Mined land rehabilitation – is there a gap between regulatory guidance and successful relinquishment?

by Vanessa Glenn, Research Officer; David Doley, Honorary Research Fellow; Corinne Unger MAusIMM, Senior Research Officer; Nic McCaffrey and Phill McKenna, Research Officers; Melina Gillespie, Senior Research Officer; Elizabeth Williams, Postdoctoral Research Fellow, Centre for Mined Land Rehabilitation, The University of Queensland

The rehabilitation of land disturbed by mining is a statutory requirement in Australia. Effective rehabilitation is essential for maintaining a 'social licence to operate'. It reduces risk for mining companies by minimising residual risk payments, reducing administrative uncertainties at closure and creating an agreed transition to post-mining landscapes.

Yet our experience and research indicates that in many cases there is inadequate guidance for companies on how to develop clear rehabilitation goals, plans and monitoring systems. Without clarity on rehabilitation requirements, it is difficult for companies to be confident that their rehabilitation will be deemed 'successful' by regulators.

Further, without effective integration into mine operation planning and costing, successful implementation of rehabilitation plans will be difficult, with end-of-mine rehabilitation challenges arising at a time when there is limited scope to alter post-mining landforms or rehabilitation objectives. This poses challenges for attaining stakeholder approval and regulatory release.

Rehabilitation guidelines are tools for driving rehabilitation plans that meet the expectations of government regulators. In this article, we describe the importance of rehabilitation guidelines and planning in Australia as part of mine closure planning, with a closer look at the recently-released Queensland rehabilitation guideline (EM1122; DEHP, 2014).

Although it forms a foundation for rehabilitation planning, we suggest that EM1122 does not provide enough clarity for industry or the regulator. We recommend that additional guidance be produced to support the mining industry to achieve acceptable and realistic rehabilitation outcomes. We discuss potential improvements to guidance by outlining key requirements for rehabilitation monitoring design and the importance of considering fauna in monitoring and completion criteria.

Rehabilitation guidelines – mine planning and regulatory context

Successful mine rehabilitation depends upon the construction of stable landforms and the revegetation or redevelopment of their surfaces to provide habitat for native fauna, opportunities for productive land uses or other agreed and sustainable purposes.

As mining is a relatively short-term use of land, rehabilitation planning should be incorporated in mine development and operational planning (ANZMEC/MCA, 2000) so that eventually the operator can surrender their environmental licence, relinquish their mining lease and transfer the land use and/or ownership to a third party.

In Australia, rehabilitation goals are typically agreed upon by the mining company and government regulator and form part of an environmental licence, permit or consent with enforceable compliance conditions. Usually, the proponent proposes rehabilitation objectives that are based on guidance material provided by the regulator in the form of rehabilitation or closure guidelines (Figure 1).

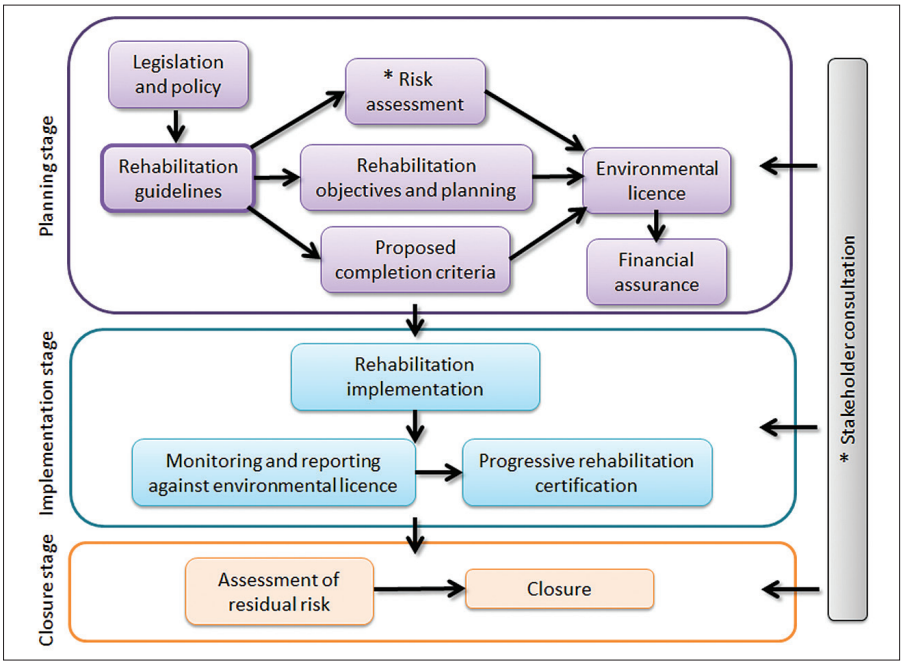

*Figure 1. Summary of the role of Queensland rehabilitation guidelines in rehabilitation planning and mine closure. * In EM1122 assessing rehabilitation failure risk is recommended but no longer required during the planning stage. Stakeholder consultation is not necessarily required during post-planning stages.*

Queensland's rehabilitation guideline EM1122

In January 2014, the Queensland Department of Environment and Heritage Protection (DEHP) released its rehabilitation guideline, 'Rehabilitation requirements for mining resource activities', also referred to as EM1122. An earlier version known as Guideline 18 was developed in May 2006 and subsequently amended in March 2011. EM1122 is based on Guideline 18, with amendments relating to the introduction of the Environment Protection (Greentape Reduction) and other *Legislation Amendment Act 2012*.

The substantive modifications from the earlier guideline are that:

1. The requirement for an Environmental Management Plan has been removed
2. Level 1 mines are now termed 'ineligible Environmentally Relevant Activities'
3. A third-party audit statement is no longer required for progressive rehabilitation certification or final surrender of an Environmental Authority (EA).

Otherwise, there is little difference between the new and old guidelines.

EM1122 provides guidance for proponents in defining rehabilitation objectives, indicators and completion criteria that are then included in the operator's EA for mining activities. It discusses factors that might need to be considered for mining companies to develop rehabilitation strategies. Assessment is based on land management units (domains), each with specific objectives and indicators that can be monitored to demonstrate whether the completion criteria have been satisfied.

EM1122 also explains in general terms the process by which the regulator (DEHP) will assess success of progressive rehabilitation or eligibility for EA surrender. In deciding whether to accept a mine's proposed rehabilitation objectives, indicators and completion criteria, DEHP considers them in the context of a hierarchy of desirability for rehabilitated mined land (Table 1). Strategies lower in the hierarchy carry a higher risk of causing environmental harm.

Why the impossible is not obligatory

In the mine planning stage, proponents may be tempted to adopt one of the highest level rehabilitation hierarchy goals (2 or 3) in order to accelerate the approval process. However, it is now widely accepted that restoration of pre-disturbance native ecosystems requires that anthropogenic disturbance is minimal (Hobbs *et al*, 2013) and that much of the disturbance associated with mining activity results in the appearance of novel ecosystems (Doley and Audet, 2013). Likewise, reconstructed agricultural systems are recognised to be fundamentally different from those that existed pre-mining (eg Baumgartl and Glenn, 2013).

These novel systems must be selected or allowed to develop in ways consistent with the novel lithology, landform and soil conditions that are generated in post-mine landscapes (Howard *et al,* 2011). Therefore, it should be more effective to set a rehabilitation goal at a level that can be attained and maintained with some degree of certainty, than to fail to meet a higher level goal with the consequent elevated residual risk and/or costs of remediation.

Thus, for most mining operations, it is more realistic to accept that the environment will be changed permanently and that rehabilitation goals that are lower in the hierarchy may be unavoidable and should be adopted deliberately with a commitment to ensure their long-term stability. It is highly unlikely, however, that leaving a mine site in an unusable or environmentally-damaging condition (hierarchy level 6) would be a defendable position to put to the regulator or stakeholders.

The likelihood that different mine types may achieve the requirements set in EM1122 varies with the type and extent of disturbance to the physical, chemical and hydrological characteristics of the site, as these conditions influence the stability of the constructed landforms and the nature of plant and animal communities that can be established on them (Doley and Audet, 2013; Howard *et al*, 2011).

Table 2 summarises likely rehabilitation outcomes for broad categories of mine type and extent of disturbance. Its purpose is to suggest that the rehabilitation options for any domain do not range over the whole spectrum of outcomes set out in EM1122 and that it may be extremely difficult and costly for a mine manager to attempt to reach an unattainable goal. Nonetheless, the general rehabilitation goals of safe, stable, non-polluting conditions should form the basis for rehabilitation planning.

What makes an effective rehabilitation guideline?

Rehabilitation guidelines such as EM1122 provide background

Level	Rehabilitation strategy
1	Avoid disturbance
2	Reinstate natural ecosystem
3	Develop a higher value land use
4	Reinstate previous land use
5	Develop a lower value land use
6	Leave the site in an unusable or environmentally-damaging condition

Table 1. Summary of rehabilitation hierarchy in EM1122. Different strategies may be applied to different domains of a lease area.

information to operators about assessment processes and regulator expectations for rehabilitation, which in turn feeds into the legal mechanism of an environmental licence (Figure 1).

Thus, it is implicitly assumed that an operator following guidance in EM1122 will be well-placed to negotiate rehabilitation requirements with the regulator and will have in place a framework for setting acceptable rehabilitation objectives, describing how land will be rehabilitated, monitoring to assess rehabilitation success and assessing the risk of rehabilitation failure. This should enable an operator to meet their regulatory requirements for rehabilitation.

However, although factors other than rehabilitation are to be considered at mine closure, the scarcity of relinquished mine leases suggests that this assumption is false; there is a gap between setting outcome-focussed rehabilitation goals and successfully achieving acceptable rehabilitation outcomes.

In this context, there is uncertainty on many fronts – for instance, in ascertaining which indicators best measure rehabilitation progress or what evidence might be accepted in determining whether final rehabilitation objectives have been met. This uncertainty is exacerbated by temporal lags (ie often, rehabilitated sites take years to decades to reach completion criteria) and lack of knowledge about whether further remediation is likely to improve or accelerate rehabilitation in these novel environments.

To address these uncertainties, guidelines need to:

1. be comprehensive, clear, unambiguous and easy to apply at a practical level – for both industry and the regulator
2. engage all stakeholders, providing platforms for consultation and agreement on well-defined, appropriate land use goals
3. be based on evidence, with sufficient supplementary documentation provided, such as links to other guidelines, resources and research findings (eg Dig Database; CMLR, 2014).

Rehabilitation is part of the bigger picture of mine closure planning

Rehabilitation is a subset of the closure planning process, along with facets such as decommissioning, contaminated land remediation, void management and water table adjustment. When a mine is designed with closure in mind, each mine feature can be created and rehabilitated in a manner consistent with the closure vision.

The Western Australian closure plan guidelines (DMP & EPA, 2011) provide a useful checklist that – if considered along with other leading practice guidance for mine closure planning – can complement a mine operator's understanding of how to apply EM1122 and the rehabilitation guidelines of other jurisdictions (refer to ANZMEC/

EM1122 goal	Disturbance type and extent			Suggested new use	Mine type
	Physical	Chemical	Hydrological		
1. Avoid disturbance	None	None	None		
2. Reinstate natural ecosystem	Remove shallow mineral layer	None or slight	Elevate water table	Conservation, water supply	Bauxite
	Remove and replace almost all material	None or slight	Little change or water-filled voids	Conservation, water supply	Mineral sands
3. Develop higher value land use	Remove all material	None or slight	Water-filled voids	Recreation, conservation	Quarrying, mineral sands
	Relocate and rearrange material	Slight to moderate	Reduce or increase PAW*	Conservation – fauna refuge	Bauxite, mineral sands, coal
4. Reinstate previous land use (non-native)	Relocate and rearrange material	Slight to moderate	Reduce or increase PAW*	Grazing, forestry, tree crops	Bauxite, mineral sands, coal seam gas
5. Develop lower value land use (native or non-native)	Relocate and rearrange material	Moderate	Reduce PAW*	Grazing, forestry, tree crops, land stability	Coal, coal seam gas, metals
	Relocate and rearrange material	Severe	Reduce PAW*	Land stability	Coal, metals

*Table 2. EM1122 rehabilitation hierarchy levels 1-5 with our suggested land use responses. The goal that is most likely to be achieved at a mine site depends on the disturbance type and extent, which is typically specific to mine type. * Plant available water.*

MCA, 2000; ICMM, 2008; RET, 2006).

This checklist asks proponents to consider a series of questions (Table 3). Unanimous 'yes' responses means that there is a high likelihood that the closure plan will be acceptable whereas 'no' to any questions indicates that the proponent's closure plan is likely to be unacceptable to the regulator. These questions are relevant to all mine sites and deserve careful and comprehensive consideration.

Improving the utility of rehabilitation guidelines – a monitoring design example

What guidance is there for preparing a monitoring program?

In EM1122, monitoring is mentioned in the context of rehabilitation process, indicators for rehabilitation objectives and completion criteria. However, there is little guidance as to what might be acceptable elements in a monitoring program. There could be more specific guidance for designing and implementing a monitoring program and how the data from monitoring might be used to assess rehabilitation success. The equivalent rehabilitation documents from NSW (DTIRIS, 2013) and WA (DMP & EPA, 2011) provide slightly more detail but the guidance is still general.

What are the elements of a good monitoring program?

The role of monitoring in rehabilitation should not be underestimated or assumed to be just another step in compliance; it should be a vital part of the rehabilitation efforts that consistently informs and alters management with trigger points throughout the rehabilitation phase of a mine. Effective rehabilitation outcomes depend on the technical quality and quantity of the environmental data collected at a given site.

There is no shortage of research, literature, successful examples and protocols from Australia and overseas on how to monitor and detect change in a range of variables. Lindenmayer & Gibbons (2012) provide examples for biodiversity monitoring. However, there are few examples in the context of mining, with the exception of the Australian Leading Practice Sustainable Development Program for the Mining Industry publications, such as 'Evaluating performance: monitoring and auditing' (RET, 2009).

1	Is the closure plan site-specific?
2	Is stakeholder consultation documented, including how concerns have been addressed?
3	Have site wastes been characterised to understand potential closure issues?
4	Have closure outcomes been defined? Eg final land uses, objectives, completion criteria, performance indicators and milestones.
5	Have the closure issues been identified with workable management measures proposed or in place?
6	Has experience from other mine sites been applied at this site (where applicable)?
7	Are there appropriate plans for further research and field trials to increase confidence in closure outcomes?
8	Are there appropriate plans for progressive rehabilitation?
9	Are there appropriate plans for closure monitoring and maintenance?
10	Are there appropriate plans for unexpected or temporary closure?

Table 3. A ten-point checklist for mine closure plans in Western Australia (paraphrased; DMP & EPA, 2011).

Therefore, the main challenge appears to be translating and implementing the key principles of monitoring at an industry and policy level. To crystallise these key principles, the following summarises our research investigations and experience of requirements for guiding the design of suitably robust monitoring programs:

- identify rehabilitation and monitoring objectives
- use a conceptual model to guide predictions of change
- choose sampling units and methods appropriate to the system (eg soil types or ecology of target species)
- avoid bias in the selection of monitoring locations
- ensure adequate spatial and temporal replication
- carry out preliminary sampling (pilot testing) to evaluate sampling design
- establish sufficient replication to enable statistical analysis of results at an acceptable power with pre-determined effects
- ensure the methods are repeatable and comparable over time
- minimise physical impact at the site
- establish well-developed partnerships with ongoing funding.

How can guidance be improved?

The development of successful mine rehabilitation monitoring programs may be limited by access to appropriate examples. There is a body of coal mine rehabilitation literature available via ACARP and the Dig Database. Other scientific literature is often available only through university libraries or by the payment of high charges for books and scientific articles. Alternatively, the relevant documents may be in the unpublished 'grey' literature and difficult to obtain (eg company reports).

Therefore, in the context of limited specific guidance on the development of mine rehabilitation monitoring programs, it is recommended that additional supporting documentation be prepared. This would provide guidance to industry and government regulators. Ideally, it should include checklists, proformas, step-by-step

methods and case studies of good examples of mine rehabilitation monitoring. An example of what this document might include for monitoring design with an overview of methods is the Monitoring Manual for Grassland, Shrubland and Savanna Ecosystems (Herrick *et al*, 2005) which is freely accessible via the internet.

Fauna monitoring – often forgotten but functionally important

Rehabilitation and closure guidelines frequently refer to the restoration of ecological processes and function and rehabilitation of habitat for native fauna. It is common for rehabilitation monitoring to assess the fundamental precursors (eg leaf litter) and/or resulting environmental products (eg soil organic carbon) of ecosystem function and processes. However, direct measures – for instance, of decomposition or nutrient bioavailability – are rarely quantified. Faunal and microbial bioindicators are valuable in this respect as they are directly involved in (and hence can provide data on) various ecological processes. This leads to confidence that rehabilitated ecosystems are functioning in a self-sustaining way.

However, uptake on monitoring faunal indicators in mining monitoring programs has been limited, potentially due to the challenges outlined above. Some of these monitoring procedures require very carefully designed and executed long-term studies which in turn require certainty of land management and funding.

Faunal indicators also give precise measures of faunal recolonisation. Rehabilitation and closure guidelines suggest or require the re-establishment or enhancement of fauna habitat as a rehabilitation objective. However, there is a pervasive assumption – for example, in the suggested indicators and completion criteria in EM1122 – that the provision of fauna habitat equates to fauna recolonisation. There is increasing evidence that this is not true (eg Cristescu *et al*, 2013). Thus, it is important to understand the links between habitation and recolonisation, set clear rehabilitation goals about fauna recolonisation and to monitor these directly.

Conclusion

Existing rehabilitation and closure guidelines play an important role in providing operators with broad to modestly detailed explanations of government regulator expectations. Correspondingly, they provide a policy framework for consistent regulation.

However, we argue that the expectations of rehabilitation outcomes are sometimes unrealistic, with agreements (albeit in good faith) between proponents and the regulator that aspire for closure outcomes that are unlikely to be achieved – rather than being evidence-based objectives.

There is increasing acceptance internationally that 'higher value' rehabilitation outcomes will be unlikely for many mines. In the current context, this paradigm of novel systems poses additional challenges for the regulator, who must acquire sufficient expertise to critically assess the site-specific suitability of rehabilitation objectives that sit outside the existing standard or 'model' conditions. Equally, suitable guidance and agreement from stakeholders is needed to prevent operators making poor decisions early in mine planning stages that will create long-lasting negative legacies.

Developing rehabilitation monitoring programs that are accurate, robust and independently verified is also important for rehabilitation and closure planning. Achieving – and then confidently demonstrating – successful rehabilitation outcomes is an important means for operators to build community confidence in the mining sector. Further development of guidance documents will assist the industry in achieving this.

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