitoring data also reveals that the salinity at each of the rehabilitation sites exceed 'typical' local and desirable levels (DnA Environmental, 2018).

However, it has been noted that salinity is always highest at the new rehabilitation sites and shows a declining trend with time at the older sites, presumed to be driven by a leaching process (DnA Environmental, 2018), which is consistent with salinity being more elevated in the lower layer samples of the present study. Encouragingly, onsite monitoring has also noted that despite the undesirable salinity, it does not appear to have had a significant effect on the ecological development of the rehabilitation areas (DnA Environmental, 2018). Colonisation of the steeper batter sites by seeded *Lolium rigidum* (rye) and establishment from the soil seed bank of *Avena fatua* (Wild Oats) has not been restricted.

In the longer term, it is noted weathering and leaching of waste rock and soil materials may alter the stability to support plant growth. For example, there may be an elevated risk of "growth-limiting" soil salinity levels arising due to waste rocks releasing salts when exposed to weathering processes / oxidation (GEM, 2008; 2009; 2016). Also, the leaching salts over time has the potential to influence the dispersive nature of materials and structural stability to rapid wetting and may result in a more erosion prone material. Salt release and leaching from weathering wastes has not been evaluated in this study. If not already undertaken, then it is recommended these concerns be addressed by CGO.

7.2 Impact of Flow Convergance

Landloch's extended modelling and simulation of the 3-D drainage networks of the individual landforms were undertaken with the assumption that 70% cover levels can be maintained in the long term. With vegetation cover levels assumed constant (70%), topographic convergence (hillslope hollows) was identified as a key driver of "erosion hazard areas" for each of the 3-D landform designs (Figure 19).

The hydrological processes leading to topographic convergence areas being erosion hazard areas are well established. Topographic convergence tends to concentrate flows over greater widths of slope. Rills/gullies will form where there is concentrated flow and the shear stress (tractive force) of the flow exceeds the shear strength of the encountered channel surface medium.

Three options are provided to mitigate the erosive impacts of topographic convergence at the landscape scale.

The first option (convergence elimination) requires landform reshaping modifications that act to reduce the angle of convergence curvature between connecting hillslopes; and thereby reduce the runoff volume (i.e., upstream contributing area) flowing through the less connected accumulating (central) drainage pathways. An optimal (quantifiable) joining curvature potentially exists for each hillslope combination, which constrains the accumulated volume and associated flow velocity/shear stress to levels that are less than the resisting shear strength of the drainage channel surface.

The second option (alternative cover engineering) involves increasing the shear stress resistance of the soil-rock matrix cover system, beyond that currently achieved by the existing CGO soil-rock matrix cover system. This may feasibly be obtained by increasing the D_{50} and D_{90} rock sizing, or altering the particle size distribution and particle shape of the soil-rock cover design to produce a more erosion resistant cover system.

The third option (drainage engineering) involves constructing rock lined engineered drainage channels in areas with convergent central drainage pathways. However, careful consideration and caution is required. Given the highly erodible and dispersive materials upon which such rock drains would be constructed, there is a quantifiable risk.

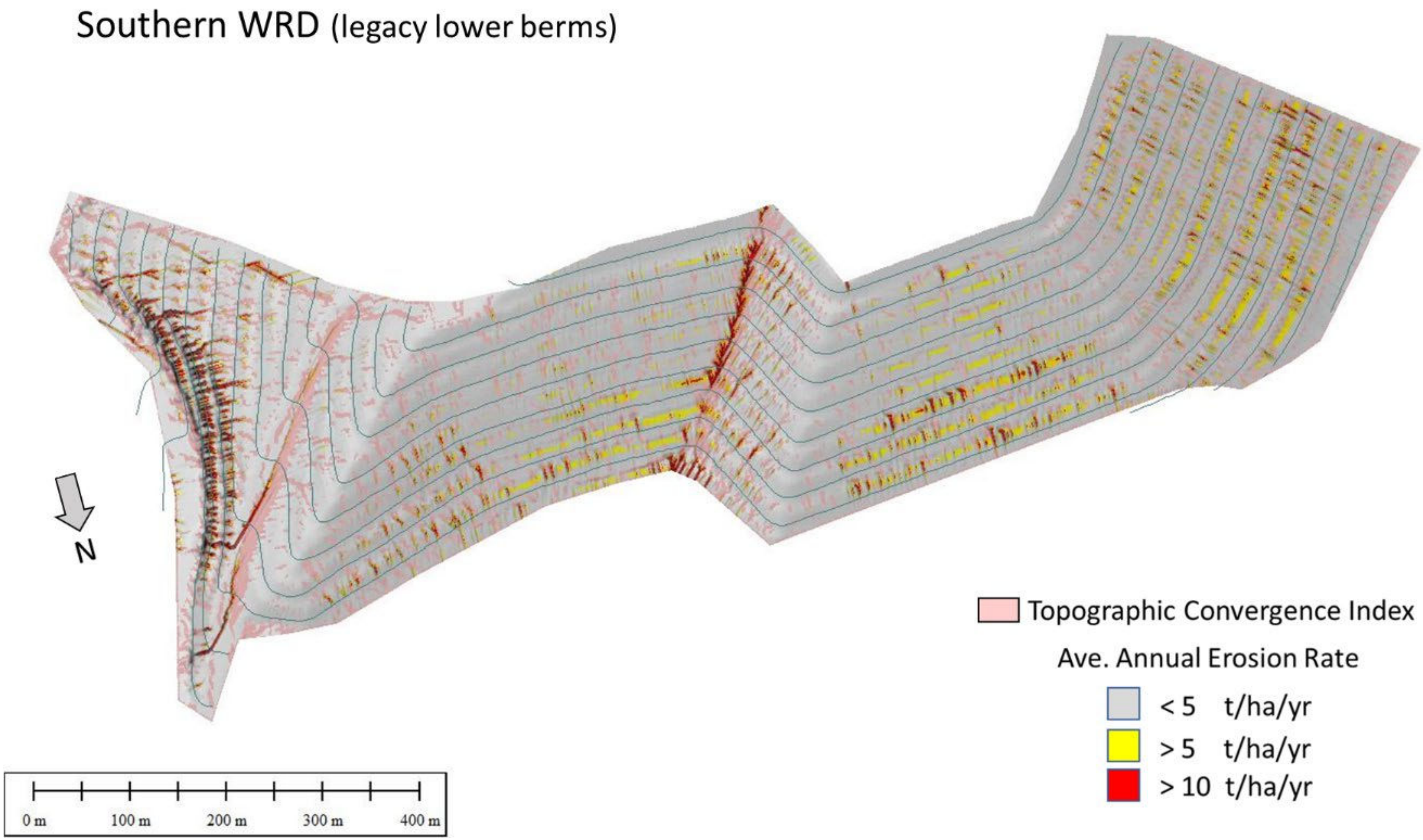


Figure 19: CGO Southern WRD legacy berms - Spatial coherence between areas of topographic convergence and "erosion hazard areas" (>5-10 t/ha/yr).

of erosion tunnelling and subsidence under the drains that may eventually lead to their collapse (Landloch, 2008).

Beyond topographic convergence at the hillslope-scale, several other "erosion hazard areas" were identified that are a result of legacy features on the existing/underlying landforms upon which the new (expanded) landforms are to be constructed. The first of these are the legacy berm features on the lower north-facing slopes of the Southern WRD, which arise from the existing Southern WRD landform footprint (Figure 19).

The risks and consequences associated with berms on waste landforms have been previously documented (Roddy and Howard, 2016; and references within). Typical problems include: (i) berms filling with sediment and overtopping, with the overtopping of concentrated flow causing widespread gullies that accelerate failure of lower berms, and (ii) Tunnel erosion triggered by water ponding on the berms, which eventually collapse in on themselves and create "instant gullies" that concentrate water into lower berms. The likelihood of both these negative outcomes are especially common on landforms that have highly erodible topsoils and dispersive and tunnel prone subsoils/wastes such as exists at GCO. Indeed, evidence of gully scars already existing within the remnant berms, suggests that berm failure has already been initiated, even before the future projection modelling (Figure 19). Given that we have demonstrated for the Southern WRD that simple linear 20% batter slopes will remain stable in the long-term, a prudent remediation strategy may be to subsume these legacy berms within the linear hillslope batters of the new expanded design.

The erosion-prone convex 'bullnose' slopes arising from legacy (existing Southern TSF) benches on the southern batters of the proposed IWL are also identified as "erosion hazard areas" (see insert, Figures 17 and 18). Compared to linear and concave slopes, convex slopes act to increase erosion rates due to the steepest gradients being in the mid and lower portions of the batter where the volume of runoff and the stresses applied to the surface by runoff is the greatest (Figure 20).

Remediation landform reshaping should be undertaken to remove the bullnose transition. For example, form a linear slope at an angle of 25% or shallower. Otherwise, an alternative sized soil-rock matrix to capping the erosion-prone bullnose transition zone may be designed and applied.

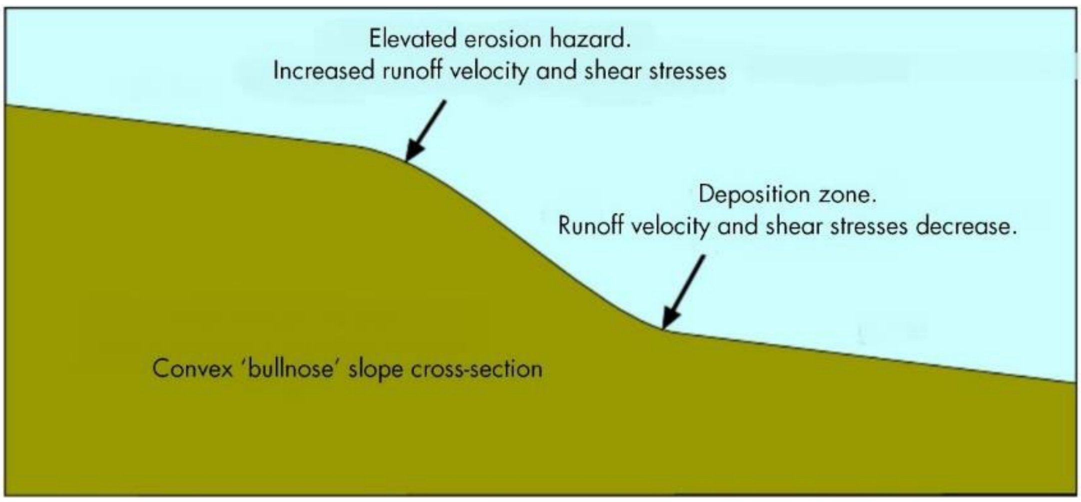


Figure 20: Concept of elevated erosion hazard on a convex 'bullnose' slope.

8 GUIDANCE FOR LANDFORM DESIGN AREA

Herein, Landloch's *Erodibility Evaluation and Landform Evolution Modelling Program* has assessed the three expanded waste landforms arising from the GCO OPC project (namely, the Northern WRD, Southern WRD, and IWL) to evaluate the long-term erosional stability of the three expanded landforms revegetated with endemic vegetation that is consistent with the surrounding landscape. Consequently, the following design-related observations and propositional understanding are specified:

i. Acceptable soil loss thresholds are (100-yr) mean erosion rate of 5 t/ha/yr for the whole slope; and at any one point along the slope.

ii. The CGO soil-rock matrix rehabilitation cover system is suitable for the proposed linear (1V:5H, 20%) profile batters of the Northern and Southern WRDs provided >50% vegetation cover can be maintained.

iii. The CGO soil-rock matrix rehabilitation cover system is suitable for the proposed linear (1V:4H, 25%) profile batters of the IWL provided that >60% vegetation cover can be maintained.

iv. Because of the conditional importance of vegetation cover, runoff rates and erosion potential of the surface and drainage lines will be high until the surface vegetative cover is well established. Once the target vegetation cover is established, it will reduce the runoff, and rates of erosion compared to flows during site establishment.

v. Existing vegetation trials at CGO provide cautious optimism that established vegetation cover levels in the order of 70% can be sustained based on average annual rainfall totals. Thus, providing confidence that the proposed linear batter design slopes of the Northern WRD (20%), Southern WRD (20%), and IWL (25%) are justifiable.

vi. Though small in spatial extent, several unstable "erosion hazard areas" have been identified across the topographically integrated (3-dimensional) drainage networks of the individual landforms that are a potential cause for future concern. If not mitigated, a likely longer-term outcome within these areas is the development of damaging erosion gullies that extend into the encapsulated waste material.

vii. The primary cause of these "erosion hazard areas" is the localised enhancement of runoff volume, velocity, and shear stress in areas of significant topographic convergence (hillslope hollows).

viii. For situations where design landform reshaping modifications permit, shallowing the angle of convergence curvature between connecting hillslopes is required. The justifiable (maximum permissible) angle of curvature could be determined for each erosion hazard area by extension of the current modelling program.

ix. For situations where landform reshaping is not possible, additional land surface protection (beyond the CGO soil-rock matrix cover system) should be engineered and implemented (e.g., alterative soil-rock matrix cover; or rock armouring of convergent drainage pathways). However, careful consideration is required. Given the highly erodible and dispersive materials upon which such rock drains would be constructed, there is a quantifiable risk of erosion tunnelling and subsidence under the drains that may eventually lead to their collapse.

x. Legacy berm-batter landform features, largely on the lower north-facing slopes of the Southern WRD, are an identified "erosion hazard area". They introduce unnecessary long-term erosion instability on the lower slopes, which already experience higher flow accumulation / slope lengths. Reshaping of these berm-batter landform features is recommended to subsume into the (herein confirmed stable) 20% linear hillslope expanded landform design.

xi. The erosion-prone 'bullnose hillslope' profile arising from legacy (existing Southern TSF) benches on the southern batters of the proposed IWL are identified as "erosion hazard areas". Remediation landform reshaping should be undertaken to remove the bullnose transition and form a linear slope at an angle of 25% or shallower. Otherwise, an alternative sized soil-rock matrix capping lining of the erosion-prone bullnose transition zone may be designed and applied.

xii. Further 3-D erosion modelling (e.g. SIBERIA) is recommended on the 'as constructed' landforms to identify areas of elevated erosion hazard that may require remedial works.

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APPENDIX A: THE CGO SOIL-ROCK MATRIX COVER SYSTEM

The CGO soil-rock matrix cover system

In recognition that the stockpiled onsite topsoil and subsoil resources tend to be highly erodible and prone to extensive gully and tunnel erosion, CGO has enacted the recommendations of technical experts (Landloch, 2008; Gilbert and Associates, 2009)) and developed a targeted 'soil-rock matrix cover system' for use as the primary capping and growth media on the rehabilitated outer batters of its constructed landforms.

The binary soil-rock matrix cover system comprises:

- A 300 mm deep rock mulch underlay of benign (primary) competent rock (approximately <300 mm in size);
- An application of approximately 10 t/ha gypsum;
- A 300 mm deep overlay of low salinity and gypsum-treated topsoil;
- Dozer cross-ripping of the rock mulch, gypsum and topsoil to a depth of 600 mm that integrates the material into a sequence of "troughs and banks" along the contour; and
- Seeding with native and/or endemic eucalypt woodland and shrub species, including an initial cover crop of rye at a standard rate of 60 kg/ha.

Surface cover layers are laid/spread using a combination of graders, dozers and dump trucks (Fig A1). The rocks brought into the surface cover via the subsequent dozer cross ripping provide additional erosion protection and reduces surface water flow velocities on landform slopes during high rainfall events. The troughs and banks act as a physical erosion measure, at least until the vegetation can become established. Vegetation trials undertaken with the prescribed soil-rock matrix cover system demonstrate that vegetation establishment is enhanced within the troughs and in micro-sites created by larger rocks in the surface cover (Figure A2).

To further enhance the benefits of the prescribed soil-rock matrix cover system, design consideration has also been given to restricting runoff on the top of the waste landforms from being discharged onto the outer batter slopes. Drainage on the top surfaces of the landforms is managed via a series of swales and interconnecting small shallow basins (depressions). The use of depressions aims to maximise internal drainage without creating permanent ponding during normal and heavy rainfall events. A rehabilitation cover system (including gypsum-treated subsoil and topsoil) that absorbs rainfall and comprises woodland vegetation promotes internal infiltration capacity. Finally, a bund around the perimeter of the top surfaces of the landforms ensures additional redundancy in the case that extreme rainfall events circumvent the efficiency of the internal drainage system.

APPENDIX B: OVERVIEW OF MINING OPERATIONS AT CGO

Overview of Mining Operations at CGO

Mining operations for the CGO are conducted within ML 1535, while additional ancillary mining operations are conducted within ML 1791. Major components of the approved CGO are included in Figure B1 and summarized below:

- an open pit (E42);
- an underground mine (in development);
- a perimeter waste rock emplacement surrounding the eastern boundary of the open pit;
- northern, southern and central tailings facilities (TSFs), encompassed by an Integrated Waste Landform (IWL);
- a lake isolation system, including a temporary isolation bund (TIB) and a lake protection bund (LPB);
- a processing plant;
- a mineralised waste stockpile;
- low grade ore stockpiles;
- hard and soft oxide ore stockpiles;
- run-of-mine (ROM) pads;
- soil (including clay) stockpiles;
- an Internal Catchment Drainage System (ICDS) (including contained water storages);
- an up-catchment Diversion System (UCDS);
- buried water supply pipelines and associated borefields and pump stations; and
- an electricity transmission line (ETL).

The Primary Mining Domain(s) covering these operational/disturbance areas are:

- Mining Domain Code 1: Infrastructure Area, including e.g., administration facilities, workshops, access, roads, and material stockpile areas;
- Mining Domain Code 2: Tailings Storage Facility;
- Mining Domain Code 3: Water Management Area, including e.g., operational sediment dams, diversions and other significant constructed drainage features;
- Mining Domain Code 4: Overburden Emplacement Area, including North Waste Rock Emplacement, Southern Waste Rock Emplacement, and the Perimeter Waste Rock Emplacement;
- Mining Domain Code 5: Active Mining Area, including the Open cut void.

An approved final (post-mining land use) and rehabilitation management programme has been developed for each of the Primary Mining Domains (Evolution Mining Rehabilitation Management Plan, 2022). To guide the CGO rehabilitation programme several Secondary rehabilitation domains have been developed as shown in Figure B2:

- Domain A1: Native Grassland/Scattered Eucalypt Woodland attendant with Mining Domain Code 1;
- Domain A2: Native Eucalypt Woodland attendant with Mining Domain Code 2;
- Domain A3: Native Grassland/Scattered Eucalypt Woodland and Riverine Woodland/Freshwater Communities attendant with *Mining Domain Code 3*,

- Domain A4: Native Eucalypt Woodland attendant with Mining Domain Code 4;
- Domain F3: Water Management Area attendant with Mining Domain Code 3;
- Domain J5: Final Void attendant with Mining Domain Code 5.

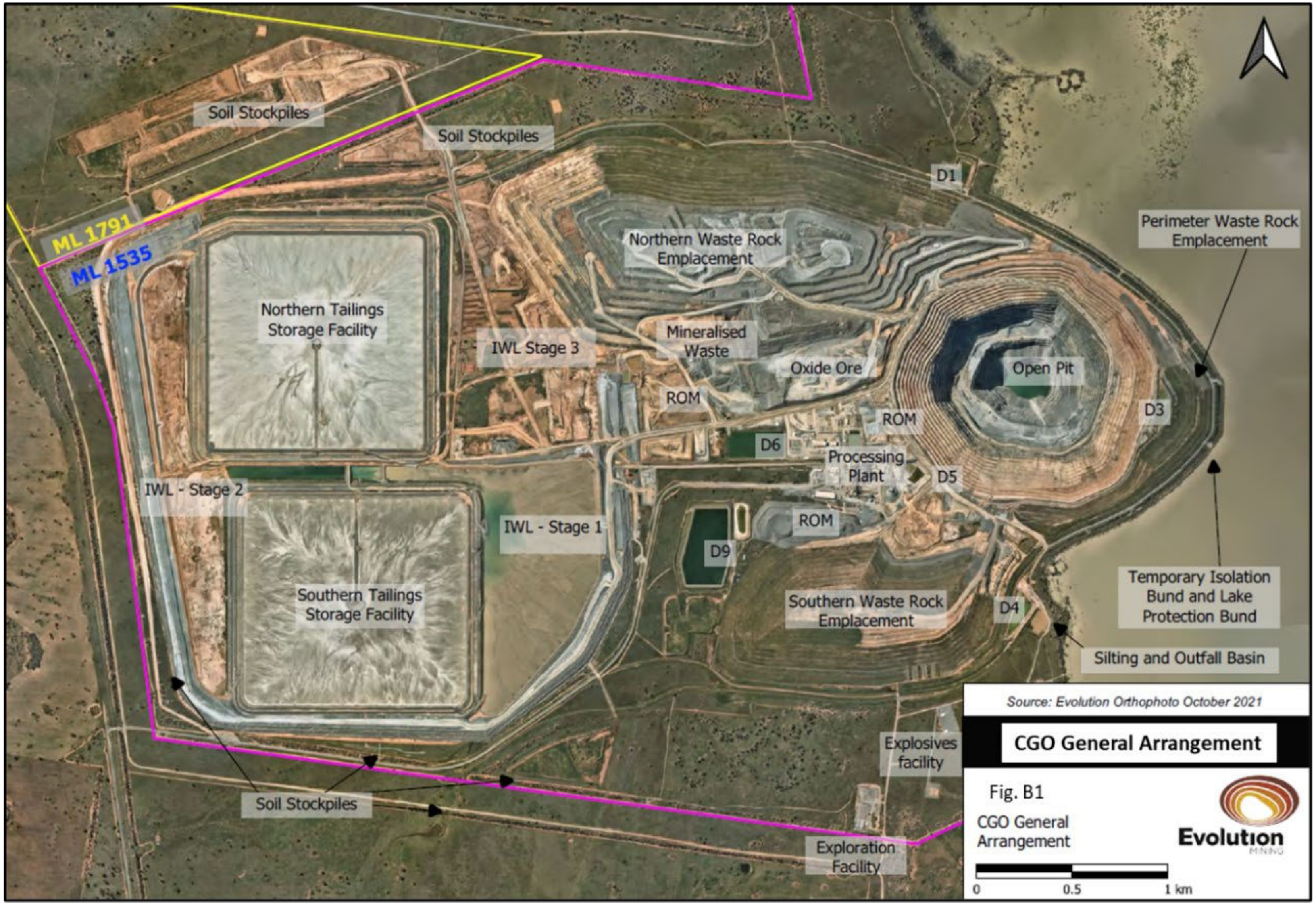


Figure B1: General arrangement of CGO mining activities (Rehabilitation Management Plan, Evolution Mining 2022).

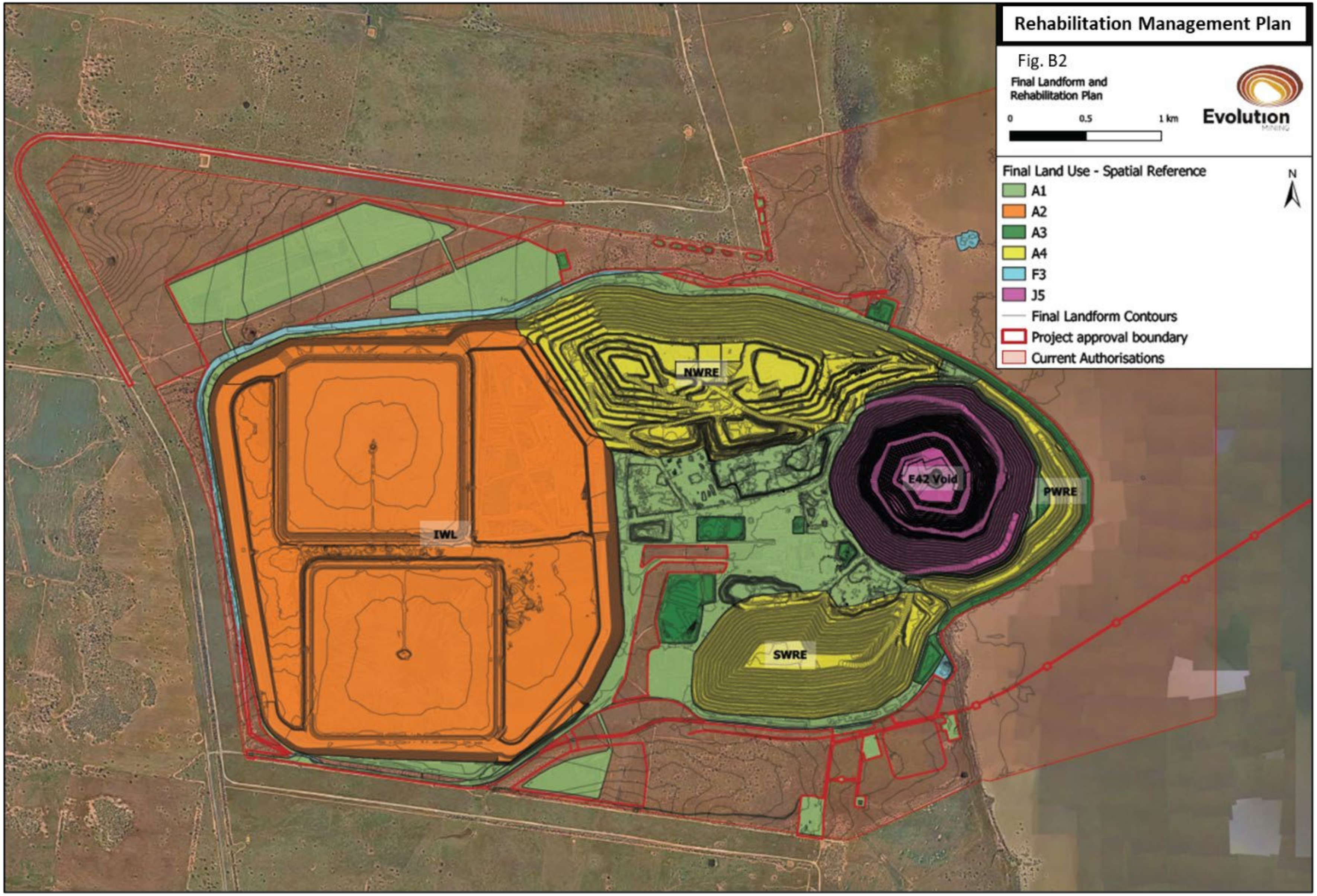


Figure B2: Final Landform and Rehabilitation Management Plan (Rehabilitation Management Plan, Evolution Mining 2022).

APPENDIX C: TABLES

Table C1: Laboratory Analysis of Soil-Rock Matrix materials.

ANALYSIS REPORT

Project Number:	EW221041
Location:	W/Lake Cowal/3407.21a
Sample Collection Date:	16/05/2022
Sample Receival Date:	24/05/2022
Sample Analysis Date:	6/02/2022
Project Contact Person:	Simon Buchanan

East West Enviroag
82 Plain St Tamworth NSW 2340
ph:02 67621733

Analyses	Unit	221041-1	221041-2	221041-3	221041-4	221041-5	221041-6
Lab No		221041-1	221041-2	221041-3	221041-4	221041-5	221041-6
Order							
Sample ID		Soil-Rock Matrix (Upper) R1	Soil-Rock Matrix (Upper) R2	Soil-Rock Matrix (Upper) R3	Soil-Rock Matrix (Lower) R1	Soil-Rock Matrix (Lower) R2	Soil-Rock Matrix (Lower) R3
Sample Depth		-	-	-	-	-	-
pH - Water	pH units	7.83	7.82	7.89	8.25	8.45	8.43
Electrical Conductivity	dS/m	0.37	0.43	0.30	1.43	1.45	1.31
Chloride	mg/kg	344	432	281	1632	1516	1526
Total Nitrogen - Kjeldahl	mg/kg	*	*	*	*	*	*
Total Phosphorus - Nitric/Perchloric	mg/kg	*	*	*	*	*	*
Phosphorus - Colwell extr	mg/kg	*	*	*	*	*	*
Potassium - Colwell ext	mg/kg	*	*	*	*	*	*
Sulphur - KCl	mg/kg	*	*	*	*	*	*
Organic Carbon	%	*	*	*	*	*	*
Copper	mg/kg	*	*	*	*	*	*
Iron	mg/kg	*	*	*	*	*	*
Manganese	mg/kg	*	*	*	*	*	*
Zinc	mg/kg	*	*	*	*	*	*
Boron	mg/kg	*	*	*	*	*	*
Cation Extraction Method	Rayment& Lyons	15A1	15A1	15A1	15A1	15A1	15A1
Cation Exchange Capacity	meq/100g	21.2	20.9	18.7	33.4	32.1	29.4
Ex Calcium Percent	%	48.34	46.85	47.11	53.41	56.86	59.19
Ex Magnesium Percent	%	32.44	31.99	33.08	21.91	19.75	18.76
Ex Potassium Percent	%	5.18	5.57	5.95	2.24	2.17	1.86
Ex Sodium Percent	%	14.0	15.5	13.8	22.4	21.2	20.1
Ex Aluminium Percent	%	0.05	0.05	0.06	0.03	0.03	0.04
Exchangeable Calcium	mg/kg	2049	1955	1766	3567	3646	3486
Exchangeable Magnesium	mg/kg	825	801	744	878	760	663
Exchangeable Potassium	mg/kg	428	453	435	292	271	214
Exchangeable Sodium	mg/kg	682	746	595	1720	1562	1364
Exchangeable Aluminium	mg/kg	1.00	1.00	1.00	1.00	1.00	1.00
Exchangeable Calcium	meq/100g	10.25	9.78	8.83	17.84	18.23	17.43
Exchangeable Magnesium	meq/100g	6.88	6.68	6.20	7.32	6.33	5.53
Exchangeable Potassium	meq/100g	1.10	1.16	1.12	0.75	0.69	0.55
Exchangeable Sodium	meq/100g	2.97	3.24	2.59	7.48	6.79	5.93
Exchangeable Aluminium	meq/100g	0.01	0.01	0.01	0.01	0.01	0.01
Calcium/Magnesium Ratio	-	1.5	1.5	1.4	2.4	2.9	3.2
Cation Extraction Method	Rayment& Lyons	15C1	15C1	15C1	15C1	15C1	15C1
Cation Exchange Capacity	meq/100g	12.5	11.7	14.4	12.0	10.5	14.7
Ex Calcium Percent	%	49.04	49.11	47.75	42.06	45.62	43.29
Ex Magnesium Percent	%	35.55	34.78	35.08	34.84	34.31	34.91
Ex Potassium Percent	%	4.09	4.50	5.09	2.37	2.60	2.19
Ex Sodium Percent	%	11.23	11.51	12.00	20.64	17.36	19.55
Ex Aluminium Percent	%	0.09	0.10	0.08	0.09	0.11	0.08
Exchangeable Calcium	mg/kg	1230	1146	1377	1010	962	1269
Exchangeable Magnesium	mg/kg	535	487	607	502	434	614
Exchangeable Potassium	mg/kg	200	205	286	111	107	125

Table C1 (cont): Laboratory Analysis of Soil-Rock Matrix materials.

Exchangeable Sodium	mg/kg	324	309	398	570	421	659
Exchangeable Aluminium	mg/kg	1.00	1.00	1.00	1.00	1.00	1.00
Exchangeable Calcium	meq/100g	6.15	5.73	6.89	5.05	4.81	6.35
Exchangeable Magnesium	meq/100g	4.46	4.06	5.06	4.18	3.62	5.12
Exchangeable Potassium	meq/100g	0.51	0.53	0.73	0.28	0.27	0.32
Exchangeable Sodium	meq/100g	1.41	1.34	1.73	2.48	1.83	2.87
Exchangeable Aluminium	meq/100g	0.01	0.01	0.01	0.01	0.01	0.01
Calcium/Magnesium Ratio	-	1.4	1.4	1.4	1.2	1.3	1.2
Gravel >2.0mm	%	*	*	*	*	*	*
Coarse Sand 0.2-2.0mm	%	*	*	*	*	*	*
Fine Sand 0.02-0.2mm	%	*	*	*	*	*	*
Silt 0.002-0.02mm	%	*	*	*	*	*	*
Clay <0.002mm	%	*	*	*	*	*	*
ADMC	%	7.4	8.0	2.9	7.3	10.9	5.9
Emerson Aggregate	Class	3a	3b	3b	4.0	4.0	4.0
Phosphorus Buffer Index	mg/kg	*	*	*	*	*	*
Field Texture	-	*	*	*	*	*	*
Gravel & Rock >200mm	%	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Gravel & Rock 150-200mm	%	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Gravel & Rock 100-150mm	%	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Gravel & Rock 75.0-100mm	%	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Gravel & Rock 63.0-75.0mm	%	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Gravel & Rock 19.0-63.0mm	%	17.2	<0.1	1.7	20.2	28.2	7.2
Gravel & Rock 6.7-19.0mm	%	4.3	1.0	3.1	14.6	11.6	8.5
Gravel 2.36-6.7mm	%	3.5	1.8	1.0	6.9	9.2	14.9
Coarse Sand 0.2-2.0mm	%	0.4	2.4	0.5	2.9	2.3	1.8
Fine Sand 0.1-0.2 mm	%	14.1	19.5	17.0	14.7	15.6	19.3
Very Fine Sand 0.02-0.1 mm	%	27.2	30.8	33.3	16.0	13.4	21.1
Silt 0.002-0.02mm	%	10.8	13.8	13.0	6.0	5.4	8.4
Clay <0.002mm	%	22.4	30.6	30.3	18.7	14.3	18.7

APPENDIX D: TESTING PHOTOGRAPHS

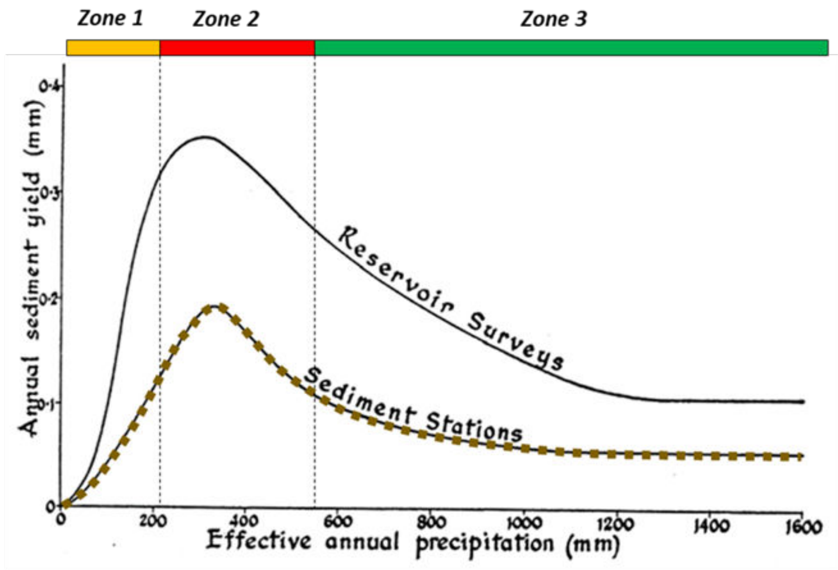
Photograph D1: Soil-Rock matrix prior to being subjected to simulated rainfall.

Photograph D2: Soil-rock Matrix after being subjected to simulated rainfall.

Photograph D3: Soil-rock matrix prior to being subjected to simulated overland flow.

Photograph D4: Soil-rock matrix undergoing simulated overland flow testing.

APPENDIX F: SEMI-ARID RAINFALL AND EROSION RELATIONSHIPS



Zone 1 : Low erosion potential due to low annual rainfall

Zone 2 : High erosion potential due to limiting annual rainfall needed to support significant vegetation cover

Zone 3 : Low erosion potential due to sufficient annual rainfall to support high vegetation cover

Figure F1: Relationship between annual rain and erosion – USA data for natural catchments (Kirby, 1969).

APPENDIX G: ADDITIONAL SIBERIA OUTPUT IMAGES

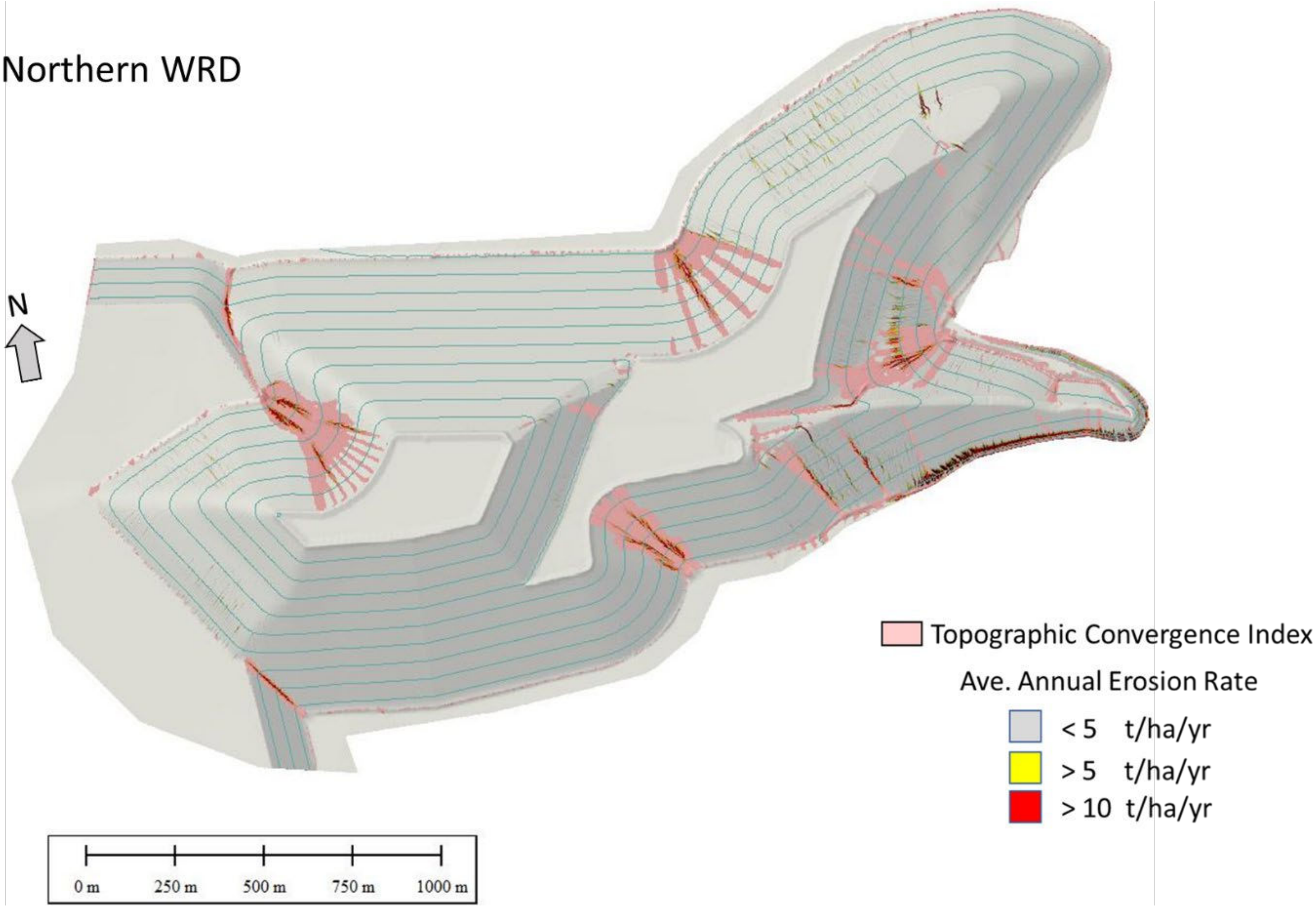


Figure G1: CGO Northern WRD - Spatial coherence between areas of topographic convergence (hillslope hollows) and "erosion hazard areas" (>5-10 t/ha/yr).

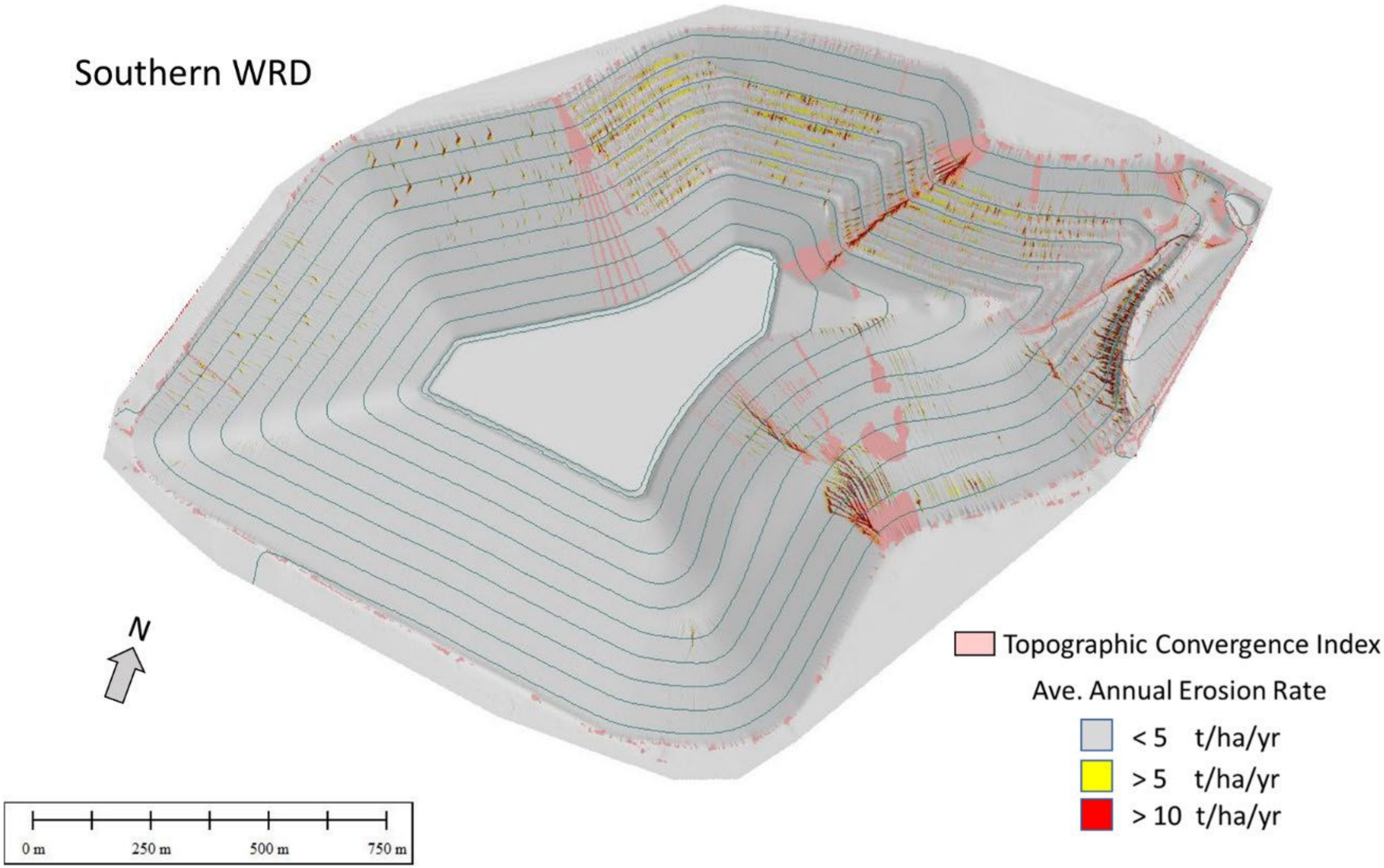


Figure G2: CGO Southern WRD - Spatial coherence between areas of topographic convergence (hillslope hollows) and "erosion hazard areas" (>5-10 t/ha/yr).

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B.1 Attachment Heading

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