Department of **Energy, Mines, Industry Regulation and Safety**

GOVERNMENT OF WESTERN AUSTRALIA

Draft

Guideline for preparing Mine Closure Plans

May 2024

Document Hierarchy for mine closure plans under the *Mining Act 1978*

Legislation	*Mining Act 1978* Mining Regulations 1981
Policy	Environmental Regulatory Strategy Environmental Objectives Policy for Mining
Guidelines	**This Document** Technical Guidance: *A framework for developing mine-site completion criteria in Western Australia (2019)*. The Western Australian Biodiversity Science Institute, Perth, Western Australia. Guidance: *Mine Closure Completion Guideline – For demonstrating completion of mine closure in accordance with an approved Mine Closure Plan (November 2021)*
Procedures	Environmental Applications Administrative Procedures

Version History

Version	Date	Changes
0.1	*2024*	Draft guidance released for stakeholder consultation

Table of Contents

PURPOSE

The purpose of this guideline is to assist applicants in preparing mine closure plans in accordance with the *Mining Act 1978* (Mining Act) and the Mining Regulations 1981 (Regulations).

For consultation purposes, Appendices 1 – 6 have been included within the guideline for stakeholder consideration and feedback, however, it is DEMIRS' intention that some of these Appendices will be removed from the finalised guideline and published separately as bespoke papers to complement the MCP Guideline.

OPERATION

This guideline takes effect from the date that amendments introduced by the *Mining Amendment Act 2022* (Amendment Act) become operational.

OBJECTIVES

The Department of Energy, Mines, Industry Regulation and Safety (DEMIRS) is responsible for regulating mineral exploration and development activities in Western Australia (WA) under the *Mining Act 1978* (Mining Act).

The objective of this guidance document is to clearly identify DEMIRS' expectations of the information required in a mine closure plan to ensure that:

- Applicants can demonstrate that a mining operation is being managed in a way that will meet DEMIRS' objective for rehabilitation and closure (*mining activities are rehabilitated and closed in a manner to make them physically safe to humans and animals, geo-technically stable, geo-chemically non-polluting/non-contaminating, and capable of sustaining an agreed post-mining land use without unacceptable liability to the State*).
- Mine closure plans submitted to DEMIRS meet the requirements set out in the Mining Act and Regulations.
- Mine closure plans received are of a high quality and provide sufficient detail on relevant factors.
- Requests for further information are minimised.
- There is transparency around the rehabilitation and closure expectations of DEMIRS for the mining industry and community.

Consistent with industry leading practice, this guidance document is based on the principle that planning for mine closure should be an integral part of mine development and operations planning and should start "up front" as part of mine feasibility studies. DEMIRS recognises that closure planning is a progressive process and that mine closure plans are evolving documents which undergo ongoing review, development, and continuous improvement throughout the life of mine.

DEMIRS recognises that not all technical information will be available at the early stages of development, however knowledge gaps relating to closure specific matters are expected to be listed in the initial mine closure plan and then refined/developed in future iterations. At all stages, DEMIRS expects mine closure plans to demonstrate, based on reliable science-based and appropriate site-specific information, that ecologically sustainable closure can be achieved. A recommended guide that assists understanding of the detail expected to be known at each stage of mining is shown in the ICMM *Closure Maturity Framework* (ICMM 2022).

Further information on mine closure planning is detailed in Appendix 1.

SCOPE

This document relates to mine closure plans submitted pursuant to section 103AT of the (amended) Mining Act.

The Mining Act defines a mine closure plan as a planning and reporting document that provides for:

- Decommissioning of a mine
- Rehabilitation of the land
- Closure outcomes
- Any other prescribed information

This guidance is for mine closure plans associated with any operation that does not qualify for DEMIRS' *Small Mining Operations* status.

Form and Content of a Mine Closure Plan

The content requirements of a mine closure plan will be prescribed in the Regulations. This guideline details the information to be provided to ensure requirements of the Mining Act and Regulations are met.

The level of information contained in a mine closure plan should be reflective of the stage of mine development (i.e. planning and design/approvals, construction, operations, decommissioning, post-closure maintenance and monitoring), with detail increasing as the mine moves towards closure.

As the planning of mine closure progresses, the level of detail presented in a mine closure plan should increase to eventually evolve into fully formed plan that facilitates execution of mine closure (ICMM 2019). Specific guidance on the level of detail expected in a mine closure plan as the mine approaches closure is described in Appendix 4.

1. Description of Mining Operation

The mine closure plan must include an up-to-date description of the mining operation (historical and current) and detailed map(s) of the location of the mining operation.

An estimated mining operation completion date/life of mine must be included.

This section should provide background information on the history and status of the site, including proposed and existing mining operations. This section is particularly helpful to understand any historical activity that has occurred and potential closure impacts from historical activity. A tenement summary should be provided which summarises the mining activities on each tenement.

Table 1. Example Tenement and mining activities summary table.

Tenement	Total Activity Area (ha)	Approved Activities
L23/9999	*29.15*	*Pipeline, Road*
M64/9999	*359.23*	*Mining Pits, workshop, WRD, Process Plant*

Maps should show all relevant mine activities, land disturbances, tenements and other land tenure. They should be set at an appropriate scale and provide context of how the operation fits with its local surroundings, illustrating where the mining operation occurs relative to surrounding features such as catchments, local communities, nearby mining operations, pastoral stations, other infrastructure, topographical features, water bodies or features. Environmentally significant features and heritage features should also be included.

2. Identification of Closure Obligations and Commitments

The mine closure plan must detail all legal obligations for rehabilitation and closure that will affect the post-mining land use and closure outcomes and provide this in a suitable format, usually referred to as a Legal Obligations Register. The rehabilitation and closure register should form part of the operator's overarching legal register for all mining activities on the site.

The register needs to include all legally binding conditions and commitments and/or legal obligations for rehabilitation and closure that are applicable under relevant state and federal legislation. The register should also include references to individual tenement conditions, mining proposals, notices of intent (NOI), letters of intent (LOI), and all other legally binding documents. An example of a legal obligations register is provided below.

Table 2. Example of a Legal Obligations Register.

LEGAL OBLIGATIONS REGISTER				
Relevant DEMIRS Approvals Statement or Tenement Conditions				
Tenement	**Condition Number**	**Closure Condition**	**How Obligation Included in Closure Strategy / MCP**	**Complete (If applicable)**
L23/9999	*12*	*All topsoil and vegetation being removed ahead of all mining operations and being stockpiled appropriately for later respreading or immediately respread as rehabilitation progresses.*	*Topsoil locations provided along with volumes available for use in rehabilitation.*	
M64/9999	*23*	*Placement of waste material must be such that the final footprint after rehabilitation will not be impacted upon by pit wall subsidence or be within the zone of pit instability. ……*	*Included in completion criteria. Abandonment Bund locations illustrated in Figure X with WRD locations marked on them*	
Ministerial Statement – (No and Date)				
Item Number		**Closure Condition, Commitment or Aspect Related to Closure**	**How Obligation Included in Closure Strategy / MCP**	**Complete (If applicable)**
Works Approval – (No and Date)				
Tenement		**Closure Condition or Aspect Related to Closure**	**How Obligation Included in Closure Strategy / MCP**	**Complete (If applicable)**
***Environmental Protection Act 1986* Licence: (No and Date) Category:**				
Number		**Aspect Related to Closure**	**How Obligation Included in Closure Strategy / MCP**	**Complete (If applicable)**
Licence to Take Water GWL – (No and Date)				
Tenement	**Item Number**	**Closure Condition or Aspect Related to Closure**	**How Obligation Included in Closure Strategy / MCP**	**Complete (If applicable)**
DEMIRS Approvals – NOI / Mining Proposal / MDCP / MCP – (No and Date)				
Item Number or Page Number		**Closure Commitment or Aspect Related to Closure**	**How Obligation Included in Closure Strategy / MCP**	**Complete (If applicable)**

The register may also include the safety or stakeholder obligations (and non-legally binding commitments) pertaining to closure. The register provides a valuable tool when setting completion criteria, as environmental commitments can be cross referenced.

Compliance with closure outcomes and relevant tenement conditions is an unconditional requirement for the government's acceptance prior to closure completion. At closure, this tool can be used as a checklist to demonstrate that all conditions, commitments and obligations have been met.

3. Baseline Data, Analysis and Implications for Closure

The mine closure plan must include a description of the existing environment (baseline data) and an analysis and interpretation of the baseline data.

Analysis and interpretation of the baseline data should describe how the wider receiving environment, receptors and exposure pathways have been considered, and identify the knowledge gaps and the risk of not having that information.

Details of the methodology used to analyse the baseline data should be provided and all relevant technical reports attached as appendices.

The collection and analysis of baseline data is an important component of closure planning as it:

- Builds on knowledge available at the initial approvals stage.
- Informs successful rehabilitation and closure.
- Identifies the issues to be managed through the mine closure process and the environmental closure risks.
- Informs the development of criteria or indicators for closure monitoring and performance.
- Informs the establishment of achievable closure outcomes and goals in a local and regional context.
- Establishes baseline conditions for closure monitoring programs.

Baseline studies and collection of environmental data should be undertaken prior to commencement of mining operations and continue through the life of the operation to adequately characterise pre-mining conditions and changes that occur during mining operations.

Before closure issues can be managed, they need to be identified through the collation of relevant closure data. Where applicable, collection and analysis of closure data must be planned for, studies designed and then implemented to meet the following minimum requirements:

- use of recognised or acceptable methodologies and standards, and
- consideration of the wider receiving environment, receptors and exposure pathways.

From a closure planning perspective, information from baseline studies undertaken prior to the commencement of mining operations, and from ongoing studies, is necessary. It is important that the collection and analysis of environmental data is continued and expanded throughout the project life and the mine closure plan updated accordingly. For each mine closure plan revision, data from research, field trials and investigations should be updated, and re-analysed to identify the spatial and temporal variations in the surrounding environments. This will assist in the refinement of closure outcomes and completion criteria, and the setting of indicators for management intervention.

The mine closure plan should provide a summary of the best available data on aspects of the physical and biological environments, as well as the social and economic aspects (where relevant) that are critical for successfully meeting mine closure outcomes. The following information should be included (where relevant and as determined by the impact assessment):

- Local climatic conditions and projected future climate profile for the area.
- Local physical conditions – topography, geology, hydrogeology, hydrology, seismicity and geotechnical data.
- Soil and waste materials characterisation – soil structure and stability (e.g. erodibility), growth medium type and block modelling of waste materials, solubility, mobility and bioavailability of hazardous materials (e.g. radioactive materials, heavy metals and materials with potential to produce contaminated drainage).
- Local and regional environmental information on flora, fauna, ecology and habitats.
- Local water resource details – type, location, extent, water quality, quantity and environmental values (ecological and beneficial uses).
- Social setting, affected communities and heritage (including natural, cultural or historic).

Under each topic the following information should be provided:

- List of completed technical studies, presented in table format similar to Table 3 below.
- Analysis of technical studies and implications for rehabilitation and closure.
    - Analysis should include a description of matters relevant to closure of the mining operation (e.g. predicted long term environmental conditions and the considerations for long term landform design).

Table 3. Example Technical studies table.

Baseline Subject	Document Reference (Including consultant / date)	Updated since last MCP or MDCP submission? YES / NO	Linked Appendix

3.1 Materials characterisation

Comprehensive physical and geo-chemical characterisation of materials (including soils, remaining ore product to be left at closure, tailings, and all other mine waste) is critical to effective closure planning and successful progressive rehabilitation. This process should start during the exploration phase and continue throughout the life of the mine.

Characterisation of materials allows for separation and selective placement of materials considered beneficial to rehabilitation and appropriate management of materials that may inhibit rehabilitation or cause detrimental effects. Beneficial aspects may include capping materials, alternative growth media or competent materials for bund construction.

Materials properties impacting rehabilitation may include those that exhibit dispersivity or otherwise physically unstable, geochemically reactive (e.g. PAF), highly saline, and any other toxic or harmful materials (e.g. asbestiform, radioactive).

Guidance on DEMIRS expectations for waste characterisation studies and how to present the information is presented in the Mine Development and Closure Guidelines. Further useful reading includes AMIRA 2002, DIIS 2016, INAP 2014 and MEND 2009.

Adequate characterisation of all materials is critical to the identification of rehabilitation materials, and management of closure issues and should include the delineation of materials properties such as:

- Soil structure and stability (e.g. erodibility).
- Growth medium type and block modelling of waste materials.
- Solubility, mobility and bioavailability of geochemically reactive or harmful substances (e.g. metals/metalloids/acidity).
- Materials with potential to produce contaminated drainage (e.g. acid-generating or sulfidic mineral waste).
- Sodic materials.
- Radioactive and asbestiform materials.

Operators should estimate the location of problematic materials and the volume that may be disturbed during operations. Materials characterisation should also be carried out for the materials intended for use in mine rehabilitation activities so that the physical, chemical and nutrient characteristics of the material are understood and evaluated to ensure it will perform according to planning expectations.

The volumes of rehabilitation materials required to fulfil closure strategies should be reconciled against available materials to ensure sufficient quantities are available for use in rehabilitation.

Validation of the predictions for materials characterisation should occur during all phases, particularly as the operation matures. Validation must include the presence of problematic materials, the properties, volumes, and placement locations. This validation would include any implications to closure and changes required to procedures or designs as a result of the validation outcomes.

3.2 Contaminated sites

Contamination in Western Australia is primarily regulated under the *Contaminated Sites Act 2003,* however the mine closure plan should consider and manage contamination over the life of mine so that the agreed post mining land use(s) can be met. The mine closure plan should demonstrate preventative strategies during operations that will be employed to manage the risk of contamination and contaminated sites at closure.

To ensure compliance with the *Contaminated Sites Act 2003* and Contaminated Sites Regulations 2006, closure strategies should be designed to incorporate investigation and remediation of contamination.

3.3 Other Closure-related Data

Other available information should be collated and referred to throughout mine closure planning with the objective of building a “base” of information or knowledge important to the closure of a particular landform or infrastructure.

Such information could include:

- Learnings from closure experience generated from other mines.
- Spatial datasets and databases.
- Design and construction of landforms and voids, including diagrams or maps showing the final landform design concept based on the post-mining land use(s), to illustrate in visual form (e.g. a 3D diagram/map or a cross-sectional diagram/map).
    - what the surrounding landscape and the final landforms will look like post-closure.
    - the long-term geotechnical stability of the final landforms post-closure.
- Availability and volumes of key materials required for rehabilitation such as competent waste rock, subsoil, topsoil and low-permeability clays (i.e. encapsulation material).
- Relevant scheduling information with respect to material stockpiling and deployment to ensure that rehabilitation materials mined early in the process are appropriately segregated and preserved for later use.
- Mathematical models to predict long term performance or environmental impacts.
- Seed mixes used in rehabilitation and any information gathered from trials, and
- Summarised results of closure and rehabilitation monitoring that has occurred to date, with the implications to closure identified.

All technical reports should be referenced in the mine closure plan, with relevant reports provided as appendices as appropriate.

3.4 Data Analysis and Implications for Mine Closure

Analysis of collected data is a critical element in understanding the issues affecting mine closure and identifying knowledge gaps. Analysis should identify issues emanating from the closure data, in order to allow for proposed solutions and setting of appropriate and achievable closure outcomes and completion criteria.

Knowledge gaps should be summarised a table such as the example provided in Table 4 below, and the risk of not having this information should be analysed. This will enable the information gaps to be prioritised and acted upon appropriately.

The knowledge gap register should identify actions needed to close the gap, ownership, and a schedule for actions. DEMIRS advises that "*Prior to closure*" is not a valid date for actions.

Table 4: Example Knowledge Gap Register

KNOWLEDGE GAPS REGISTER						
Knowledge Gaps from the last MDCP / MCP						
#	**Section of the MCP**	**Knowledge Gap**	**Planned Action**	**Action Owner Title / Role**	**Timing for Completion**	**Progress**
1	*Chapter 4 Baseline Data*	*Results of monitoring to date not known*	*a. Summarise monitoring data to date*	*Environment Advisor*	*December 2022*	*Complete*
			b. Assess the implications for closure from the monitoring results	*Environment Manager*	*December 2023*	*In progress*
2	*Chapter 4.3 Contaminated Sites*	*Extent of contamination around the old Pit ABC fuel facility*	*Undertake a Contaminated Sites Preliminary Site Investigation at Pit ABC fuel facility area*	*Environment Manager*	*August 2023*	*Complete*
New Knowledge Gaps Identified						
#	**Section of the MCP**	**Knowledge Gap**	**Planned Action**	**Action Owner Title / Role**	**Timing for Completion**	**Progress**
1	*Chapter 7.7 PAF*	*Unknown quantity and location of PAF material in WRD 6*	*Drilling of WRD6 to identify locations and estimate the volumes of PAF materials*	*Mining Manager*	*December 2023*	
2	*Chapter 7.7 Materials Balance*	*Topsoil and alternative growth materials volumes unknown*	*Materials surveyed for inclusion in site-wide materials balance*	*Technical Services – Senior Surveyor*	*January 2024*	
3	*Chapter 4.3 Contaminated Sites*	*Removal of contamination around the old Pit ABC fuel facility*	*Arrange for Contaminated materials at Pit ABC fuel facility area to be excavated and placed in the bio-remediation area*	*Mining Manager*	*November 2023*	

Where applicable, data analysis should consider the natural background levels of particular elements (such as naturally occurring radioactive materials or metals) and possible environmental impacts from other sources including nearby mining operations and other land uses which may affect the closure strategy or management of the site.

Results from monitoring undertaken during the life of mine should be analysed to identify any implications for closure. As an example, where monitoring of rehabilitation identifies erosion as an issue, the mine closure plan should consider implications for the design parameters for landforms or the use of berms/bunds, etc.

Analysis should also include consideration of the operation in relation to its spatial context. For example:

- Will rehabilitated areas be representative of surrounding undisturbed native vegetation, or will there be limitations?
- Will waste rock landforms be stable long-term, require ongoing management, or will design changes be required?
- Will landforms be analogous to the pre-mining environment, or how will they fit into the local landscape?
- How will impacts to sensitive receptors be minimised?

4. Stakeholder Engagement

The mine closure plan must include up-to-date information on the engagement that has been undertaken with stakeholders relevant to rehabilitation and mine closure and a strategy for ongoing engagement.

The stakeholder engagement strategy should set out how an operator will identify stakeholders, the level of engagement each stakeholder requires, how engagement will be undertaken and documented, and what outcomes for closure are discussed and agreed upon. The strategy should be reviewed periodically to ensure that the required outcomes for engagement are occurring and updated where required.

4.1 Stakeholder Engagement Register

A summary of stakeholder engagement can be provided in the mine closure plan but should be supported by a detailed stakeholder engagement register in the appendices. A stakeholder engagement register should include:

- Identification of who the stakeholders were.
- Date of engagement.
- Description of the nature of the engagement and level of information provided to stakeholders.
- Comments and issues raised by stakeholders.
- Operator response to concerns raised.
- Stakeholder response to the proposed resolution.

An example stakeholder engagement register is shown in Table 5.

Table 5. Example Stakeholder engagement register.

Stakeholder Engagement Register					
Date of each Engagement	**Description of Engagement**	**Stakeholders (Include name and/or titles)**	**Stakeholder comments/issue (Reference)**	**Proponent Response and/or resolution**	**Stakeholder Response**
03/03/2023	*Quarterly meeting*	*Traditional owners: Mr J. Smith Mrs O. Jones Proponent: Mr Y. Ulrich (Operations Manager)*	*Concern regarding impacts to water quality and quantity in a nearby spring*	*Monitoring quality and quantity of the spring water to be undertaken. Remedial action as required. Traditional owners kept informed of results.*	*Acceptable*
27/06/2023	*Meeting to discuss potential post-mining land uses*	*Pastoralist neighbour: Mr S. Thomas Proponent: Miss C. Grey (Environment Manager)*	*Concerns about any hole or pit to be left behind after mining*	*Will include in closure design and provision practical measures to make safe (to humans and animals) any hole or pit left after mining*	*Acceptable*

The names and/or titles of participants in the consultations is important where personnel turnover may impact on the corporate knowledge or the key stakeholder participants change.

Key decisions or outcomes determined through stakeholder engagement should be appropriately documented (e.g. minutes of meetings) and referenced in the mine closure plan. Depending on the quality and effectiveness of stakeholder engagement information provided, DEMIRS may contact stakeholders to verify statements made in the register.

5. Post Mining Land Use(s)

The mine closure plan must identify the proposed post-mining land use and demonstrate how the post-mining land use is:

- relevant to the environment in which the mine will operate or is operating.
- achievable in the context of post-mining land capability.
- acceptable to the key stakeholders, and
- ecologically sustainable in the context of the local and regional environment.

Where possible, proponents are encouraged to consider applying resources to achieve improved land management and ecological outcomes on a wider landscape scale, as well as the potential for multiple land uses.

DEMIRS acknowledges that end land uses may change over time, as more information is acquired through progressive rehabilitation, further consideration of post mining land use options and continued stakeholder engagement. Where appropriate the mine closure plan should detail any proposed changes to the post mining use that are being considered and the reasons for the proposed change. Agreement of the post mining land use with key stakeholders is an essential aspect as the operation nears closure. It is DEMIRS expectations that the post mining land use is accepted by key stakeholders as the operation approaches the decommissioning phase (generally 2 years prior to cessation of operations).

The mine closure plan should identify all potential (or pre-existing) environmental legacies (including contaminated sites) that may restrict post-mining land use options. Early engagement and agreement with key stakeholders where residual liabilities will be left at closure is essential, particularly as to how these will be managed considering land tenure, access and post-closure risk management.

For further guidance refer to the Western Australian Biodiversity Science Institute, *A framework for developing mine-site completion criteria in Western Australia* (2019).

6. Closure Risk Assessment

The mine closure plan must include an environmental closure risk assessment that:

- Identifies all of the environmental risk pathways relevant to the decommissioning and closure of a site.
- Identifies appropriate management strategies to be applied to minimise the environmental impacts of each identified risk pathway.
- Evaluates these risks using DEMIRS standardised risk framework.

The standardised risk assessment framework is presented in Appendix 3 of the Mine Development and Closure Proposal Guidelines. It is intended that the same risk assessment framework is used for both the Mine Development and Closure Proposal and the mine closure plan.

The risk assessment presented in the mine closure plan must cover all relevant risk pathways related to rehabilitation and closure. Where appropriate, these may be carried over from an existing Mine Development and Closure Proposal, however, it is expected that the risk assessment is updated over the life mine as further information is gathered, and knowledge gaps are addressed.

In determining relevant closure risks, consideration should be given to all the risk that will occur in progressive rehabilitation, decommissioning and temporary closure phases. When applying the risk assessment framework all factors and consequences are relevant and should be considered.

The outcome of the risk assessment should be presented in a risk register and included in the mine closure plan.

6.1 Identification of closure risks

The mine closure plan must identify closure risks and their potential environmental impacts post-mining and must propose workable management mechanisms. This will allow strategies, mitigation measures and closure designs to be developed and refined, assessed, and reviewed in the years leading up to closure and will address standard or site-specific management of inherent risks as well as identifying any continuous improvement actions.

This process should be integrated with stakeholder engagement and take into account stakeholder concerns and learnings from previous experience.

Depending on the size and complexity of the project, detailed information on the key closure risks and proposed management mechanisms may be presented for the project/site in its entirety or broken down into domains or features (Section 8.1).

Examples of risk pathways that should be included in a mine closure plan, where appropriate, include:

- Access following closure (both human and fauna).
- Impacts to flora, fauna, water systems (surface and ground water) post closure.
- Impacts from materials characteristics (chemical and physical).
- Climatic impacts.
- Cultural values potential impacts.
- Financial (cost to close, sterilisation, premature closure, etc)

Further guidance on closure related risks is presented in Appendix 2.

6.2 Risk Assessment Implications for Mine Closure

Following the risk assessment, it is critical to understand the issues affecting mine closure and identifying any knowledge gaps. Knowledge gaps need to be included in the knowledge gap register and the risk of not having this information be analysed. This will enable the information gaps to be prioritised and acted upon appropriately.

7. Closure Outcomes and Completion Criteria

The mine closure plan must include:

- Closure outcomes.
- Completion criteria that are capable of demonstrating achievement of the closure outcomes.

It is recommended this information is presented in table format (Table 6)

Table 6. Table detailing the closure outcomes that will be achieved along with the associated completion criteria and monitoring.

#	Closure Outcomes	Domain	Risk Pathway	Completion Criteria	Performance Indicator(s) (if required)	Monitoring
1						
2						

7.1 Closure Outcomes

Closure outcomes are defined under the *Mining Amendment Act 2022* as the outcomes, objectives or goals to be achieved at the completion of the decommissioning of a mine, and the rehabilitation of the land, in respect of which a tenement is granted.

These outcomes must be consistent with the post-mining land use(s), reflecting environmental values, and must be specific to provide a clear indication to Government and the community on what the proponent commits to achieve at closure.

If an Approvals Statement exists for the site, the mine closure plan should include the closure outcomes recorded on the statement. For operations that don't yet have an Approvals Statement, the mine closure plan should include the closure outcomes and completion criteria from the most recent approved mine closure plan.

Where variations to closure outcomes recorded on an Approvals Statement are proposed, a request must be submitted to DEMIRS to vary the outcomes via a Mine Development and Closure Proposal. This request must be supported by suitable evidence to justify the proposed changes.

7.2 Completion Criteria

Completion criteria are necessary to demonstrate the success of rehabilitation and mine closure and the achievements of closure outcomes. They should be developed in consultation with key stakeholders, including DEMIRS, and should align to the phase of the project.

Completion criteria should follow the S.M.A.R.T principle and be:

- Specific enough to reflect a unique set of environmental, social and economic circumstances.
- Measurable to demonstrate that rehabilitation is trending towards analogue indices (note avoid the use of terms such as 'significant', 'minimises' or other phrases that cannot be measured).
- Achievable or realistic so that the criteria being measured are attainable but set to reflect analogue sites.
- Relevant to the outcomes that are being measured and the risks being managed and flexible enough to adapt to changing circumstances without compromising outcomes.
- Time-bound so that the criteria can be monitored over an appropriate time frame to ensure the results are robust for ultimate closure completion.

Once established and agreed to by the relevant regulators, the completion criteria (and associated performance indicators) will form the basis on which mine closure performance is measured and reported to Government (and the community where applicable).

Development of completion criteria and associated performance indicators should commence at the project approval stage and be refined in mine closure plan revisions to respond to monitoring, research and trial information and any other information or change as appropriate.

The identified completion criteria and associated performance indicators must be able to demonstrate that rehabilitation is progressing as anticipated, particularly where numerical modelling is utilised to predict long term (usually in the order of 300 years or longer) environmental performance for such structures as waste rock landforms. Where applicable, details on the numerical modelling used, including assumptions and limitations, should be provided as an appendix to the mine closure plan.

The Western Australian Biodiversity Science Institute's (WABSI), *A framework for developing mine-site completion criteria in Western Australia* (WABSI, 2019) establishes a methodology that links the post-mining land uses to the DEMIRS closure outcomes (note - referred to as *closure objectives* by WABSI), reference sites, and attributes to the completion criteria and to subsequent monitoring. Utilising this format will achieve the required links between these important closure aspects through:

- Post-mining land use.
  - is informed by stakeholder's views and agreed by key stakeholders.
  - is achievable (considers land capability and tenure).
  - all PMLU options considered are discussed (choices are justified), and
  - environmental and social values are evaluated alongside economics.
- closure outcomes (or WABSI objectives).
  - must be compatible with the PMLUs and agreed by DEMIRS.
  - identify aspects such as environmental, social, cultural / heritage, landform stability, and liabilities - risk based, key to achieving PMLU, safety, or requested by stakeholders.
  - each aspect has one or more closure outcomes, clearly states a commitment, and
  - closure outcomes need to be realistic, achievable, relate to the PMLU, and agreed.
  - references inform the performance measure and target range for completion criteria.
  - references are established in early stages of mining, e.g. baseline conditions and analogue sites.
  - references include comparative natural sites, research and trials (evidence-based), or benchmarking, and
  - the processes used to select references is documented and decisions justified in the mine closure plan.
- attributes are required to form specific completion criteria.
  - these are parameters (quantifiable), tasks (verifiable), or other indicators that are used to define completion criteria.
  - the WABSI Framework provides attribute examples according to aspects such as water and drainage, waste, stability, soil fertility and surface profile, flora and vegetation, fauna, ecosystem function and social / economic aspects, and
  - attribute risk-based prioritisation considers criticality to achieve an outcome (relevance).
- the S.M.A.R.T. principle is utilised for designing completion criteria.
  - a threshold, target, or validation is required for each completion criteria (supporting the PMLU).
  - early criteria must meet the specific, measurable, and relevant of SMART as a minimum.

- achievable is determined through understanding references / benchmarking / leading practice, and
- time-bound can be refined during revision MCPs but finalised prior to the mine closure plan (execution).

- monitoring relates directly to evaluating completion criteria.
  - reference targets and ranges need to be clear and monitoring suitable to support completion criteria.
  - a specified monitoring plan needs to track progress to meeting completion criteria, with corrective actions.
  - monitoring during operations may be required to support developing completion criteria, and
  - continue many years post-closure (depending on timeframes for rehabilitation, impact, or recovery).

The WABSI framework is recommended reading for proponents developing completion criteria. An additional reference for the attributes and how they relate to the monitoring and evaluation program can be found in the Leading Practice Sustainable Development Program publication on *Evaluating Performance: Monitoring and Auditing (*DFAT 2016h).

8. Closure Implementation

The mine closure plan must include a closure works programme with information on the specific tasks that will be undertaken to decommission and rehabilitate the mine and achieve the closure outcomes.

This must also include:

- Timeframes for decommissioning and progressive rehabilitation tasks.
- Closure designs for landforms.
- Tasks that will be implemented in the event of premature or early closure or suspension of operations.

8.1 Domain Model

A useful approach to mine closure planning and implementation is to divide up the closure work and segregate the operation into specific areas or domains. Each domain is treated as a separate entity within an overall plan and includes landforms or infrastructure with similar rehabilitation, decommissioning and closure requirements / outcomes. Examples of domains at a mine are:

- Ore processing area.
- Infrastructure.
- Tailings storage facilities.
- Waste dumps / landforms.
- Roads / airstrips.
- Borefields / pipelines / powerlines / rail (infrastructure corridors).
- Process and raw water facilities.
- Open mine voids, and

- Underground declines / shafts.

For accuracy, it is recommended that closure planning utilise Geographical Information System (GIS) digital terrain models and aerial photographs to illustrate domain features and boundaries. Computer-aided design (CAD), or other three-dimensional models are recommended for planning and visualisation of waste landforms, voids, tailings dams and other structures integration into the surrounding landscape.

The domain model provides a useful focal point for developing strategies for closure implementation and helps to facilitate structured risk assessment and management. However, closure planning and implementation should also consider the whole of landscape scale to ensure effective integration of final land uses.

8.2 Closure work schedule

Closure implementation planning should commence in the early stages of mine development, including at the approvals stage, and then be refined throughout the operational phase.

The closure implementation section of a mine closure plan should include:

- Relevant closure outcomes and completion criteria as project objectives.
- A project schedule (e.g. works program/schedule - GANNT chart or similar).
- Identification of the critical path, and milestones for achieving decommissioning, rehabilitation and closure of the mine site as a whole.
- Additional detail for decommissioning of specific infrastructure.
- A schedule for progressive rehabilitation (trials, research, earthworks) throughout the life of mine.
- Closure designs for any post-mining landforms or other features associated with mining. For example, landform designs for all structures that will be left at closure, a detailed landscape drawing of the whole site showing drainage lines / features, flood modelling for the operation after closure works are implemented, locations / size and materials requirements for any abandonment bunds.
- Contingencies for premature or early closure or suspension of operations.
- Schedule of work for performance monitoring and maintenance tasks.

Further information on the above requirements is provided below in sections 8.3 – 8.6.

The level of information provided at any stage of the project needs to demonstrate that closure requirements have been appropriately identified and can be achieved with the expected remaining life of mine. The closure work programs should be reviewed and updated regularly to reflect operational changes and/or new information.

As the operation approaches the decommissioning phase (generally 2 years prior to cessation of operations), a more refined mine closure plan with a greater level of detail on closure implementation will be required. Specific guidance on the level of detail expected in a mine closure plan as the mine approaches this phase described in Appendix 4

Scheduling of closure work tasks should be documented in a Closure Task Register similar to that shown in Table 7 below. The table should be broken into sections indicating *During Operations*, *During Decommissioning* and *Post Cessation of Rehabilitation Work*, but also be specific to closure or rehabilitation tasks (i.e. no operational items).

Table 7. Example Closure Task Register.

CLOSURE TASK REGISTER					
Closure & Rehabilitation Tasks During Operations					
#	**Domain**	**Works to be undertaken including Outcomes**	**Responsible Role / Owner**	**Timing**	**Status**
1	*Pits*	*Rehabilitate WRD 666*	*Mining Manager*	*2023*	*In Progress*
2	*Pits*	*Trial on ripping depth*	*Mining Manager*	*2022*	*Complete* *Trial plot established, monitoring commenced*
3	*WRD*	*Monitoring of Ripping Depth Trial*	*Environment Manager*	*2026*	*In Progress*
4	*Pit xxx*	*Establish Abandonment Bund*	*Mining Manager*	*2023*	*Complete, except haul road access points*
5	*Pit 123*	*Backfill to surface*	*Mining Manager*	*2028*	*Backfilling with waste from Pit xxx*
Closure & Rehabilitation Tasks During Decommissioning					
#	**Domain**	**Works to be undertaken including Outcomes**	**Responsible Role / Owner**	**Timing**	**Status**
1	*Plant*	*Demolition of Process Plant*	*Closure Manager*	*2028*	
2	*Plant*	*Contaminated Sites – Preliminary Site Investigation*	*Closure Manager*	*2029*	
Closure & Rehabilitation Tasks Post Closure					
#	**Domain**	**Works to be undertaken including Outcomes**	**Responsible Role / Owner**	**Timing**	**Status**
1	*Pit xxx*	*Finalise Abandonment Bund - Close haul road access points*	*Mining Manager*	*2029*	

8.3 Research, investigations, and trials

Each mine closure plan revision should include an updated closure work schedule that includes current research, investigations and trials that are being undertaken to progressively prepare for closure. Research tasks may be a one-off investigation such as undertaking a waste characterisation program for a landform or a series of tasks leading to trials that can take years (or decades) to provide relevant data/information.

The information obtained from research, investigations and field-based trials can be used to help close knowledge gaps and determine the most appropriate rehabilitation strategies to implement.

8.4 Progressive rehabilitation

Each mine closure plan submission should include a schedule of work for progressive rehabilitation tasks showing key tasks and key milestones and approximate timing required for each task and should include:

- Contamination management.
- Estimating, reconciling and scheduling rehabilitation material inventories.
- Staged construction and earthworks.
- Landform surface treatments (ripping, selective application of topsoil, placement of materials).
- Revegetation research and trials.
- Rehabilitation performance monitoring.
- Ongoing improvement and refinement of rehabilitation techniques.

Progressive rehabilitation activities should be fully integrated into the day-to-day mining operations to ensure materials and resources are available to undertake the work required. Mine planning and engineering decision-making processes should optimise opportunities for progressive rehabilitation earthworks consistent with the post-mining land use(s) and closure outcomes.

8.5 Early Closure - Permanent Closure or Suspended Operations under Care and Maintenance

Although practical planning for early closure (permanent or suspended operations under care and maintenance) may not be very detailed in the initial stages of the project, consideration needs to be given in the mine closure plan relating to how closure scenarios that may arise from economic, environmental, safety or other external pressures will be dealt with.

The mine closure plan needs to detail the activities to be undertaken in the event of early closure or suspension of operations. These may include:

- Ongoing environmental management activities (weeds, feral animal, water management, waste management, rehabilitation monitoring, etc).
- Site security and access management.
- Maintenance and monitoring for high-risk landforms (e.g. tailings storage, heap leach, contaminant ponds, open pits, PAF waste, etc).
- De-energising and isolation of inactive electrical systems, safe storage of chemicals.
- De-gassing and purging of pipelines and storage tanks containing hazardous materials / problematic materials to ensure operational or emergency response readiness.
- Removal of excess chemicals, fuels, explosives, and other potentially contaminating HAZMAT, or dangerous goods from site.
- Rehabilitation of areas where mining has been completed.
- Making the site safe from inadvertent public access.

The mine closure plan should also demonstrate that appropriate materials are available on site and contingencies are provided to make landforms such as tailings storage facilities and waste landforms secure, stable and non-polluting / non-contaminating.

Where implementation of an accelerated closure process may need to occur, tenement holders should inform the relevant Environmental Officers at DEMIRS to advise of any accelerated closure and seek advice on site-specific requirements. If an approved mine closure plan is in place, and a premature closure occurs, the operation will be well placed to respond.

Tenement holders need to be aware that under the *Work Health and Safety Act 2020* they are required to notify the DEMIRS Directorate inspector of mines of the suspension of a mining operation. See further template documents on DEMIRS webpage for notifications of commencement, suspension, recommencement, and abandonment.

8.6 Decommissioning

A mine closure plan should include information on how a mining operation will be decommissioned. Since the decommissioning phase usually takes place at the end of mine life, limited detail on the strategy and activities required for decommissioning of plant and infrastructure may be acceptable in the early stages of the project for mid to long life mining projects.

At least two years prior to the planned end of a mine site, project and/or operation, DEMIRS will require the mine closure plan to contain more specific detail on the planning and implementation of the decommissioning phase.

Further guidance on the level of detail expected in the mine closure plan as the mine approaches closure is described in Appendix 5.

9. Closure Monitoring and Maintenance

The mine closure plan must include information on the monitoring that will be undertaken to track the site’s progress towards achieving the closure outcomes. This must include a description of:

- The monitoring to be undertaken to track progress of tasks identified in the closure works programme.
- Description of proposed post-closure monitoring.
- Description of the monitoring methodology.

The monitoring must show clear links to the Closure Outcomes and Completion Criteria and how their achievement will be demonstrated.

The mine closure plan needs to include appropriate detail on a closure performance monitoring and maintenance framework during progressive rehabilitation and post closure, including descriptions of the methods used, quality control system and an appropriate remediation strategy.

The mine closure plan should demonstrate linkages between operational monitoring and closure monitoring. As an example, collection of ongoing temporal data during operations can provide a dataset suitable for assessing whether completion criteria will be met at closure. Monitoring should identify regional changes (e.g. long-term groundwater level decline due to climatic drivers or spread of a new invasive species) to be able to differentiate between mine-related impacts that require rehabilitation effort and issues beyond the operators control.

The performance monitoring results will normally be reported to DEMIRS in environmental reporting. The report must document progress against the agreed completion criteria. Where applicable, the results of rehabilitation trials need to be analysed and also presented in the environmental reporting; remedial action(s) undertaken in response to not meeting agreed performance indicators should also be reported. The results should also be used to update the mine closure plan in summary form and the implications for closure planning identified. The guidelines for the preparation of environmental reporting are available on the DEMIRS website.

A preliminary plan for closure monitoring and maintenance may be acceptable in the early stages of the project. As the operation approaches closure, DEMIRS will require the mine closure plan to contain a detailed Post-Closure Monitoring and Maintenance Program. This should include the type and frequency of monitoring proposed to address / show achievement of the relevant completion criteria.

The proposed monitoring program should be presented in a table format similar to Table 8 below.

Table 8. Example of closure monitoring program table.

MONITORING PROGRAM					
Closure & Rehabilitation Tasks During Operations					
Location	**Closure Outcomes / Completion Criteria**	**Performance Indicator(s) and Triggers for Remedial Action**	**Timing**	**Owner**	**Details of Measurement Tools and Monitoring Methods to be Undertaken**
Closure & Rehabilitation Tasks During Decommissioning					
Location	**Closure Outcomes / Completion Criteria**	**Performance Indicator(s) and Triggers for Remedial Action**	**Timing**	**Owner**	**Details of Measurement Tools and Monitoring Methods to be Undertaken**
Closure & Rehabilitation Tasks Post Closure					
Location	**Closure Outcomes / Completion Criteria**	**Performance Indicator(s) and Triggers for Remedial Action**	**Timing**	**Owner**	**Details of Measurement Tools and Monitoring Methods to be Undertaken**

It is important that provision be made in closure planning for an adequate period of post-closure monitoring and maintenance, including provision for remedial work if monitoring shows completion criteria are not being met. Of particular importance is the development of support mechanisms for the monitoring and maintenance phase, when operational support (accounting, maintenance, earthmoving equipment, personnel, accommodation etc.) are usually no longer available on site (ANZMEC/MCA 2000).

The proposed monitoring techniques must be able to demonstrate that the site-specific completion criteria and performance indicators have been met. Evidence that adequate resources have been set aside to implement post closure monitoring and maintenance should be provided in the mine closure plan.

There must be a sufficient timeframe nominated to undertake monitoring and maintenance until it can be demonstrated that closure outcomes and completion criteria have been met. In the early stages of the project or where detailed information on closure performance is not available, a minimum post closure monitoring period should be provided for in the mine closure plan, usually in the order of a minimum of 10 years (depending on regional specific climatic conditions and implication of climate change). Justification should be provided for why the nominated monitoring period has been selected. Post mining monitoring timeframes can be greatly reduced in situations where progressive rehabilitation with an effective monitoring program has been implemented in the early /mid stage of the mine life.

For further guidance refer to the Western Australian Biodiversity Science Institute, *A framework for developing minesite completion criteria in Western Australia* (WABSI 2019).

10. Closure cost estimation

The mine closure plan must include details of the closure costing methodology undertaken to estimate the cost of closure, and provide a predicted closure cost.

The objective of financial provisioning for closure is to ensure that adequate funds are available during operations to implement progressive rehabilitation and also at the time of closure to reduce the risk of the community being left with an unacceptable liability. To that end, it is essential that the cost of closure be estimated as early as possible and refined as more knowledge is gained during operations.

DEMIRS recognises that providing verifiable closure cost estimate at the early stages of a mine's life is subject to many assumptions and unforeseen events. The predicted closure cost can be presented as a range:

- $100,000 to $1,000,000
- $1,000,000 to $5,000,000
- $5,000,000 to $20,000,000
- $20,000,000 to $50,000,000
- $50,000,000 to 100,000,000
- > $100,000,000

The closure cost estimate needs to be based on reasonable, site-specific information and data gained throughout the life of the project and regularly reviewed to reflect changing circumstances and levels of risk. This will ensure that the accuracy of closure costs is refined and improved with time and will assist with management and mitigation of high-risk issues.

The cost estimate can be treated as confidential if required.

It should be noted that levies paid into the MRF required under the *Mining Rehabilitation Fund Act 2012* and the *Mining Rehabilitation Fund Regulations 2013* are non-refundable and are separate to the internal accounting provisions for closure and rehabilitation. Mining Rehabilitation Fund rates should not be used to offset the costs for rehabilitation. The estimates made under the MRF scheme are not suitable for use as the closure cost estimate under these guidelines.

11. Management of Information and Data

The mine closure plan should include a description of data management strategies, and summary of information and data relevant to mine closure that has been provided to DEMIRS.

Adequate data management is an important step in quality control of data, with leading practice data management and reporting systems able to provide automated alerts for key parameters and facilitate timely production of reports (DFAT 2016e).

These records are valuable during the operational phase as well as post-mining to provide:

- A history of rehabilitation and closure implementation at the site
- A history of past developments
- Information for incorporation into state and national natural resource data bases, and
- The potential for improved future land use planning and / or site development.

The closure related information should then be reported in the mine closure plan or via DEMIRS environmental reporting processes to maintain an up-to-date reference for the department.

This section should detail the management systems in place to control and maintain information and data relevant to closure. Consideration needs to be given for how such data will be transferred to any other future tenement holder(s) to enable continuity of effective progressive closure. The mine closure plan should also include a summary of the data provide to DEMIRS in table format similar to Table 9 below. This table would be enhanced with each mine closure plan submission and may appear as an Appendix in the MCP.

Table 9. Example Management of Closure Information Table.

Management of Closure Information			
Domain	**Feature**	**Data provided / Technical Report / Report name**	**Reporting mechanism / Date**
Pits	Pit xxx Abandonment Bund	Material of construction.	MCP 2021
	Pit xxx Abandonment Bund	Audit of as constructed.	Environmental Reporting - 2022

The closure information provided should contain information for each domain or feature, with the objective of building a “base” of information for that particular domain or feature.

Information may include, but not be limited to:

- The current status of the domain or feature.
- Information from spatial datasets and databases.
- Design and construction information.
- Monitoring information or other information that meets a specific purpose (e.g. maps, area statistics, species lists or modelled environmental impacts).
- All relevant technical reports.

The domain/feature information can then be utilised to efficiently obtain knowledge relevant to closure. For example, for an existing waste landform domain or feature, a search could be carried out on the information available on the waste landform(s), such as:

- The year of construction of a waste rock landform.
- Design parameters such as angle of batter slope angles and details of surface water management features.
- Waste rock mineralogy types.
- Chemical and physical properties of the waste material.
- Presence and location of encapsulation cells.
- Status of rehabilitation.
- Trials undertaken and seed mixes used in rehabilitation.
- Any information on trials that have been carried out on the waste landform(s).

Since mine closure planning is a dynamic process requiring regular review and updates, a system-based approach can facilitate management of information and provide the ability to update documentation, in addition to integrating closure planning with day-to-day management activities (DEH, 2002).

Electronic systems which incorporate both mine closure planning and environmental management system functionality can provide an effective tool for capturing current closure planning activities and maintaining up-to-date closure information and data. These systems can hold data in perpetuity and provide online or static output (information and data) as required.

The value of site-specific data and information should not be underestimated; it is essential to have a system in place to capture all relevant closure knowledge in the event that key personnel leave the site. Electronic mine closure systems that can store large amounts of data are suitable for this purpose.

12. Reviewed Mine Closure Plans

Where closure information is reviewed and updated through the mine closure planning process the updated mine closure plan should include:

- A revision summary table that clearly outlines all changes made to the closure information (section 12.1).
- A summary table documenting how the aspects identified by DEMIRS (or another agency) for improvement in the prior revision of the mine closure plan have been addressed (section 12.2).

- A table documenting how the knowledge gaps identified in the prior revision of the mine closure plan have been addressed, as well as any new gaps identified (section 12.3).

12.1 Revision Summary Table

A mine closure plan should contain a summary table indicating the sections where changes have been made and a summary of information pertaining to the changes. DEMIRS may request the modifications in the revised and resubmitted document during assessment to be highlighted to assist in finalising the assessment process.

Please see the mine closure plan checklist (Appendix 6) that can be a useful tool for reviewing mine closure plans.

In the circumstance where there has been no mining and/or rehabilitation activities undertaken during the review period, proponents will still be required to submit a reviewed mine closure plan. This reviewed mine closure plan should include other closure planning activities that will have taken place during this period (e.g. ongoing stakeholder consultation, knowledge gap actions/trails and research and rehabilitation monitoring); and these activities need to be reported in the context of mine closure planning.

12.2 Summary Table of Improvement Actions Identified

DEMIRS acknowledges that mine closure plans are continuously developed over the life mine and as such DEMIRS many consider the mine closure plan acceptable subject to aspects of closure planning being further developed and refined in subsequent mine closure plan revisions.

Revised mine closure plans should contain a table that includes these noted comments for improvement with responses on how they have been addressed in the current version. An example of improvement table is presented as Table 10 below.

Table 10. Table of improvement action from DEMIRS.

<table>
<tr><th colspan="5">TABLE OF IMPROVEMENT ACTIONS FROM PREVIOUS MDCP / MCP APPROVALS</th></tr>
<tr><td colspan="2" rowspan="2">DEMIRS Reg ID:</td><td></td><td rowspan="2">Date Approved:</td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><th>#</th><th>Section of the MCP</th><th>Comments from Approval Letter</th><th>Proponent Response</th><th>Sections Changed</th></tr>
<tr><td>1</td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td></td><td></td><td></td><td></td></tr>
</table>

Only the latest DEMIRS comments for improvement need be shown, historical comments are not required unless they were not addressed previously (in which case justification needs to be provided).

12.3 Knowledge Gaps Progress and Actions

Revised mine closure plans should include an updated knowledge gaps register (Table 4), documenting how the knowledge gaps identified in the prior revision of the mine closure plan have been addressed, as well as any new gaps identified.

REFERENCES

ANZMEC/MCA 2000, *Strategic Framework for Mine Closure*, Australian and New Zealand Minerals and Energy Council and Minerals Council of Australia, National Library of Australian Catalogue Data.

DFAT 2016a, *Mine Rehabilitation*, Leading Practice Sustainable Development Program for the Mining Industry produced by the Department of Foreign Affairs and Trade, Canberra.

DFAT 2016b, *Preventing Acid and Metalliferous Drainage*, Leading Practice Sustainable Development Program for the Mining Industry produced by the Department of Foreign Affairs and Trade, Canberra.

DFAT 2016c, *Risk Management*, Leading Practice Sustainable Development Program for the Mining Industry produced by the Department of Foreign Affairs and Trade, Canberra.

DFAT 2016d, *Community Engagement and Development*, Leading Practice Sustainable Development Program for the Mining Industry produced by the Department of Foreign Affairs and Trade, Canberra.

DFAT 2016e, *Mine Closure*, Leading Practice Sustainable Development Program for the Mining Industry produced by the Department of Foreign Affairs and Trade, Canberra

DFAT 2016h, *Evaluating Performance: Monitoring and Auditing*, Leading Practice Sustainable Development Program for the Mining Industry produced by the Department of Foreign Affairs and Trade, Canberra.

DEMIRS 2014, *Mining Rehabilitation Fund – Guidance*, Department of Energy, Mines, Industry Regulation and Safety, Western Australia.

ICMM 2019, *Integrated Mine Closure – Good Practice Guide,* 2nd Edition, International Council on Mining & Metals, London, United Kingdom, February 2019.

ICMM 2022, *Closure Maturity Framework – Tool for closure User Guide,* International Council on Mining & Metals, London, United Kingdom, January 2022.

WABSI 2019, Young, R.E., Manero, A., Miller, B.P., Kragt, M.E., Standish, R.J., Jasper, D.A., & Boggs, G.S. (2019). *A framework for developing mine-site completion criteria in Western Australia: Project Report*. The Western Australian Biodiversity Science Institute, Perth, Western Australia

APPENDICES

Appendix 1	Planning for Mine Closure
Appendix 2	Overview of Specific Mine Closure Issues
Appendix 3	Principles of Stakeholder Engagement
Appendix 4	Guidance on pit lake assessment through a risk-based approach
Appendix 5	Guidance on Development of Mine Closure Plan to Execution Phase
Appendix 6	Mine Closure Plan Checklist

Appendix 1 – Planning for Mine Closure

Principles of mine closure planning

DEMIRS' objective for rehabilitation and mine closure is that mining activities are rehabilitated and closed in a manner to make them (physically) safe to humans and animals, (geo-technically) stable, (geo-chemically) non-polluting / non-contaminating, and capable of sustaining an agreed post-mining land use, and without unacceptable liability to the State.

It is recommended that any residual liabilities relating to the agreed land use are identified and agreed to by the key stakeholders. Key stakeholders would not be accountable for any residual liabilities not identified by proponents that occur as a result of unexpected closure or failure to close a site properly.

The following key principles and approaches should be considered when preparing a mine closure plan (DFAT 2016a):

- From the project approval stage throughout mine life, the mine closure plan should demonstrate that ecologically sustainable mine closure can be achieved consistent with agreed post-mining outcomes and land uses, and without unacceptable liability to the State.
- Planning for mine closure should be fully integrated in the life of mine planning and should start as early as possible and continue through to final closure and relinquishment. For new projects, closure planning should start in the project feasibility stage (before project approvals).
- Mine closure plans must be site-specific. Generic "off-the-shelf" closure plans will not be accepted.
- Closure planning should be risk-based, taking into account results of materials characterisation, data on the local environmental and climatic conditions, and consideration of potential impacts through contaminant pathways (including but not limited to site activities or infrastructure) and environmental receptors.
- Consultation should take place between proponents and stakeholders which should include acknowledging and responding to stakeholders' concerns. Information from consultation is central to closure planning and risk management.
- Post-mining land uses should be identified and agreed upon through consultation before approval of new projects. This should take into account the operational life span of the project and should include consideration of opportunities to improve management outcomes of the wider environmental setting and landscape, and possibilities for multiple land uses. For existing mining projects, post-mining land uses should be agreed upon as soon as practicable.
- Materials characterisation needs to be carried out prior to project approval to a sufficient level of detail to develop a workable closure plan. This is fundamental to effective closure planning. For existing operations, this work should start as soon as possible. Materials characterisation should include the identification of materials with potential to produce acid, metalliferous or saline drainage, dispersive materials, erosive rock, fibrous and asbestiform materials, and radioactive materials, as well as benign materials intended for use in mine

rehabilitation activities. The identification of good quality rehabilitation material (e.g. benign, fresh rock) should also be carried out.

- Closure planning should be based on adaptive management. Closure plans should identify relevant experience from other mine sites and research, and how lessons learned from these are to be applied.
- Closure plans should demonstrate that appropriate systems for closure performance monitoring and maintenance and for record keeping and management are in place.

Risk based approach to mine closure planning

DEMIRS endorses a risk-based approach to mine closure planning as it reduces cost and uncertainty in the closure process (ANZMEC/MCA 2000). The benefits of a risk-based mine closure process include:

- Identifying a range of closure scenarios commensurate with risk.
- Early identification of potential risks to successful closure.
- Development of acceptable and realistic criteria to measure performance.
- Orderly, timely and cost-effective closure outcomes.
- Reduced uncertainty in closure costs, and
- Continual improvement in industry rehabilitation standards (e.g. cover design, and management of contaminated drainage, erosion and seepage).

Staged approach to mine closure planning

Progressive development of a mine closure plan throughout the mine lifecycle, as shown in the figure in the Stakeholder Engagement section (Section 4) and progressive rehabilitation, are critical to the successful implementation of mine closure planning and achieving DEMIRS' rehabilitation and closure objectives.

Consistent with a risk-based approach, the level of detail required by DEMIRS increases with the level of risk associated with each key closure component and time to closure. This is displayed in the figure, with further reading available in ICMM 2019 and ICMM 2022.

Proponents must provide a sufficient level of detail on key closure components at each stage of mining. Key closure components include:

- Post-mining land use.
- Closure outcomes.
- Completion criteria.
- Collection and analysis of closure data, and
- Materials characterisation, including mineral waste.

The structure of a mine closure plan is designed to assist industry compile mine closure plan information in a sequential order that is easier to use and for DEMIRS to assess.

Mine closure planning for rehabilitation

Rehabilitation is a critical part of mine closure planning and is referred to throughout this document. For mine closure planning, it is important to separate the different components of a mine site into those that can be restored, those that can be rehabilitated, those that can be revegetated, and those that will not return any environmental value in the foreseeable future (i.e. areas that will remain a significant residual impact). This allows different outcomes to be considered across a mine site.

Some disturbances may be able to be ecologically restored - to restore the landscape to conditions similar to the surrounding (non-mined) environment, including physical, biological and chemical processes. Examples may include small tracks or construction area laydowns.

However, there can be significant challenges to achieving this 'restoration' level of mine closure in WA.

It is important to remember that continual improvement in rehabilitation techniques will occur over time and proponents should actively include this in their mine closure planning.

Effective, early planning will minimise rehabilitation costs. Taking a more integrated and progressive approach to mine rehabilitation during operations can achieve effective mine rehabilitation and aid in meeting closure outcomes (DFAT 2016a). DEMIRS encourages proponents to progressively rehabilitate, where possible, recognising that some forms of mining, e.g. strip mining (minerals sands) may make progressive rehabilitation more feasible. For large scale hard rock mines, proponents should consider using pits for backfilling waste (particularly where there are multiple pits) and progressively rehabilitate areas where possible, e.g. linear and supporting infrastructure areas. DEMIRS recognises that revegetation is likely to be more successful in temporarily disturbed areas.

Progressive rehabilitation can also provide an early indication as to whether the mine closure plan needs to change to meet closure outcomes proposed by the proponent and whether closure outcomes are realistic and achievable. Furthermore, progressive rehabilitation enables contamination issues to be adequately managed in an appropriate manner and within an appropriate timeframe based on the risk posed. Not managing contamination issues in a timely manner can result in an increase of the extent of that contamination and represent an exponentially greater cost of remediation at mine closure. There is a large overall benefit, not only in cost, to dealing with contamination through a progressive process, rather than leaving such actions to the point of closure, which can be many years (or decades) in some cases.

For existing mine sites, attention needs to be given to the best pragmatic options for mine closure. DEMIRS recognises the issues with older mine sites where no or little mine closure planning has occurred early enough in the process and the challenges this presents in returning environmental values. Proponents in this position are encouraged to commence discussions with DEMIRS as early as possible to review what options are available. The options may include determining which areas of a mine site can realistically be rehabilitated to return environmental values and which cannot. These options are not about removing environmental responsibilities in preparing for mine closure, which should be ongoing throughout the life of a mine.

There is an expectation that should alternative options be considered, it must still be demonstrated that there is an overall environmental net benefit. Where changes to conditions are proposed that cause additional environmental impacts to the original proposal, proponents will need to consider any significant residual impacts that may result from those changes.

Appendix 2 – Overview of Specific Mine Closure Issues

Some closure issues currently facing mining projects include, but are not limited to:

- Hazardous materials.
- Hazardous and unsafe facilities.
- Contaminated sites.
- Acid and metalliferous drainage (amd).
- Radioactive materials.
- Fibrous (including asbestiform) materials.
- Non-target metals and target metal residues in mine wastes.
- Management of mine pit lakes.
- Adverse impacts on surface and groundwater quality.
- Dispersive and sodic materials.
- Erosive materials.
- Design and maintenance of surface water management structures.
- Dust emissions.
- Flora and fauna diversity/threatened species.
- Challenges associated with rehabilitation and revegetation (see section 8 closure implementation).
- Visual amenity.
- Heritage issues.
- Sensitive receptors.
- Regulatory requirements.
- Alteration of the direction of groundwater flow.
- Alteration of the depth to water table of the local aquifers, and
- Alteration of the hydrology and flow of surface waters.

Not all issues will be relevant for all mine sites, and at a particular mine site there may be additional challenges to mine closure not identified above. Technical advice should be sought from appropriately qualified experts and/or regulators in relation to identification and management of issues at any particular site.

Key rehabilitation and closure issues identified by DEMIRS are:

- Acid and metalliferous drainage.
- Dispersive materials.
- Rehabilitation.
- Radioactivity, and
- Mine pit lakes.

This appendix provides a general overview of the following specific mine closure issues:

- Acid and metalliferous drainage.
- Dispersive materials.

- Rehabilitation.
- Radiation management.

More detailed Pit Lake Assessment guidance is provided in Appendix 4.

Acid and metalliferous drainage

Acid and metalliferous drainage has the potential to impact on water quality during operations and post closure.

i. Definition

Mine drainage may consist of acid drainage and/or metalliferous drainage. Acid and metalliferous drainage (AMD) originates when sulfide material is exposed to air and water. Metalliferous drainage can occur when acid is neutralised, but concentrations of some metals remain elevated at near neutral or alkaline conditions (DFAT 2016b). Potential sulfide-bearing material includes waste rock, pit wall rock and tailings.

ii. Potential impacts

AMD is recognised as one of the most serious environmental issues associated with mining (http://www.inap.com.au). Over the past 30 to 40 years, as mining operations have evolved to large-tonnage open cut operations, the mass of sulfidic material with the potential to create AMD has increased dramatically (DFAT 2016b).

Acid and metalliferous drainage from old mine sites can cause ongoing pollution lasting for centuries or even millennia. As AMD (containing sulfuric acid, high concentrations of metals and low oxygen concentrations) enters groundwater and surface water systems, it can present a major risk to aquatic life, riparian vegetation and water resources (DFAT 2016b).

Where there are AMD issues at mine sites, remediation and treatment costs can be high and can prevent the closure completion of mining leases. There is also the potential for impacts from other contaminated mine drainage, particularly drainage which contains toxic metals and metalloids and saline drainage.

iii. Identification and characterisation

Proponents need to collect adequate information to be able to identify the potential for AMD and other contaminated mine drainage. Adequate geochemical characterisation is critical to be able to accurately predict water quality (Kuipers et al, 2006). Sampling for geochemical testing must be representative of geological materials at the project site (including country and host rock). Sampling designs should consider existing data, mine plans and spatial variability of the geological materials. Geochemical characterisation of deposits and determination of potential environmental issues can be complex. DEMIRS recommends suitably experienced and qualified professionals undertake this work.

If testing shows there is an unacceptable risk of acid, metalliferous, or other contaminated drainage, the proponent should demonstrate in the initial mine closure plan that the proposed management strategy will provide a sustainable closure solution. This includes sustainable closure of mine waste rock landforms, tailings facilities and mine pit lake(s).

The risk of generating AMD through the mine dewatering process also needs to be assessed and managed appropriately. AMD can be generated through dewatering as the water table is lowered, chemical changes can occur as rock strata dry out, resulting in acid and/or metalliferous drainage being generated.

Progressive evaluation of AMD risk, commencing during the exploration phase and continuing throughout mine planning, provides the data necessary to quantify potential impacts and management costs prior to significant disturbance of sulfidic material (DFAT 2016b).

If the geology of the area is such that AMD may be an issue, the results of appropriate geochemical testing and risk assessment for both acid drainage and metalliferous drainage (noting that metalliferous drainage can occur in the absence of acid drainage) must be presented upfront at the approval stage.

Static tests take a “stocktake” of the minerals present and their potential to cause or alleviate AMD. Kinetic and other detailed tests can be used to assess how AMD may develop over time (DFAT 2016b). Proponents should estimate the location of sulfide-bearing rock and the amount that may be disturbed during operations. Proponents should also estimate the total sulfur content of waste rock and fines. While a total sulfur content of 0.3 per cent is used as a guide, below which the risk to water quality may be low, there may be risks to water quality at lower sulfur content values. Proponents must undertake a site-specific assessment, including identifying sensitive receiving environments, to determine the AMD risk.

DEMIRS recognises that kinetic leach testing can take up to 24 months before sufficient data is available for effective interpretation of the AMD characteristics of a material, and this may affect assessment and approval timeframes. Where kinetic and other long duration testing is required due to potentially harmful materials being present but has not been completed during the assessment/approval stages, it may be required as part of the mine closure plan.

In addition to characterising potential AMD sources, other chemical and physical processes that can affect water quality must be considered when assessing management options and the potential for AMD risk. For example, in assessing the potential for acid generation, caution needs to be exercised in relying on limestone to neutralise acid drainage because of the phenomenon of armouring (i.e. the limestone becoming coated with non-reactive material) which results in rapid loss of neutralising capacity (Hammarstrom et al. 2003).

Current methods of geochemical testing and risk assessment are set out in the US AMD handbook (Maest et al. 2005), and the international AMD handbook known as the Global Acid Rock Drainage Guide (GARD Guide) (INAP http://gardguide.com/).

iv. Management

If the potential for AMD and/or other contaminated mine drainage has been identified, proponents must demonstrate through the mining proposal or Environmental Impact Assessment process that there are measures capable of managing the issue. Efforts should focus on prevention or minimisation, rather than control or treatment.

It is strongly recommended that proponents refer to the GARD Guide (INAP http://gardguide.com/) for detailed guidance on characterisation, prediction, management and treatment for AMD.

Dispersive Materials

Dispersive materials are those materials that are structurally unstable and disperse in water into basic particles (such as sand, silt and clay). Dispersive materials tend to be highly erodible and present problems for rehabilitation and successfully managing earthworks (DFAT 2016a). Dispersive materials affect stability of post-mining landforms and can also contribute to contaminated mine drainage.

The information in this section is based on a study report coordinated by the then Australian Centre for Mining Environment Research (C.A Vacher et al. 2004).

Note that the information provided here focuses on soil properties and may not be applicable to crushed rock materials. Specific advice should be sought from a suitably qualified expert in relation to identification and management of dispersive materials at any particular mine site.

Ensuring that constructed landforms have adequate resistance to erosion is a major component of mine site rehabilitation works. The presence of soil materials susceptible to tunnelling or piping has large impacts on landform stability and rehabilitation. In general, the development of tunnel erosion has been attributed to the presence of dispersive soils or mine wastes. Tunnel erosion can lead to gully erosion being the dominant erosion mechanism, contributing to the failure of engineered structures aimed at controlling erosion. The presence of tunnel erosion also typically means that site remediation and stabilisation are extremely difficult, and that erosion problems are likely to be particularly persistent.

Dispersion occurs when the individual particles in a soil are separated from each other as excess water is supplied. Soils containing high levels of exchangeable sodium (Na^+), known as “sodic” soils, are widely recognised to be particularly susceptible to dispersion. Saline soils may initially be non-dispersive but continued leaching of the contained salts can result in the material becoming dispersive over time. Application of saline water (e.g. for dust suppression) on non-dispersive soils can also result in the material becoming dispersive over time.

Materials susceptible to tunnelling fall into three groups:

- Saline sodic;
- Non-saline sodic; and
- Fine, non-sodic materials of low cohesive strength.

Dispersion tests are the most useful laboratory tests for identifying the susceptibility of a soil to tunnelling, though it should be noted that tunnel formation is not entirely confined to dispersive materials.

There are strong interactions between the design of constructed landforms and the development of tunnel erosion. Water ponded on saline sodic materials can result in the leaching of salt by the ponded water, reduced soluble salt, increased dispersion followed by development of tunnel erosion. For non-cohesive materials, long durations of ponding are also a major factor in developing tunnel erosion.

In order to predict the mid to longer term performance of landforms (“as mined” materials can have properties that change after placement in landforms), it is essential that the inevitable micro-structural, chemical and mineralogical evolution of wastes can be predicted and the impact of these changes on erosion hazard determined. Initial soil parameters that provide information on tunnel erosion potential are:

- Electrical conductivity (EC) to assess potential salinity constraints on dispersion.
- Exchangeable cations, with particular emphasis on exchangeable sodium percentage (ESP) to assess dispersion potential.
- Potentials for slaking and dispersion (Emerson test).
- Particle size distribution (to provide an indication of soil cohesion and liquefaction contributions to tunnel formation/failure), and
- Clay mineralogy (for swelling influence).

Based on the data obtained, a judgment can be made on which subsequent tests are most appropriate. Leaching column tests provide a good indication of the hydraulic conductivity of a material and of its potential for sealing or blockage of soil pores to occur. Erodibility measurements provide an indication of the potential for continued development of tunnels (and tunnel gullies). Characteristics contributing to high erodibility are also factors in the initiation (dispersive and poor structural strength nature) and potential progression and severity of tunnelling when it has occurred.

The best management option available to mine sites that excavate materials susceptible to tunnelling is to ensure that those materials are not exposed to ponded runoff or through drainage. Early diagnosis of potential tunnelling problems and adoption of strategies to prevent such long-term instability are essential for successful mine closure.

Rehabilitation

i. Definition

Rehabilitation is defined as the return of disturbed land to a safe, stable, non-polluting/non-contaminating landform in an ecologically sustainable manner that is productive and/or self-sustaining and consistent with the agreed post-mining land use. Progressive rehabilitation also includes the undertaking of trials, monitoring of trial performance and closing of knowledge gaps. Rehabilitation outcomes may include revegetation, which is defined as the establishment of self-sustaining vegetation cover after earthworks have been completed.

Mine site rehabilitation should be designed to meet three key objectives:

- The long-term stability and sustainability of the landforms, soils and hydrology of the site.
- The partial or full repair of ecosystem capacity to provide habitats for biota and services for people (WA EPA 2006).
- The prevention of pollution of the surrounding environment.

ii. Applying the mitigation hierarchy to minimise disturbed areas

DEMIRS expects proponents to apply the mitigation hierarchy (avoid, minimise and rehabilitate) to minimise the area associated with the mining proposal that will be disturbed, and hence the area to be rehabilitated. DEMIRS recognises that rehabilitation can be a considerable cost. Maximising planning reduces site disturbance and ensures that material such as waste rock is close to its final location which can reduce some of the costs associated with rehabilitation (DFAT 2016a).

iii. Rehabilitation objectives

Rehabilitation objectives are established through defining the post-mining land use(s) and site-specific closure outcomes consistent with those land use(s). Completion criteria are necessary to provide the basis on which successful rehabilitation, mine closure, and achievements of closure outcomes are determined.

iv. Progressive rehabilitation

DEMIRS expects mine sites to be progressively rehabilitated where possible. Progressive rehabilitation is important as it provides opportunities for testing rehabilitation practices, and for the gradual development and improvement of rehabilitation methods (DFAT 2016a). Progressive rehabilitation can reduce costs over the long term by improving rehabilitation outcomes and minimising the requirement to rework poorly rehabilitated areas.

Mine planning and engineering decision-making processes should optimise opportunities for progressive rehabilitation consistent with the post-mining land use(s) and closure outcomes. Progressive rehabilitation activities should be fully integrated into the day-to-day mining operations to ensure materials and resources are available to undertake the work required.

v. Key elements of rehabilitation

For more general information on mine rehabilitation, including environmentally sustainable design of artificial landforms, proponents should refer to the Leading Practice Handbook on *Mine Rehabilitation* (DFAT 2016a).

vi. Landform design

It is critical to design landforms to minimise the costs of construction and long-term maintenance. Landform design should consider (DFAT 2016a):

- Placement of landforms - avoid surface water flow paths, proximity to project boundaries).
- Height/footprint – balance footprint to minimise disturbed area, with height to be able to construct and maintain a stable landform, height should also consider the local topography to reduce the waste landform prominence in the landscape.
- Drainage – consider control of drainage, with engineered solutions, if appropriate.
- Mode of construction – to enable selective placement of problem materials, and
- Profiles – angle and shape of battered slopes, use of berms or concave slopes.

vii. Landform construction

The mine closure plan should demonstrate landforms, soil profiles and soil characteristics will be consistent with the proposed final land use.

viii. Materials characterisation

Characterisation of topsoils and overburden should start as early as the exploration phase and continue throughout the pre-feasibility and feasibility phases as a basis for mine planning. The requirement for materials characterisation continues during the operation of the mine to include any materials that will be stored in waste landforms or left at closure, particularly where the ore grade and mine plan change in response to altered market conditions (DFAT 2016a).

For stabilisation and rehabilitation of landforms, characterisation of materials present may enable selective placement during landform construction to minimise risks of erosion or revegetation failure. It may also enable remedial work, planning or investigations to be timelier and cost-effective (DFAT 2016a).

ix. Materials handling

Waste rock landforms should be constructed to avoid oxidation, which can occur when waste is end-dumped and oxygen enters the larger boulders at the toe of the landform and flows upwards to the finer material (DFAT 2016a). Sufficient benign material should be available to encapsulate problem material in waste rock landforms and tailings storage facilities.

x. Drainage

Landforms should be constructed to mimic natural drainage patterns as much as possible to avoid erosion. Where drainage, infiltration and seepage from landforms may impact the water quality of surface and groundwater systems, engineered solutions may be required, such as covers, liners, and drainage systems to collect and direct runoff and seepage.

xi. Revegetation

Approaches to successful revegetation are rapidly evolving in Western Australia, and companies are encouraged to keep abreast of current research and development in this field.

A key to the successful creation of post-mining revegetation is the incorporation of rehabilitation considerations from the commencement of exploration through to mine closure - the “whole-of-mine-life” approach and maximising available resources particularly topsoil, seed and soil substrate (growth medium).

The revegetation of sustainable native vegetation communities using local species requires consideration of a number of key components including identifying the community’s constituents and their attributes, and identifying abiotic (soil, geology, hydrology, aspect, topography, micro-niche) conditions necessary for the establishment and persistence of the community.

Biotic components in rehabilitation after mining include optimising use of available plant (topsoil, seed and plants) and soil substrate (plant growth medium and parent material).

xii. Species and community identification – vegetation surveys

Information necessary for benchmarking and establishing species/community revegetation targets includes:

- A full list of species for the impacted area and associated communities.
- Clear delineation of communities, including species whose presence/absence or variation in abundance defines each community.

- The appropriate spatial scale at which to assess communities.
- The range of variation for species richness and cover that can be expected.
- The relative abundance of the most important species in each community, and
- Post-rehabilitation monitoring to inform operators of the level of success in re-establishing appropriate plant communities and to assist in the refinement of rehabilitation procedures.

xiii. Topsoil

Soil seedbanks have many advantages as sources of material for rehabilitation including that they are species rich, genetically representative of original populations, and may be relatively easy to manage if standards (see below) are adhered to. Topsoil is therefore a vital and highly effective medium for restoring terrestrial ecosystems in Western Australia.

Research has demonstrated that the following key standards are critical for effective use of topsoil to maximise soil seedbank retention, seedling germination and seedling establishment:

- **Stripping**: seeds of native species mostly reside in the top 10cm. Due to technical limitation, stripping should focus on retrieving this top layer to a maximum depth of 20cm.
- **Timing of stripping**: always strip dry soil and ensure soil remains dry at all times during transfer, storage and replacement phases.
- **Topsoil storage**: The final height of a topsoil stockpile will be determined by the size of machinery utilised to create them. Topsoil stockpiles should only be single truck dumped height, never be flattened / shaped with bulldozers, or a second layer of dumping implemented. Topsoil stripped and stockpiled by scrapers may need aeration by ripping to remove compaction caused by the discharge method.
- **Topsoil spreading**: replace topsoil at the depth appropriate to emergence capability of seeds – ideally, this is a depth no greater than 5cm as most native seeds cannot emerge from depths greater than 5cm (optimum is 1-2cm), however the final depth implemented will be machinery dependent.

xiv. Growth medium

Plant growth and function is therefore an appropriate indicator of potential long-term sustainability of rehabilitation sites. For most mine sites there will be a deficit in growth medium that will need to be addressed by investigating the use of mine waste materials as alternative growth medium to support plant establishment. The growth medium for rehabilitated sites should ideally reflect the functional nature of the pre-mined landscape and provide:

- Seasonal groundwater dynamics allowing for comparable plant water use and acquisition strategies with pre-mined systems.
- Comparable plant nutrition potential with pre-mined systems and include chemical attributes that are non-toxic, non-acid producing, non-saline, non-sodic and of suitable ph, and

- Comparable structural attributes with pre-mined systems ensuring environmental stability and non-hostility for plant growth characterised by low erosion potential, suitable air-filled porosity, suitable bulk density and being non-dispersive.

xv. Standards for seed collection and use

For areas where topsoil is not capable of returning the stipulated level of biodiversity, the reliance on seed to achieve targets is increased. The seed supply chain (see figure below) provides the key steps that are critical for considering how wild seed is sourced and utilised correctly. For most regions, information on site and species-specific requirements is not available.

xvi. Seed collection and storage

Procedures to optimise seed resources should focus on those below:

- Correct species identification (all seed must be represented by a herbarium-quality voucher specimen).
- Adequate genetic provenance is delineated (consult relevant provenance specialists for advice).
- Timing of seed harvest to maximise seed quality, viability, and storability.
- Correct seed handling to ensure seed is not damaged during the collection and cleaning phases.
- Processing approaches that optimise seed quality and purity.
- Developing seed production systems in which seed supply or collection capability does not or cannot meet seed demand, and
- Ensuring adequate and appropriate storage of seed in a purpose-designed and managed seedbank facility preferably with seed equilibrated to 15 per cent relative humidity stored for short to medium-term (1-5y) at 5ºc; long-term (>5y) at -18ºc.

xvii. Seed use

Procedures to optimise seed resources should also identify:

- An understanding of seed dormancy and germination limitations of target species.
- Utilising seed-germination enhancement technologies including seed priming, seed cueing, seed dormancy release and seed dormancy control, seed coatings, delivery-to-site techniques, germination and establishment optimisation, and stress control.
- Understanding interactions of seed-use technologies with post-mined / rehabilitated landscapes, and
- Landscapes (biotic and abiotic) to optimise plant regenerative capacity.

Figure 1. The seed supply chain.

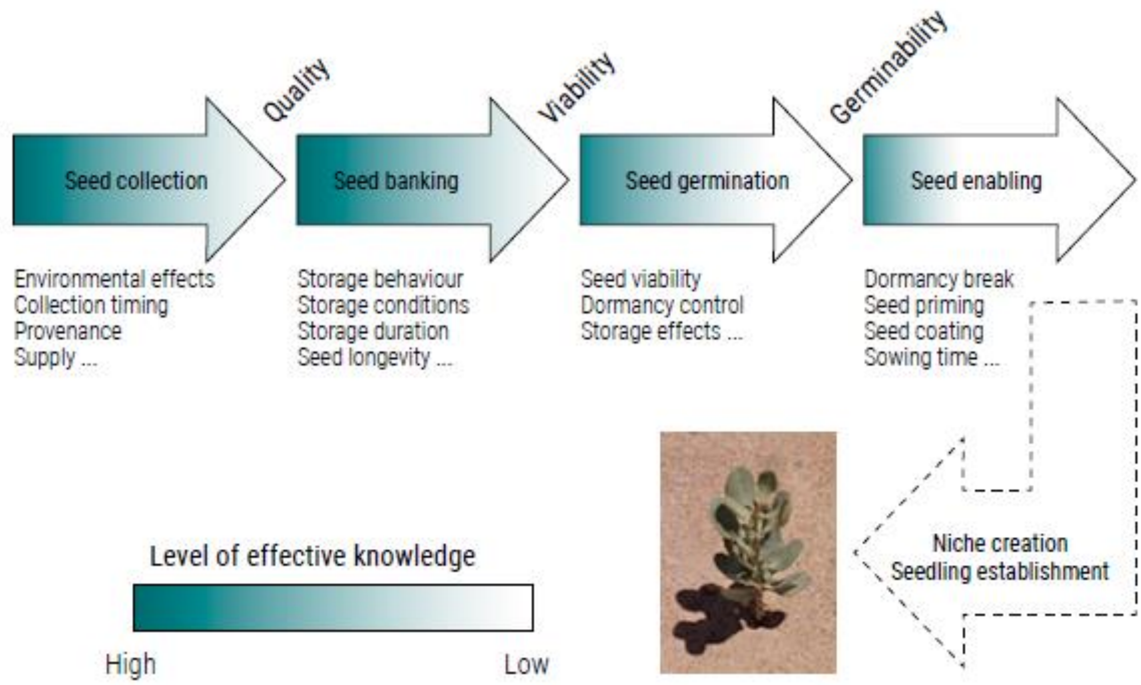
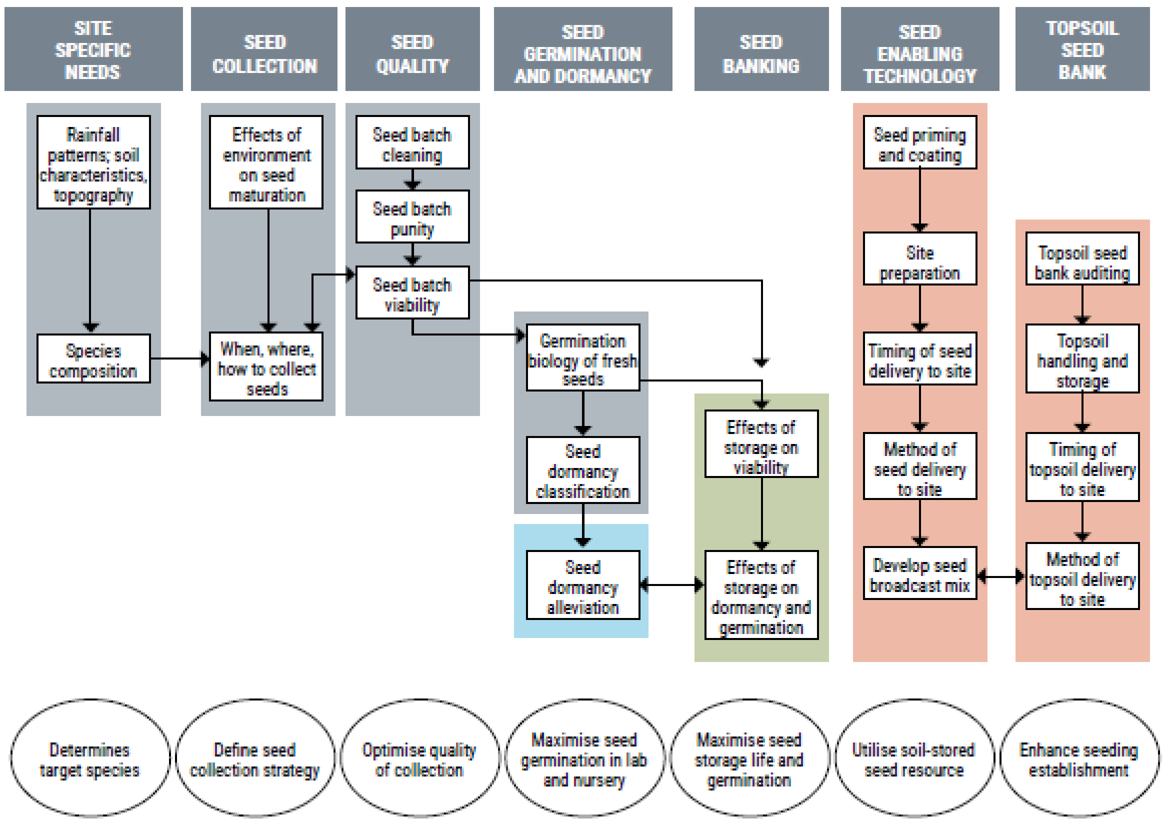


Figure 2 A systematic approach to developing whole-of-mine revegetation techniques.



xviii. Research and trials

Research and on-site rehabilitation trials are important to collect data that will assist in the refinement of closure outcomes and completion criteria. This is particularly important for elements of the mine site where it is difficult for progressive rehabilitation to occur (e.g. large-scale open pits and permanent waste rock landforms). For example, monitored trials are generally required to develop the most appropriate slope treatments for landforms at a particular mine site (DFAT 2016a). Research and field trials are also important to optimise the success of revegetation.

xix. Monitoring and maintenance

As progressive rehabilitation and trials occur, monitoring should begin to assess the success of rehabilitation, identify whether changes to the mine closure plan are required and whether any remedial action is necessary to meet closure outcomes and whether closure outcomes are realistic and achievable.

Proponents should develop a rehabilitation monitoring program for operations and post-closure that is specific for the mine site so that performance can be measured against completion criteria.

Radiation management

For sites where radioactive materials may be an issue (for example uranium or mineral sands mines), radiation management will be one of the key considerations for closure planning.

During all stages of closure planning, radiation management should demonstrate compliance with the two important guiding principles in radiation protection - the “as low as reasonably achievable” or ALARA principle and the “best practicable technology” principle. These principles have been defined by the International Commission on Radiological Protection (ICRP), endorsed by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA 2005) and adopted in WA radiation protection legislation:

- “The ALARA principle has the meaning stated in Clause 117 of ICRP Publication 60 (ICRP 1991, p.29, Item 4.3.2). The broad aim is to ensure that the magnitude of the individual doses, the number of people exposed, and the likelihood of incurring exposures where these are not certain to be received, are all kept as low as reasonably achievable, economic and social factors being taken into account”.
- “‘best practicable technology’ is that technology available from time to time, and relevant to the project in question, which produces the minimum occupational doses, member-of-public doses both now and in the future, and environmental detriment that can be reasonably achieved, economic and social factors taken into account”.

It should be noted that the current system of radiation protection has been based on human health considerations because it is generally believed that the standard of environmental control required for protection of people will ensure that other species are not put at risk (ARPANSA 2002 & 2005). Notwithstanding this, the ICRP (ICRP 2007) recommended that *"it is necessary to consider a wider range of environmental situations, irrespective of any human connection with them"*. ARPANSA has examined the recommendations of ICRP on radiological protection of non-human species (ICRP 2008) and applicability to the Australian uranium mining context (ARPANSA 2010).

In WA, the *Radiation Safety Act 1975*, administered by the Radiological Council, regulates all aspects of radiation protection including the transport of radioactive materials. In addition, there are radiation protection controls placed on the mining industry through Part 16 of the Mines Safety and Inspection Regulations 1995. A Radiation Management Plan must be prepared and submitted for approval by the State Mining Engineer (unless a written exemption is obtained). The Radiation Management Plan must include a Radioactive Waste Management Plan (RWMP) and "an outline of the proposal for the eventual decommissioning and rehabilitation of the mine" (Regulation 16.7).

The objective of a RWMP is "to ensure that there is no unacceptable health risk to people, both now and in the future, and no long-term unacceptable detriment to the environment from the waste so managed, and without imposing undue burdens on future generations" (ARPANSA 2005). In designing and planning for mine closure, the RWMP should be developed in conjunction with the overall project environmental management plan and use a risk-based approach (DRET/GS/DEWHA 2010). The RWMP should also demonstrate the application of the "ALARA" and "best practicable technology" principles (ARPANSA 2005).

Before mining operations commence, the results of an approved baseline environmental radiation monitoring program must be submitted to the relevant regulators. The establishment of the "baseline" conditions is an important part of the development of a RWMP:

> "*A monitoring program designed to evaluate baseline conditions should be developed in conjunction with the relevant regulatory authority. It is important that it be commenced early enough to allow seasonal variations in pre-existing conditions to be evaluated prior to commencement of the project. These 'baseline' conditions should be established prior to any collection of significant amounts of radioactive material through ground disturbance exercises*" (ARPANSA 2005).

The development of an environmental radiation monitoring program, including the "baseline" monitoring program, is essential to identify potential and critical radionuclide (and chemical) pathways by which the environment and humans may be affected during mining and post-mining (IAEA 2002). Such monitoring as is needed to verify the effectiveness of engineering design should be applied to validate models and predictions, and to demonstrate compliance with discharge limits and operational discharge procedures (ARPANSA 2005). The RWMP, which includes appropriate radiation monitoring programs, must be referenced in the mine closure plan. Radionuclide transport in groundwater should be modelled over the very long term (until it can be shown that concentrations have reached a state of equilibrium). Before final closure of a mining operation, a plan for the final management of radiation at the mine, including details of decommissioning and final rehabilitation must be submitted to the relevant regulators. This plan must be referenced in the mine closure plan submitted prior to decommissioning.

It should be noted that after the mine is closed, rehabilitation sites are inspected and monitored at intervals in such a way as is approved by the relevant regulators. This requirement must be incorporated in the development of the post-closure monitoring program and referenced in the mine closure plan as appropriate.

The post-mining environmental radiation level should not result in discernible changes to the baseline conditions and should preserve any environmental value or beneficial use that supports the agreed post-mining land use(s).

Detailed information on radiation management in mining is provided in the *WA Guidelines on Naturally Occurring Radioactive Material (NORM) in Mining and Mineral Processing* (or WA NORM Guidelines), available on DEMIRS website:

(http://www.dmp.wa.gov.au/Documents/Safety/MSH_GL_ManagNORM.pdf).

The WA NORM Guidelines provide a comprehensive set of guidelines for the management of NORM radiation, including guidelines for preparation of a radiation management plan, guidelines on radiation monitoring, radiation dose assessment and reporting, and guidelines on management strategies for radioactive dust and waste.

i. Best Practice Uranium Mining

The World Nuclear Association (WNA) provides the following principle for decommissioning and site closure (principle 11):

> *"In designing any installation, plan for future site decommissioning, remediation, closure and land re-use as an integral and necessary part of original project development. In such design and in facility operations, seek to maximise the use of remedial actions concurrent with production. Ensure that the long-term plan includes socio-economic considerations, including the welfare of workers and host communities, and clear provisions for the accumulation of resources adequate to implement the plan. Periodically review and update the plan in light of new circumstances and in consultation with affected stakeholders. In connection with the cessation of operations, establish a decommissioning organisation to implement the plan and safely restore the site for re-use to the fullest extent practicable. Engage in no activities – or acts of omission – that could result in the abandonment of a site without plans and resources for full and effective decommissioning or that would pose a burden or threat to future generations".*

The International Atomic Energy Agency (IAEA) has also published guidelines on sustainable development principles (IAEA 2009) and best practice principles (IAEA 2010) specific to uranium mining, based on global experience. Designing and planning for closure through an integrated and iterative process is a key to sustainable development (IAEA 2009, section 2). Guidance on best practice application in environmental management and mine closure planning includes baseline data collection, stakeholder involvement, impact assessment, risk assessment, designing for closure and waste management (IAEA 2010, section 3).

The Commonwealth guide "*Australia's In Situ Recovery Uranium Mining Best Practice Guide: Ground Waters, Residues and Radiation Protection*" (DRET/GS/DEWHA 2010) outlines best practice principles and approaches to in situ recovery (ISR) or in situ leach (ISL) uranium mining, including guidance on best practice mine closure and site rehabilitation (Attachment 1, page 18-21). The majority of these principles would be applicable to uranium mining by traditional mining techniques (underground and open cut).

The best practice principles and approaches outlined in the above references are consistent with the principles of the *Strategic Framework for Mine Closure* (ANZMEC/MCA 2000), and should be incorporated in mine closure planning and the preparation of mine closure plans for uranium mining and processing operations.

Appendix 3 - Principles of Stakeholder Engagement

Stakeholder engagement is a key component of mine closure planning. Early and continuous engagement with stakeholders enables operators to better understand and manage stakeholder expectations and the potential risks associated with closure. This approach will also enable possible changes to operations to enable certain post mining land use options. Failure to undertake a stakeholder engagement program may compromise mine closure outcomes.

It is important that all stakeholders have their interests and concerns considered and where appropriate, addressed, and that the key stakeholders have an opportunity to provide feedback on the response or proposed action to address their interests and concerns, particularly when determining post-mining land-use and closure outcomes.

Adequate and appropriate resourcing is critical to good quality and successful engagement. It is important that resourcing for engagement is understood and considered in the early planning process and detailed in the Stakeholder Engagement Strategy. Resources may include financial, human and technological support, and can also include stakeholder-related expenses.

DEMIRS encourages regular engagement between a mining company and the local community or communities throughout all stages of mine development in order to manage the potential socio-economic and environmental impacts of mine closure. While the operational phase brings many social and economic changes and opportunities to communities, mine closure will bring different challenges and opportunities. Development of community programs should be aimed at strengthening a community over the long term. When managing potential environmental impacts from mine closure, an informed community (e.g. by establishing a consultative closure committee) can provide a useful forum for discussion and communication on closure issues (DFAT 2016d & DFAT 2016e).

The level of engagement required will depend on the classification of stakeholders, as detailed below and should be tailored to the group being targeted.

Table 1. Stakeholder classifications

Key stakeholders	Stakeholders
Directly impacted groups – including underlying landholders, government agencies administering reserves and responsible for approvals and regulation, traditional owner groups, post mining landowners / managers, etc	Groups that require engagement but do not have a direct involvement in the operation – other government agencies, surrounding landholders, local Shire / authorities, community groups, Landcare groups etc.

Stakeholder Engagement based on Stage of Mining

Stakeholder engagement needs to occur throughout all stages of mine closure planning, including project approvals (see Figure 1).

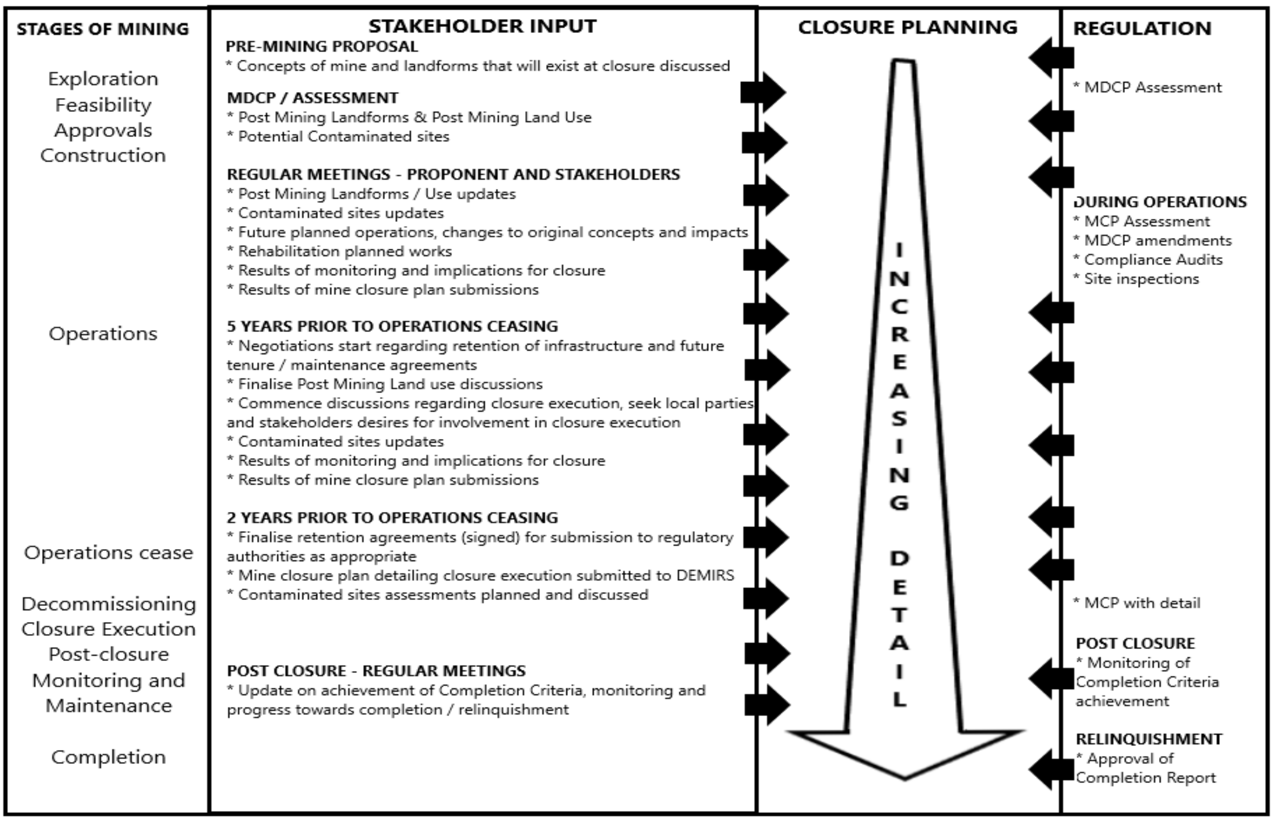


Figure 1. Integrating stages of mining with level of stakeholder engagement.

A range of approaches to stakeholder engagement can be employed throughout the different mine phases or when certain issues need to be addressed. For further guidance, the leading practice *Community Engagement and Development* handbook (DFAT 2016d) may be referred to.

A guide to the level of stakeholder engagement that should be undertaken, based on the stage of mining are set out in Table 2 below.

Table 2. DEMIRS expectations for stakeholder engagement

Stage of mining	DEMIRS Expectations	Level of engagement required	Level of information required
Investigations / pre-mining (first MDCP stage)	• Identification of stakeholders (key vs other) • Develop a stakeholder engagement plan. • Post-mining land use (PMLU) identified	• Contact regarding land access, introduction to proposed activities. • Develop and present the proposed post-mining land use to key stakeholders / land	• Records of meetings, discussions, times, dates and stakeholders in a stakeholder register • Follow up of any queries or concerns, with the resolution or close out

		managers	documented
Operations	• PMLU discussed and agreed with key stakeholders. • Closure outcomes and completion criteria developed to support the PMLU	• Regular scheduled engagement as per the stakeholder engagement plan • Refinement of post-mining land use, where indicated	• Records of all engagement relevant to closure, with issues / topics discussed, times and dates, who attended, and what the outcomes of the engagement were. • Stakeholder register updated. • Records of any issues / topics that require follow-up or clarification
Decommissioning and Closure Execution	• Works undertaken in accordance with an approved Mine Closure Plan to support achievement of outcomes, criteria and PMLU	• Regular updates showing progress with decommissioning and closure tasks. • Regular updates detailing tracking towards meeting outcomes/ criteria, with any proposed adjustments discussed	
Post Closure Monitoring and Maintenance	• Monitoring and maintenance as per the Mine Closure Plan		
Relinquishment	• Gain sign off for post-closure transfer of assets, or relinquishment	• Signed agreements for handover of assets	• Copies of signed agreements, any documentation pertaining to handover of assets

Appendix 4 – Guidance on Pit Lake Assessment Through a Risk Based Approach

1. Introduction

The assessment of pit lakes is a key area of focus for a number of regulatory agencies. Pit lakes form once mining below the water table ceases and the mine pit is no longer dewatered, allowing the mine voids to fill with groundwater. DEMIRS recognises that not all mine sites will have permanent pit lakes and the environmental risk will vary for sites where pit lakes will develop.

While many pit lakes may not present a critical risk (see Table 2), the long-term nature of their presence represents a potentially unacceptable public liability, health and ecological risk. WA has approximately 2,000 mine voids of which more than half have the potential to become pit lakes (EPA, 2013). This Appendix has been developed to provide an overview of the appropriate approach to assessing the risk of pit lakes. A number of resources are referenced in this overview, however, due to the site-specific nature of pit lake assessments, proponents and consultants are encouraged to discuss proposed approaches with DEMIRS.

DEMIRS understands that aspirational end uses (such as a regional lake with recreational or agricultural values) are not always possible, especially in the many arid environments of WA. Any final management strategy for a pit lake that requires active remediation (ongoing water treatment or active pumping of fluids) is discouraged due to the ongoing financial liability. DEMIRS will also give due consideration to the impact of the proposal upon future access to known or undiscovered resources.[1]

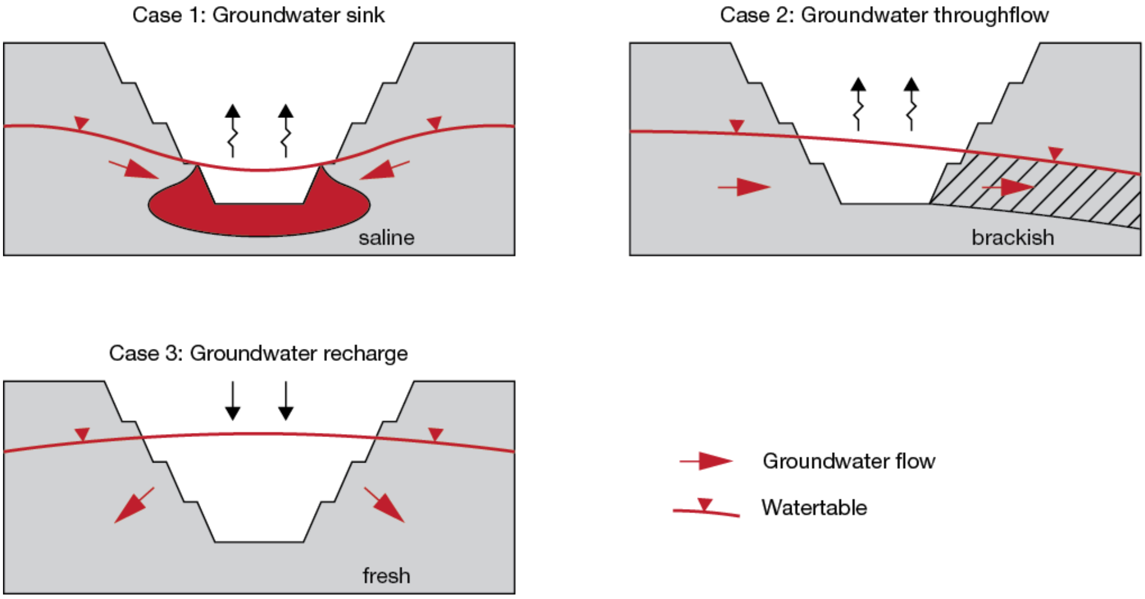
A sterilisation report should be submitted to DEMIRS in cases where any resources are likely to be sterilised by infilling of a pit. The form is not required for shallow deposits such as mineral sands, bauxite or nickel laterite where resources are not likely to be sterilised.

i. Types of pit lakes

Pit lakes are characterised through a number of approaches, the most common of which is the hydrological system the lake develops. As shown in Figure 1 below, the hydrological systems a pit lake may develop are (1) sink, (2) throughflow and (3) recharge (Johnson and Wright, 2003). Pit lake systems also have the propensity to develop a number of geochemical and biological systems that need to be considered in their classification (Kumar et al., 2012). The examples below show what could occur with different types of pit lakes and different salinity regimes. Note that this may not apply to all pit lakes and a site-specific assessment is required.

[1] This is in the form of a sterilisation report to the Executive Director of the Geological Survey of Western Australia.

Figure 1. The three most common types of classification for pit lakes (from Johnson and Wright, 2003).



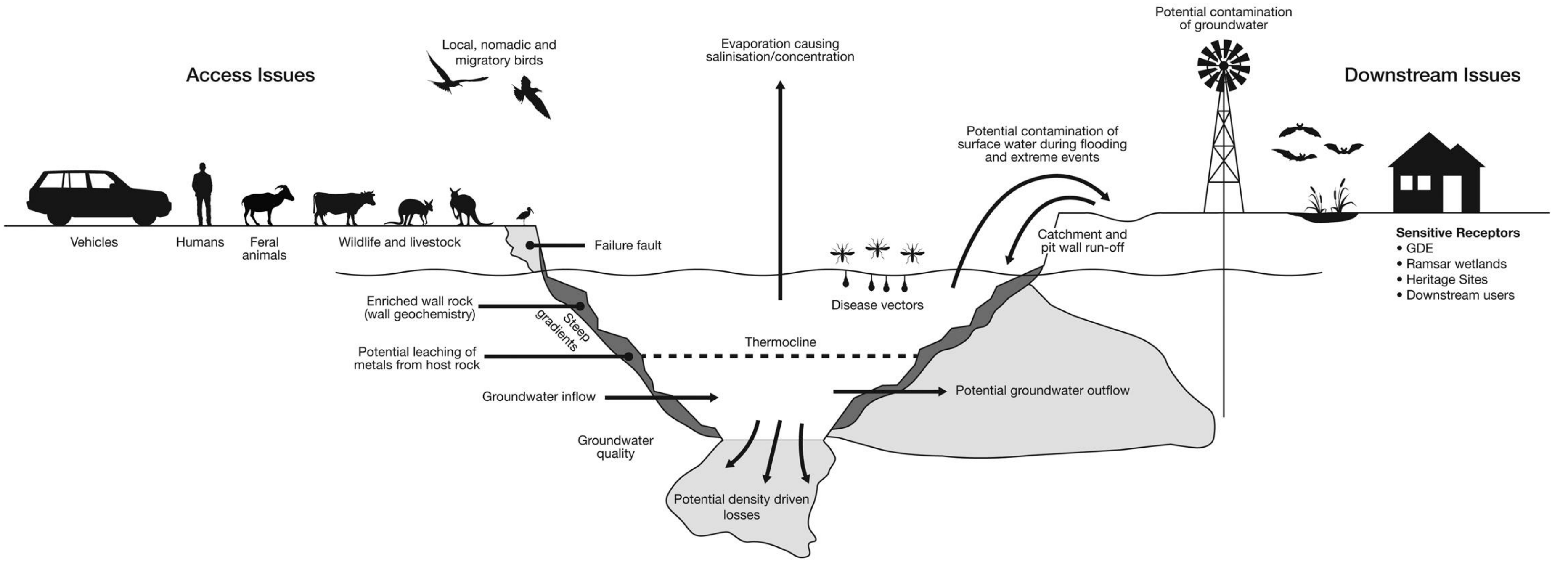
2. Assessment of pit lakes

The difficulty with assessing the potential environmental impacts associated with pit lakes is that the impacts will generally occur after the mine closes. Water levels in the pit may take hundreds of years to recover to a stable water level. Changes in water quality and water chemistry may occur over thousands of years (EPA, 2013).

The assessment of pit lakes is a multidisciplinary science and requires a considerable understanding of the site characteristics, including aspects such as climate, hydrogeology, hydrology, geochemistry, geology and proximity to sensitive receptors. An understanding of the likely shape of the pit lake, it's potential to become colonised and develop into an ecosystem and likely visitation habits of humans and fauna are also critical (Schafer and Eary, 2009).

A site conceptual model, as shown in Figure 2 below is critical to understanding how each aspect of a pit lake may interact (McCullough and Lund, 2010). The site conceptual model will identify potential sources, pathways and receptors which can be assessed further when data gathering has been completed and a risk assessment can be undertaken in more detail. It is also very common and often critical to develop conceptual models for each aspect of the pit lake assessment such as geochemistry, hydrogeology and hydrology, ecology and limnology (see Castendyk, 2009 for a review). An understanding of the aspects of a pit lake that might lead to a higher risk will allow for more focus on these aspects during data gathering and monitoring programs, so that the level of work undertaken, avoidance measures and mitigation actions are commensurate with the risk that the pit lake represents.

Figure 2. An example of a site pit lake conceptual model including examples of sources, pathways and receptors (adapted from McCullough and Lund 2006).


Access Issues
Local, nomadic and migratory birds
Evaporation causing salinisation/concentration
Potential contamination of groundwater
Downstream Issues
Potential contamination of surface water during flooding and extreme events
Vehicles
Humans
Feral animals
Wildlife and livestock
Failure fault
Catchment and pit wall run-off
Sensitive Receptors
• GDE
• Ramsar wetlands
• Heritage Sites
• Downstream users
Disease vectors
Enriched wall rock (wall geochemistry)
Steep gradients
Thermocline
Potential leaching of metals from host rock
Groundwater inflow
Potential groundwater outflow
Groundwater quality
Potential density driven losses

ii. Geochemistry and sources of metals or other contaminants

All pathways for contaminant transfer to a pit lake through appropriate testing methods should be understood when determining the final pit lake water quality. Source documents such as the GARD Guide (www.gardguide.com) and the Leading Practice Program publication - *Preventing Acid and Metalliferous Drainage* (DFAT 2016c) are a good starting point for determining likely contaminant pathways. However, there are other potential contaminant sources for pit lakes and standardised testing used for acid rock drainage may not always be appropriate. Proponents should use a fit-for-purpose approach when assessing a pit lake.

Pit lakes may receive inflows of water from a number of potential sources of contaminants such as tailings storage facilities, waste rock landforms, integrated and co-mingled waste landforms, mine site landfills and sewage treatment plants, the host rock and geology surrounding the pit, other mines in the nearby area and groundwater enriched with certain metals.

Typically, the most important source of pit lake contaminants will be groundwater and the geology surrounding the area of the pit void. The geology may contain sulfidic minerals or minerals that will leach metals/metalloids (metals herein) under neutral and alkaline conditions after exposure to oxidising conditions (MEND, 2004). If leaching does occur, metals may enter the pit lake from seepage through the pit walls and basement, groundwater inflows and potentially from surface runoff (Schafer and Eary, 2009).

In the early stages of understanding pit lake formation, it is critical to undertake appropriate geochemical testing such as kinetic humidifier tests or other appropriate leach tests (e.g. using sequential leaching methods) on the geological units that will leach metals (not necessarily just those high in sulfur) into a pit lake. The more information that is gathered on the geochemistry of an area, the greater the confidence will be with the pit lake model and the greater the ability to interpret and explain the likely source of metals entering a pit lake.

The large degree of upscaling for initial geochemical testing, the long-term nature of pit lake development and the potential for changes to mine scheduling necessitate continued geochemical testing and monitoring for metal leaching during the operational phases of projects (Schafer and Eary, 2009). Post-closure monitoring for sites may also be required due to the potential for rebounding water to interact with oxidised layers of geology and for the pit lake water to interact with the pit wall geology during lake formation (Oldham, 2014).

iii. Controls of geochemistry and analogues

The use of analogue sites or regionally known geological information to determine likely leaching of metals and dominate ions can be important for verifying and determining likely final metal concentrations in pit lakes. In regions such as Nevada in the United States, it is known that certain kinds of geologies will result in pit lakes with certain types of metals (Shevenell et al., 1999). Such an understanding becomes critical for modelling of pit lakes where there is not yet appropriate validation or optimisation because it can be used to verify modelling scenarios and likely dominating metal species.

iv. Hydrology and water chemistry

A good understanding of the hydrogeology (groundwater) and hydrology (surface water) is essential to be able to model and determine the nature of a pit lake that will form after closure. For greenfield mine sites it is not possible to validate a pit lake hydrological model at the early stages of assessment, particularly aspects such as groundwater drawdown, rebound and water level stabilisation (see Modelling section below). However, it is possible to gather enough hydrogeological information to have a good understanding of the predicted groundwater drawdown and determine a number of potential rebound scenarios (Niccoli 2009).

Where surface water flows into a pit lake (e.g. creek diversion), it is critical that the seasonal flow rates are determined, as flow rates will vary throughout the year and can result in changes to the lake water quality and the type of lake (sink or through-flow) which forms during different times of the year and with different rainfall events e.g. 1 in 10 year, 1 in 100 year, 1 in 1000 year, Probable Maximum Precipitation event (PMP).

In arid zones, climate and water flowing into the pit lake will often be two key variables for determining pit lake water quality (Johnson and Wright, 2003). For this reason, it is important that along with determining accurate water flows into a pit lake, the baseline quality of that water is determined over a suitable period of time (and appropriate flow events) e.g. at least two years. Due to phenomena such as evapo-concentration, it may also be useful to measure some groundwater contaminants to trace levels, as metals even at low concentrations can concentrate several orders of magnitude greater than their baseline value over the modelled period for the pit lake, e.g. 500-1000 years.

v. Climate

Climate has a major influence on pit lake formation and dynamics. The evaporative flux and the precipitation rate on a pit lake along with groundwater inflow are key variables for determining if a pit lake will become a throughflow or sink (Kumar et al., 2009). Evaporation (especially in many arid to semi-arid regions) will determine the rate at which evapo-concentration causes salinity and metal concentrations to increase (Shevenell, 2000). For this reason the evaporative flux is particularly important for modelling pit lakes but it is also very difficult to determine using pan evaporation data and coefficients for natural lakes. Shevenell also noted in a study on two pit lakes that were sinks, that the evaporative flux was significantly less than predicted and less than natural lakes.

Temperature and other climate variables such as storm frequency and wind will be key variables for determining the type of limnology a lake develops, including the likelihood of stratification, either permanently or semi-permanently (Jewell, 2009). For example, in WA many pit lakes greater than 10-20m deep stratify during the summer period where a thermocline develops between the upper warmer water and cooler lower water. During winter these two upper layers mix as the upper layer cools (e.g. Sivapalan, 2005). Mixing of the upper two layers can be hastened by the presence of storms and high wind events.

vi. Limnology and Water Quality

The dynamics of a pit lake, such as stratification and cycling of different layers within the lake during the year, will impact on water quality, in particular the redox state of the water and the solubility of metals. Mixing of water will also influence the salinity and concentration of metals in different layers of the lake. While stratification and pit lake dynamics can be difficult to accurately model in the early stage of an assessment, the initial assessment of a pit lake should consider how stratification may impact on water quality and provide suitable justification for the approach taken (see schematic below). Later stages of pit lake assessment (as the mine moves towards closure), should include modelling of stratification, because at this stage pit lake models will need to be calibrated with field data to accurately predict the likely future lake water quality post-mining. The future shape of the pit lake may also need to be considered when mining in unconsolidated sediments or calcretes, which can collapse and result in shallower water bodies than those originally assessed.

vii. Modelling

Modelling of a pit lake is very difficult and should not be solely relied upon to assess the final pit lake characteristics. As with other types of environmental modelling, no model of a pit lake will be completely accurate, especially in the early stages of the assessment of a mining proposal. It should be noted that more detailed modelling at this early stage (coupling of models) may not be more accurate than simpler models. As with other types of modelling, a poor understanding of the system being modelled, and poor data quality or availability may produce a model with meaningless results. There is a need to understand the system being modelled first through processes as outlined above. Oldham (2014) notes that anyone modelling should:

- Have appropriate field-based geochemical and hydrological data.
- Model a number of potential scenarios including sensitivity analyses.
- Have continued updating of models during operations and closure.

In the early stages of pit lake assessment, it may be pertinent to produce simpler models and mass balances of major solutes (e.g. acidity, carbonates, sulfates) relative to the data availability. In the later stages of a mine life, it is important that these models are improved so that future water quality predictions with a certain degree of accuracy can be validated with post closure water quality data.

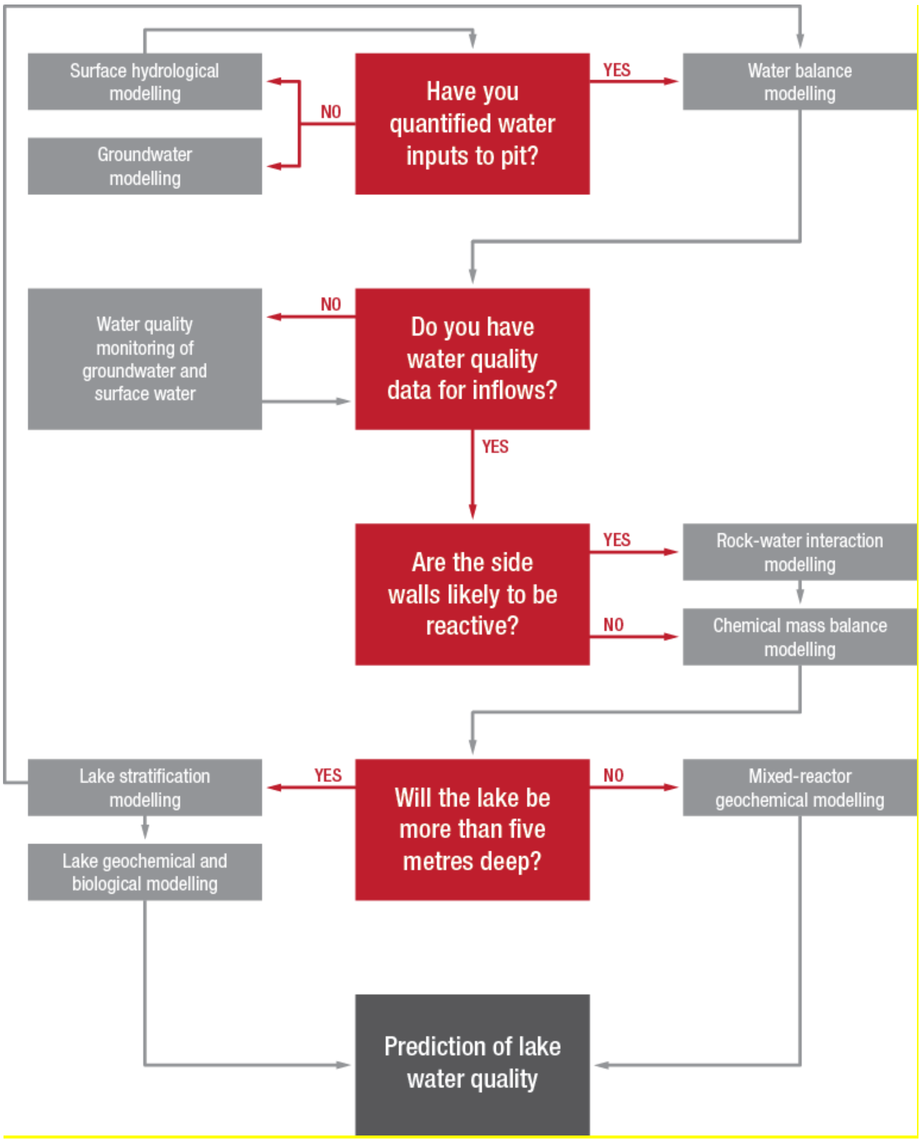
In all cases of pit lake modelling, it is critical for all pit lake assessments to consider and explicitly state:

- The assumptions used to model the pit lake.
- The limitations of data being used to model the pit lake, (e.g. Lack of appropriate evaporative flux data).

- The major sources of solutes into the system, (e.g. Groundwater vs geology of the pit walls).
- The limitations of the software, errors induced from coupling models, source code and geochemical databases used for the modelling, (e.g. Hydrological boundary condition cannot determine outflow).
- How the modelled lake may differ from the actual pit lake dynamics and how this may impact on water quality predictions, (e.g. Stratified lake likely to occur but model assumes a completely mixed lake).
- How the geometry of the lake and depth relative to the ground surface may impact on limnology and water quality (particularly important as mine scheduling and pit geometry typically change during operations), and
- Which modelled scenarios are more realistic than others and which key variables (e.g. Dominant ions in solution) are most sensitive to changes.

While pit lake modelling cannot be solely relied upon in a pit lake assessment, the research into this area is improving. A number of valuable resources have been developed to guide modelling of pit lakes (e.g. Vandenberg et al. 2011, Oldham 2014). These provide an overview of the general models used for pit lakes and the assumptions for different models. The flow chart from Oldham, (2014) shown as Figure 3 below outlines the decision process to undertake when modelling pit lakes at the more advanced stages of mine life prior to closure. It should provide anyone attempting to model a pit lake with an understanding of what data may be missing when undertaking a modelling exercise or what aspects of a simpler model may not match the real-life situation.

Figure 3. Decision process for modelling a pit lake (adapted from Oldham, 2014)



Scenario testing and sensitivity analysis

Scenario testing and sensitivity analyses should be used during modelling because it is difficult to predict water quality, in particular trace metal concentrations, with a high degree of accuracy during the initial assessment of water quality for mining proposals (Maest et al. 2005; Schafer and Eary 2009). Scenario testing should consider a range of likely (including worst case) scenarios for the different aspects of a pit lake, including geochemical and hydrological aspects (e.g. Muller et al. 2010 and 2011).

Examples of scenario testing for the hydrological components of a pit lake might include the potential for outflow from the lake during floods, unexpected increases in hydraulic conductivity (e.g. preferential pathways or large fractures not identified during initial assessment) or density-driven flow. Density-driven flow has been identified as a potential concern in many arid regions where terminal sinks have the propensity to leak into surrounding aquifers and offer a potential pathway for contaminants to be transported to sensitive receptors. Model scenarios should be run for an appropriate time period, commensurate with the risk of the pit lake, which could be until a geochemical equilibrium is reached or for a particular time period (e.g. 1,000 or 10,000 years).

Sensitivity analyses should be performed on both geochemical and hydrological components of a pit lake model to determine which parameters within the system are the most sensitive to change (Oldham 2014). Scenario testing and sensitivity analyses will provide information on the aspects of a mine, which if changed during operations, may lead to a pit lake representing a higher risk than anticipated during the initial assessment stage of the mining proposal and therefore requires appropriate contingency steps to be undertaken (e.g. avoidance or mitigation) to reduce the risk of the pit lake during operations.

Model validation

Pit lake models should continue to be refined through each stage of mining. The pit lake model will not be able to be validated during the initial assessment of the mining proposal or during operations. For many pit lakes hydrological rebound of the water level to a steady state or geochemical equilibrium will not be reached for many years after closure, even hundreds of years (Schafer and Eary 2009). For this reason, it is imperative that pit lake assessments use the best available data during assessment and operations. Operation of a mine will offer insights into the character of a site that cannot be understood during the initial assessment and approval stages of a mine, such as potential leaching of metals from a particular geological unit or higher than anticipated flow rates during dewatering. Therefore, it is imperative that where a component of a pit lake model can be validated (e.g. groundwater model during assessment or drawdown model during operations), that this occurs, so that the pit lake model and the risk assessment of the pit lake can be updated.

DEMIRS encourages proponents to verify (where they cannot validate) the pit lake models with information from other pit lakes with similar geology, climate and hydrology. Proponents can also use analogues of geology as noted above and can also undertake some laboratory studies to verify some results, e.g. batch tests (see Schafer and Eary, 2009). The verification process is focused primarily on reducing the uncertainty within the pit lake model and putting in place appropriate avoidance, mitigation and management actions so that any potential risks are reduced prior to becoming substantial liabilities. Where pit lakes represent a significant to critical risk or there is a substantial uncertainty with the understanding of the pit lake, post-closure monitoring of the pit lake over a long period of time (for example, decades) should occur until pit lake models can be optimised and validated, to accurately predict future water quality.

3. Risk Assessment

The risk assessment of pit lake water quality involves determining the possible linkages between water quality and sensitive receptors. The scenario of source –> pathways > receptor is commonly used to determine if any contaminants in the water are likely to interact with a sensitive receptor (see McCullough and Lund 2010 or the Contaminated Sites Series of Guidelines for more detailed information). Where pit lakes are highly polluted and/or represent a critical to high risk they may be subject to the *Contaminated Sites Act 2003*.

There are a number of scenarios for pit lakes where a receptor may interact with water quality. For example, direct interaction may occur where birds fly onto the pit lake and drink the water, or indirect interaction may occur where an ecosystem develops and emergent insects which contain contaminants are consumed by birds. Table 1 below outlines potential sources, pathways and receptors. Note that it does not provide an exhaustive list and it has not identified primary sources of metals e.g. pit walls, groundwater or other sources as noted above.

Table 1: Common sources, pathways and receptors for pit lakes

Source	Pathways	Receptors
Mine pit lake water: • Source of salinity/acidity • Source of heavy metals and metalloids • Source of nutrients	Water: • Mine pit lake water • Groundwater outflow • Density-driven outflow Biota: • Biomagnification and/or bioaccumulation of heavy metals	Humans: • Workers • Public Biota: • Birds • Mammals (e.g. native, feral or agricultural) • Reptiles • Aquatic organisms • Groundwater Dependent Ecosystems Groundwater values • Public drinking water sources • High value wetlands and creeks

viii. Risk assessment and water quality criteria

The application of appropriate water quality criteria (such as ANZECC 2000) can be confusing when undertaking an assessment of a pit lake. The application of appropriate criteria will often be determined by the risk assessment undertaken and which pathways are likely to result in a receptor being exposed (Hakonson et al. 2009). For example, if it is likely that water from a pit lake will flow to a water abstraction bore used for potable water and there are no other exposed receptors, then the use of drinking water standards would be appropriate. Likewise, if it is likely that water from a pit lake will flow to a water abstraction bore for livestock watering and there are no other exposed receptors, then the use of the livestock drinking standards would be appropriate.

In many arid regions, where mammals and humans are excluded through good pit closure design and the lake is a terminal sink in which density-driven plumes are unlikely to occur, the main receptor that will interact with the pit lake water is likely to be birds and there may not be a specific water quality guideline available. In these cases, appropriate site-specific assessment of impacts is warranted taking into consideration the types of pathways that avian or other flying vertebrates are likely to uptake contaminants e.g. food, water, dermal contact or secondary pathways for higher predatory birds. In these cases, it’s also important to consider the potential for a pit lake to develop into some form of ecological system, either with limited (e.g. one or two trophic levels) or significant biological levels of organisation (e.g. several trophic levels including predatory vertebrates such as fish) (Hakonson et al., 2009). The key drivers for an ecosystem developing in a lake will include the nutrient levels, potential for seeding of the lake with organisms (e.g. diversion of a river into the lake) and future water quality.

Other types of risks

There are a few other types of risks that need to be taken into consideration when assessing a pit lake. These include:

- Vectors (mosquitoes, birds etc.) And disease transfer.
- Drowning of humans, wildlife and stock.
- Increased abundance of feral animals (e.g. Goats are highly tolerant of saline water) and the impacts of this on revegetation and regional conservation activities.
- Changes to the pit lake from seismic and extreme events.
- Discharge to waterways or groundwater receptors via connections with underground workings.
- Pit wall collapse and the impacts on humans, or by humans, in the nearby vicinity.

When assessing these types of risks, it is important to identify ways to avoid, mitigate or manage the risk through limiting access to the site or providing suitable egress points for anything to leave the pit lake. As for the risk assessment of impacts from water quality in a pit lake, the strategy chosen for other types of risks should consider the likelihood and consequence of the risks as identified through a risk assessment (see below for further details).

ix. Risk Matrix

The risk examples that follow have focused on some common risks that a pit lake may represent. It has been developed as a guide and it is expected that other scenarios to those mentioned below will occur. It is expected that operators will assess their site and identify the risk from a future pit lake, so that the key aspects contributing to the risk can be avoided, mitigated and managed as much as possible during the operational phases of a project. For example, appropriate handling of potential acid-forming materials will reduce the potential for water quality problems when the pit lake develops. Likewise, understanding how pit geometry may impact on final water quality will allow operators to understand how partial backfilling may improve future water quality.

Table 2: Examples of different risks

Example	Comments and Corrective Actions
• Loss of life or serious injury to humans. • Regional scale impacts to groundwater will occur and groundwater has a high value e.g. priority drinking water source (i.e. if pit lake will become through flow system and pit lake quality is very poor). • Site contains significant quantities of acid forming materials and will represent an unacceptable ongoing liability to the state. • Scheduled, listed or declared rare and/or threatened species of flora or fauna present on site will be adversely impacted at a regional scale.	Risks need to be reduced to an acceptable level through avoidance and mitigation. This may be achieved through reducing the risk of a particular aspect of the pit lake, e.g. avoiding rocks high in acid-forming materials, identifying measures to stop water outflow. Risk can also be reduced by analysing possible future scenarios (e.g. backfill vs open lake). If the risks cannot be reduced, then the mine may not be considered to be acceptable. Monitoring and management will be required to prove that risks are reducing through good management actions on site. Post-closure monitoring for a significant period of time is likely to be required.

Example	Comments and Corrective Actions
• Scheduled, listed or declared rare and/or threatened species of flora or fauna present on site likely to be adversely impacted at a local scale. • Acidification of water and major impacts to humans likely to occur from recreational use of water. • Assessment or modelling of long-term pit water quality indicates likely prolonged degradation of local groundwater quality. • Stock watering bores within proximity of site likely to be impacted.	Risks are likely to need to be reduced through appropriate avoidance, mitigation and management measures. Monitoring would be required to show that risks are not increasing and any proposed measures are reducing the risk.
• Water quality neutral and contains some contaminants well above recreational guidelines. Pit lake is accessible to humans for recreation and moderate impacts to humans will occur.	Site-specific risks need to be assessed through appropriate methodologies. Appropriate avoidance or mitigation methods need to be put in place to manage the risk. Monitoring would be required to validate the assumptions of the risk assessment, especially for those aspects of the mine which could change the risk
• Scheduled, listed or declared rare and/or threatened species of flora or fauna present on site could potentially be impacted at a local scale. • Some acidification of pit water likely and some access to water available to humans, birds and mammals. • Possible localised groundwater impacts from pit lake water and potential groundwater use.	Risks may need to be reduced through appropriate mitigation or management measures. Monitoring would be required to show that risks are not increasing and any proposed measures are managing or reducing the risk.
• Pit lake water found to be unlikely to impact any receptors through appropriate studies but will have a low salinity that would be palatable for birds.	Monitoring would be required to validate the assumptions of the risk assessment, especially for those aspects of the mine which could change the risk, e.g. potential acid-forming materials identified during mining.

Example	Comments and Corrective Actions
• Pit lake will contain water with the same chemistry as groundwater and water will flow out of the lake to groundwater.	Monitoring would be required to validate the assumptions of the risk assessment, especially for those aspects of the mine which could change the risk, e.g. potential acid-forming materials identified during mining.

x. Stages of assessment towards closure

The assessment of pit lakes requires a staged approach with data gathering, monitoring and analysis requirements based on the risk that the aspect of the pit lake represents. For higher risk sites, due to the high level of liability involved, considerable work and commitments are likely to be required during the environmental impact assessment of the project and will need to be continued through to operations and closure. It is anticipated that for higher risk sites, the risk may be reduced through avoidance, mitigation and management measures, which would need to be verified through monitoring during the operational and closure stages of a mine site.

4. Evolution of Pit Lake Science

Pit lakes represent some of the more complex systems to assess from an environmental viewpoint. The long-term nature of the pit lake presence in the landscape coupled with the anthropogenic nature of their occurrence means that it is not possible to rely on all data from natural lake systems and the evolving science in this area can change relatively quickly. For this reason, it is critical that proponents speak with DWER and DEMIRS if they are likely to have a moderate to critical risk pit lake. DWER and DEMIRS are committed to working with proponents to ensure they are aware of the requirements when undertaking pit lake assessments.

Appendix 5 – Guidance on Development of Mine Closure Plan to Execution Phase

As an operation approaches the decommissioning and closure phase, the Mine Closure Plan needs to be revised to provide the level of detail needed for the execution of closure on the site.

Guidance on the planning required as the site progresses towards closure can be found in the ICMM *Integrated Mine Closure – Good Practice Guide* (ICMM 2019) and ICMM *Closure Maturity Framework – Tool for Closure User Guide* (ICMM 2022).

Following completion of all closure works, monitoring and maintenance must continue until it can be demonstrated that the agreed closure outcomes and associated completion criteria have been met. A Mine Closure Completion Report can be submitted to seek formal acceptance from DEMIRS that rehabilitation and closure obligations under the Mining Act have been met, as described in the Mine Closure Completion Guideline.

Guidance on the level of detail that should be provided in a mine closure plan as an operation approaches closure is provided below.

1) Updated Legal Obligations Register

As an operation approaches the decommissioning and closure phase, operators should ensure that the Legal Obligations Register has been updated with the items completed, with evidence of completion. Where an item is not complete, the register should provide the work required for completion and a date expected to be completed. An example of a detailed legal obligations register is provided as Table 1 below.

Table 1. Example of detailed legal obligations register.

LEGAL OBLIGATIONS REGISTER				
Relevant DEMIRS Tenement Conditions				
Tenement	**Condition Number**	**Closure Condition**	**How Obligation Included in Closure Strategy / MCP**	**Complete (If applicable)**
M01/100, M01/101	3	Topsoil and vegetation to be removed ahead of mining operations and appropriately stockpiled for later respreading or immediately respread as rehabilitation progresses.	Topsoil map and volumes available included in MCP.	Ongoing
M01/100	4	Placement of waste material must be such that the final footprint after rehabilitation will not be impacted upon by pit wall subsidence or be within the zone of pit instability to the satisfaction of the Executive Director, Resource and Environmental Compliance,	Included in completion criteria. Site plans and cross section provided showing location of open pits in relation to zone of instability.	Yes

		Department of Mines, Industry Regulation and Safety.		
M01/100, M01/101	5	All mining related landforms and disturbances must be rehabilitated, in a progressive manner where practicable, to ensure they are safe, stable, non-polluting, integrated with the surrounding landscape and support self-sustaining, functional ecosystems or alternative agreed outcome to the satisfaction of the Executive Director, Resource and Environmental Compliance, Department of Mines, Industry Regulation and Safety	Incorporated into closure outcomes and completion criteria.	Ongoing
M01/100, M01/101	6	All reasonable measures will be taken to construct tailings storage, vat leach or heap leach facilities in a manner to prevent discharges from the facility to the environment.	Closure strategy for TSF detailed in Section X of MCP to demonstrate landform will be stable and non-polluting at closure.	Ongoing
M01/100, M01/101	7	All rubbish and waste will be appropriately managed and disposed.	Included in completion criteria.	Ongoing
Ministerial Statement xxx – xx/xx/xxxx (No and Date)				
condition Number		**Closure Condition, Commitment or Aspect Related to Closure**	**How Obligation Included in Closure Strategy / MCP**	**Complete (If applicable)**
10		Closure planning would be undertaken in consultation with Traditional owners and ensure access considerations are taken into account	Regular stakeholder engagement with traditional owners on closure strategy.	Ongoing
11		Local provenance seed and propagated material would be used, if required, to rehabilitate disturbed areas	Local seed collection and nursery established. Ongoing propagation trials	Ongoing

22		Revision of the site surface water numerical model during operations to further refine assumptions and inform closure designs and strategies	Identified as knowledge gaps to be address as further surface water monitoring data is collected.	Ongoing
DEMIRS Approvals – NOI / Mining Proposal / MDCP xxx – xx/xx/xxxx (No and Date)				
Item Number or Page Number	**Document details**	**Closure Commitment or Aspect Related to Closure**	**How Obligation Included in Closure Strategy / MCP**	**Complete (If applicable)**
55	MP REG ID 20XY1	XY pit to be partially backfilled with waste rock.	Included in completion criteria. Captured in mining planning sequence.	completed
70	MP REG ID 30VX1	PAF material is encapsulated in landforms in accordance with the approved design	Included in completion criteria. WRL designs presented in Section X of MCP.	Ongoing

2) Ongoing Stakeholder Engagement

The mine closure plan should include an updated Stakeholder Engagement Register clearly showing the consultation with stakeholders over time and identifies the topics of discussion and outcomes achieved. DEMIRS may request records (e.g. minutes of meetings), demonstrating in depth conversations on post-mining land use (PMLU), retained infrastructure, completion criteria and standards to be used in the PMLU.

The PMLU should be agreed with key stakeholders and an understanding developed of any specific requirements for closure.

3) Handover of infrastructure requested by other parties

Where infrastructure is to be retained post closure, liability for the infrastructure must be appropriately transferred to a responsible person/entity. Retention agreements should be provided in the mine closure plan where possible, identifying the proposed new responsible person/entity, maintenance agreements and proposed handover conditions.

Should final signed agreements not be available, then minutes of meetings with the drafted agreements can be included. Mining infrastructure that may be of use on a pastoral lease post closure can be retained by the pastoralist through an application to the Pastoral Lands Board to transfer liability from the mining company.

Tenement holders will need to demonstrate appropriate transfer of liability has occurred for any mining infrastructure to be retained on site.

4) Compliance with the requirements of the Contaminated Sites Act 2003 including remediation of contaminated areas

Site contamination as a result of mining operations and the risk associated with contamination, must be managed throughout the life of mine.

As party of the Closure Risk Assessment (Section 6), the MCP should clearly identify areas of the site that may be contaminated as per the classifications shown in the *Contaminated Sites Act 2003*, together with the sites that have been reported to date, and the classifications assigned. This is best achieved by a site map illustrating the areas combined with a table showing the location, description of contamination and the classification. These classifications are documented in the DWER guidelines. 'Contaminated' is defined in the Act as:

Contaminated – in relation to land, water or a site, means having a substance present in or on that land, water or site at above background concentrations that presents, or has the potential to present, a risk of harm to human health, the environment or any environmental value.

A list of contamination that occurred during operations and the remedial actions conducted would be useful to indicate areas for further investigation.

Where appropriate a schedule should be included for any Preliminary Site Investigations (PSI) work that cannot be conducted until after cessation of operations or demolition works (such as soil contamination under processing plants or workshops, etc) including responsible person, tasks and due dates.

5) Finalisation of completion criteria

DEMIRS expects the completion criteria to be further refined over the life of mine with finalised criteria presented as the site progresses closer to closure (typically 2 to 5 years prior to closure). For further guidance on developing completion criteria refer to the Western Australian Biodiversity Science Institute's (WABSI), *A framework for developing mine-site completion criteria in Western Australia* (WABSI, 2019).

Stakeholders' agreement on the completion criteria are essential at this stage.

6) Schedule/Timeline for the implementation of the closure works/tasks

As the site progresses towards closure DEMIRS would expect the closure task register to be well developed with detailed timeframes for implementation of closure tasks.

7) Completion of rehabilitation works

The MCP closure implementation section should include the 'as-built' reports of structures that have already been rehabilitated, together with monitoring results and learnings from the implementation. Where appropriate, how these learnings have been used to improve future rehabilitation works.

The MCP should include a timeline for the implementation of any remaining rehabilitation/closure earthworks/tasks which provides the task, task owner and completion date. Use of a project planning tool (such as GANNT charts or Microsoft Project) is recommended to allow understanding of the interactions and interdependency of tasks.

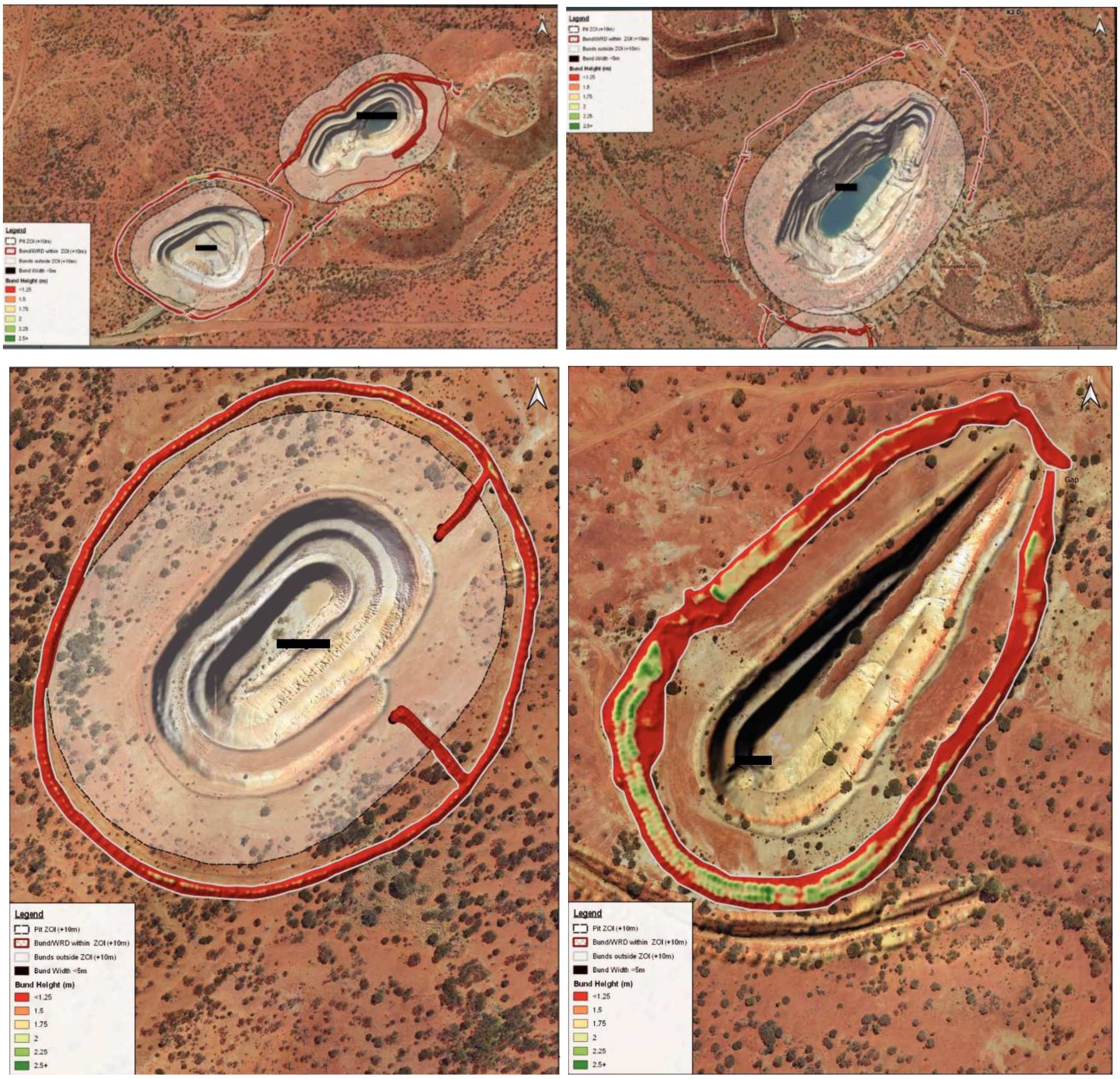
Where the site has Underground workings, the details of making safe all access routes to the underground workings should be included.

Where the site has Open Cut Pits, the measures taken to make the area safe to exclude 'inadvertent' access should be shown. Should the use of Abandonment Bunds be selected, the Abandonment Bunds placement and an audit of construction 'as-built' must be conducted to identify remaining works. This audit should also list the works and responsible person, with due date. An example of an Abandonment Bund audits as either figure or tables presented in Table 2 and Figure 2. These formats provides a quick assessment of the efficacy of the Abandonment Bunds at the site.

Table 2: Example summary table showing performance of the Abandonment Bund in relation to the various factors giving a pass/fail assignment to each factor.

Pit	ZOI		Gaps		Height		Width		Material	
Pit A	Fail	100% of the bund is within ZOI	Pass	No gaps	Fail	98% of the bund is less 2 m high	Pass	100% bund > 5 m basal width	Pass	Material sufficiently resistant to erosion.
Pit B	Pass	100% outside ZOI	Fail	1 large gap	Pass	100% of the bund > 2m high	Pass	100% bund > 5 m basal width	Pass	Material sufficiently resistant to erosion.

Figure 2. Example of pictorial audit of open pit abandonment bunding. Picture note whether factors such as gaps, height, width and construction meet relevant requirements.



8) Construction of final landforms and drainage structures

The closure implementation section of the mine closure plan should provide detailed information on the construction of final landforms and drainage structures.

The requirements for this aspect are two parts:

(1) Provide closure designs and detailed drawings with sufficient detail that someone could implement the design, and

(2) Identify all features on a site-wide plan map that shows regional catchment(s), reinstated surface drainage, land users, receptors, and constructed landforms and features with sufficient detail to see each component part (larger scale or inset maps may be needed for bigger or more complex sites / areas).

A good way to approach this is to ask "*Does the design include enough information to proceed to competitive tender for the works (descriptive and schematically)*?" If the answer is no, then this is not enough detail for the MCP submission.

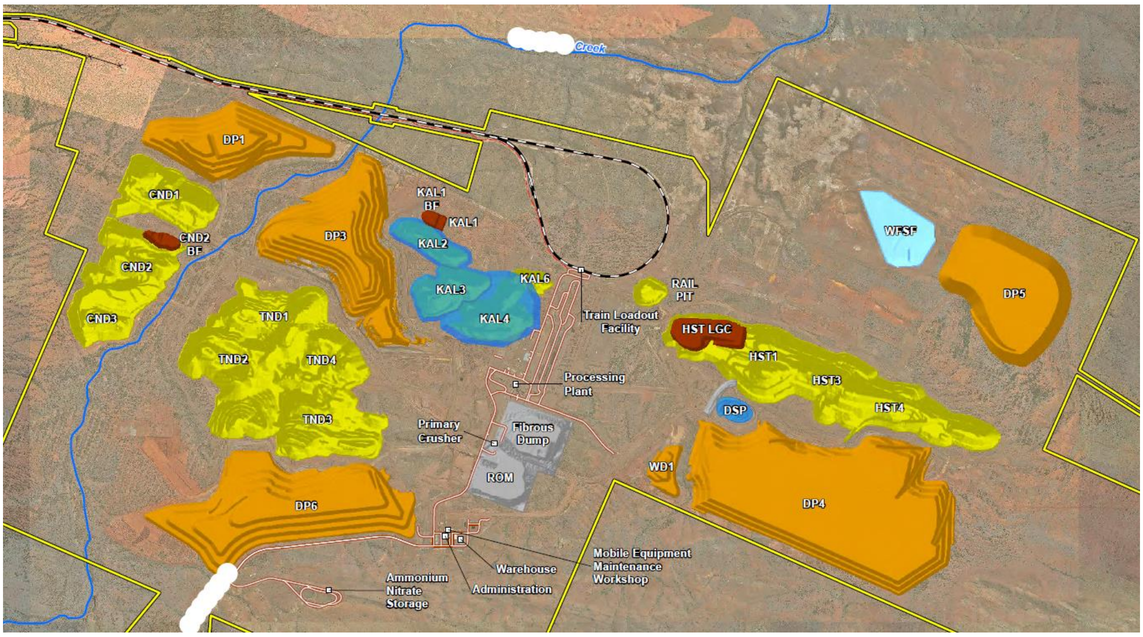
The MCP should include detailed closure designs for landforms, pit voids, and engineered or diverted site drainage (levees, embankments, diversions) typically 2 to 5 years prior to the specific landform commencing rehabilitation. Detailed designs information should include picture/schematic/drawing of the whole site at cessation of mining operations showing landscape, drainage (including diversions, levees), natural and constructed topographical features, abandonment bunds, ZOI, and any underground accesses should be supplied. This would ideally be in such a format as to allow DEMIRS appraisal in GIS or as a ‘site flyover’. The information should clearly show the ‘built’ formations in relation to the naturally occurring formations. Technical drawings or cross sections showing detailed information for landforms, buried infrastructure, engineered drainage showing key design criteria should be provided. These can be in either ‘design’ phase or ‘as-built’ and should include information such as heights, angles, surface treatments (rock armour, topsoil, etc), minimum distance specifications from floodplains and / or zone of instability, the presence of any containment cells for problematic materials (i.e. tailings, PAF, landfill, tyres, asbestos, radioactive materials, unsuitable materials, etc), and underground workings safety measures.

Supporting technical information for materials characterisation, QA/QC, installation records should also be provided to support ‘as built’ records.

An example of maps and drawings showing pre and post rehabilitation landforms in relation to surrounding landscapes are shown in the Figures 3 and 4 below.

Figure 3. Example figure illustrating design of landforms in relation to the surrounding landscape pre and post closure.

Pre-rehabilitation



Post rehabilitation

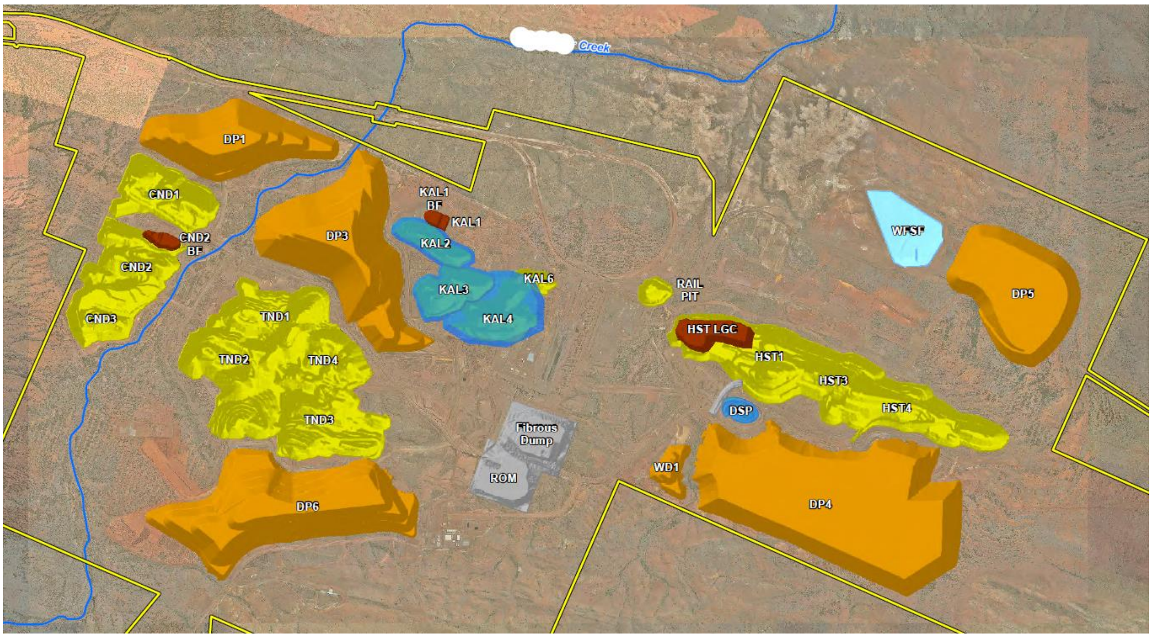
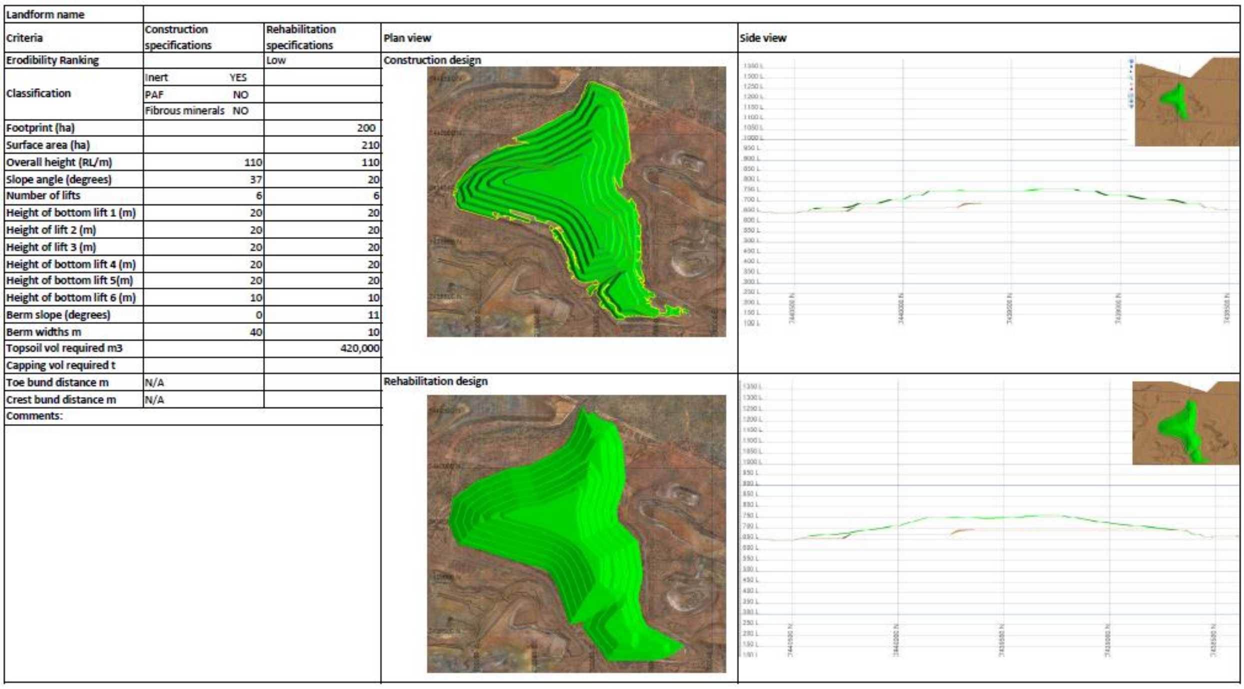


Figure 4. Example of rehabilitation and design diagrams for mining landforms to remain post closure.



Landform name			
Criteria	Construction specifications		Rehabilitation specifications
Erodibility Ranking			Low
Classification	Inert	YES	
	PAF	NO	
	Fibrous minerals	NO	
Footprint (ha)			200
Surface area (ha)			210
Overall height (RL/m)		110	110
Slope angle (degrees)		37	20
Number of lifts		6	6
Height of bottom lift 1 (m)		20	20
Height of lift 2 (m)		20	20
Height of lift 3 (m)		20	20
Height of bottom lift 4 (m)		20	20
Height of bottom lift 5(m)		20	20
Height of bottom lift 6 (m)		10	10
Berm slope (degrees)		0	11
Berm widths m		40	10
Topsoil vol required m3			420,000
Capping vol required t			
Toe bund distance m	N/A		
Crest bund distance m	N/A		
Comments:			

The MCP should also a site wide map that considers and illustrates where applicable:

- Surface water diversion structures, culverts, and any other constructed features.
- Flood modelling
- The proximity of the site to nearby infrastructure, heritage sites, retained and/or public roads, residential communities, and environmental receptors. Any impacts

on these features predicted by analytical or numerical models (e.g. flooding, contamination, erosion, subsidence) must be shown with previously conducted supporting technical studies included. The potential for failure of any built structure to impact any of these local features must also be shown (some examples: TSF failure dam break assessment extent, pit void capture of a major tributary, pit wall collapse impacting public road or inhabited areas, WRD slumping / erosion plumes, etc).

9) The safe demolition and decommissioning of plant and infrastructure

Prior to decommissioning consultation should occur with a registered plant demolition company/consultant to provide a practical assessment of the potential for recycling of plant and infrastructure, the stages of demolition, safety precautions and preparatory works at the cessation of operations (such as pigging/flushing of pipelines, depressurisation, removal of chemicals/gases, disconnection and de-energising of power, etc), safety precautions for demolition and the making good of the demolition site following works. This consideration should be included in the MCP.

The MCP should also advise the location of any disposal needed (chemicals, concrete, plant/infrastructure, etc). Any buried services that will remain at closure should be noted on a specific site plan, this should also include any landfill sites, with depth to infrastructure marked.

Plant and infrastructure suitable for recycling that has been identified should be listed together with likely destination.

10) Monitoring and measurement against completion criteria

The MCP should include a comprehensive monitoring schedule that demonstrates how the monitoring will be used to show attainment of the closure outcomes and completion criteria. An example is shown below as Table 3.

Following completion of all closure works, the post closure monitoring program as outlined in the mine closure plan is to be undertaken to demonstrate achievement of the agreed closure outcomes and associated completion criteria. Remedial and maintenance works may be required during this period based on monitoring results and trends to ensure closure outcomes will be achieved. Once post-closure monitoring results demonstrate achievement against the completion criteria and closure outcomes over a sufficient timeframe, tenement holders seek formal acceptance from DEMIRS that rehabilitation and closure obligations under the Mining Act have been met. Acceptance is sought through submission of a mine closure completion report in accordance with DEMIRS Mine Closure Completion Guideline. Mine closure completion reports may also be submitted progressively to close out parts of a mine if appropriate.

DEMIRS encourages operations to work towards meeting their completion criteria and achieving approval of a mine closure completion report. This process releases tenement holders from relevant environmental obligations under the Mining Act.

Table 3. Example of detailed monitoring program

MONITORING PROGRAM					
Closure & Rehabilitation Tasks During Operations					
Location	**Closure Outcomes / Completion Criteria**	**Performance Indicator(s) and Triggers for Remedial Action**	**Timing**	**Owner**	**Details of Measurement Tools and Monitoring Methods to be Undertaken**
Ref123	*#1 CC on Rehab – (detail)*	*Target on Plant density – (detail) Trigger: < 50%*	*Annually - April*	*Environment Manager*	*OFA Program – utilising quadrats 10m x 10m (detail)*
Ref234	*#2 CC on Rehab – (detail)*	*Target on Plant Diversity – (detail) Trigger: <20*	*Annually - April*	*Environment Manager*	*OFA Program – utilising quadrats 10m x 10m (detail)*
WRD123	*#3 CC on Rehab – (detail)*	*Monitoring of Ripping Depth Trial Trigger: Rip lines non-existent*	*Annually - April*	*Environment Manager*	*OFA Program – utilising quadrats 10m x 10m (detail)*
Pit xxx	*#4 CC on Pit Lake – (detail)*	*Target on water quality Trigger: metals > x ppm*	*Quarterly*	*Mining Manager*	*Water sampling and analysis for (detail)*
Pit 123	*#5 CC on Water level – (detail)*	*Target on water table recovery Trigger: Water level < m RL*	*Monthly*	*Mining Manager*	*Survey of water level*
Closure & Rehabilitation Tasks During Decommissioning					
Location	**Closure Outcomes / Completion Criteria**	**Performance Indicator(s) and Triggers for Remedial Action**	**Timing**	**Owner**	**Details of Measurement Tools and Monitoring Methods to be Undertaken**
Ref123	*#1 CC on Rehab – (detail)*	*Target on Plant density – detail Trigger: < 50%*	*Annually - April*	*Environment Manager*	*OFA Program – utilising quadrats 10m x 10m (detail)*
Ref234	*#2 CC on Rehab – (detail)*	*Target on Plant Diversity – detail Trigger: <20*	*Annually - April*	*Environment Manager*	*OFA Program – utilising quadrats 10m x 10m (detail)*
etc					
Closure & Rehabilitation Tasks Post Closure					
Location	**Closure Outcomes / Completion Criteria**	**Performance Indicator(s) and Triggers for Remedial Action**	**Timing**	**Owner**	**Details of Measurement Tools and Monitoring Methods to be Undertaken**
Ref123	*#1 CC on Rehab – (detail)*	*Target on Plant density – detail Trigger: < 50%*	*Annually (April) Until 2031, 3 yearly until 2042*	*Environment Manager*	*OFA Program – utilising quadrats 10m x 10m (detail)*
Pit 123	*#5 CC on Water level – (detail)*	*Target on water table recovery Trigger: Water level < m RL*	*Annually until 2042*	*Mining Manager*	*Survey of water level*
etc					

The MCP should provide a summary of the monitoring results and learnings of structures that have already been rehabilitated, shown in such a way as to demonstrate the performance over time of the individual monitoring points and the structure overall.

Where appropriate, how the learnings from monitoring have been used to improve subsequent or future rehabilitation works (such as earthworks methodology, slope angles, seed species, topsoil application, etc) should also be included.

The monitoring results should clearly show how they relate to the completion criteria at individual monitoring points and at structures as a whole.

An example summary table demonstrating performance against the closure outcomes and completion criteria is presented below.

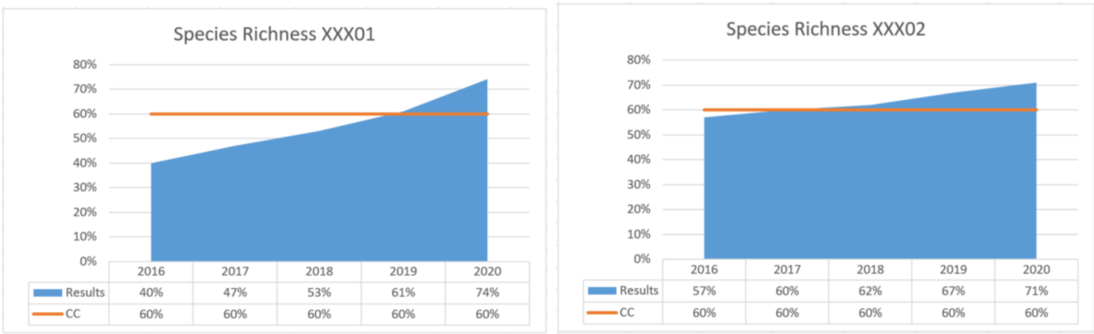
Table 4. Example of a monitoring results summary that demonstrate performance against closure outcomes and completion criteria.

Site Feature	Monitoring Point & Year	Monitoring Method & Results	Closure Outcome	Completion Criteria	Below, At Target or Achieved
WRD1	XXX01	Species Richness	Rehab resembles natural vegetation	Species richness at least 60% of analogue site average	
	2016	40%			Below
	2017	47%			Below
	2018	53%			Below
	2019	61%			Achieved
	2020	74%			Achieved
	XXX02				
	2016	57%			Below
	2017	60%			At Target
	2018	62%			Achieved
	2019	67%			Achieved
	2020	71%			Achieved
	etc				
WRD1	AVERAGE				Achieved

The results can also be shown graphically as demonstrated in Figure 5. All summarised results Should be supported by reports.

The monitoring will be used to show achievement of the closure outcomes and completion criteria, but can also highlight triggers for remedial works that may be required.

Figure 5. Example of monitoring for completion criteria shown graphically.



11) Knowledge gaps

All identified knowledge gaps must be finalised, or at the very least to be scheduled with responsible person and a due date that is before the expected cessation of operations on the site. This means that there is active work occurring, and hence machinery and personnel to undertake any work needed to finalise the knowledge gaps. An example being establishing rehabilitation trial sites.

Knowledge gaps should be finalised (not still open), or at least to be scheduled with responsible person and due date prior to cessation of operations.

Appendix 6 - Mine Closure Plan Checklist

Please cross reference page numbers from the mine closure plan where appropriate and provide comments or reasons for No (N) or Not Applicable (NA) answers. For mine closure plan revisions please indicate where updates have been made to the previous revision and a brief summary of the change.

No	Mine Closure Plan (MCP) checklist	Y/N/NA	Page No.	Comments	Changes from previous version (Y/N)	Page No.	Summary
1	Has the Checklist been endorsed by a senior representative within the tenement holder/ operating company? (See bottom of checklist.)						
Public Availability							
2	Are you aware that all approved MCPs will be made publicly available?						
3	Is there any information in this MCP that should not be publicly available?						
4	If “Yes” to Q3, has confidential information been submitted in a separate document/section?						
Cover Page, Table of Contents							
5	Does the MCP cover page include: • Project title • Company name\ Contact details (including telephone numbers and email addresses) • Document ID and version number • Date of submission (needs to match the date of this checklist)						*E.g. company name change*
Scope and Purpose							
6	State why the MCP is submitted (e.g. as part of a mining proposal, a reviewed MCP or to fulfil other legal requirements)						*E.g. As part of mining proposal*
Project Overview							

7	Does the project summary include: • Land ownership details (include any land management agency responsible for the land / reserve and the purpose for which the land / reserve [including surrounding land] is being managed). • Location of the project. • Comprehensive site plan(s). • Background information on the history and status of the project.						
Legal Obligations and Commitments							
8	Does the MCP include a consolidated summary or register of closure obligations and commitments?						
Stakeholder Engagement							
9	Have all stakeholders involved in closure been identified?				N		
10	Does the MCP include a summary or register of historic stakeholder engagement with details on who has been consulted and the outcomes?				Y	60	*E.g. new stakeholders identified and stakeholder engagement register updated*
11	Does the MCP include a stakeholder consultation strategy to be implemented in the future?				Y	61	*E.g. stakeholder strategy included*
Post-mining land use(s) and Closure outcomes							
12	Does the MCP include agreed post-mining land use(s), closure outcomes and conceptual landform design diagram?				Y	62	*E.g. Updated closure outcomes*
13	Does the MCP identify all potential (or preexisting) environmental legacies, which may restrict the post mining land use (including contaminated sites)?						
14	Has any soil or groundwater contamination that occurred, or is suspected to have occurred, during the operation of the mine, been reported to DWER as required under the *Contaminated Sites Act 2003*?						
Development of Completion Criteria							
15	Does the MCP include an appropriate set of specific completion criteria and closure performance indicators?				Y	62	*E.g. Updated closure outcomes*

16	Does the MCP include baseline data (including pre-mining studies and environmental data)?						
17	Has materials characterisation been carried out consistent with applicable standards and guidelines (e.g. GARD Guide)?						
18	Does the MCP identify applicable closure learnings from benchmarking against other comparable mine sites?						
19	Does the MCP identify all key issues impacting mine closure outcomes and outcomes (including potential contamination impacts)?						
20	Does the MCP include information relevant to mine closure for each domain or feature?				Y	64	*E.g. MCP updated as a new mining proposal was submitted*
Identification and Management of Closure Issues							
21	Does the MCP include a gap analysis/risk assessment to determine if further information is required in relation to closure of each domain or feature?						
22	Does the MCP include the process, methodology, and has the rationale been provided to justify identification and management of the issues?						
Closure Implementation							
23	Does the MCP include a summary of closure implementation strategies and activities for the proposed operations or for the whole site?				Y	66	*E.g. Updated as a new mining proposal for the operation was approved*
24	Does the MCP include a closure work program for each domain or feature?						
25	Does the MCP contain site layout plans to clearly show each type of disturbance as defined in Schedule 1 of the MRF Regulations?						
26	Does the MCP contain a schedule of research and trial activities?						
27	Does the MCP contain a schedule of progressive rehabilitation activities?						
28	Does the MCP include details of how unexpected closure and care and maintenance will be handled?						
29	Does the MCP contain a schedule of decommissioning activities?						

30	Does the MCP contain a schedule of closure performance monitoring and maintenance activities?						
Closure Monitoring and Maintenance							
31	Does the MCP contain a framework, including methodology, quality control and remedial strategy for closure performance monitoring including post-closure monitoring and maintenance?						
Financial Provisioning for Closure							
32	Does the MCP include costing methodology, assumptions and financial provision to resource closure implementation and monitoring?				Y	67	*E.g. Costings updated to reflect current market values*
33	Does the MCP include a process for regular review of the financial provision?						
Management of Information and Data							
34	Does the MCP contain a description of management strategies including systems and processes for the retention of mine records?						

Corporate Endorsement:

I hereby certify that to the best of my knowledge, the information within this mine closure plan and checklist is true and correct and addresses all the requirements of the Guidelines for Mine Closure Plans approved by the Director General of the Department of Mines, Industry Regulation and Safety.

Name: ________________________ Signed: _______________________

Position: ______________________ Date: _________________________

(NB: The corporate endorsement must be given by tenement holder(s) or a senior representative authorised by the tenement holder(s), such as a Registered Manager or Company Director

Government of Western Australia

Department of Energy, Mines, Industry Regulation and Safety

8.30am – 4.30pm

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