Department of **Mines, Petroleum and Exploration**

GOVERNMENT OF WESTERN AUSTRALIA

Guideline

Guideline for preparing Mine Closure Plans

November 2025

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 Small Mining Operations Policy
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 Application Administrative Procedures Mining Development and Closure Proposal and Approvals Statement Framework

Version history

Version	Date	Changes
1.0	June 2011	Initial publication 'Guidelines for Preparing Mine Closure Plans'
2.0	May 2015	Document reviewed 'Guidelines for Preparing Mine Closure Plans'
3.0	March 2020	Statutory requirements and guidance material published into separate documents 'Mine Closure Plan Guidance – How to prepare in accordance with Part 1 of the Statutory Guidelines for Mine Closure Plans'
4.0	January 2023	Document reviewed and minor administrative amendments made 'Mine Closure Plan Guidance – How to prepare in accordance with Part 1 of the Statutory Guidelines for Mine Closure Plans'
5.0	March 2025	Document reviewed and aligned with Mine Development and Closure Proposal and Approvals Statement Framework 'Guideline for preparing Mine Closure Plans'
6.0	November 2025	Content updates 'Guideline for preparing Mine Closure Plans'

Contents

Purpose

The purpose of this guideline is to assist the preparation of a Mine Closure Plan (MCP) in accordance with the *Mining Act 1978* (Mining Act) and the Mining Regulations 1981 (Regulations).

Operation

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

Objectives

The Department of Mines, Petroleum and Exploration (DMPE) is responsible for regulating mineral exploration and development activities in Western Australia (WA) under the Mining Act and is the lead agency for mine closure in WA.

The objective of this guidance document is to clearly identify DMPS's expectations of the information required in an MCP to ensure that:

- Mine closure will achieve DMPE Environmental Objectives for rehabilitation and mine closure, namely that mining activities are rehabilitated and closed in a manner to make them physically safe to humans and animals, geotechnically stable, geochemically non-polluting/non-contaminating, and capable of sustaining an agreed post-mining land use (PMLU), with consideration for cultural values and without unacceptable liability to the state.
- MCPs submitted to DMPE meet the requirements set out in the Mining Act and Regulations.
- MCPs received are of a high quality and provide sufficient detail on relevant factors.
- There is transparency on the rehabilitation and closure expectations of DMPE for the mining industry and community.

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

DMPE also 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 identified in the Mining Development and Closure Proposal (MDCP) and further refined and addressed in the MCP.

At all stages DMPE expects MCPs to demonstrate, based on reliable science-based and appropriate site-specific information, that ecologically sustainable closure can be achieved. A recommended guide that assists in understanding the detail expected to be known at each stage of mining is shown in the International Council on Mining and Metals (ICMM) Closure Maturity Framework (ICMM 2022).

Scope

This document relates to MCPs submitted pursuant to Section 103AT of the Mining Act. The Mining Act defines an MCP as a planning and reporting document that provides for:

- decommissioning of a mine;
- rehabilitation of the land;
- closure outcomes; and
- any other prescribed information.

Guidelines for preparing Mine Closure Plans

The content requirements of an MCP are set out in the Mining Act and Regulations. This guideline details the information to be provided to ensure requirements of the Mining Act and Regulations are met. A glossary of definitions and acronyms is provided in Appendix 1.

A number of standard tables are included to guide operators on the information to be presented in an MCP. It is recommended operators use the standard tables to ensure all relevant information is included to maximise efficiency and consistency of review.

The level of information contained in an MCP needs to be reflective of the stage of mine development (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 an MCP should increase to eventually evolve into a fully-formed plan that facilitates execution of mine closure (ICMM 2019). Specific guidance on the level of detail expected in a MCP as the mine approaches closure is described in Appendix 2 and Appendix 8.

1. Description of mining operation

r.58N(a) A Mine Closure Plan must include a description of the mining operations carried out or to be carried out on the site of the mining lease or miscellaneous licence.

r.58N(b) A Mine Closure Plan must include a map of the site, showing the location or locations at which the mining operations are or are to be carried out.

The MCP must include an up-to-date written description of the mining operation (historical and current) and detailed map(s) of the location of the mining operation showing all disturbed areas, approved disturbances (where works are not commenced), general location of site features/activities and the sites location relative to the local environment and local communities. Map(s) showing the location of site features (dams, stockpiles, plant, roads, etc) are also required.

Detailed designs will form part of Section 8.

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

This section is particularly helpful to understand any historical activity that has occurred and potential closure impacts from historical activity. To ensure all relevant information is provided, it is recommended a tenement summary table is included which summarises the mining activities on each tenement as shown in Table 1.

Table 1. Example tenement and mining activities summary table.

Tenement	Tenement expiry date	Total activity area (ha)	Approved activities
L23/9999	24/08/2027	29.15	Pipeline, road
M64/9999	18/11/2028	359.23	Mining void, workshop, WRL, process plant

Maps should show all relevant mine activities, land disturbances, rehabilitation (excluding exploration rehabilitation), tenements, public drinking water source areas and other land tenure. They should be set at an appropriate scale so that all features are clearly identifiable 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, any public reserved lands, other infrastructure, topographical features, water bodies or features. Environmentally significant features and heritage features should also be included.

Maps and descriptions may be presented in a domain model approach (see Section 8.1).

2. Identification of closure obligations and commitments

r58(N)(c) A Mine Closure Plan must include a list of requirements arising under any written law or any Commonwealth Act that affect or will affect:

i) the relevant activities; or

ii) the closure outcomes; or

iii) the use or uses to which each location at which relevant activities are to be carried out will be put after the completion of the relevant activities.

The MCP 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 legal obligations 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. This includes approvals applicable to other agencies under regulations and acts other than the Mining Act. The register should also include references to Approval Statements, individual tenement conditions, mining proposals (MPs), notices of intent (NOI), letters of intent (LOI), and all other legally binding documents. An example of a legal obligations register is provided as Table 2 below.

Table 2. Example of a legal obligations register (with data entry examples).

Closure and rehabilitation legal obligations register				
Relevant DMPE 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 stockpile 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 waste rock landform locations marked on them.	
L23/9999, M64/9999	Closure outcome C3	Constructed landforms are designed with consideration of visual amenity, cultural values and local topography.	Cultural areas have been excluded from footprint. Waste landforms will be blended to the topography and maximum height restrictions to ensure below local topography.	

<table>
<tr><td colspan="5">Closure and rehabilitation legal obligations register</td></tr>
<tr><td colspan="5">Ministerial statement – (number and date)</td></tr>
<tr><th>Item number</th><th colspan="2">Closure condition, commitment or aspect related to closure</th><th>How obligation included in closure strategy/MCP</th><th>Complete (if applicable)</th></tr>
<tr><td></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td colspan="5">Works approval – (number and date)</td></tr>
<tr><th>Tenement</th><th colspan="2">Closure condition, commitment or aspect related to closure</th><th>How obligation included in closure strategy/MCP</th><th>Complete (if applicable)</th></tr>
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<tr><td colspan="5">Environmental Protection Act 1986 licence: (number and date) Category:</td></tr>
<tr><th>Number</th><th colspan="2">Aspect related to closure</th><th>How obligation included in closure strategy/MCP</th><th>Complete (if applicable)</th></tr>
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<tr><td></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td colspan="5">Licence to take groundwater – (number and date)</td></tr>
<tr><th>Tenement</th><th>Item number</th><th>Closure condition, commitment or aspect related to closure</th><th>How obligation included in closure strategy/MCP</th><th>Complete (if applicable)</th></tr>
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<tr><td colspan="5">Public Reserve Lands (conservation and Land Management Act 1984) requirements</td></tr>
<tr><td></td><td colspan="3"></td><td></td></tr>
<tr><td></td><td colspan="3"></td><td></td></tr>
<tr><td colspan="5">DMPE approvals – NOI/MP/MDCP/MCP – (number and date)</td></tr>
<tr><th>Item number or page number</th><th colspan="2">Closure condition, commitment or aspect related to closure</th><th>How obligation included in closure strategy/MCP</th><th>Complete (if applicable)</th></tr>
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The register may also include the safety or stakeholder obligations (and non-legally binding commitments) pertaining to closure to provide a complete overview of obligations. Other considerations for inclusion would be:

- contaminated sites requirements;
- Aboriginal Heritage agreements and sites;
- requirements for relinquishment (including transfer of assets, infrastructure, liability); and
- agreements associated with land access.

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. Environmental data, analysis and implications for closure

r58N(f) A Mine Closure Plan must include a description of the environment that will or may be affected by the relevant activities, including:

iv) appropriate measurements of the features of that environment (the environmental data); and

v) an analysis and interpretation of the environmental data.

The MCP must include a description of the existing environment (baseline data) and data collected during construction/operational phases (operational data), together with an analysis and interpretation of the data relevant to closure.

Collection and analysis of environmental data is essential in order to achieve or support the following:

- build upon information provided in previous approvals or MDCP submissions;
- establish baseline environmental conditions for developing analogues, benchmarking and planning for rehabilitation trials;
- identify the environmental issues and risks to be managed leading into mine closure and during closure implementation;
- be sufficiently detailed to inform:
  - land capability requirements for PMLU(s);
  - adaptive risk management for closure (throughout life of mine);
- develop achievable closure outcomes and completion criteria and appropriate monitoring and measurement strategies; and
- underpin successful planning and implementation for rehabilitation and closure.

Before closure issues can be managed, they need to be identified through the collation of relevant closure data. It is important that the collection and analysis of environmental data is continued and expanded throughout the project life and the MCP is updated accordingly. For each MCP revision, data from monitoring, research, field trials and investigations need to be updated and re-analysed. This will assist in the refinement of completion criteria and the setting of indicators for management intervention.

Sections 3.1 to 3.7 provide guidance on aspects of data collection and analysis relevant to closure planning and how this may be presented in the MCP. Environmental data should focus on addressing DMPS's environmental factors. Guidance on the type of information and studies to be considered for each factor is presented in DMPS's 'Guideline for Preparing Mining Development and Closure Proposals'.

3.1 Environmental and social setting

The MCP should include information on the environmental and social setting in which the mining operation is located. Aspects to consider include:

- existing and historical land uses, land tenure and planning provisions;
- the social setting and any affected communities;
- heritage (including natural, cultural or historic);
- local climatic conditions and projected future climate profile for the area;
- topographic relief and geomorphology;
- seismicity; and
- conservation significant values or any other limiting factors that may impact on closure.

3.2 Baseline data

Baseline studies and collection of baseline environmental data will typically commence before mining operations are approved/commenced and are expected to be ongoing during operations to adequately characterise pre-mining conditions.

The MCP should provide a summary of the best available and current data on aspects of the physical and biological environments that existed prior to operations at the site. Where this information is missing (potentially due to historic mining) then the use of data collected adjacent to the operation with interpretation to the site, may be appropriate. The baseline data should also consider the social, cultural and economic aspects (where relevant) that may be critical for successfully meeting mine closure outcomes.

Periodic review and update of baseline data should be incorporated into closure planning to demonstrate ongoing and adaptive risk management is informing the MCP.

3.3 Operational data

The MCP should provide a summary of the data collected during construction/operational phases (operational data) and where relevant, during the decommissioning and closure phases.

Operational studies and collection of operational environmental data will typically continue on an ongoing basis during operations to adequately characterise any changes that may occur during mining operations to the pre-mining conditions or provide outcomes of such activities as rehabilitation (through regular monitoring).

It is recommended any completed desktop, field assessments or technical studies are summarised in the table format presented in Table 3 to remove the need to submit all referenced reports for every MCP submission. Reports should be attached in full for the first MCP submission and subsequently presented in the table for reference in future MCP submissions. Inclusion of the table allows for clarity on the studies/reporting conducted, and those that have been previously submitted to DMPE and will assist DMPE officers in the review of MCP submissions. Only new, or updated reports need to be included in the current MCP submission appendices.

Table 3. Example technical studies table.

Baseline subject	Document reference (Including consultant/date)	Reg ID if previously submitted	Updated since last submission? YES/NO	Linked appendix number
Soils	Baseline soil study, Banksy Environmental Consultants, May 2023	60015	No	Appendix A
Waste characterisation	Characterisation of waste rock materials, Geochemical Consulting, January 2025	N/A	Yes	Appendix B

3.4 Materials characterisation

Comprehensive physical and geochemical 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.

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

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

- 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 or highly erodible materials);
- materials with other chemical/physical properties that will affect stability or success of rehabilitation (e.g. low pH, low fertility, poor structural integrity, water holding capacity);
- sodic or dispersive materials; and
- radioactive and asbestiform/fibrous materials.

Operators should estimate the location of problematic materials and the volume that may be disturbed during operations. Materials characterisation needs to 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.

Availability and volumes of key materials required for rehabilitation such as competent waste rock, non-erodible materials, subsoil, topsoil and low-permeability encapsulation material need to be discussed. The volumes of rehabilitation materials required to implement closure strategies should be reconciled against available materials to ensure they are available for use in rehabilitation and be presented as a materials balance.

Discussion should also consider how these materials will be managed during operations to ensure double handling is minimised, availability of materials is secured and they are stockpiled to ensure quality for rehabilitation.

Validation of the predictions for materials characterisation will occur during all phases, particularly as the operation matures. Validation should 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.

Modelling (such as erosional modelling, long-term geochemical testing and modelling) may be included to demonstrate the closure implications of the characteristics found.

Further guidance on waste characterisation studies and how to present the information is presented in DMPS's Guideline for Preparing Mining Development and Closure Proposals. Additional relevant references include AMIRA 2002, DIIS 2016, INAP 2014 and MEND 2009.

3.5 Contaminated sites

Contamination in WA is primarily regulated under the *Contaminated Sites Act 2003* (Contaminated Sites Act), however the MCP will need to consider and manage potential or known contamination over the life of mine to ensure that the agreed PMLU(s) can be met. Where appropriate, the MCP should identify potential or known contamination and discuss what implications this may have for mine closure. This may include preventative strategies and remedial actions carried out during operations to manage the risks of contamination and contaminated sites at closure.

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

Presentation of contaminated sites reported areas and remedial actions in the MCP will allow the review of the achievability of the proposed PMLU(s).

3.6 Other closure-related data

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

Such information could include:

- learnings from closure experience generated from other mines;
- spatial datasets and databases used to compile closure-related information;
- visual representation of what the surrounding landscape and the final landforms will look like post closure;
- monitoring of the long-term geotechnical stability of the final landforms post closure;
- mathematical models to predict long-term performance or environmental impacts;
- measured and predicted water balance for future landforms including pit lakes (including seepage rates), waste rock landforms (WRLs) and Tailings Storage Facilities (TSFs);
- 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.

3.7 Data analysis and implications for mine closure

Analysis and interpretation of the environmental data should describe how the wider receiving environment, receptors and exposure pathways have been considered, and identify the implications of the operation on these. Presentation of the implications of the data should consider the landforms remaining at closure, potential contamination, water related changes and the PMLU.

During this data analysis and implications process, knowledge gaps may become apparent and the risk of not having that information identified. This step is an important part of identifying and understanding issues/closure-related risks and knowledge gaps that require further work. Analysis will also help to develop solutions and set appropriate and achievable completion criteria.

It is recommended knowledge gaps are summarised in a table such as the example provided in Table 4, together with the implication of not having this information. This will enable the information gaps to be prioritised and actions set appropriately in Section 12.3.

Table 4. Example presentation of knowledge gaps requiring further work from assessment of baseline data.

#	Aspect	Knowledge gap	Implication of not having information
1	Baseline data	Results of monitoring not known.	Risk to receptors poorly defined.
2	Contaminated sites	Extent of contamination around the historic East Pit fuel facility.	No nearby receptors but fuel facility still active.
3	PAF	Unknown quantity and location of PAF material in South WRL.	Acidic seepage has been recently observed from toe of South WRL moving towards South Creek.
4	Materials balance	Topsoil and alternative growth materials volumes unknown.	Implications for rehabilitation.
5	Contaminated sites	Removal of contamination around the historic East Pit fuel facility.	Reportable under CS Act. Disposal area yet to be defined.

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 WRLs 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

r.58N(d) A Mine Closure Plan must include details or any consultation that the relevant lodging party has undertaken in relation to any of the following:

vi) the relevant activities;

vii) the closure outcomes; and

viii) the use to which the location will be put after the completion of the relevant activities.

Stakeholder engagement ensures closure planning considers existing and future impacts associated with the mine, and the post-mining landscape. It is an essential component of closure planning, particularly for identifying suitable PMLU(s) and understanding the environmental values that need to be captured in closure outcomes.

The MCP must include up-to-date information on the identification of key stakeholders, engagement that has been undertaken with key stakeholders relevant to rehabilitation and mine closure, a record of the engagement and a strategy for ongoing engagement.

Stakeholder engagement is further explained in Appendix 5, which provides more information on the principles of stakeholder engagement and a guide to the level of stakeholder engagement that should be undertaken based on stage of mining.

4.1 Stakeholder identification and engagement

Key stakeholders are defined as directly impacted groups including underlying landholders, reserve vestees, Traditional Owner groups/Native Title claimants and post-mining landowners/managers. Key stakeholders need to be clearly defined and actively engaged throughout the life of mine.

Other stakeholders can be identified and engagement undertaken as required on relevant matters that concern them.

For all lands identified as public drinking water source areas, a key stakeholder will be the Department of Water and Environmental Regulation (DWER) Water Source Protection Planning and should be consulted regarding the rehabilitation to ensure compatibility with this use.

Examples of aspects to be discussed as part of stakeholder engagement include:

- mining activities planned/in progress/future potential;
- considerations for cultural values;
- PMLU;
- disposal of infrastructure;
- rehabilitation and closure activities, particularly to make the site physically safe to humans and animals;
- landform designs and topography considerations;
- geotechnical stability, geochemical aspects; and
- capability to sustain an agreed PMLU.

4.2 Stakeholder engagement register

A summary of all stakeholder engagement undertaken should be presented in the form of a stakeholder engagement register.

At a minimum, the stakeholder engagement register should include the information as set out in standard register format provided in Table 5. The register must be a complete record of all engagement relating to mine rehabilitation and closure (not just the period of review).

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)**	**Applicant response and/or resolution**	**Stakeholder response**
03/03/2023	Quarterly meeting	Traditional Owners: (Mr J. Smith) (Mrs O. Jones) Applicant: (Operations Manager) (Communities Manager)	Concerns regarding impacts to water quality and quantity in a nearby spring (minutes shown in Appendix xx).	Monitoring quality and quantity of the spring water to be undertaken throughout the life of mine. Traditional Owners kept informed of results.	Acceptable
21/06/2023	Meeting to discuss potential. PMLU(s).	Pastoralist neighbour: (Mr S. Thomas) Applicant: (Environment Manager)	Concerns about any hole or pit to be left behind after mining (minutes shown in Appendix xx).	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 are 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 accepted by stakeholders) and, where appropriate, provided with the MCP.

Where there are sensitivities with name(s) or information related to stakeholder engagement, this can be provided as a separate confidential appendix.

4.3 Stakeholder engagement strategy

The stakeholder engagement strategy sets out how an operator will continue to engage with stakeholders throughout the closure planning and implementation stages. Managing stakeholder expectations over time is a key issue the strategy should address.

The type of information, level of engagement each stakeholder requires, how and when engagement will be undertaken and documented, how issues will be identified and resolved and what outcomes for closure are to be discussed and agreed upon should be outlined in the strategy. Importantly, the strategy should be discussed with and agreed to by stakeholders to ensure their needs are met.

The strategy needs to be regularly reviewed and updated as required, to determine whether the outcomes for engagement are being achieved.

5. Post-mining land use(s)

r.58N(m) A Mine Closure Plan must include details of the use or uses to which each location at which relevant activities are to be carried out will be put after the completion of the relevant activities.

The MCP must identify the proposed PMLU(s) and demonstrate how it is:

- relevant to the environment in which the mine is operating;
- achievable in the context of post-mining land capability;
- acceptable to the key stakeholders;
- considerate of cultural values; and
- ecologically sustainable in the context of the local and regional environment.

Where possible, tenement holders 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.

The following land use options provide a guide to identifying appropriate PMLU(s):

- Reinstate 'natural' ecosystems to be as similar as possible to the original ecosystem.
- Reinstate the pre-mining land use.
- Develop an alternative land use with beneficial uses other than the pre-mining land use. Note – suitable tenure will be required for alternative land use options. Examples:
  - options involving advanced infrastructure projects may be considered viable, including renewable energy generation;
  - commercial development; or
  - residential use.
- Note – multiple land use areas may exist on one site.

In the early stages of a mining project, it may be acceptable for provisional or proposed post-mining land use(s) to be identified provided that there has been adequate engagement with the key stakeholders. However, there needs to be a clear process and timeline to further identify or refine the agreed PMLU(s) as part of the stakeholder engagement process.

DMPE acknowledges that PMLU(s) may change over time as more information is acquired through progressive rehabilitation, further consideration of PMLU options and continued stakeholder engagement.

Agreement of the PMLU with key stakeholders is an essential aspect as the operation nears closure. It is a DMPE expectation that the PMLU is accepted by post-mining landholders/key stakeholders as the operation approaches the decommissioning phase (at least two years prior to cessation of operations), as demonstrated in the minutes/outcomes of stakeholder engagement meetings.

Acceptance of the PMLU by key stakeholders means there is a shared understanding of what will be achieved at closure. Where there might not be consensus with all key stakeholders on the PMLU, it will be the role of government to work with applicants and underlying land holders/managers to resolve this on a case-by-case basis.

The MCP should identify all potential (or pre-existing) environmental legacies (including contaminated sites) that may restrict PMLU 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.

6. Closure risk assessment

r.58N(g)(i) (ii) and **(iii)** A Mine Closure Plan must include a comprehensive risk assessment including:

i) details of risks of not achieving the closure outcomes that arise out of the carrying on of the relevant activities (closure risks);

ii) an evaluation of the closure risks using a risk assessment methodology acceptable to the Executive Director, Resource and Environmental Compliance Division; and

iii) details of the management strategies to be applied to minimise the closure risks.

The MCP 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; and
- evaluates these risks using DMPE standardised risk framework.

The standardised risk assessment framework is presented in Appendix 3. The same risk assessment framework must be used for both the MDCP and the MCP.

The risk assessment presented in the MCP needs to cover all relevant risk pathways related to rehabilitation and closure. Where appropriate, these rehabilitation and closure risks may be carried over from an existing MDCP, however, it is expected that the MCP risk assessment is updated over the life of mine as further information is gathered and knowledge gaps are addressed.

In determining relevant closure risks, consideration should also be given to the risks that may occur post closure, in progressive rehabilitation, decommissioning and temporary care and maintenance or closure phases. When applying the risk assessment framework all environmental factors and consequences are relevant and must be considered.

The risk assessment needs to:

- Identify all the risk pathways and potential direct and indirect environmental impacts affecting DMPE environmental factors across all stages of the mine life.
- Evaluate the risk to derive an inherent risk rating prior to the application of treatments.
- Identify appropriate risk management treatments using the hierarchy of hazard control.
- Re-evaluate the risk pathways to derive a residual risk rating.
- Demonstrate that all residual risks are managed to as low as reasonably practicable (ALARP) and consistent with DMPE environmental objectives.

The outcome of the risk assessment needs to be recorded in the risk register as presented in Appendix 3 and included in the MCP. The risk register has been designed to assist in identifying the appropriate closure outcomes required to ensure DMPE environmental objectives can be met. The risk register should identify for each risk pathway:

- the appropriate, relevant DMPE standard closure outcome (refer to Appendix 7); and/or
- whether a site-specific outcome is required.

6.1 Identification of closure risks

The MCP will identify closure risks and their potential environmental impacts post-mining and propose workable management mechanisms. This will allow strategies, mitigation measures and closure designs to be developed, 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 must be integrated with stakeholder engagement and take into account stakeholder concerns and learnings from previous experience. The risk assessment process should be undertaken using appropriate internal or external expertise to ensure the assessment is adequately informed by people with the relevant technical knowledge and 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(s)ite in its entirety or broken down into domains or features (Section 8.1).

Examples of risk pathways that should be considered during the risk assessment include:

- safe access for humans and fauna post closure impacted by pit/landform instability, open voids, unstable ground, open water sources (dams or water filled voids);
- impacts to flora, fauna, water (surface and groundwater) and ecosystems post closure associated with erosion/sedimentation, poor revegetation performance, fire/flood;
- impacts associated with changing climate and its driving influence on site hydrology/ hydrogeology/ water balance, fire, rainfall patterns and how this affects other risk factors (revegetation performance, landform stability);
- impacts to environmental values due to adverse materials characteristics (chemical and physical) such as salinity, acidity and hazardous materials (asbestiform, silica dust, radioactive, metals/ metalloids, cyanide, other processing chemicals);
- landform instability (erosion and geotechnical) driven by rainfall, runoff, floods, earthquake, slope failure, material compaction/competence;
- potential impacts to cultural values;
- impacts to public reserved lands; and
- financial (cost to close, sterilisation, premature closure, etc).

Further guidance on closure related risks is presented in Appendix 4.

6.2 Risk assessment implications for mine closure

Following the risk assessment, it is critical to understand the issues affecting mine closure and identify any knowledge gaps. Knowledge gaps need to be included in the knowledge gap register (Section 12.3) and the implications 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

s.103AR A Mine Closure Plan is a planning and reporting document that provides for the closure outcomes.

r.58N(g)(iv) A Mine Closure Plan must include a statement of measurable criteria that can be employed in determining whether the closure outcomes have been achieved.

The MCP must include:

- closure outcomes (as recorded on the Approvals Statement if appropriate);
- completion criteria that can demonstrate achievement of the closure outcomes; and
- details of the monitoring that will be undertaken to demonstrate achievement of closure outcomes.

The closure outcomes, completion criteria and monitoring should be presented in table format and include the information set out in Table 6.

Table 6. **Closure outcomes table with the associated completion criteria and monitoring (including data entry example).**

#	Closure outcomes	Domain	Risk pathway	Completion criteria	Monitoring/ measurement
	From the Approvals Statement, standard DMPE list or site specific.	Where appropriate.	Link to the risk identified in Section 6.	Criteria capable of demonstrating achievement of closure outcomes.	Monitoring method.
1	C2.0 The placement of mined materials/ infrastructure in relation to excavations will be such that the final footprint after rehabilitation is not located within the potential zone of instability (PZoI).	WRL.	Landforms placed within PZoI resulting in structural failure causing impacts to the environment.	All landforms will be placed outside the PZoI.	Aerial survey annually during operations. Aerial survey at start of closure implementation.

7.1 Closure outcomes

Closure outcomes are defined in the Amendment Act 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.

The closure outcomes must be consistent with the PMLU(s), reflecting environmental values and must be specific to provide a clear indication to government and stakeholders on what the tenement holder commits to achieve at closure.

If an Approvals Statement exists for the site, the MCP must include the closure outcomes recorded on that statement. An MDCP will need to be submitted to DMPE for assessment to amend closure outcomes recorded on an Approval Statement. For operations that do not yet have an Approvals Statement, the MCP should include the closure outcomes and completion criteria from the most recently approved MP or accepted MCP.

DMPE have developed a series of standard environmental outcomes (for operational phases) and standard closure outcomes that are intended to ensure mining activities meet DMPS's environmental objectives. These standard outcomes may also be applicable to operations who have not submitted an MDCP (thus do not have an Approvals Statement), when proposing any change to closure outcomes prior to transitioning to an Approvals Statement. These standard outcomes are presented in Appendix 7.

Site-specific closure outcomes can also be developed for an operation where the standard closure outcomes do not cover the areas required.

7.2 Completion criteria

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

Completion criteria needs to follow the SMART 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 indicators; and
  - 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; and
  - often set to reflect analogue sites.
- Relevant
  - to the outcomes that are being measured and 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.

In contrast to the closure outcomes which are set at the approval stage and are not refined over time (where an Approvals Statement exists), it is expected that completion criteria will be refined through the mine closure planning process. Development of completion criteria and associated performance indicators should commence at the project approval stage and be refined in MCP 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 used to predict long-term (usually in the order of 300 years or longer) environmental performance for such structures as WRLs. Where applicable, details on the numerical modelling used, including assumptions and limitations, should be provided as an appendix to the MCP.

Once established and agreed to by the relevant regulators/key stakeholders, 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).

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.

7.3 Using the Western Australian Biodiversity Science Institute framework for developing completion criteria

In 2019 DMPE partnered with the Western Australian Biodiversity Science Institute (WABSI) and industry to develop 'A framework for developing mine-site completion criteria in Western Australia (WABSI, 2019)'. This guideline establishes a methodology that links the PMLU(s) to DMPE closure outcomes, to completion criteria and to subsequent monitoring. Note – closure outcomes are referred to as closure objectives by WABSI.

Using this format will achieve the required links between these important closure aspects through:

- determining PMLU that considers social, environmental and economic factors, is achievable in the context of land capability and tenure, considers options (choices are justified) and is acceptable to key stakeholders;
- ensuring closure outcomes (or WABSI objectives) are compatible with PMLU, identify important aspects (environment, social/cultural, water, landforms, liabilities) and selected considering site-specific risks and values;
- establishing clear references (benchmarks/analogues) to determine performance or achieving of SMART completion criteria using attributes to quantify or verify the criteria; and
- developing monitoring to determine the baseline for any given attribute and to establish progress towards or achievement of completion criteria.

The WABSI framework is not mandatory, however provides a useful guide for 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, 'Evaluating Performance: Monitoring and Auditing (DFAT 2016)'.

8. Closure implementation

r.58N(i) A Mine Closure Plan must include a closure work program to be undertaken after other relevant activities have ceased including:

i) details of tasks comprised in the relevant activities;

ii) a timeframe for the completion of those tasks;

iii) plans for the final form of landforms affected by the relevant activities; and

iv) details of additional or alternative tasks that will be undertaken in the event of premature or temporary closure of a mine on the site.

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

The MCP must include:

- a closure work schedule for progressive rehabilitation (trials, research, earthworks), decommissioning and closure tasks required to achieve closure of the site;
- closure designs for any post-mining landforms or other features associated with mining:
    - for example, detailed 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; and
- contingencies for premature or early closure or suspension of operations.

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 schedule must be reviewed and updated regularly to reflect operational changes and/or new information.

As the operation approaches the decommissioning phase (generally two years prior to cessation of operations), a more refined MCP with a greater level of detail on closure implementation is required. Specific guidance on the level of detail expected in an MCP as the mine approaches this phase is described in Appendix 8.

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 may include:

- ore processing area;
- infrastructure;
- TSFs;
- WRLs (may include the run-of-mine stockpile);
- roads/airstrips;
- bore fields/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 use 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. Shape files may be submitted electronically to aid in the DMPE review process.

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

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

Scheduling of closure work tasks should be documented in a closure task register similar to that shown in Table 7. The table can be broken into sections indicating:

- during operations;
- during decommissioning;
- post cessation of rehabilitation work; and
- also be specific to closure or rehabilitation tasks (i.e. not operational tasks).

DMPE advises that ‘prior to closure’ is not a valid date for action timings or status, nor is leaving most actions towards the end of operational life of a mine considered an acceptable approach to closure planning. Proper planning and implementation demonstrate a commitment to progressive closure for the operation.

Table 7. Example rehabilitation and closure task register.

Rehabilitation and closure task register					
Operational and progressive rehabilitation tasks					
#	**Domain**	**Works to be undertaken including outcomes**	**Responsible role/ owner**	**Timing**	**Status**
1	WRL	Construct PAF material containment cell for North WRL.	Mining Manager	2025	Completed
2	WRL	Profile lower embankments of South WRL to design specifications.	Mining Manager	2026	Ongoing
2	WRL	Trial on ripping depth for South WRL.	Mining Manager	2024	Monitoring
3	WRL	Monitoring of ripping depth trial on South WRL.	Environment Manager	2028	
4	Mining void	Establish abandonment bund for South Pit.	Mining Manager	2028	
5	Mining void	Backfill to surface North Pit.	Mining Manager	2026	
Decommissioning and closure tasks					
#	**Domain**	**Works to be undertaken including outcomes**	**Responsible role/ owner**	**Timing**	**Status**
1	Plant	Demolition of process plant.	Closure Manager	2035	
2	Plant	Contaminated sites – preliminary site investigation.	Closure Manager	2036	
3	Mining void	Establish monitoring program of South Pit for pit lake recovery and water quality.	Closure Manager	2035	
Post-closure monitoring and maintenance tasks					
#	**Domain**	**Works to be undertaken including outcomes**	**Responsible role/ owner**	**Timing**	**Status**
1	Mining void	Finalise abandonment bund for South Pit - close haul road access points.	Mining Manager	2036	
2	WRL	Monitor and remediate as required.	Mining Manager	Until completion criteria are met.	

The selection of the appropriate domain model requires consideration, especially for areas such as satellite deposits which may present an opportunity for closure at a different time to the main operations. This opportunity may use a specific domain model, or a separate MCP to enable this to occur.

8.3 Research, investigations and trials

The rehabilitation and closure work schedule could include research, investigations and trials that are being planned, or 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 and 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

The rehabilitation and closure work schedule should demonstrate how closure and rehabilitation tasks have been integrated into the day-to-day mining operations. Effective mine planning optimises opportunities for rehabilitation earthworks as areas become available, rather than undertaking large scale rehabilitation works at the completion of operations. Examples of progressive rehabilitation activities 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;
- removal of redundant infrastructure;
- rehabilitation performance monitoring; and
- ongoing improvement and refinement of rehabilitation techniques.

Each area undergoing progressive rehabilitation should have detailed design and planning to ensure that the appropriate design parameters are used, and the final landform fits to the overall site post-mining land use strategy.

8.5. Closure designs

The MCP must include closure designs for the key mining features that will remain post closure. Details should include:

- design parameters and justification for the design;
- detailed diagrams or cross sections; and
- landscape drawings of the site showing drainage lines/features and flood modelling.

The closure designs presented early in the mine life may be conceptual but will need to be refined in the subsequent MCP submissions. Final designs are required at a minimum of two years prior to implementation. The level of information provided in the MCP needs to provide sufficient information to indicate landforms can be successfully rehabilitated and closed.

Where landforms present long-term erosion risks, incorporate dispersive materials or store PAF materials, modelling is recommended to demonstrate the landform will be safe, stable, non-polluting and self-sustaining for the long term. Hydrological models are also recommended to assess impacts to surface water or groundwater.

8.6 Contingencies for premature or early closure or suspension of operations

Although practical planning for early closure (permanent or temporary 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 MCP relating to how closure scenarios that may arise from economic, environmental, safety or other external pressures will be actioned.

The MCP needs to detail the activities to be undertaken in the event of early/unplanned 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 (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; and
- impacts to any aquatic facilities/pools/spas, drinking water systems, non-potable water systems and wastewater systems on mine sites or adjacent FIFO camps (contact a liaison officer at Department of Health (DoH) Water Unit for more specific advice).

The MCP should also demonstrate that appropriate materials are available on site and contingencies are provided to make landforms such as TSFs and waste landforms secure, stable and non-polluting/ non-contaminating.

Where implementation of an accelerated closure process may need to occur, tenement holders should consult with DMPE to advise of the accelerated closure and seek advice on site-specific requirements. If a well-developed MCP 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 DMPE Directorate Inspector of Mines of the suspension of a mining operation. For further guidance, the DMPE website contains documentation detailing notifications of commencement, suspension, recommencement and abandonment.

8.7 Decommissioning and execution

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

At this stage the MCP should include information on how a mining operation will be decommissioned. Since the decommissioning phase usually takes place at the end of mine life, conceptual level of 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. This detail and the closure strategies are then expected to be developed further and improved during operations.

Further guidance on the level of detail expected in the MCP as the mine approaches closure is described in Appendix 8 which provides clarity on the following aspects that should be included in the MCP to an execution level of detail:

- updated legal obligations register;
- ongoing stakeholder engagement;
- handover of infrastructure requested by other parties;
- compliance to *Contaminated Sites Act* requirements including remediation;
- finalisation of completion criteria;
- schedule for implementation of closure works/tasks;
- completion of rehabilitation works;
- construction of final landforms and drainage structures;
- safe demolition and decommissioning of plant and infrastructure;
- monitoring and measurement against completion criteria; and
- knowledge gaps finalisation.

9. Closure monitoring and maintenance

r58N(h) A Mine Closure Plan must include details of the monitoring that will be undertaken while the relevant activities are carried out to establish whether the closure outcomes are being achieved including:

i) details of the monitoring methods and activities that will be employed; and

ii) information about the timing and frequency of monitoring activities.

The MCP must include information on the monitoring that will be undertaken to track the site's progress towards achieving the closure outcomes and completion criteria. The monitoring described in this section provides further detail to that summarised for closure outcomes and completion criteria that is summarised in the MCP as per Table 6.

This must include a description of:

- proposed post-closure monitoring; and
- the monitoring (and sampling) methodology including frequency and expected duration post closure.

The monitoring must show clear links to the closure outcomes and completion criteria and how their achievement will be demonstrated. This section should also include adaptive management processes (to be used where it is identified that a site is not progressing towards achieving the closure outcomes), including remediation trigger values and subsequent actions.

The MCP should demonstrate links between operational monitoring and closure monitoring. For 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 any regional impacts (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 operator's control.

The monitoring results for closure will normally be reported to DMPE in regular environmental reporting, which continues until completion criteria are met. The report must document progress against the agreed completion criteria. Where applicable, the results of rehabilitation trials should be analysed and presented in the regular environmental reporting. Remedial action(s) undertaken in response to not meeting agreed performance indicators should also be reported. The results should also then be used to update the MCP and the implications for closure planning identified. The guidelines for the preparation of regular environmental reporting are available on the DMPE website.

Preliminary information regarding closure monitoring and maintenance may be acceptable in the early stages of the project. As the operation approaches closure, or if early closure is confirmed, DMPE will require the MCP to be updated to include a detailed post-closure monitoring and maintenance program. This should include the type and frequency of monitoring proposed to address(es) how achievement of the relevant completion criteria.

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

Table 8. Example of closure monitoring program table.

Monitoring program					
Closure and 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**
North WRL	Rehabilitated land is consistent with agreed reference vegetation communities and/or with the PMLU.	Target for plant density.	Mining Manager	2025	Completed
Closure and 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**
Reference site A	Rehabilitated land is consistent with agreed reference vegetation communities and/or with the PMLU.	Target for plant density. Trigger: < 50%.	Annually April	Environment Manager	EFA monitoring
Closure and 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**
South Pit	Groundwater levels and characteristics reflect original levels and characteristics and/or support the target ecosystem and post- mining land use.	Target on water table recovery. Trigger: water level < x m RL	Annually until 2042	Mining Manager	Survey of water level

It is important that consideration be made in closure planning for an adequate period of post-closure monitoring and maintenance, including consideration 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 MCP.

There needs to 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 MCP, usually in the order of 10 years, depending on regional specific climatic conditions, the implications of climate change and the attainment of completion criteria. 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 stages of mine life.

For further guidance refer to the WABSI, '*A framework for developing mine site completion criteria in Western Australia* (WABSI 2019)'.

10. Closure cost estimation

r.58N(i)(iv) A Mine Closure Plan must include an estimate or projection of the cost of implementing the closure work program and an explanation of the method used to make the estimate or projection.

The MCP must include details of the closure costing methodology undertaken to estimate the cost of closure and provide a predicted (estimated) closure cost based on the current/actual land disturbance and features existing on the site. The cost estimate should show an indicative +/- cost variation range (e.g. cost +/- 30 per cent), the date that the closure cost estimate was conducted and the next planned revision date.

Providing a cost estimate for closure demonstrates financial liability is being actively considered and managed as a risk during operations. To that end, it is essential that the cost of closure be estimated in the early mine life and continues to be refined as more knowledge is gained during operations.

The process and methodology for calculating the cost estimates must be transparent and verifiable with all assumptions documented. DMPE recognises that providing verifiable closure cost estimates at the early stages of a mine's life is subject to many assumptions and unforeseen events.

For clarity, the costs required are to fully implement the MCP as presented, including all current disturbances, constructions, landforms and obligations without accounting treatments or discounting.

As closure planning evolves, the indicative +/- cost variation range (e.g. cost +/- 30 per cent) is to be refined over time, to a +/- 20 per cent maximum at the execution level of detail stage. The closure cost estimate needs to be based on reasonable, site-specific information and data gained throughout 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.

DMPE may request a fully detailed closure costing report to be submitted and/or an independent audit to be conducted.

It should be noted that levies paid into the Mining Rehabilitation Fund (MRF) required under the *Mining Rehabilitation Fund Act 2012* and the Mining Rehabilitation Fund Regulations 2013 are separate to a company's internal accounting provisions for closure and rehabilitation. 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.

Where there are sensitivities with closure cost estimate or information related to closure costing, this can be provided as a separate confidential appendix.

11. Management of information and data

The MCP should include a description of data management strategies.

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 to inform closure strategies;
- 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 is reported in the MCP or via DMPE 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), should a tenement be sold, to enable continuity of effective informed closure.

The domain model can be considered for the collection and storage of closure data with the objective of building a 'base' of information for each domain or feature.

Information may include, but is not limited to:

- the 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); and
- all relevant technical reports.

The domain/feature information can then be used 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 WRL;
- design parameters such as 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 and the material encapsulated;
- status of rehabilitation, surface treatments and application of topsoil;
- details of trials undertaken, and seed mixes used in rehabilitation; and
- monitoring and analyses of results for landforms.

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 Systems (EMSs) 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 MCP should include:

- a revision summary table that clearly outlines all changes made to the closure information (see Section 12.1);
- a summary table documenting how the aspects identified by DMPE (or another agency) for improvement in the prior revision of the MCP have been addressed (see Section 12.2); and
- a table documenting how the knowledge gaps identified in the prior revision of the MCP have been addressed, as well as any new gaps identified (see Section 12.3).

12.1 Revision summary table

An MCP should contain a summary table indicating the sections where changes have been made and a summary of information pertaining to the changes. DMPE may request the modifications in the revised and resubmitted document during review to be highlighted to assist in finalising the review process. Where available, a 'tracked changes' version of the MCP may be submitted to allow ease of review by DMPE.

In circumstances where there has been no mining and/or rehabilitation activities undertaken during the review period, DMPE still expects that the MCP has been reviewed and updated. The MCP revision should include other closure planning activities that will have taken place during this period (e.g. ongoing stakeholder consultation, knowledge gap actions/trials 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

DMPE acknowledges that MCPs are continuously developed over the life mine and as such DMPE may consider the MCP acceptable subject to aspects of closure planning being further developed and refined in subsequent MCP revisions. This will rely heavily on the MCP containing an adequate risk assessment and identification of knowledge gaps and time-bound schedule to close the gaps.

Revised MCPs should contain a table that includes these noted comments for improvement with responses to how they have been addressed in the current revision. An example of an improvement actions response is presented as Table 9.

Table 9. Example improvement actions from previous MDCP/MCP submissions.

Improvement actions from previous MDCP/MCP submissions				
DMPE Reg ID: REG ID 123456		Date approved: 13/04/2022		
#	Section of the MCP	DMPE comments	Response	Sections changed
1	Completion criteria	Refinement of completion criteria related to encapsulation of problematic materials is required.	Criteria has been updated.	Section X and Table Y
2	Stakeholder engagement	Continue to engagement with land managers regarding finalising completion criteria.	Further consultation undertaken.	Section Z
3	Environmental and closure data	Updated material balance for the project (including estimation of rehabilitation material volume requirements) to be provided in the next revision.	Materials balance updated.	Section W

Only the latest DMPE 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 MCPs should include an updated knowledge gaps register, documenting how the knowledge gaps identified in the prior revision of the MCP have been addressed, as well as any new gaps identified. At a minimum, the knowledge gap register should include the information set out in standard register format provided in Table 10.

These knowledge gaps will need to identify actions needed to close the gap, the ownership of actions, and a schedule for their completion. DMPE advises that 'prior to closure' is not a valid date for actions, nor is leaving most actions towards the end of operational life of a mine considered an acceptable approach to closure planning.

Table 10: Example knowledge gap register.

Knowledge gaps register						
#	**Aspect**	**Knowledge gap**	**Planned action**	**Action owner title/role**	**Timing for completion**	**Progress**
1	Contaminated sites	Extent of contamination around the historic East Pit fuel facility.	Undertake a contaminated sites preliminary site investigation at East Pit fuel facility area.	Environment Manager	August 2023	Complete
2	PAF	Unknown quantity and location of PAF material in South WRL.	Drilling of South WRL to identify locations and estimate the volumes of PAF materials.	Environment Manager	December 2025	
3	Materials balance	Topsoil and alternative growth materials volumes unknown.	Materials surveyed for inclusion in site-wide materials balance.	Technical Services – Senior Surveyor	January 2025	
4	Contaminated sites	Removal of contamination around the historic East Pit 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 2026	
5	Climate	Impact of climate change.	Analyse environmental monitoring data (e.g. rainfall, temperature, and vegetation data) to identify any trends relating to climate change which may affect closure and determine if any of these will materially affect closure planning for the mining operation.	Closure Manager	2030	

Knowledge gaps register						
#	**Aspect**	**Knowledge gap**	**Planned action**	**Action owner title/role**	**Timing for completion**	**Progress**
6	WRLs	Landform evolution and stability over the long term.	Conduct waste landform evolution modelling to understand potential erosion rates and refine the WRL and TSF closure designs, if needed.	Closure Manager	December 2025	
7	Mining void	Final abandonment bund location for South Pit.	Undertake a study to finalise abandonment bund strategy and confirm adherence to the relevant guidelines or otherwise confirm geotechnical stability. This study will be undertaken once the final South Pit footprint has been confirmed.	Mine Manager	December 2027	

12.4 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.

DMPE 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.

Appendix 1: Definitions and acronyms

Term	Definition
Activity envelope	The spatial extent within which the mining activities will be located.
Approvals Statement	As defined in Section 103AP of the *Mining Act 1978*. An Approvals Statement is a document that, in relation to a mining lease or a miscellaneous licence, records the following information: • an approval given to an activity on land the subject of the mining lease or the miscellaneous licence proposed in a mining development and closure proposal; • any conditions attached to the approval; • any relevant information; • the closure outcomes included in a mining development and closure proposal relating to the mining lease or the miscellaneous licence; and • the date by which a Mine Closure Plan for the land the subject of the mining lease or the miscellaneous licence must be lodged.
As low as reasonably practicable (ALARP)	Any measure which is practicable, and the implementation cost (money, time, effort) is not grossly disproportionate to the benefit, the measure is considered 'reasonably practicable', and implementation is expected.
Bed load zone	Layer of material above the riverbed where sediment particles, primarily sands, and gravels are transported by rolling, sliding, or bouncing, rather than being fully suspended in the water column.
Category/aspect	The element of the activity that can interact with the environment to cause an impact.
Closure period	The period after rehabilitation and closure works have been completed and monitoring occurs.
Closure outcome	As defined in Section 103AA of the *Mining Act 1978*. Closure outcomes mean: • in relation to a mining development and closure proposal – the outcomes, objectives or goals to be achieved at the completion of the decommissioning of a proposed mine, and the rehabilitation of the land, the subject of a mining lease or a miscellaneous licence to which the mining development and closure proposal relates; and • in relation to a Mine Closure Plan – 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 mining lease or a miscellaneous licence is granted.
Completion criteria	Agreed standards or levels of performance that indicate the success of rehabilitation and attainment of closure outcomes, and enable an operator to determine when its liability for an area will cease.
Consequence	The scale and type of effect of the potential impact on the environmental factor.
Conservation significant vegetation	Threatened and priority flora, fauna and ecological communities, locally endemic, range extensions, unusual or new species or species with a restricted distribution.
Consultation	A process that permits and promotes the two-way flow of ideas and information. Effective consultation is based on principles of openness, transparency, integrity and mutual respect. Two-way communication is not just the issuance of letters or documents alone.

Term	Definition
Contaminated	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 present, or has the potential to present, a risk of harm to human health, the environment or any environmental value.
DBCA	Department of Biodiversity Conservation and Attractions.
DMPE	Department of Mines, Petroleum and Exploration.
DMPE environmental objectives	The related environmental objective for each environmental factor is the desired goal that, if met, will indicate that the proposed activities are not expected to have a significant impact on that factor of the environment. DMPE objectives are identified in the Environmental Objectives Policy for Mining.
Design report	The design report is a more complex and detailed report that presents an analysis of the background conditions and investigations undertaken when planning engineered landforms and structure such as a TSF. The design report is expected to evaluate: • variations in the surface and sub-surface profile and their impact on physical and engineering properties; • specified design and operational parameters, including relevant tolerances and their impact on the integrity and performance of the landform/structure; • monitoring and inspection requirements; and • the proposed closure approach to be adopted. For further guidance on design reports for TSFs refer to the DMPE '*Guide to the preparation of a design report for Tailings Storage Facilities* (TSFs) (2015)'.
Detrimental impact	Causing harm or damage.
Disturbed	Area where vegetation has been cleared and/or topsoil (surface cover) removed.
Domain	A group of landform(s) or infrastructure that has similar rehabilitation and closure requirements and objectives.
DWER	Department of Water and Environmental Regulation.
Ecosystem	Means a dynamic complex of ecological communities and the non-living chemical and physical parts of their environment interacting as a functional unit.
Environmental factor	A part of the environment that may be impacted by a mining activity.
Environmental outcome	As defined in the Mining Regulations 1981.
Environmental value	A beneficial use and/or an ecosystem health condition.
Geotechnical stability	Refers to the condition where the rates of change of parameters specific to geotechnical properties meet agreed criteria.
Groundwater	Water held underground in the soil or in pores and crevices in rock.
Growth media	Material identified as capable of supporting vegetation establishment.
Habitat	The area and resources used by a particular organism.
Impact	Interaction of an aspect of an activity with an environmental factor.
Inherent risk	The risk before any risk treatments are applied.
Introduced fauna	Non-native fauna species.

Term	Definition
Key mining activities	Defined as the following activity categories: • evaporation pond; • heap leach or vat leach facility; • mining void; • significant water diversion or management structure; • tailings or residue storage facility; • WRL or overburden stockpile; and • minerals-in-brine: – evaporation pond (minerals-in-brine); – halite/salt stockpile; – minerals-in-brine abstraction trench.
Key stakeholder	As defined in the Mining Regulations 1981.
Knowledge gap	The difference between what an operator knows versus what the regulator requires them to know.
Level of risk	Magnitude of a risk or combination of risks, expressed in terms of the combination of consequence and likelihood.
Life of mine	Determination of the number of years a site will mine and process ore based on various input conditions, including economic, environmental and business considerations.
Likelihood	The probability of an activity impacting on an environmental factor to produce the predicted consequence.
Localised/local	The activity envelope plus adjacent study areas associated with the mining operation.
Maintain	To keep in existence or continuance, preserve, retain or to keep in a specified state, position, etc.
Mine activity reference	Name given to a particular activity at the mine for ease of identification, for example 'Western Waste Rock Landform' or 'Tailings Storage One'.
Mine Closure Plan (MCP)	A document defined under 103AR of the *Mining Act 1978*.
Mining Development and Closure Proposal (MDCP)	As defined in the *Mining Act 1978*.

Term	Definition
Mining operations	As defined in Section 8 of the *Mining Act 1978*. Mining operations means any mode or method of working whereby the earth or any rock structure, stone, fluid or mineral bearing substance may be disturbed, removed, washed, sifted, crushed, leached, roasted, distilled, evaporated, smelted, combusted or refined, or dealt with for the purpose of obtaining any mineral or processed mineral resource therefrom whether it has been previously disturbed or not and includes; • the removal of overburden by mechanical or other means and the stacking, deposit, storage and treatment of any substance considered to contain any mineral; • operations by means of which salt or other evaporites may be harvested; • operations by means of which mineral is recovered from the sea or a natural water supply; and • operations by means of which a processed mineral resource is produced and recovered; the doing of all acts incident or conducive to any such operation or purposes.
Open disturbance	Land which has been disturbed for mining activities where rehabilitation work (to meet agreed closure outcomes) has not yet been completed.
Other mining activities	Other mining activities incidental or conducive to the mining operations, including: • fuel storage facility; • workshop; • landfill site; • sewage pond; • building (other than accommodation or plant); • transport or service corridor; • laydown or hardstand; • core yard; • topsoil stockpile; and • processing equipment or stockpile associated with basic raw material extraction.
Permanent	Irreversible changes to environment caused by the mining operation.
Phase of mine life	These phases include yet to commence, construction, operation, care and maintenance, rehabilitation and closure.
Pollutant	A substance that results in contamination of the environment, especially soil, water or atmosphere.
Post-mining land use (PMLU)	Term used to describe a land use that occurs after the cessation of mining operations.
Potential zone of instability (PZoI)	The potential area of ground that can be disturbed by the failure of the open pit walls over the long term.
Problematic materials	Materials that have the potential to detrimentally impact on humans and the environment and require careful and appropriate management (e.g. PAF materials, metalliferous materials, radioactive materials, asbestiform materials, dispersive materials, etc).
Processed materials	Waste materials generated from the onsite processing of ores.

Term	Definition
Receptor	A biophysical entity which may be impacted by an aspect of the mining operation.
Recoverable impact	Impact that can be rectified to be consistent with prior environmental conditions.
Regional	The broader terrestrial area within which the mining operation occurs.
Rehabilitation	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, consistent with the agreed PMLU. Rehabilitation can also include studies, trials and monitoring of trial performance that demonstrate the closure option for the site is achievable or closes knowledge gaps.
Residual risk	The risk remaining after risk treatment.
Risk	The chance of something happening that will have an impact on objectives. It is measured in terms of consequences, and their likelihood of occurrence.
Risk analysis	Process to comprehend the nature of risk and to determine the level of risk.
Risk assessment framework	Set of components that provide the foundations and organisational arrangements for undertaking risk assessments including risk identification, risk analysis, risk evaluation and risk treatment.
Risk identification	Process of finding, recognising and describing risks.
Risk management	Coordinated activities to direct and control an organisation with regard to risk.
Risk treatment	Process to modify risk.
Safe	A condition where the risk of adverse effects to people, livestock, other fauna and the environment in general has been reduced to a level acceptable to all stakeholders.
Sensitive receptors	Sensitive receptors are environmental features that may have an increased sensitivity to contaminants. Examples may include: • threatened ecological communities; • priority ecological communities; and • public drinking water source protection areas. With regards to water resources that are sensitive receptors, reference should be made to the Water Quality Protection Note (WQPN) 4: 'Sensitive water resources, for inclusion and definition of a sensitive water receptor'.
Significant water diversion or management structure	Significant infrastructure associated with the diversion, capture and/or transport of water flows such as diversion bunds higher than 3 m, seawall and/or groundwater curtain.
Short range endemic species	Terrestrial and freshwater invertebrates that have naturally small distributions of less than 10,000 km². Within this distribution, the actual areas occupied may be small, discontinuous or fragmented.

Term	Definition
Small mining operation	Activities must be limited to: • scraping and detecting; • dry blowing; • the following activities for a total footprint for the mining operation of 10 ha or less; – mining excavations (pits, costeans, quarries, shafts, winzes, harvesting, dredging), leaching operations and tailings treatment operations; and – any construction activities incidental or conducive to the activities above including plant, TSFs and overburden stockpiles. DMPE generally considers that a small mining operation does not involve the mining of uranium, mineral sands or rare earth elements. The mining development and closure proposal pro forma for small operations cannot be used as a mechanism to seek approval for amendments to sites or projects that are not considered small mining operations.
Source of risk	Source of potential harm or situation.
Stable	A condition where the rates of change of specified parameters meet agreed criteria.
Subterranean fauna	Subterranean fauna are defined as fauna that live their entire lives (obligate) below the surface of the earth. They are divided into two groups: • stygofauna – aquatic and living in groundwater; and • troglofauna – air-breathing and living in caves and voids.
Surface water	Water that collects on the surface of the ground. May be pooled on the surface or composed lakes, creeks, and rivers.
Tailings Storage Facility (TSF)	An area used to store and consolidate processed materials (known as tailings).
Target ecosystem	The specific biological community or environment that is to be achieved.
Unwanted event	A situation or condition where there is a loss of control of the hazard that leads to harm.
Waste rock landform (WRL)	Areas associated with the storage of unprocessed subsurface or waste rock material resulting from a mining operation.
Water table	The level below which the ground is saturated with water.
Weeds	Plants that establish and persist in a natural ecosystem where they did not previously exist. Weeds may, or may not, have detectable environmental or economic impact.
Widespread	To a greater extent than the activity envelope and adjacent study areas.

Appendix 2: Planning for mine closure

1. Principles of mine closure planning

DMPS's 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, geotechnically stable, geochemically non-polluting/non-contaminating and capable of sustaining an agreed PMLU with consideration for cultural values 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 post-mining landholders. These landholders/key stakeholders would not be accountable for any residual liabilities not identified by operators that occur because of unexpected closure or failure to close a site properly.

The following key principles and approaches should be considered when preparing an MCP (DFAT 2016a):

- From the project approval stage throughout mine life, the MCP 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).
- MCPs 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 tenement holders/operators and stakeholders which should include acknowledging and responding to stakeholders' concerns. Information from consultation is central to closure planning and risk management.
- PMLU(s) 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, PMLU(s) 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. MCPs should identify relevant experience from other mine sites and research, and how lessons learned from these are to be applied.
- MCPs should demonstrate that appropriate systems for closure performance monitoring and maintenance and for record keeping and management are in place.

2. Risk based approach to mine closure planning

DMPE 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).

3. Staged approach to mine closure planning

Progressive development of an MCP throughout the mine lifecycle (Figure 1) and progressive rehabilitation are critical to the successful implementation of mine closure planning and achieving DMPS's rehabilitation and closure objectives.

Consistent with a risk-based approach, the level of detail required by DMPE increases with the level of risk associated with each key closure component and time to closure. This is displayed in Figure 1, with further reading available in ICMM 2019 and ICMM 2022.

Operators must provide a sufficient level of detail on key closure components at each stage of mining.

Key closure components include:

- PMLU;
- closure outcomes;
- completion criteria;
- collection and analysis of closure data; and
- materials characterisation, including mineral waste.

The structure of an MCP is designed to assist industry compile MCP information in a sequential order that is easier to use and for DMPE to assess.

Stages of mining	Stakeholder input	Closure planning	Regulation
Exploration Feasibility Approvals Construction	**Pre-submission** • Concepts of mine and landforms that will exist at closure discussed	I C R E A S I N G D E T A I L	• MDCP assessment
	MDCP/assessment • Post Mining Landforms and Post Mining Land Use • Potential contaminated sites		
	Regular meetings – proponent ano stakeholders • Post Mining Landforms/use updates • Contaminated sites updates • Future planned operations, changes to original concepts and impacts • Rehabilitation planned works • Results of monitoring and implications for closure • Results of mine closure plan submissions		**During operations** • MCP assessment • MDCP amendments • Compliance audits • Site inspections
Operations Operations cease	**5 years prior to operations ceasing** • Negotiations start regarding retention of infrastructure and future tenure/maintenance agreements • Finalise Post Mining Land use discussions • Commence discussions regarding closure execution seek local parties and stakeholders desires for involvement in closure execution • Contaminated sites updates • Results of monitoring and implications for closure • Results of mine closure plan submissions		• MCP with detail
Decommissioning Closure execution Post-closure Monitoring and Maintenance	**2 years prior to operations ceasing** • Finalise retention agreements (signed) for submission to regulatory authorities as appropriate • Mine closure plan detailing closure execution submitted to DMPE • Contaminated sites assessments planned and discussed		**Post closure** • Monitoring of completion criteria achievement
Completion	**Post closure – regular meetings** • Update on achievement of completion criteria, monitoring and progress towards completion/relinquishment		**Relinquishment** • Approval of completion report

Figure 1. Integrating stages of mining and mine closure planning with level of stakeholder engagement.

4. Mine closure planning for rehabilitation

Rehabilitation is a critical part of mine closure planning and is referred to throughout this document.

It is important to remember that continual improvement in rehabilitation techniques will occur over time and operators 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). DMPE encourages operators 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, operators 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. DMPE recognises that revegetation is likely to be more successful in temporarily or short duration disturbed areas.

Progressive rehabilitation can also provide an early indication as to whether the MCP needs to change to meet closure outcomes committed to by the tenement holder and whether closure outcomes are realistic and achievable. Furthermore, progressive rehabilitation enables potential contamination issues (such as erosion) 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. DMPE 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. Operators in this position are encouraged to commence discussions with DMPE 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; they 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, operators will need to consider any significant residual impacts that may result from those changes.

5. Mine closure planning detail at stages of mine life

An indication of the required level of detail for each stage of mining is shown in Table 11.

Table 11. Indication of required level of closure detail.

Stages of mining	Environmental data collection and analysis with implications to closure	Materials characterisation	Stakeholder engagement	Post-mining land use(s)	Identification of key issues/risk assessment	Closure outcomes	Completion criteria	Closure implementation and monitoring	Financial provision assumptions
Exploration	Baseline environmental data collected before work starts. Exploration information to be used in rehab and closure planning collation (e.g. waste characteristics and drill hole database).	Samples collected from drill program. Testing commenced.	Stakeholders identified. Stakeholder engagement instigated, PMLU options and plans for closure discussed. Present the risk assessment, particularly as it pertains to closure of the site and residual risks.	Provisional post-mining land use options based on preliminary exploration results.	Exploration based closure risk assessment. Updated depending on drilling outcomes finding high-risk items/ materials.	Indicative, except for high-risk items.	Mainly exploration based: • Drill holes capped. • Rehab and ripping of pads and tracks. • Sample piles and sumps rehab. • Sample bags and rubbish removed. Draft operations criteria.	Preservation of topsoil. Preliminary closure schedule except for high-risk items.	Process, methodology and assumptions transparent and verifiable. Based on reasonable site-specific information.
Planning and design/ environmental assessment stage	Development of the operation, with rehab and closure in mind (e.g. waste landform design and location).	Detailed materials characterisation including geochemical and physical properties, volumes, and potential material uses.	Consultation continues, proposed PMLU options, refined risks and plans for closure discussed. Consultation strategy defined.	Options well advanced or finalised.	Closure based risk assessment conducted and mitigation strategies incorporated into mine design.	Outcomes well advanced or finalised.	Ensure criteria reflect operations risks and closure outcomes. Criteria reflect SMART principles.	Design encapsulation areas for troublesome materials (e.g. acid and/or metalliferous drainage, dispersive materials). Closure schedule planned.	Process, methodology, assumptions transparent and verifiable. Updated to reflect increased knowledge of the operation.
MDCP Submission and Approvals Statement issued									
Construction	Construction practices that make rehab and closure easier. (e.g. topsoil clearing and appropriate surface water management).	Commence management of troublesome materials (e.g. create encapsulation areas).	Consultation continues, proposed PMLU option agreed and plans for closure discussed. Discuss risks at closure.	Options well advanced or finalised.	Initial risk assessment reviewed to ensure mitigations implemented and are working. Any new risks captured, and mitigation strategies put in place.	Closure outcomes now form part of Approvals Statement.	Ensure criteria reflect operations risks and closure outcomes. Criteria meet SMART principles and refer to analogue sites.	Topsoil preservation. Capping materials preservation. Analogue sites established.	Process, methodology, assumptions transparent and verifiable. Updated to reflect increased knowledge of the operation.
MCP Submission(s) during operations									
Construction	Construction practices that make rehab and closure easier (e.g. topsoil clearing and appropriate surface water management).	Commence management of troublesome materials (e.g. create encapsulation areas).	Consultation continues, proposed PMLU option agreed and plans for closure discussed. Discuss risks at closure.	Options well advanced or finalised.	Initial risk assessment reviewed to ensure mitigations implemented and are working. Any new risks captured, and mitigation strategies put in place.	Closure outcomes now form part of Approvals Statement.	Ensure criteria reflect operations risks and closure outcomes. Criteria meet SMART principles and refer to analogue sites.	Topsoil preservation. Capping materials preservation. Analogue sites established.	

Stages of mining	Environmental data collection and analysis with implications to closure	Materials characterisation	Stakeholder engagement	Post-mining land use(s)	Identification of key issues/risk assessment	Closure outcomes	Completion criteria	Closure implementation and monitoring	Financial provision assumptions
Operations	Research, studies and rehab trials to test design assumptions and close knowledge gaps. Report on monitoring.	Continued validation and verification sampling and analysis during operations. On-site trials for rehab designs (e.g. to confirm batter angles, erosion resistance).	Review stakeholder engagement strategy and plan. Consultation continues. Residual risks at closure. Commence discussion of any assets desired to be retained at closure.	Options well advanced or finalised. Additional PMLU options or repurposing of the land may arise.	Risk assessment reviewed to ensure mitigations implemented and are working. Any new risks captured, and mitigation strategies put in place. Number of reviews occur during mine life.	Closure outcomes now form part of Approvals Statement. Changes require an MDCP submission.	Criteria now quantifiable and meet SMART principles. Relate to analogue sites. Informed by monitoring data.	Encapsulation practices continue. Progressive rehab undertaken during operations. Potential for closure of parts of operation. Ongoing monitoring of rehab areas and analogues. Landform designs developed. Closure schedule at high detail.	Process, methodology, assumptions transparent and verifiable. Updated to reflect increased knowledge of the operation. Expected to be refined and improved over time.
MCP submission – to greater detail for execution of closure									
Decommissioning	Finalised outcomes of trials inform final landform design. Monitoring results of progressive rehab.	Validated results inform final closure designs.	Residual risks. Signed agreements for any retained assets (e.g. tenure, maintenance and liability transfer).	Implementation commences.	Risk assessment reviewed to ensure mitigations implemented and are working. Decommissioning risks added with mitigation strategies put in place.	Closure outcomes now form part of Approvals Statement.	Criteria achievement tracked and compared to analogue sites.	Full closure schedule. Landform designs finalised. Implementation commenced. Monitoring program finalised. Implementing PMLU.	Process, methodology, assumptions transparent and verifiable. Updated to reflect increased knowledge of the operation. Not expected to change now.
Post-closure monitoring and maintenance	Comparison of monitoring to completion criteria.	Further study may be needed should completion criteria not be met.	Consultation continues until closure completion.	Audit to check achievement of PMLU.	Review success of mitigations. Allows refinement of methodology for next operation.	Audit to check achievement of closure outcomes.	Monitoring against criteria. Audit to check achievement.	Mitigations/repairs should completion criteria not be met.	Reconciliation of actual costs to projected. Allows refinement of methodology for next operation.
Completion report submission									

Appendix 3: DMPE environmental risk assessment framework

To ensure the environmental and closure risks associated with the mining activities are appropriately identified and managed, an environmental risk assessment must be undertaken using DMPE standardised framework. This risk assessment framework is further described below.

The framework should be used in consideration of the terminology and definitions presented in Appendix 1.

For mining operations within a public drinking water source area, the risk assessment should consider the Department of Water and Environmental Regulation Water Quality Protection Note 77, 'Risk assessment process for public drinking water source areas' and Water Quality Protection Note 11, 'Assessing and managing risks in public drinking water source areas'.

The risk assessment process includes the following steps:

- risk identification;
- risk analysis;
- risk evaluation;
- risk treatments; and
- risk register.

The relevant aspects of each of these steps is detailed below.

1. Risk identification

Risk identification involves a systematic listing of risk pathways based on the project scope, activities and relevant environmental values. To appropriately identify risks, DMPE requires the description of the risk pathway is presented with three components:

- unwanted event;
- cause of the risk; and
- description of the impact.

Risk pathways which are not identified cannot be managed, therefore a considered effort is required at this step of the process. To assist in this, DMPE recommends operators:

- seek advice from experienced operators, specialists, stakeholders and relevant regulatory agencies; and
- research and incorporate learnings from previous environmental incidents that have occurred from similar activities around Australia and internationally.

Risk identification requires an adequate and appropriate environmental understanding of the operating area, informed by baseline data and/or environmental data collected during operations, without which the risk pathways or potential impacts may not be identified. Operators are required to undertake surveys and studies to meet all relevant industry standards to minimise limitations of the data. Following collection of the environmental data, detailed analysis is required to establish the key environmental sensitivities and how these might be impacted by the mining activities.

An example of how to appropriately identity risk pathways and potential impacts is provided in Table 12.

Table 12. Example of how to describe a risk pathway.

Risk pathway
Example 1 **Inadequate description of risk pathway:** • **Poor placement of mined materials during operations.** **Well defined risk pathway:** • **Poor placement of highly dispersive materials during operations leads to erosion and resulting smothering of native vegetation.**
Example 2 **Inadequate description of risk pathway:** • **Generation of acidic or metalliferous drainage.** **Well defined risk pathway:** • **Poor placement of PAF materials during operations leads to generation of acidic or metalliferous drainage which results in soil/water contamination and impacts on health of surrounding native vegetation.**

2. Risk analysis

The risk level is analysed by determining both the consequence and likelihood of each risk pathway, firstly for the inherent (untreated) risk and then for the residual (treated) risk.

The risk pathway should be analysed to determine the most plausible consequence of the risk event based on DMPE standard consequence descriptors Table 13. Descriptors have been developed to link directly to DMPE environmental factors.

The risk pathway should be analysed to determine the most plausible likelihood of the risk event occurring based on DMPE standard likelihood descriptors Table 14. The descriptors have been developed to capture operational and closure timescales. Where a risk pathway is related to rehabilitation and closure it may be more appropriate to consider the closure timescale.

Based on the consequence and likelihood, the risk level of the risk pathway must be determined using DMPE standard risk matrix Table 15.

The risk analysis should be undertaken considering the limitations of the data and information used, where data is incomplete, absent or the uncertainty of an impact increases. Any uncertainty should be reflected in a higher inherent risk. In most cases submission cannot be adequately assessed if the environmental data is deemed inadequate. However, where knowledge gaps cannot be reasonably filled prior to commencement of a mining operation, applicants should demonstrate the application of the precautionary principle, to minimise the potential for environmental harm and actions added to the knowledge gaps table with actions to address the data gap.

3. Risk evaluation

Risk evaluation involves determining whether the inherent risk and the residual risk is acceptable in the context of DMPS's environmental objectives. Where risks are not acceptable, appropriate treatments need to be determined using the hierarchy of hazard control: eliminate, avoid, minimise or mitigate.

Generally, even a risk pathway with a low inherent risk level will still require industry best practice environmental management to be applied.

Where risk evaluation determines a risk pathway and its potential impact(s) are not acceptable (inherent extreme risk), the applicant is required to undertake further studies or investigate alternative options.The outcomes of this work would require revision of the risk analysis step for the relevant risk pathway.

4. Risk treatment

The risk assessment should document all proposed risk treatments for each risk pathway. The proposed effectiveness of treatments must be analysed using DMPE standard framework to determine the residual risk level and ensure the principle of ALARP and DMPE objectives are met.

The selection of treatments should demonstrate the preferential application of the hierarchy of hazard control:

1. Where reasonably practicable, eliminate or avoid the risk, by not undertaking the risky activity. For example, changing the project layout to avoid clearing of threatened flora or changing pit designs to avoid disturbance of PAF material.
2. Reduce the risk by substituting a different activity which poses a lower risk. For example, backfilling a pit void with waste rock instead of constructing a WRL.
3. Control the risk with an engineered solution. For example, having a specifically designed adverse materials management cell in a WRL, or the use of automatic (instead of manual) shut-off valves.
4. Mitigate the risk using administrative procedures. For example, reducing speeds on mine roads, daily checks of a TSF or warning signals/signs.

Treatments which rely on control or mitigation of the risk should not be considered as the first option as failure of the treatment is likely to result in environmental harm. Applying these risk treatments will result in a reduction of the likelihood level only, not the consequence.

The higher the inherent risk of an unwanted event, the more reliable and robust the selected risk treatments are required to be.

A low inherent risk generally requires less detail of the selected risk treatments, especially if these treatments use existing industry standards or codes, however, these standards need to be stated.

Where an inherent risk of medium or high requires specific management measures, provide a comprehensive description of the proposed treatments e.g. encapsulation plan for PAF materials and associated diagrams of the encapsulation cell. This information may not fit within the risk register table and may need to be provided in the body of the document or as an appendix, however, the key management points are required to be summarised within the risk register table.

The risk register needs to detail how the risk treatments fit into the mitigation hierarchy.

5. Risk register

The risk assessment should be presented in DMPE standard risk register presented in Table 16. A copy of the risk register should be included within the submission. The register should be used to summarise all risk pathways identified for all phases of mine life and demonstrate how these risks can be adequately managed to ALARP and meet DMPE environmental objectives.

ALARP is defined as 'any measure which is practicable, and the implementation cost (money, time, effort) is not grossly disproportionate to the benefit, the measure is considered 'reasonably practicable' and implementation is expected'. The criterion is not 'reasonably affordable'. Justifiable cost, time and effort is not determined by the financial constraints or viability of the project.

Risk treatments should demonstrate that all residual risks are ALARP and will not impact DMPS's key environmental objectives. In some instances, established and/or standard industry practices and procedures may meet the ALARP principle, however, in other instances more stringent risk treatments may be required.

Reducing a risk to ALARP involves a balance between the cost (money, time, effort) and the resultant risk reduction. This level represents the point at which the cost required for further reduction measures becomes unreasonably disproportionate to the additional risk reduction obtained.

Justification for selection of risk treatments, and how they reduce the risk to ALARP, may include details of other options which upon evaluation were rejected, as the costs were grossly disproportionate to the benefit. It should be noted that, over time, costs associated with some risk treatments may reduce, therefore, treatments that initially appeared grossly disproportionate to the benefit may eventually become reasonably practicable.

Operators will outline the environmental and closure outcomes that will be met to ensure the mining operation meets DMPS's environmental objectives. The risk assessment will identify the risk treatments/ management required to be implemented to meet these outcomes. Operators should continually review and improve environmental management to maintain residual risks at an ALARP level and ensure outcomes are met. The establishment and maintenance of an EMS is one method applicants can use to embed continuous improvement.

6. Environmental standards, codes and guidance

Where applicable, reference Australian Standards, code of practices and other established guidelines when describing risk treatments.

Where there are no relevant standards or the risk is new or emerging, proposed management strategies are required to be more detailed to provide confidence to the department that the applicant understands the risk and has demonstrated that appropriate treatment can be implemented.

Table 13. DMPE risk assessment framework consequence descriptors.

Objectives and environmental factors		Environmental indicator	Category label				
Environmental factor	**Objective**		**Insignificant**	**Minor**	**Moderate**	**Major**	**Severe**
Flora, vegetation and fauna	To protect flora and vegetation, subterranean fauna and terrestrial fauna so that biological diversity and ecological integrity are maintained.	Ecosystem function	Negligible impact/change to ecological processes and/or function.	Localised impact/change to ecological processes and/or function resulting in a recoverable impact within 1 year.	Alteration to ecological processes and/or function resulting in a recoverable impact within 5 years.	Alteration to ecological processes and/or function resulting in a recoverable impact within 10 years.	Alteration to ecological processes and/or function resulting in a potentially non-recoverable impact.
		Flora and vegetation	No direct loss of native vegetation although increased stress may be incurred through indirect or induced pressures. And/or No direct loss of conservation significant vegetation.	Localised and short-term (< 1 year) loss of native vegetation which is widely distributed outside of the activity envelope.	Medium-term (1–5 years) loss of native vegetation which is widely distributed outside of the activity envelope. Project places minimal pressure on continued survival of conservation significant vegetation on a local scale.	Long-term (5–10 years) loss of native vegetation which is not widely disturbed outside the activity envelope. Project places significant pressure on continued survival of conservation significant vegetation on a regional scale.	Permanent loss of native vegetation causing significant pressure or potential extinction of conservation significant vegetation on a regional scale.
		Fauna	No decrease in fauna habitat and/or fauna abundance. And/or No direct loss of conservation significant fauna.	Localised and short-term (< 1 year) decrease in fauna habitat and/or fauna abundance.	Medium-term (1–5 years) decrease in fauna habitat and/or fauna abundance.	Significant, widespread, and/or persistent regional decrease in fauna habitat and/or fauna abundance. Long-term (5–10 years) decrease in fauna habitat and/or abundance.	Permanent regional loss of fauna habitat and/or loss of conservation significant fauna habitat and/or conservation significant fauna population.
		Environmental threats (weeds, pathogens and introduced fauna)	Manageable, localised infestation/spread within the activity envelope that does not result in competition/impact with native species.	Manageable, localised infestation/spread that results in minor competition/impact with native species.	Localised infestation/spread that results in competition/impact with native species requiring considerable management/control measures.	Regional infestation/spread that results in competition/impact with native species requiring extensive management/control measures.	Uncontrollable regional infestation/spread that results in competition/impact with native species and regional loss of vegetation communities or flora.

Objectives and environmental factors		Environmental indicator	Category label				
Environmental factor	**Objective**		**Insignificant**	**Minor**	**Moderate**	**Major**	**Severe**
Inland water	To maintain the hydrological regimes, quality and quantity of groundwater and surface water so that environmental values are protected.	Surface water quality	Negligible changes to local surface water quality that negatively impacts environmental values.	Minor and or short-term (< 1 year) change to surface water quality that negatively impacts environmental values.	Moderate and or medium-term (1–5 years) change to surface water quality that negatively impacts environmental values.	Long-term decline (5–10 years) in surface water quality that negatively impacts environmental values.	Decline in surface water quality that negatively impacts environmental values on a regional scale. Non-recoverable impact.
		Surface water quantity	Incidental, short-term changes to local surface water volumes. Negligible impact to environmental values or water users.	Minor, short-term changes to local surface water volumes. Recoverable within 1 year and/or localised impact to environmental values or water users.	Medium-term changes to surface water volumes. Recoverable within 1–5 years and/or negative impact to environmental values or water users.	Long-term changes to surface water volumes. Recoverable within 10 years and/or negative impact to environmental values or water users.	Project causes permanent modifications to surface water volumes. Non-recoverable impact/ permanent impact to environmental values or water users.
		Ground water quality	Incidental, short-term changes to local groundwater quality. Negligible impact to environmental values.	Short-term (< 1 year) localised decline in groundwater quality that negatively impacts environmental values.	Medium-term (1–5 years) localised decline in groundwater quality that negatively impacts environmental values.	Long-term (5–10 years) regional decline in groundwater quality that negatively impacts environmental values.	Permanent decline in groundwater quality that negatively impacts environmental values. Non-recoverable impact.
		Ground water quantity	Incidental changes to local groundwater levels/ availability. and/or negligible impact to environmental values or water users.	Local changes to groundwater levels/ availability. Recoverable within 1 year and/ or localised impact to environmental values or water users.	Changes to groundwater levels/availability in the medium-term. Recoverable within 5 years and/or negative impact to environmental values or water users.	Regional changes to groundwater levels/availability in the long-term. Recoverable within 10 years and/or negative impact to environmental values or water users.	Regional changes to groundwater levels/availability in the long-term. Non-recoverable impact permanent impact to environmental values or water users.
Terrestrial environmental quality	To maintain the quality of land and soils so that environmental values are protected.	Soil resources	Incidental loss of soil resources has short-term impact on associated environmental values within activity envelope.	Loss of soil resources has medium-term impact on associated environmental values on a local scale.	Loss of soil resources has long-term impact on associated environmental values on a local scale.	Loss of soil resources resulting in a short to medium-term impact on associated environmental values on a regional scale.	Loss of soil resources that has a permanent impact on associated environmental values on a regional scale.
		Land contamination	Incidental land contamination within activity envelope, easily treatable in short-term (< 1 week) and does not result in adverse impacts on associated environmental values.	Land contamination localised and treatable in medium-term (< 1 year) and does not result in adverse impacts on associated environmental values.	Localised land contamination. rectifiable within 5 years and results in minor adverse impacts on associated environmental values in the short to medium-term.	Land contamination on a regional scale (beyond activity envelope) resulting in adverse impacts on associated environmental values. Results in clean-up requiring specialist remediation within 10 years and/or medium to long-term management.	Land contamination on a regional scale (beyond activity envelope) resulting in permanent damage with severe environmental and socioeconomic disruption. Results in clean-up requiring specialist remediation > 10 years, and/or permanent residual impact.

Objectives and environmental factors		Environmental indicator	Category label				
Environmental factor	**Objective**		**Insignificant**	**Minor**	**Moderate**	**Major**	**Severe**
Rehabilitation and mine closure	Mining activities are rehabilitated and closed in a manner to make them physically safe to humans and animals, geotechnically stable, geochemically non-polluting/non-contaminating, and capable of sustaining an agreed PMLU, with consideration for cultural values and without unacceptable liability to the State.	Landscape	Closed/rehabilitated site is virtually indistinguishable from surrounding landscape and topography.	Closed/rehabilitated site integrates seamlessly with surrounding landscape and topography whereby it is not easily noticeable from a distance.	Closed/rehabilitated site integrates with surrounding landscape and topography, however mining-produced landforms or disturbances are distinguishable from a distance.	Closed/rehabilitated site has some features/landforms that do not integrate readily with the surrounding landscape and topography, however, only compromises local landscape values.	Closed/rehabilitated site has features/landforms that do not integrate readily with the surrounding landscape and topography, which compromises regional landscape values.
		Physical safety (to humans and animals)	Rehabilitated areas are physically safe to humans and animals.	Site is safe and any safety issues are contained and require no residual management.	Site is safe and any safety issues require minor, ongoing maintenance by the operator.	Site is unsafe and requires long-term management or intervention (i.e. < 25 years).	Site is unsafe and will cause an ongoing residual effect (i.e. 25+ years)/perpetual management.
		PMLU	PMLU can be easily achieved and sustained without any liability to the State. PMLU is acceptable to key stakeholders.	PMLU can be achieved with minimal management required.	PMLU cannot be sustained without some management.	PMLU cannot be sustained without ongoing management.	PMLU cannot be sustained. PMLU is not acceptable to key stakeholders.
		Physical and geotechnical stability	Site is stable. Post-mining landforms are demonstrated to be physically stable with only incidental erosion.	Post-mining landforms are stable, but may experience minor erosion, such as minor rilling.	Post-mining landforms are generally stable, but may experience moderate erosion, such as limited gullying.	Post-mining landforms are unstable, with significant erosion, such as tunnelling and gullying, and/or subsidence.	Post-mining landforms are likely to fail (e.g. TSF embankment failure), with extensive ongoing management issues.
		Land contamination	Post-mining landforms are geochemically stable and are proven to be non-polluting/ non-contaminating.	Post-mining landforms are geochemically stable but may discharge minor amounts of pollutants to groundwater and surface water on a seasonal basis that does not result in contamination.	Post-mining landforms are generally stable but may discharge moderate levels of pollutants to groundwater and surface water that does not result in contamination.	Post-mining landforms discharge pollutants to groundwater and surface water causing short to medium-term (< 10 years) contamination.	Post-mining landforms discharge pollutants to groundwater and surface water causing long-term (> 10 years) to permanent contamination.

Table 14. Risk assessment framework likelihood descriptors.

Descriptor	Operations		Closure	
	Frequency	Description	Probability[1]	Description
Almost certain	Once or more per year	The risk event is expected to occur in most circumstances. High number of known incidents across industry.	> 90%	Likely to occur/commence within a 1 year period from closure commencement. **AND/OR** Occurs 5 to 10 times in 2 years.
Likely	Once in 5 years	The risk event is expected to occur in some common circumstances. Regular incidents known across industry.	70–90%	Likely to occur/commence within a 1–5 year period from closure commencement. **AND/OR** Occurs 5 to 10 times in 10 years.
Possible	Once in 10 years	The risk event might occur in some circumstances. Incidents known across industry.	30–70%	Likely to occur/commence within a 5–20 year period from closure commencement. **AND/OR** Occurs 5 to 10 times in 20 years.
Unlikely	Once in 20 years	The risk event could occur in some uncommon circumstances, as this is known to occur at comparable sites. Some occurrences known across industry.	5–30%	Likely to occur/commence within a 20–50 year period from closure commencement. **AND/OR** Occurs 5 to 10 times in 50 years.
Rare	Once in 50 years	Highly unlikely, but the risk event may occur in exceptional circumstances, as may have occurred at comparable sites. Very few or no known occurrences across industry.	< 5%	Unlikely but possible to occur/commence within a 100 year period from closure commencement. **AND/OR** Occurs 1 to 5 times in 300 years.

1 Probability is provided as alternative method to consider the likelihood of the risk event occurring post closure (closure timescale).

Table 15. Risk assessment framework risk matrix.

Risk matrix		Most Credible consequence level				
		Insignificant	Minor	Moderate	Major	Severe
Likelihood	**Almost certain**	Medium	High	High	Extreme	Extreme
	Likely	Medium	Medium	High	Extreme	Extreme
	Possible	Low	Medium	Medium	High	Extreme
	Unlikely	Low	Low	Medium	High	High
	Rare	Low	Low	Medium	Medium	High

Table 16. Risk register (including data entry examples).

Risk ID number	Key environmental factor	Category aspect(s)	Domain	Risk pathway	Phase(s) of mine life	Inherent risk			Risk treatment	Residual Risk			Environmental or closure outcomes	Comments
						Consequence	Likelihood	Risk rating		Consequence	Likelihood	Risk rating		
1	Flora, vegetation and fauna	Environmental threats	All	Vehicle and machinery movement introduce and spread weeds resulting in competition/impact to native vegetation.	Construction Operation Care and maintenance Closure	Moderate	Likely	High	Mitigate: Maintain data for location of recorded weeds. Periodically inspect weed risk areas. Implement vehicle/machinery hygiene procedures to ensure vehicles and machinery are free of soil and vegetation.	Moderate	Possible	Medium	F5. No increase in the diversity, distribution, and population of weed species and pathogens within the tenement(s) or surrounding land, as a result of mining activities.	Weed surveys have been undertaken to determine presence and distribution of weeds.
2	Land and soil	Land contamination	WRL	Exposure of PAF materials to water and air during operations leads to generation of acidic or metalliferous drainage which results in soil/water contamination and impacts on health of surrounding native vegetation.	Operations Care and maintenance Closure	Major	Likely	Extreme	Control: PAF management plan implemented: During operations mined waste rock material with > 0.2% sulfur identified and placed within PAF cell in centre of waste rock landform. Material covered with minimum 5 m of NAF material.	Major	Rare	Medium	T1. Mined/processed materials managed to ensure any seepage and drainage is contained/controlled so that environmental values are protected. C1. Constructed landforms are physically and geotechnically stable, minimise erosion and support native revegetation and/or the PMLUs. C4. Constructed landforms are geochemically non-polluting.	Comprehensive waste rock characterisation studies completed to identify PAF material. High level of confidence.
3	Inland water	Surface water	WRL	WRLs block surface water flows to Smith Creek resulting in changes to surface waterflow and volumes.	Operations Care and maintenance Closure	Major	Likely	Extreme	Avoid/eliminate: Waste rock landform will not be constructed within 50 m of drainage lines identified within the activity envelope.	Major	Rare	Medium	W2. Surface water managed in a manner that prevents detrimental impacts to hydrological and ecological function and uses of surrounding surface water features and land. C6. Surface drainage patterns, flows and characteristics are reinstated in a manner consistent with the regional drainage function and/or PMLU.	
4	Rehabilitation and mine closure	Physical and geotechnical stability	WRL	Landforms placed within PZoI resulting in structural failure causing impacts to the environment.	Closure	Moderate	Likely	High	Avoid/eliminate: Waste rock landform will be not constructed within the PZoI.	Moderate	Rare	Medium	C2. The placement of mined materials/infrastructure in relation to excavations will be such that the final footprint after rehabilitation is not located within the PZoI.	

Appendix 4: 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/or 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 and priority flora, fauna and ecological communities, locally endemic species, range extensions, unusual or new species or species with a restricted distribution;
- challenges associated with rehabilitation and revegetation;
- visual amenity;
- heritage/cultural values issues;
- sensitive receptors;
- regulatory requirements;
- alteration of the direction of groundwater flow;
- alteration of the depth to water table of 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 DMPE are:

- AMD;
- dispersive materials;
- rehabilitation;
- radioactivity; and
- mine pit lakes.

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

1. AMD.
2. Dispersive materials
3. Rehabilitation
4. Radiation management

More detailed pit lake assessment guidance is provided in Appendix 6.

1. Acid and/or metalliferous drainage

AMD has the potential to impact water quality during operations and post closure.

a) Definition

Mine drainage may consist of AMD. 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.

b) Potential impacts

AMD is recognised as one of the most serious environmental issues associated with mining. 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).

AMD 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.

Many of the issues with AMD can be mitigated or prevented through adequate identification, characterisation and treatment of PAF materials.

c) Identification and characterisation

Operators 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. DMPE 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 operator should demonstrate in the initial MCP that the proposed management strategy will provide a sustainable closure solution. This includes sustainable closure of mine WRLs, tailings facilities and mine pit voids/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 AMD 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). Operators should estimate the location of sulfide-bearing rock and the amount that may be disturbed during operations. Operators 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 risk, there may be risks to water quality at lower sulfur content values. Operators must undertake a site-specific assessment, including identifying sensitive receiving environments, to determine the AMD risk.

DMPE 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, which 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 MCP.

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).

d) Management

If the potential for AMD and/or other contaminated mine drainage has been identified, operators must demonstrate through the MDCP approval or environmental impact assessment processes that there are measures capable of managing the issue. Efforts should focus on prevention or minimization rather than control or treatment.

2. 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 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 and 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.

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) 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.

3. Rehabilitation

a) 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 PMLU. 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); and
- the prevention of pollution of the surrounding environment.

b) Applying the mitigation hierarchy to minimise disturbed areas

DMPE expects operators to apply the mitigation hierarchy (avoid, minimise and rehabilitate) to minimise the area associated with the proposal that will be disturbed, and hence the area to be rehabilitated. DMPE 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).

c) Rehabilitation objectives

Rehabilitation objectives are established through defining the PMLU(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.

d) Progressive rehabilitation

DMPE expects mine sites to be progressively rehabilitated. 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 reduces 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 PMLU(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.

e) Key elements of rehabilitation

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

f) Landform design

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

- placement of landforms to avoid surface water flow paths and proximity to project boundaries;
- height/footprint, balancing 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, considering control of drainage, with engineered solutions, if appropriate;
- mode of construction to enable selective placement of problem materials; and
- profiles including angle and shape of battered slopes, use of berms or concave slopes.

g) Landform construction

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

h) Materials characterisation

Characterisation of topsoils and overburden should start during 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 will 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).

i) Materials handling

WRLs 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 WRLs and TSFs.

j) 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.

k) Revegetation

Approaches to successful revegetation are rapidly evolving in WA 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 self-sustaining 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).

Rehabilitation trials undertaken while the mine is operating will allow a suitable seed mix to be defined, as well as clarifying which soil substrates will best support rehabilitation.

l) 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;
- 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; and
- scientific research on species relevant to the site that may improve the return of species in rehabilitated areas.

m) 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 WA.

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 10 cm. Due to technical limitation, stripping should focus on retrieving this top layer to a maximum depth of 20 cm. Appropriate soils at depths greater than 20 cm should be classified as 'subsoil' and stockpiled separately.
- Timing of stripping: always strip dry soil and ensure soil remains dry during transfer, storage and replacement phases.
- Topsoil storage: The final height of a topsoil stockpile will be determined by the size and type of machinery used to create them. Topsoil stockpiles should only be single truck dump 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 5 cm as most native seeds cannot emerge from depths greater than 5 cm (optimum is 1–2 cm), however the final depth implemented will be machinery dependent. Rehabilitation trials can help define the appropriate depth of topsoil and whether it is beneficial to add an alternative growth medium to achieve best optimal results.

n) Growth medium

Plant growth and function is 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.
- 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.

o) Standards for seed collection and use

For areas where topsoil has been demonstrated to be incapable of returning the stipulated level of biodiversity, the reliance on seed to achieve targets is increased. The seed supply chain (see Figure 1) provides the key steps that are critical for considering how wild seed is sourced and used correctly. For most regions, information on site and species-specific requirements is not available.

p) 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.
- 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 (ont to five years) at 5ºc; long term (> five years) at –18ºc.

q) Seed use

Procedures to optimise seed resources should also identify Figure 2:

- an understanding of seed dormancy and germination limitations of target species;
- using 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.

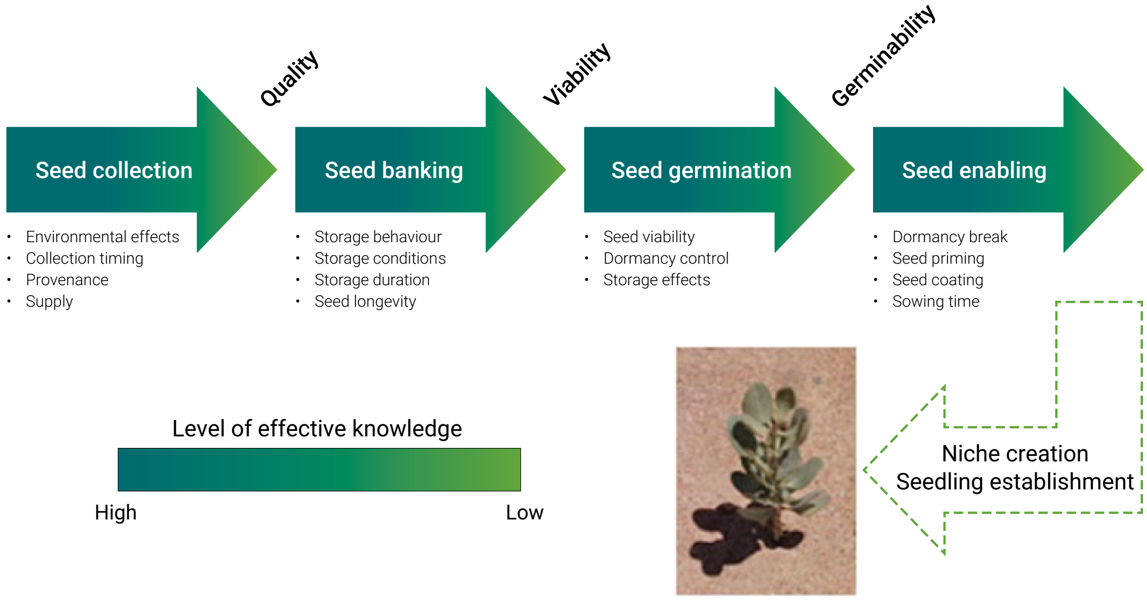

Figure 2. The seed supply chain.

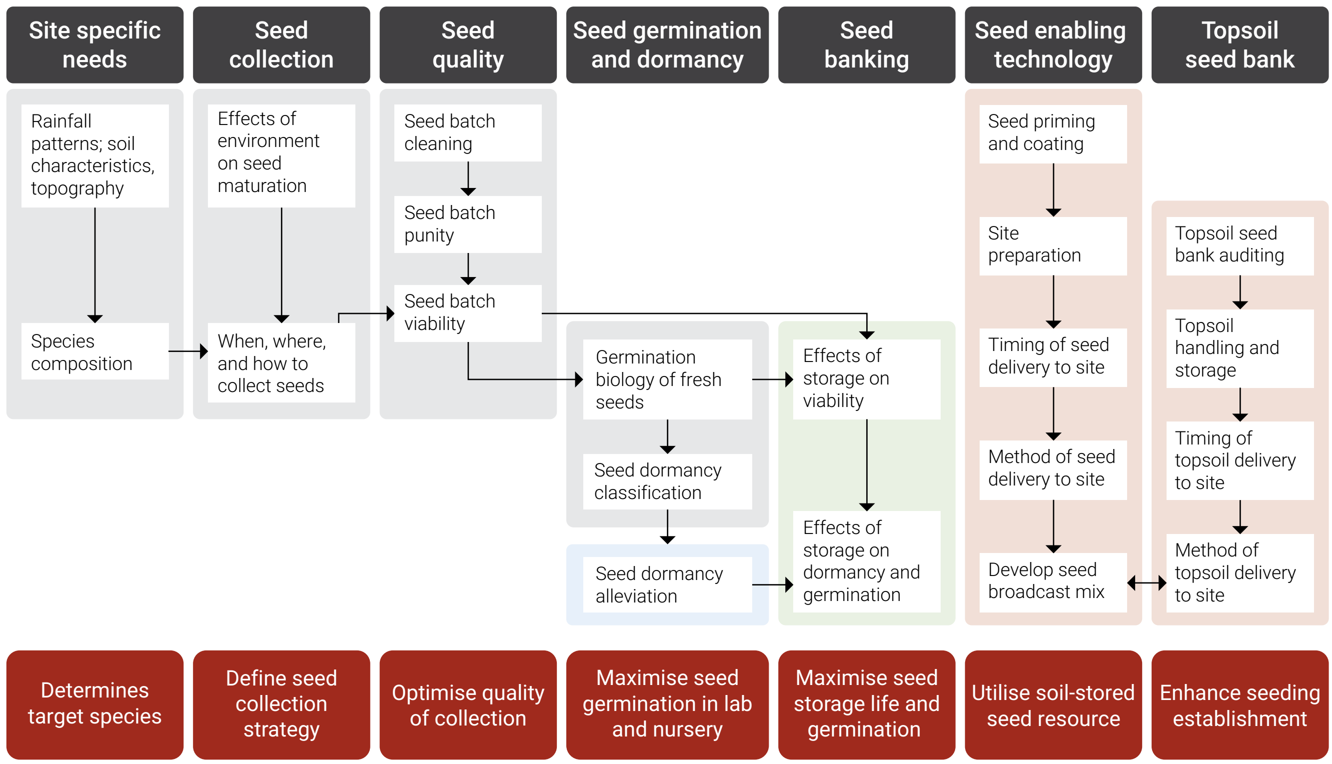

Figure 3. A systematic approach to developing whole-of-mine revegetation techniques.

r) Research and trials

Research and on-site rehabilitation trials are vital 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 WRLs). 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.

s) Monitoring and maintenance

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

Operators 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.

4. Radiation management

The WHS (Mines) Regulations 2022, Part 10.2, Division 3, Subdivision 3.2, apply to exploration, mining and mineral processing operations in the state that use or handle Naturally Occurring Radioactive Materials (NORM). The regulations highlight the need to establish and implement radiation management plans (RMP) in accordance with 641N and radioactive waste management plans (RWMP) in accordance with 641O for sites that encounter NORM and meet the definition of radioactive materials. These plans must be sufficiently detailed to ensure that workers, the community and the environment will not be adversely affected during mine operations or afterwards. As such these plans must contain measurable actions and performance standards to verify compliance.

The Radiological Council, which administers the *Radiation Safety Act 1975* (RS Act) and its subsidiary legislation, is responsible for all aspects of industrial, research and medical radiation safety in WA. This includes prescribing occupational and public radiation dose limits. The RS Act regulates the keeping and use of prescribed radioactive substances, irradiating apparatus and electronic products and requires that the premises upon which these are used or stored are 'registered' and the users are 'licensed'. As such joint approval of some aspects of radiation management may exist.

Under conditions of licence and registration of a mining operation imposed under section 36 of the RS Act, the mining operation is currently required to comply with the *Radiation Protection Series 9, 'Code of Practice* and *Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing* (2005)' (RPS-9), published by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA). In order to ensure consistency between the two regulatory frameworks, the WHS Mines Regulations also require mining operations to comply with specified sections of RPS-9, while acknowledging that the WorkSafe Commissioner may implement specific conditions to the mining industry in WA.

The RWMP is an essential component of the mine closure process. A key component of the RWMP is the establishment of 'baseline' conditions. As such a baseline environmental radiation survey must be conducted and approved prior to any mining operations commencing that may change radiological conditions. It is expected that radiological conditions should be no greater after site rehabilitation than pre mining.

> '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 RMP and RWMP shall include an environmental radiation monitoring program to occur regularly throughout the life of the operation in addition to the 'baseline' monitoring program. The monitoring program is essential to:

- identify potential and critical radionuclide (and chemical) pathways by which the environment and humans may be affected during and after mining (IAEA 2002);
- validate models and predictions;
- guarantee compliance with discharge limits and operational discharge procedures; and
- verify the effectiveness of engineering designs (ARPANSA 2005).

The RWMP shall:

- include appropriate radiation monitoring programs;
- address the transport of radionuclides in groundwater including modelling over a very long period of time (until equilibrium concentrations are established);
- detail a plan for the final management of radiation at a mine, including decommissioning and final rehabilitation;
- predict the impact that the radioactive waste may have based on likely future use of the site;
- cover the inspection and monitoring activities and intervals after the mine has been closed; and
- be submitted to the relevant regulator before final closure.

The MCP must reference the RWMP.

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

This document provides a comprehensive set of guidelines for managing NORM radiation in WA, including guidelines on how to prepare a radiation management plan, guidelines on how to monitor radiation, guidelines on how to estimate and report radiation doses and guidelines on how to manage radioactive dust and waste.

Appendix 5: Principles of stakeholder engagement

Stakeholder engagement is a key component of mine closure planning. Early and continuous engagement with key 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 PMLU options. Failure to undertake a meaningful stakeholder engagement program will compromise mine closure outcomes.

It is important that all key 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.

DMPE 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 in Table 17 and should be tailored to the group being targeted.

Table 17. Stakeholder classifications.

Key stakeholders	Stakeholders
Directly impacted groups – including underlying landholders, government agencies administering reserves and responsible for approvals and regulation, Traditional Owner groups, Native Title holder groups (as relevant) and post-mining landowners/managers, etc.	Groups that require engagement but do not have a direct involvement in the operation – including other government agencies, surrounding landholders, local shire/authorities, community groups, Landcare groups, etc.

1. Stakeholder engagement based on stage of mining

Stakeholder engagement needs to occur throughout all stages of mine closure planning, including project approvals (see Figure 4).

Stages of mining	Stakeholder input	Closure planning	Regulation
Exploration Feasibility Approvals Construction	**Pre-submission** • Concepts of mine and landforms that will exist at closure discussed	ICREASING DETAIL	• MDCP assessment
	MDCP/assessment • Post Mining Landforms and Post Mining Land Use • Potential contaminated sites		
	Regular meetings – proponent ano stakeholders • Post Mining Landforms/use updates • Contaminated sites updates • Future planned operations, changes to original concepts and impacts • Rehabilitation planned works • Results of monitoring and implications for closure • Results of mine closure plan submissions		**During operations** • MCP assessment • MDCP amendments • Compliance audits • Site inspections
Operations	**5 years prior to operations ceasing** • Negotiations start regarding retention of infrastructure and future tenure/maintenance agreements • Finalise Post Mining Land use discussions • Commence discussions regarding closure execution seek local parties and stakeholders desires for involvement in closure execution • Contaminated sites updates • Results of monitoring and implications for closure • Results of mine closure plan submissions		
Operations cease Decommissioning Closure execution	**2 years prior to operations ceasing** • Finalise retention agreements (signed) for submission to regulatory authorities as appropriate • Mine closure plan detailing closure execution submitted to DMPE • Contaminated sites assessments planned and discussed		• MCP with detail **Post closure** • Monitoring of completion criteria achievement
Post-closure Monitoring and Maintenance Completion	**Post closure – regular meetings** • Update on achievement of completion criteria, monitoring and progress towards completion/relinquishment		**Relinquishment** • Approval of completion report

Figure 4. Integrating stages of mining and mine closure planning 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 handbook, 'Community Engagement and Development' (DFAT 2016d) may be referred to.

A guide to the level of stakeholder engagement that should be undertaken, based on the stage of mining is set out in Table 18.

Table 18. DEMIRS expectations for key stakeholder engagement.

<table>
<tr><th>Stage of mining</th><th>DEMIRS expectations</th><th>Level of engagement required</th><th>Level of information required</th></tr>
<tr><td>Investigations/ exploration/pre-mining</td><td>• Identification of stakeholders (key vs other).
• Develop a stakeholder engagement plan.
• PMLU options identified.
• Risk assessment for closure exists.
• PMLU discussed and agreed with key stakeholders.
• Plans for closure discussed.</td><td>• Contact regarding land access, introduction to proposed activities.
• Present the risk assessment, particularly as it pertains to closure of the site and residual risks.
• Develop and present the proposed post-mining land use to key stakeholders/ land managers.</td><td>• 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 documented.</td></tr>
<tr><td>Construction/ operations</td><td>• PMLU forms part of MDCP submission
• Closure outcomes and completion criteria developed to support the PMLU.
• PMLU and Approvals Statement form part of Approvals Statement.</td><td>• Regular scheduled engagement as per the stakeholder engagement plan.
• Present the risk assessment, particularly as it pertains to closure of the site and residual risks.
• Additional post-mining land use options that may arise or repurposing of the land.</td><td rowspan="3">• 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.</td></tr>
<tr><td>Decommissioning and closure execution</td><td>• Works undertaken in accordance with an approved MCP to support achievement of outcomes, criteria and PMLU.</td><td rowspan="2">• Regular updates showing progress with decommissioning and closure tasks.
• Present the risk assessment, particularly as it pertains to closure of the site and residual risks.
• Additional post-mining land use options that may arise or repurposing of the land.
• Regular updates detailing tracking towards meeting outcomes/criteria, with any proposed adjustments discussed.</td></tr>
<tr><td>Post-closure monitoring and maintenance</td><td>• Monitoring and maintenance as per the MCP.</td></tr>
<tr><td>Relinquishment</td><td>• Gain sign-off for post closure transfer of assets, or relinquishment.</td><td>• Signed agreements for handover of assets.</td><td>• Copies of signed agreements, any documentation pertaining to handover of assets.</td></tr>
</table>

Appendix 6: 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. DMPE 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, 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, operators and consultants are encouraged to discuss proposed approaches with DMPE.

DMPE 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.DMPE will also give due consideration to the impact of the proposal upon future access to known or undiscovered resources.[2]

A sterilisation report should be submitted to DMPE 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.

a) 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 5, 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.

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

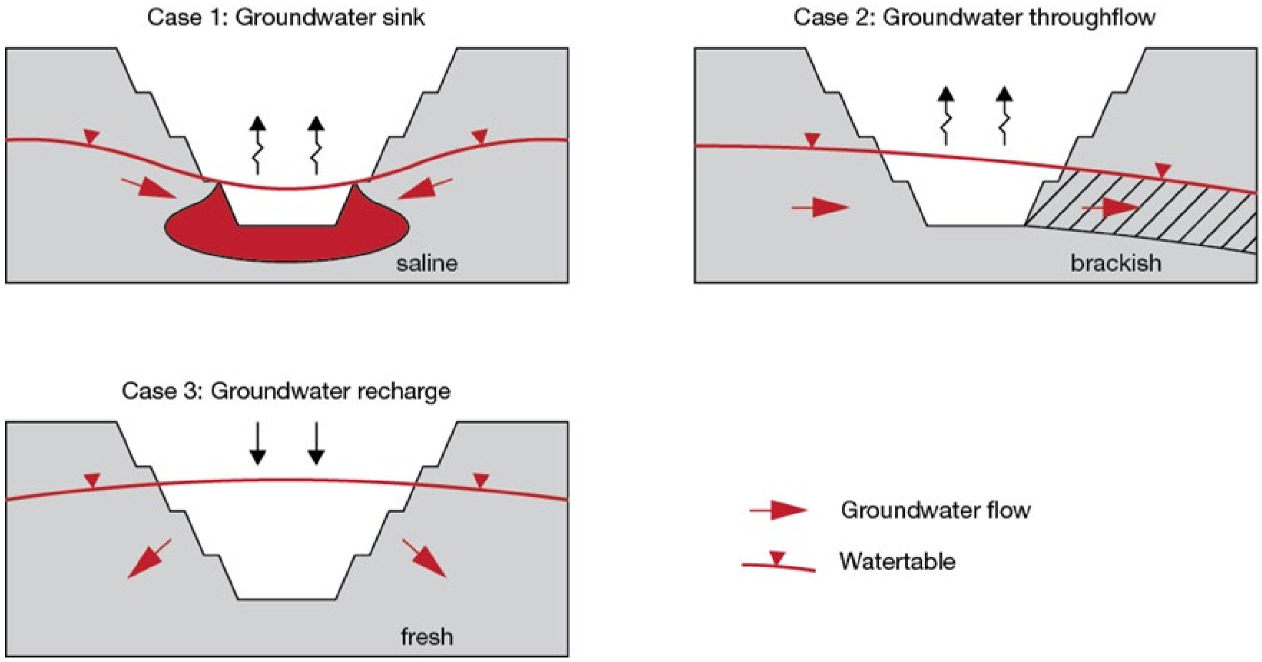


Figure 5. The three most common types of classification for pit lakes (from Johnson and Wright, 2003).

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, its 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 6 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.

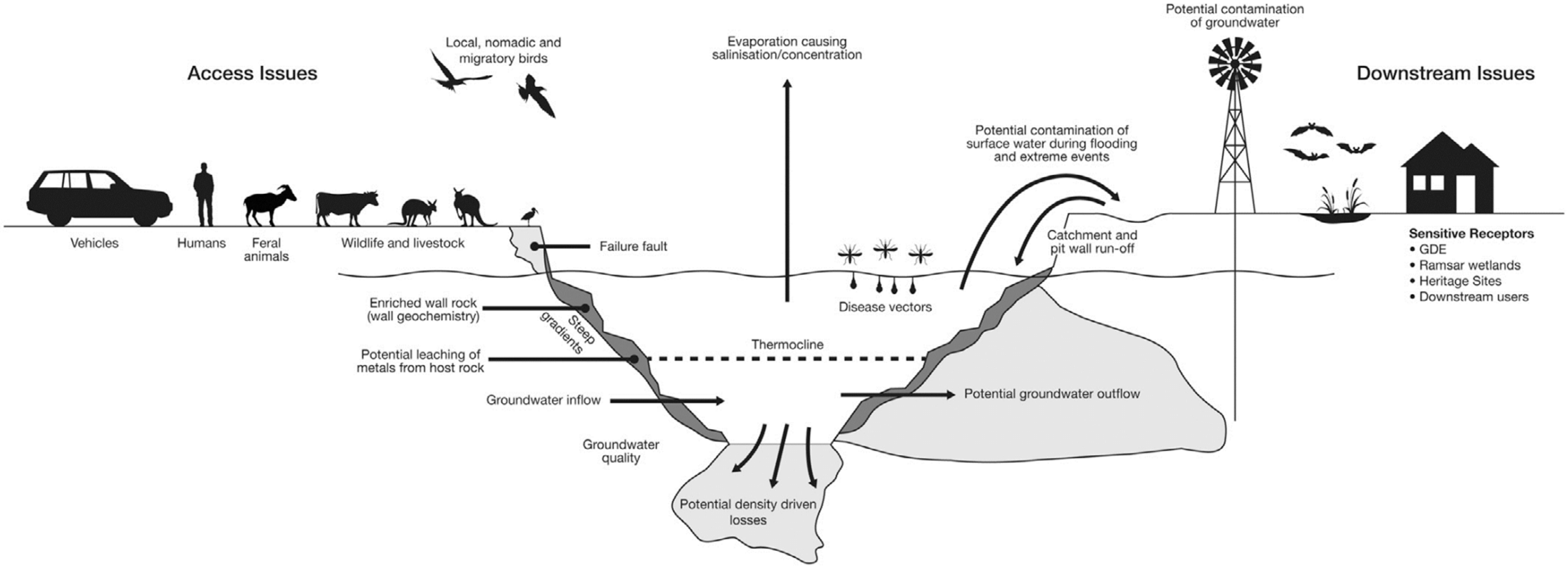


Figure 6. An example of a site pit lake conceptual model including examples of sources, pathways and receptors (adapted from McCullough and Lund, 2006).

b) 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. Operators 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 TSFs, WRLs, 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).

c) Controls of geochemistry and analogues

The use of appropriate 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 dominate metal species.

d) Hydrology and water chemistry

A good understanding of 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). 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. one in 10 -year, one in 100-year, one in 1000-year, Probable Maximum Precipitation (PMP) event.

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 to 1000 years.

e) 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 to 20 m 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.

f) 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 Figure 7).

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.

g) 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 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; and
- 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 (adapted from Oldham, 2014) shown as Figure 7 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.

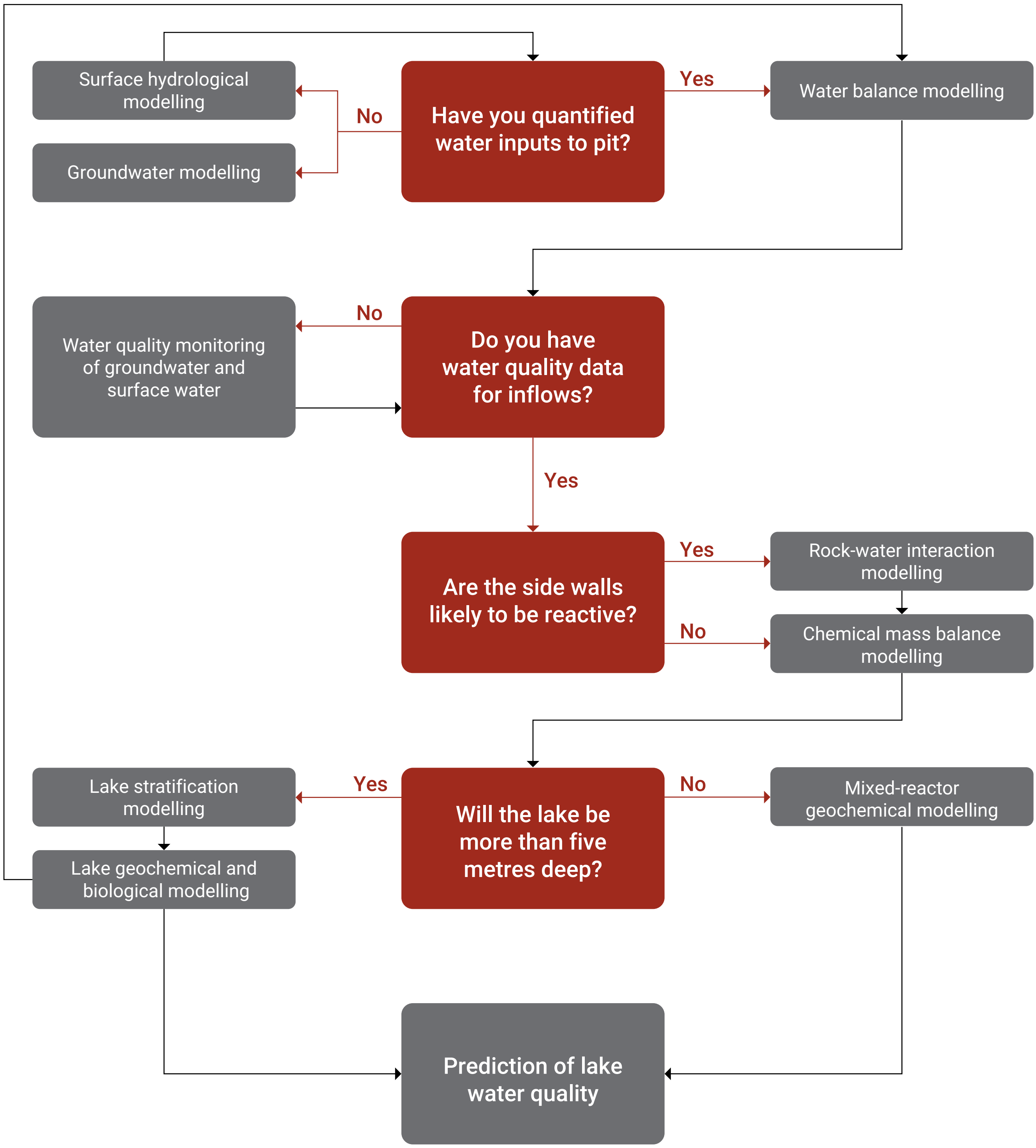


Figure 7. Decision process for modelling a pit lake (adapted from Oldham, 2014).

h) 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 a proposal (Maest et al, 2025; 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 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.

i) 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 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. 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.

DMPE encourages operators to verify (where they cannot validate) the pit lake models with information from other pit lakes with similar geology, climate and hydrology. Operators 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 links 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*.

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 19 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 19. 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

j) 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; and
- 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.

k) 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 20. Examples of different risks.

Example	Comments and corrective actions
• Loss of life or serious injury to humans. • Regional scale impacts to groundwater and environmental values will occur. For example a pit lake located in a priority drinking water source area will become a flow through system and the water quality of the pit lake is 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.
• 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.

l) 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 operators speak with DWER and DMPE if they are likely to have a moderate to critical risk pit lake. DWER and DMPE are committed to working with operators to ensure they are aware of the requirements when undertaking pit lake assessments.

Appendix 7: DMPE standard environmental and closure outcomes

DMPE standard environmental and closure outcomes that should be adopted where the relevant risk pathway exists.

Environmental factor	Objective	Category/aspect	ID #	DMPE standard environmental outcomes
Terrestrial environmental quality	To maintain the quality of land and soils so that environmental values are protected.	Land contamination	T1.0	Mined/processed materials managed to ensure any seepage and drainage is contained/controlled so that environmental values are protected.
			T2.0	All environmentally hazardous chemicals, rubbish and materials are removed from site or stored in a manner that prevents detrimental impacts to the surrounding environment.
		Mined materials	T3.0	Mined/processed materials managed to be safe and geotechnically stable.
		Soil resources	T4.0	Mining activities are managed to prevent erosion and sedimentation leading to detrimental impacts to the surrounding environment.
			T5.0	All suitable topsoil, growth media or rehabilitation resources being harvested, stored and maintained in a manner that allows for its successful use in rehabilitation.
Inland waters	To maintain the hydrological regimes, quality and quantity of groundwater and surface water so that environmental values are protected.	Surface water	W1.0	No contamination of surface water as a result of mining activities.
			W2.0	Surface water managed in a manner that prevents detrimental impacts to hydrological and ecological function and uses of surrounding surface water features and land.
		Groundwater	W3.0	No contamination of groundwater as a result of mining activities.
			W4.0	Groundwater levels are managed to prevent detrimental impact upon the surrounding environment and/or water users.
Flora, vegetation and fauna	To protect flora and vegetation, subterranean fauna, and terrestrial fauna so that biological diversity and ecological integrity are maintained.	Flora and vegetation	F1.0	Mining activities undertaken in a manner that avoids detrimental impacts to native vegetation outside of the activity envelope.
			F2.0	Mining activities undertaken in a manner that minimises detrimental impacts to native vegetation within the activity envelope.
		Fauna	F3.0	Mining activities undertaken in a manner that avoids detrimental impacts to native fauna outside the activity envelope.
			F4.0	Prevention of avoidable death or injury to native fauna from mining related activities within the activity envelope.
		Environmental threats (weeds and pathogens)	F5.0	No increase in the diversity, distribution, and population of weed species and pathogens within the tenement(s) or surrounding land, as a result of mining activities.
		Environmental threats (introduced animals)	F6.0	No increase in the diversity or population of introduced animal species within the tenement(s) or surrounding land, as a result of mining activities.
Environmental factor	**Objective**	**Category/aspect**	**ID #**	**DMPE standard closure outcomes**
Rehabilitation and mine closure	Mining activities are rehabilitated and closed in a manner to make them physically safe to humans and animals, geotechnically stable, geochemically non-polluting/non-contaminating, and capable of sustaining an agreed post-mining land use, with consideration for cultural values and without unacceptable liability to the State.	Physical and geotechnical stability	C1.0	Constructed landforms are physically and geotechnically stable, have minimal erosion and support native revegetation and/or the PMLU(s).
			C2.0	The placement of mined materials/infrastructure in relation to excavations will be such that the final footprint after rehabilitation is not located within the PZoI.
		Landscape	C3.0	Constructed landforms are designed with consideration of visual amenity, cultural values and local topography.
		Geochemical stability	C4.0	Constructed landforms are geochemically non-polluting.
		Land contamination	C5.0	All environmentally hazardous chemicals, rubbish and contaminating materials have been removed, treated, managed and disposed in a manner consistent with the PMLU.
		Surface water	C6.0	Surface drainage patterns, flows and characteristics are reinstated in a manner consistent with the regional drainage function and/or PMLU.
		Groundwater	C7.0	Pit lakes will not have a detrimental impact on the surrounding environment or other water resources and/or are consistent with the PMLU.
			C8.0	Groundwater levels and characteristics reflect original levels and characteristics and/or support the target ecosystem and PMLU.
		Flora and vegetation	C9.0	Rehabilitated land is consistent with agreed reference vegetation communities and/or with the PMLU.
		Fauna	C10.0	Rehabilitated areas provide habitat for native fauna, indicative of the target ecosystem and PMLU.
		Ecosystem function	C11.0	The rehabilitated ecosystem has function and resilience indicative of the target ecosystem and PMLU.
		Physical safety	C12.0	The rehabilitated landscape is made safe to humans and animals.
			C13.0	All underground work is managed and closed to ensure long-term ground stability and prevent ground subsidence.
		Infrastructure	C14.0	No infrastructure left on site unless agreed by post-mining land manager(s) and/or owner(s).

Appendix 8: Guidance on development of a Mine Closure Plan to execution phase

As an operation approaches the decommissioning and closure phase, the MCP 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 DMPE 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 an MCP 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 21.

Table 21. Example of a detailed legal obligations register (note: not all register parts are shown).

Legal obligations register				
Relevant DEMIRS tenement conditions				
Tenement	**Condition number**	**Closure condition**	**How obligation included in closure strategy/MCP**	**Complete**
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, Department of Energy, Mines, Industry Regulation and Safety.	Included in completion criteria.	Ongoing

Legal obligations register				
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 Energy, 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 (Number 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

Legal obligations register				
DEMIRS approvals – NOI/mining proposal/MDCP XXX – XX/XX/XXXX (Number 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 MCP should include an updated stakeholder engagement register clearly showing the consultation with stakeholders over time and identifies the topics of discussion and outcomes achieved. DMPE may request records (e.g. minutes of meetings), demonstrating in depth conversations on 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. Agreements on the retention of infrastructure should be provided in the MCP 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 can be of use on a pastoral lease post closure can be retained by the pastoralist through an application directly to DPLH for the Pastoral Lands Board (PLB) consideration to transfer liability from the mining company. Each application would be dealt with independently. Should the PLB not accept the transfer, the infrastructure will need to be removed.

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

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

As part of the closure risk assessment, the MCP should clearly identify areas of the site that may be contaminated as per the classifications shown in the Contaminated Sites Act, 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 Contaminated Sites 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 should be included to indicate that contamination has been managed adequately.

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) including responsible person, tasks and due dates.

5. Finalisation of completion criteria

DMPE 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 two to five years prior to closure). For further guidance on developing completion criteria refer to the 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 for the implementation of the closure works/tasks

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

An example work schedule would include information the following:

- domain/sub-domain;
- key activity;
- activity description;
- completion criteria/target;
- work schedule; and
- monitoring programme.

Domain	Key activities	Activity description	Target/guideline for acceptance	Preliminary clocure schedule (12 months)						Monitoring and maintenance (10 years)									
				% Comp	Prior to closure	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Magazine area	Topsoil	Topsoil material from magazine area to be stockpiled adjacent works.	Adequate volumes of topsoil or alternative growth medium for	0%															
	Identify	All buildings, safety devices and traffic signage to be decommissioned. Identify items to be removed last.	Stakeholder consultation and Operations Director approval.	90%															
	Program	Program the de commissioning.	Rehabilitated as programmed.	90%															
	Assocatied equipment	All stock to be removed by a licenced carrier. All fire safety and first aid devices; extinguishers, snake bite kits, first aid kits and safety signage for removal from site.	All associated equipment removed from site.	0%															
	Isolate	Electrician to disconnect all services.	Zero HSE Incidents.	0%															
	Buidlings and fences	Removal of transportable buildings/ converted sea containers.	Buildings and fencing materials for reuse/recycle.	0%															
	Contamination	Formal Environmental Inspection to thoroughly check area over for any contamination.	Magazine footprint condition acceptable to DWER.	0%															
	Footings/ concrete	Removal of all footings and concrete structures for appropriate disposal off site.	No footings or concrete structures to re main on site .	0%															
	Waste	Removal of all waste to appropriate facility.	Zero waste on site. Removed to approved/ licenced facilities.	0%															
	Signage	Removal of magazine signage; directional, parking, muster point, stop/give way and speed limit signage.	Removal from site for reuse/ recycling.	0%															
	Earthworks	Earth bunds to be flattenend and landform to be reconstructed.	Magazine footprint to blend in with the surrounding landforms	0%															
	Spread	Spreading of previously stockpiled topsoil to a depth of approximately 50 mm.	and to re-establish natural or original drainage patterns.	0%															
	Rip	Deep ripping to 500 mm in dry conditions to loosen compacted material and enable water and seed infiltration.	Re-establish vegetation consistent with (or trending towards) the baseline flora data.	0%															
	Monitor	Monitoring of rehabilitated footprint against agreed outcomes and implementation of corrective measure where outcomes are not met.		0%															

Figure 8. Example of detailed work schedule for domain/feature part of larger mine site.

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 schedule 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 and include the due date. Examples of an abandonment bund audit as a table are presented in Table 22, where a 'pass' relates to having met the current DMPE guidance for an abandonment bund or 'fail' illustrates that additional work is required. Figure 9 illustrates a schematic method of displaying the audit findings. These formats provide a quick assessment of the efficacy of the abandonment bunds at the site.

Table 22: **Example summary table showing performance of the abandonment bund in relation to the various factors giving a pass/fail assignment to each factor.**

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

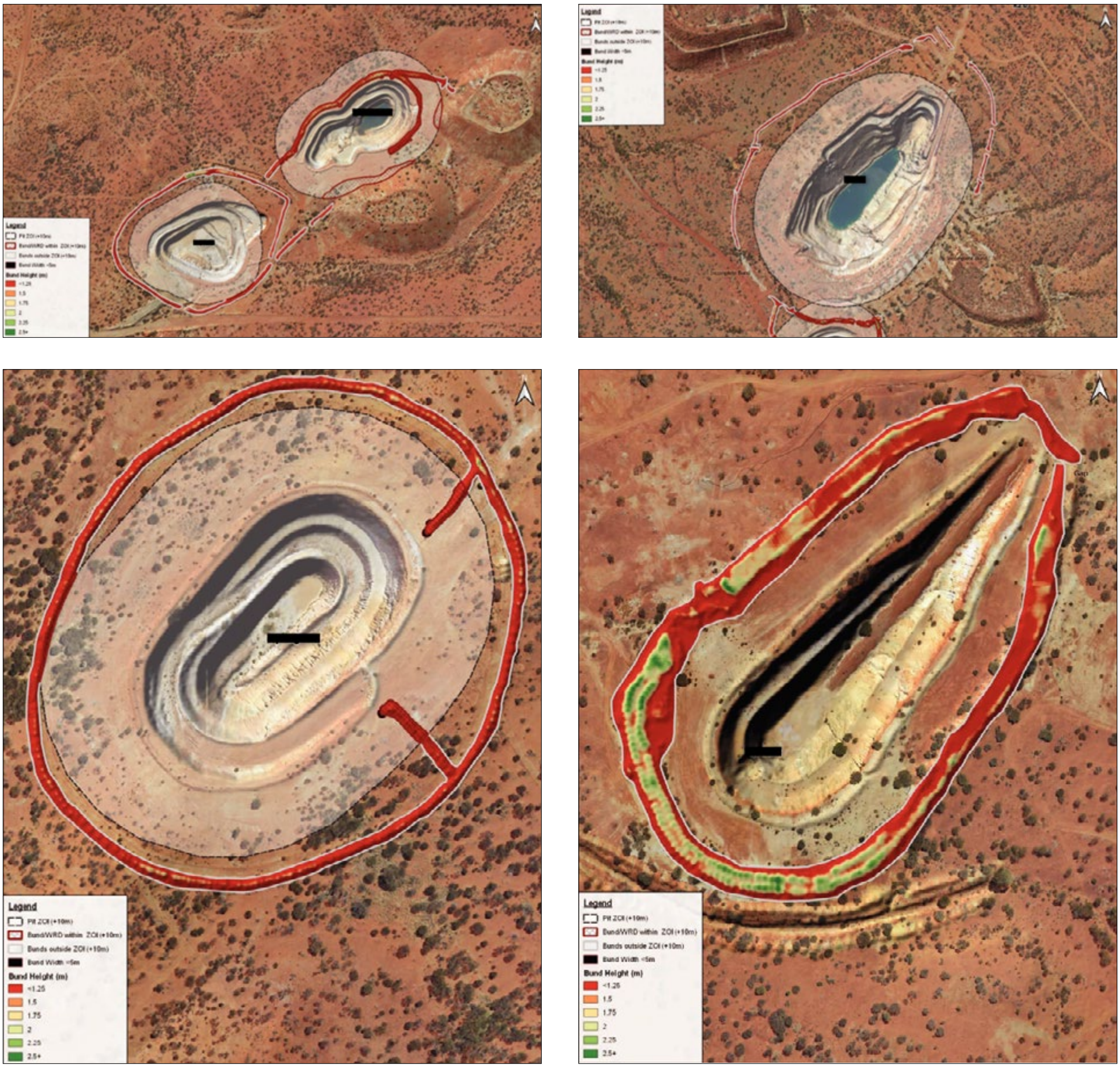


Figure 9. Example of pictorial audit of open pit abandonment bunding. Picture notes whether factors such as gaps, height, width and construction meet relevant requirements.

8. Construction of final landforms and drainage structures

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

The requirements for this aspect consists of two parts:

1. Provide closure designs and detailed drawings with sufficient detail that someone could implement the design.
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)?'

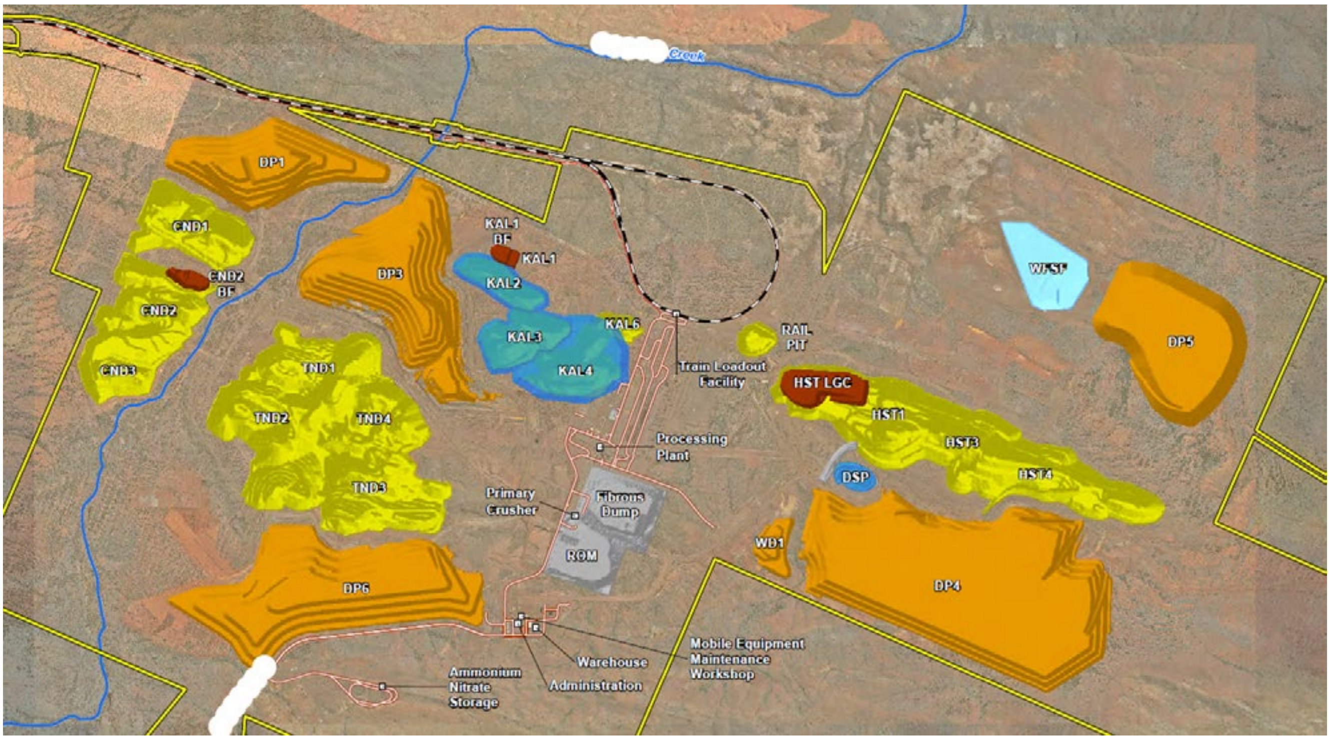
If the answer is no, then this is not enough detail for the MCP submission.

The MCP should include detailed closure designs for landforms, pit voids and engineered or diverted site drainage (levees, embankments, diversions) typically two to five 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 DMPE 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 Figure 10 and Figure 11.

Pre-rehabilitation



Post-rehabilitation

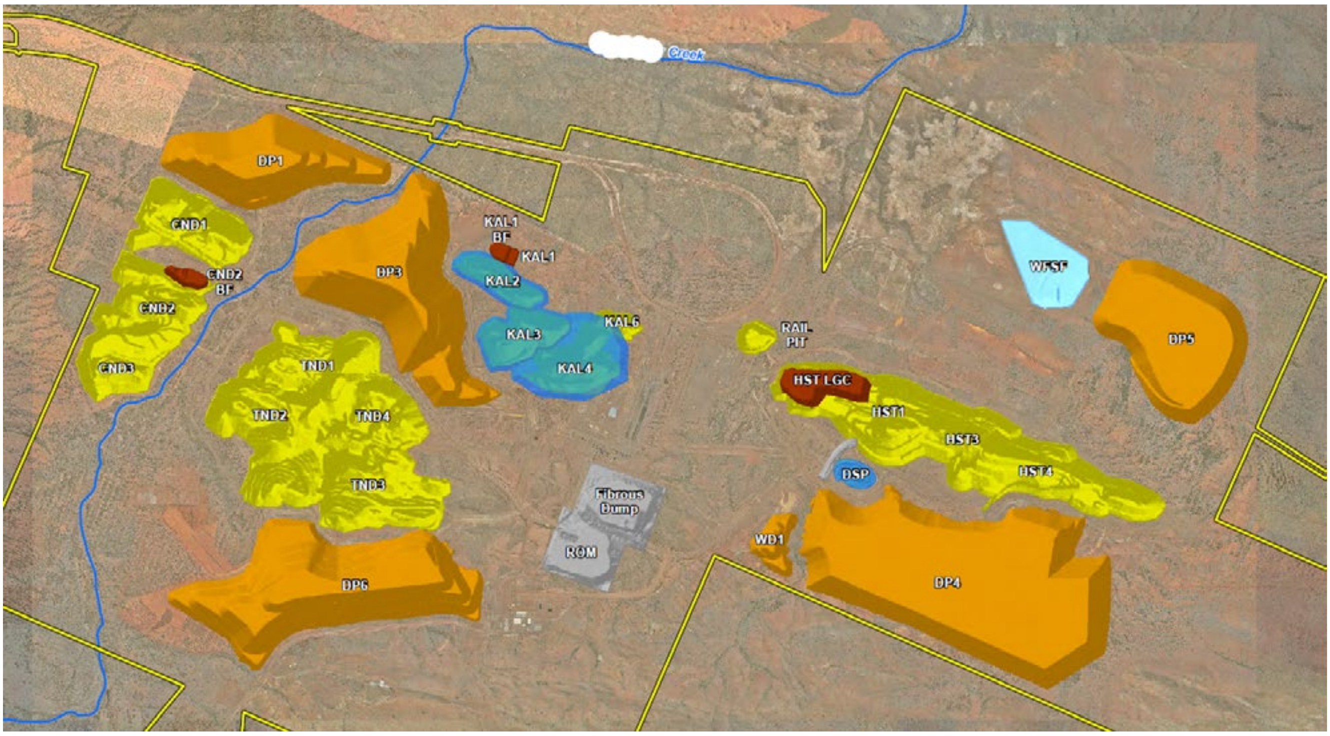
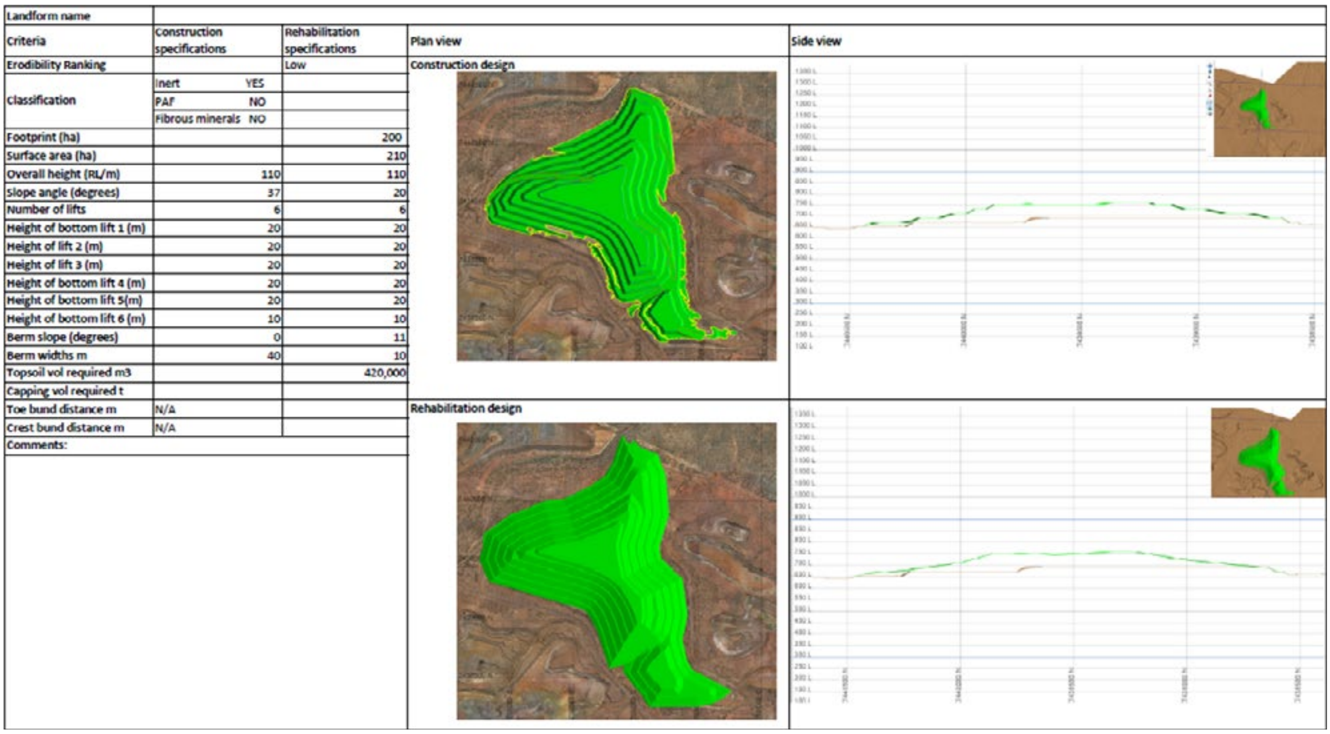


Figure 10. Example figure illustrating design of landforms in relation to the surrounding landscape pre and post closure.



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:		

Figure 11. Example of rehabilitation and design diagrams for mining landforms to remain post closure.

The MCP should also contain a site wide map(s) that consider and illustrate 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) should be shown with previously conducted supporting technical studies included; and
  - the potential for failure of any built structure to impact any of these local features should 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, WRL 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), 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.

Disposal options need to be undertaken in consideration of the PMLU, remoteness of the operation and any cultural considerations.

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 as Table 23.

Following completion of all closure works, the post-closure monitoring program as outlined in the MCP 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 DMPE 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 *DMPE Mine Closure Completion Guideline*. Mine closure completion reports may also be submitted progressively to close out parts of a mine if appropriate.

DMPE 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 23. Example of detailed monitoring program.

Monitoring program					
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 and rehabilitation tasks during operations					
Reference site 1	Rehabilitated land is consistent with agreed reference vegetation communities and/or with the PMLU.	Target on Plant density – (detail). Trigger: < 50%	Annually – April	Environment Manager	EFA Program – utilising quadrats 10 m x 10 m (detail).
Reference site 1	Rehabilitated land is consistent with agreed reference vegetation communities and/or with the PMLU.	Target on Plant Diversity – (detail). Trigger: < 20	Annually – April	Environment Manager	EFA Program – utilising quadrats 10 m x 10 m (detail).
Closure and rehabilitation tasks during operations					
South waste rock landform	Constructed landforms are physically and geotechnically stable, have minimal erosion and support native revegetation and/or the post-mining land uses.	Monitoring of Ripping Depth Trial. Trigger: Rip lines non-existent.	Annually – April	Environment Manager	EFA Program – utilising quadrats 10 m x 10 m (detail).
South Pit	Pit lakes will not have a detrimental impact on the surrounding environment or other water resources and/or are consistent with the PMLU.	Target on water quality Trigger: metals > x ppm	Quarterly	Mining Manager	Water sampling and analysis for (detail).
South Pit	Groundwater levels and characteristics reflect original levels and characteristics and/ or support the target ecosystem and PMLU.	Target on water table recovery. Trigger: Water level < m RL	Monthly	Mining Manager	Survey of water level.

Monitoring program					
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 and rehabilitation tasks during decommissioning					
Reference site 1	Rehabilitated land is consistent with agreed reference vegetation communities and/or with the PMLU.	Target on Plant density – detail. Trigger: < 50%	Annually – April	Environment Manager	EFA Program – utilising quadrats 10 m x 10 m (detail)
Reference site 1	Rehabilitated land is consistent with agreed reference vegetation communities and/or with the PMLU.	Target on Plant Diversity – detail Trigger: < 20	Annually – April	Environment Manager	EFA Program – utilising quadrats 10 m x 10 m (detail).
Closure and rehabilitation tasks during decommissioning					
Reference site 1	Rehabilitated land is consistent with agreed reference vegetation communities and/or with the PMLU.	Target on Plant density – detail. Trigger: < 50%	Annually (April) until 2031, 3 yearly until 2042.	Environment Manager	OFA Program – utilising quadrats 10 m x 10 m (detail).
South Pit	Groundwater levels and characteristics reflect original levels and characteristics and/ or support the target ecosystem and PMLU.	Target on water table recovery. Trigger: Water level < m RL	Annually until 2042	Mining Manager	Survey of water level.

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) 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.

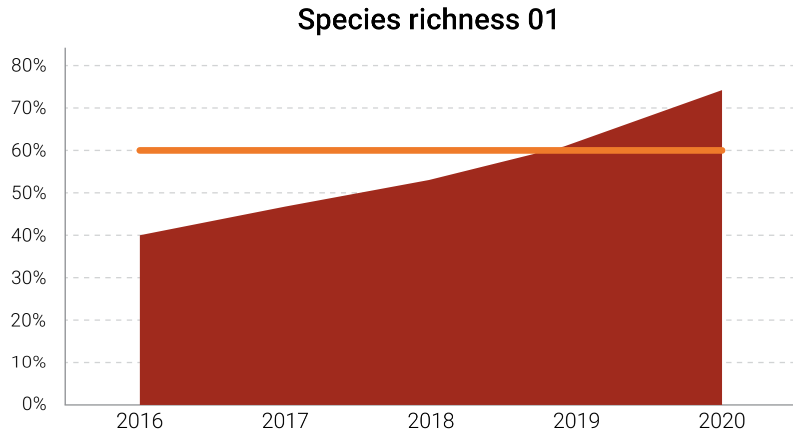
An example summary demonstrating performance against the closure outcomes and completion criteria is presented on Table 24.

Table 24. Example of a monitoring results summary that demonstrate performance against closure outcomes and completion criteria.

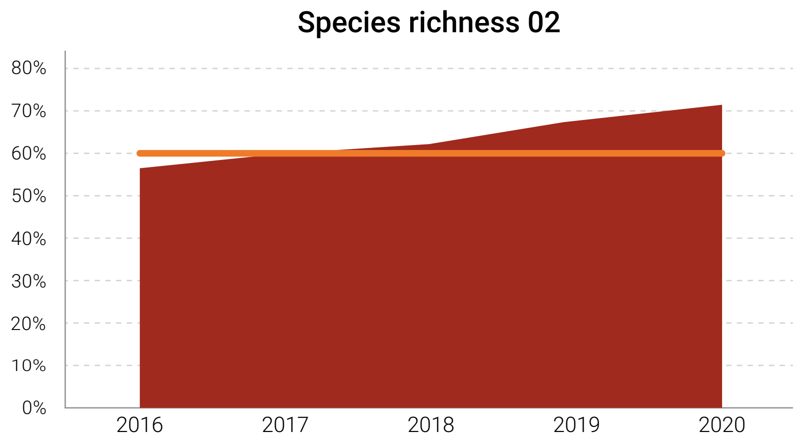
Site feature	Monitoring point and year	Monitoring method and results	Closure outcome	Completion criteria	Below, at target or achieved
WRL	XXX01	Species richness	Rehab resembles natural vegetation.	Species richness at least 60% of analogue site average.	
	2016	40%			Below
	2017	47%			Below
	2018	53%			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				
WRL	AVERAGE				Achieved

The results can also be shown graphically as demonstrated in Figure 12. 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.



	2016	2017	2018	2019	2020
Results	40%	47%	53%	61%	74%
CC	60%	60%	60%	60%	60%



	2016	2017	2018	2019	2020
Results	57%	60%	62%	67%	71%
CC	60%	60%	60%	60%	60%

Figure 12. Example of monitoring for completion criteria shown graphically.

Government of Western Australia

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8.30am – 4.30pm

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