

Rehabilitation Reference Library

Exploration and Mining

Community and Environment Society

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AusIMM

Table of Contents

1	Introduction	3
2	Rehabilitation Guidelines	5
2.1	Nationwide	5
2.2	Queensland	6
2.3	New South Wales	8
2.4	Northern Territory	9
2.5	South Australia	10
2.6	Tasmania	11
2.7	Victoria	12
2.8	Western Australia	14
2.9	International	16
3	Key Rehabilitations Aspects	17
3.1	Material Characterisation	17
3.2	Community Engagement	21
3.3	Landform Design and Construction	23
3.4	Reconstruction of the Soil Profile	26
3.5	Vegetation Establishment & Fauna Recolonisation	28
3.6	Rehabilitation Monitoring	31

1 Introduction

Mine rehabilitation generally comprises the design and construction of stable, non-polluting landforms as well as the establishment of a sustainable ecosystem or alternative vegetation, depending upon desired post-operation land use (DIIS and DFAT, 2016¹). Rehabilitation is a costly process, and opportunities to repeat unsuccessful rehabilitation works are often limited. In order to be successful, rehabilitation programs must follow a number of steps (Figure 1) (DIIS and DFAT, 2016).

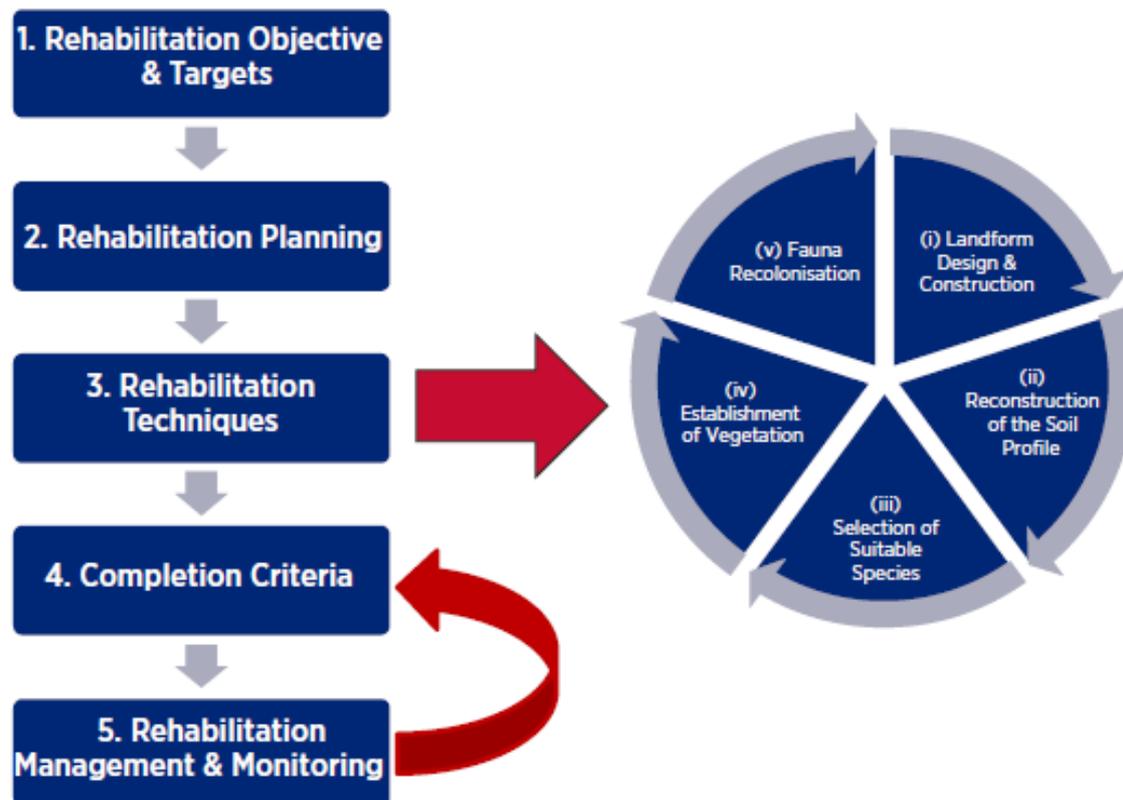


Figure 1: Stages of rehabilitation planning and implementation (DIIS and DFAT, 2016).

There is an increasing focus on social licence to operate and good demonstrable rehabilitation should be a core business value for mining companies. In many instances mining companies may not have specific rehabilitation expertise and rehabilitation management becomes the responsibility of a generic environmental officer/advisor or in the early stages of operations, mining engineers and geologists. Also, design and construction of landforms requires input from many disciplines including geology and mine engineering to understand issues including material availability, material characterisation, schedules and economic design. This document was created to provide guidance for non-rehabilitation professionals to access informative material on rehabilitation within the minerals industry.

The information within this document was compiled by the AusIMM Community and Environment Society. Sources include (in most cases) web-based documents published by various government departments, universities, international organisations, and industry associations. Note: some documents, books and articles may require purchasing; in those cases the link within this document directs to the purchasing website.

¹ Department of Industry, Innovation and Science (DIIS) & Department of Foreign Affairs and Trade (DFAT), 2016. *Leading Practice Sustainable Development program- Mine Rehabilitation*. September 2016. Commonwealth of Australia, Canberra ACT.

The references provided in this document have been split into two sections:

- **Rehabilitation Guidelines** – This section includes general related references with a particular focus on Stage 1 - Rehabilitation Objectives & Targets, Stage 2 - Rehabilitation Planning, and Stage 4 - Completion Criteria from Figure 1. This section has been split into Nationwide (Australia), Australian states and international applicable references.
- **Key Rehabilitation Aspects** – This section provides more detailed references (including articles and case studies) on specific rehabilitation aspects with a particular focus on Stage 2 - Rehabilitation Planning, Stage 3 - Rehabilitation Techniques and Stage 5 - Rehabilitation Monitoring from Figure 1. This section has been split into:
 - Material Characterisation;
 - Community Engagement;
 - Landform Design;
 - Reconstruction of the Soil Profile;
 - Vegetation Establishment & Fauna Recolonisation; and
 - Rehabilitation Monitoring.

This document is intended to be a dynamic document, that may be updated regularly to allow for the inclusion of new guidelines and/or updated versions of the documents contained within. The Community and Environment Society webpage will link to the most recent version of this Rehabilitation Reference Library.

2 Rehabilitation Guidelines

2.1 Nationwide

Handbook: Leading Practice Sustainable Development Program - Mine Rehabilitation
Department of Industry, Innovation and Science (DIIS) & Department of Foreign Affairs and Trade (DFAT), 2016
http://www.industry.gov.au/resource/Documents/LPSDP/LPSDP-MineRehabilitationHandbook.pdf
<p>"This handbook addresses mine rehabilitation, one of the themes in the Leading Practice Sustainable Development Program. The primary audience for this handbook is management at the operational level—those who are responsible for implementing leading practice at mining operations. It is also relevant to people with an interest in leading practice biodiversity management in the mining industry, including environmental officers, mining consultants, governments and regulators, non-government organisations, neighbouring and mine communities, and students. All users are encouraged to work together in partnership, taking up the challenge to continually improve the mining industry's standards of rehabilitation, as part of its sustainable development performance. Improved performance can be achieved through applying the principles outlined in this handbook.</p> <p>This handbook outlines the key principles and procedures now recognised as leading practice for planning, implementing and monitoring rehabilitation:</p> <ul style="list-style-type: none"> • Understanding the importance of rehabilitation and its business case for the mining sector; • establishing rehabilitation objectives, targets and success criteria; • planning to rehabilitate through engaging with stakeholders, setting objectives and completion criteria, and establishing rehabilitation baselines; and • integrating and implementing rehabilitation plans during the life of the operation monitoring and reporting mine-site rehabilitation performance."
Handbook: Leading Practice Sustainable Development Program - Mine Closure
Department of Industry, Innovation and Science (DIIS) & Department of Foreign Affairs and Trade (DFAT), 2016
http://www.industry.gov.au/resource/Documents/LPSDP/LPSDP-MineClosureCompletionHandbook.pdf
"This handbook addresses mine closure and completion, one of the themes in the Leading Practice Sustainable Development Program. The program aims to identify key issues affecting sustainable development in the mining industry and provide information and case studies that illustrate a more sustainable basis for the industry."
Guideline: Mine Rehabilitation in the Australian Minerals Industry
Minerals Council of Australia, 2016
http://www.minerals.org.au/file_upload/files/reports/Mine_rehabilitation_in_the_Australian_minerals_industry_FINAL.pdf
"This publication showcases leading practice examples of mine rehabilitation within the minerals industry. The case studies used have been undertaken by suitably qualified environmental professionals in adherence to normal professional standards."

2.2 Queensland

2.2.1 Exploration

Information Sheet: Environmental Requirements for Small Scale Mining Activities
Department of Environment and Heritage Protection, 2014
https://www.ehp.qld.gov.au/assets/documents/regulation/rs-is-environmental-requirements-small-scale-mining.pdf
<p>"Activities that are consistent with the definition of small scale mining activities in the Environmental Protection Act 1994 (EP Act) do not require an environmental authority. Only activities carried out under prospecting permits, mining claims and exploration permits (minerals) are included in the definition of small scale mining activity (refer to Attachment A).</p> <p>All small-scale mining activities are subject to the conditions prescribed in Schedule 2C and 2D of the Environmental Protection Regulation 2008 (the Regulation). Prescribed conditions relate to rehabilitation and financial assurance requirements. These have been outlined in this information sheet."</p>

2.2.2 Mining

Guideline: Rehabilitation Requirements for Mining Resource Activities
Department of Environment and Heritage Protection, 2014
https://www.ehp.qld.gov.au/assets/documents/regulation/rs-gl-rehabilitation-requirements-mining.pdf
"This guideline is to assist mining companies to propose acceptable rehabilitation outcomes and strategies during the planning stages of a mine or when changes to the proposed rehabilitation outcomes and strategies become necessary during the operational stages of a mine."

Mine Rehabilitation and Closure (MRC) Wiki
Central Queensland Mine Rehabilitation Group (CQMRG)
http://mrcwiki.org.au/bin/view/Main/
The industrial application of a Mine Rehabilitation and Closure Wiki (MRC Wiki) is as a source of information with links to useful tools to support planning and implementation of rehabilitation and closure, in addition to a facility for information sharing and guidance. The MRC Wiki provides an entry point for rehabilitation and closure practitioners, with a focus on Central Queensland, to the existing tools and knowledge management resources reviewed. The MRC Wiki also has the capacity for users to add in other potentially useful tools, not included in this review. Practitioners can share their knowledge and provide links to new knowledge and improve practices on the ground by learning from successes and failures which influence mine rehabilitation and closure practices.

Rehabilitation Report and Progressive Rehabilitation Certification
Department of Environment and Heritage Protection
https://www.business.qld.gov.au/running-business/environment/licences-permits/rehabilitation/certification
"Progressive rehabilitation allows a holder of an environmental authority (EA) for a resource activity, to reduce the amount of financial assurance held by the administering authority. A EA holder can apply for progressive rehabilitation if they want to surrender part of the resources tenure. Progressive rehabilitation involves the staged restoration of disturbed areas during the exploration, construction or development and resource extraction phases of your project, instead of large-scale works at the end of your project."

The holder of an environmental authority must submit either a final rehabilitation report as part of the requirements of an application to surrender an environmental authority or a progressive rehabilitation report as part of an application for progressive certification."

2.3 New South Wales

Fact Sheet: Exploration and Mining Rehabilitation
Department of Industry, Resources and Energy, 2016
http://www.resourcesandenergy.nsw.gov.au/_data/assets/pdf_file/0008/619838/PUB16-177-Exploration-and-mining-rehabilitation-fact-sheet-FINAL.pdf
"This fact sheet provides a general overview of rehabilitation in NSW. The NSW Government has strict conditions that ensure exploration and mining affected land is left in a safe and stable condition and that local communities are not unduly affected. Post-mining rehabilitation can take many forms such as the removal of infrastructure, securing of mine entrances and shafts, remediation of contaminated land, landscaping and revegetation."

2.3.1 Exploration

Exploration Code of Practice: Rehabilitation
Department of Industry, Resources and Energy, 2015
http://www.resourcesandenergy.nsw.gov.au/_data/assets/pdf_file/0008/565955/Exploration-Code-of-Practice-Rehabilitation.pdf
"This Code of Practice sets out mandatory requirements (NSW) and provides title holders with related guidance regarding the expected performance to ensure that exploration is undertaken in a manner that manages and minimises risk and achieves sustainable rehabilitation outcomes."

Handbook: NSW Minerals Industry Exploration Handbook, Leading Practice for NSW Explorers
NSW Minerals Council, 2013
http://www.nswmining.com.au/NSWMining/media/NSW-Mining/Publications/1309_NSW-Minerals-Exploration-Handbook_FINAL.pdf
"This guide provides a valuable reference as well a practical guide for explorers who must find the minerals needed to sustain the jobs, investment and economic strength of this great state. This edition provides the most up-to-date information on compliance and leading practice, as well as more case studies so explorers in NSW can 'get it right from the beginning'." Rehabilitation is detailed in Section 5.

2.3.2 Mining

Guideline: ESG3: Mining Operations Plan (MOP) Guidelines
NSW Trade and Investment, Regional Infrastructure and Services – Division of Resources and Energy, 2013
http://www.resourcesandenergy.nsw.gov.au/_data/assets/pdf_file/0009/475434/ESG3-Mining-Operations-Plan-MOP-Guidelines-September-2013.pdf
"The Mining Operations Plan is a tool used by the Department (NSW) to monitor the progress of mining and rehabilitation activities across the life of a mine. ESG3: Mining Operations Plan (MOP) Guidelines, September 2013 (ESG3) details a new process for monitoring and managing progression towards successful rehabilitation outcomes. The Guideline requires industry to identify and provide measurable data and demonstrate that proposed rehabilitation outcomes are achievable and realistic within a given timeframe."

2.4 Northern Territory

2.4.1 Exploration

Advisory Note: Construction and Rehabilitation of Costeans and Bulk Sample Pits
Department of Mines and Energy, July 16
https://nt.gov.au/_data/assets/pdf_file/0013/203332/aa7-006-construction-and-rehabilitation-of-costeans-and-bulk-sample-pits-advisory-note.pdf
The aim of this Advisory Note is to outline the minimum construction and rehabilitation requirements for exploration costeans and bulk sample pits.

Advisory Note: Clearing and Rehabilitation of Exploration Gridlines and Tracks
Department of Mines and Energy, July 2016
https://nt.gov.au/_data/assets/pdf_file/0011/203330/aa7-005-clearing-and-rehabilitation-of-exploration-gridlines-and-tracks-advisory-note.pdf
The aim of this Advisory Note is to outline the minimum clearing and rehabilitation requirements for Exploration tracks and Gridlines.

Advisory Note: Construction and Rehabilitation of Exploration Drill Sites
Department of Mines and Energy, September 2016
https://nt.gov.au/_data/assets/pdf_file/0015/203334/aa7-029-construction-and-rehabilitation-of-exploration-drill-sites.pdf
This Advisory Note outlines the approach for the construction of drill pads, benches and drill holes. It also provides advice on the rehabilitation of drill sites, including the capping and plugging of drill holes and appropriate abandonment of bores

2.5 South Australia

2.5.1 Exploration

Guideline: Preparation of a Program for Environment Protection and Rehabilitation (PEPR) for Low Impact Mineral Exploration in South Australia

Department of State Development

<https://sarigbasis.pir.sa.gov.au/WebtopEw/ws/samref/sarig1/image/DDD/MRGMG8.pdf>

"The generic PEPR for low impact mineral exploration in South Australia has been developed by the Department of State Development's Mineral Resources Division to ensure that low impact activities are conducted in a manner that will reduce any potential environmental impacts and facilitate the approval process. These guidelines describe the scope of low impact exploration activities, relevant environmental aspects, land access and/or consultation requirements, management of environmental impacts and rehabilitation requirements."

2.5.2 Mining

Guideline: Preparation of a Program for Environment Protection and Rehabilitation (PEPR) for Metallic and Industrial Minerals (Excluding Coal and Uranium) in South Australia.

Department of State Development, Nov 2015

<https://sarigbasis.pir.sa.gov.au/WebtopEw/ws/samref/sarig1/image/DDD/MRGMG2B.pdf>

"These guidelines have been prepared by the department to assist the tenement holder prepare programs for environment protection and rehabilitation (PEPRs) required under the Mining Act 1971 for authorising operations and directly related activities on mineral leases (MLs) and any associated miscellaneous purposes licences (MPLs). This guideline is exclusively for metallic and industrial minerals."

2.6 Tasmania

Guideline: Decommissioning & Rehabilitation Plan (DRP) A Guideline for the Tasmanian Mining Industry

Environmental Protection Authority (EPA), Dec 2011
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http://epa.tas.gov.au/documents/drp_guidelines_2011.pdf

"A guideline for the preparation of a decommissioning and rehabilitation plan for the Tasmanian mining industry. A Decommissioning and Rehabilitation Plan (DRP) is a plan approved by the Director, Environment Protection Authority (EPA), that formally recognises and sets out an agreed documented environmental management strategy for the decommissioning and rehabilitation (D&R) of an activity (eg mine) prior to and after the cessation of the activity."
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2.7 Victoria

2.7.1 Exploration

Code of Practice for Mineral Exploration
Department of Economic Development, Jobs, Transport and Resources, Earth Resources Regulation
http://earthresources.vic.gov.au/earth-resources-regulation/licensing-and-approvals/minerals/guidelines-and-codes-of-practice/code-of-practice-mineral-exploration
"The Code provides practical guidance about how exploration work should be conducted in Victoria to meet regulatory requirements and environmental standards under the MRSD Act or the Mineral Resources (Sustainable Development) (Mineral Industries) Regulations 2013 (MRSDMI Regulations). It is based on the principle that well-planned and managed exploration projects should have little or no lasting impact on the environment and impose minimal disruption to other land users and the community." The Code includes sections on waste, drill hole decommissioning and general rehabilitation.

Guidelines: Exploration and Rehabilitation of Mineral Exploration Site
Department of Economic Development, Jobs, Transport and Resources, Earth Resources Regulation
http://earthresources.vic.gov.au/earth-resources-regulation/licensing-and-approvals/minerals/guidelines-and-codes-of-practice/exploration-and-rehabilitation-of-mineral-exploration-sites
"The purpose of the Guidelines is to assist licensees to ensure that exploration in Victoria is carried out in an effective and responsible manner with the least environmental disturbance reasonably practicable, and that areas of land disturbed during exploration activities are rehabilitated to an acceptable standard."

Guidelines: Abandonment of Mineral Drillholes
Department of Economic Development, Jobs, Transport and Resources, Earth Resources Regulation
http://earthresources.vic.gov.au/earth-resources-regulation/licensing-and-approvals/minerals/guidelines-and-codes-of-practice/abandonment-of-mineral-drillholes
"The Guidelines provide advice to licensees under the Mineral Resources Development Act 1990 on the abandonment of mineral drillholes. They apply to all mineral exploration and mine development drillholes, drilled on both Exploration and Mining Licences."

2.7.2 Mining

Guidelines: Rehabilitation Plans & Other Environmental Aspects of Work Plans
Department of Economic Development, Jobs, Transport and Resources, Earth Resources Regulation
http://earthresources.vic.gov.au/earth-resources-regulation/licensing-and-approvals/minerals/guidelines-and-codes-of-practice/rehabilitation-and-environmental-aspects-of-mining-and-extractive-work-plans
"The Guidelines are an advisory document. They provide guidance on matters that DEDJTR generally looks at in assessing plans. They do not set requirements for plans, beyond those statutory requirements, which are already in place." Reference is also made to the Mine Rehabilitation Handbook produced by the Australian Mining Industry Council and Best Practice in Environmental Management in Mining produced by the Federal Environment Protection Agency.

Guidelines: Permitted Clearing of Native Vegetation Biodiversity Assessment Guidelines
Department of Environment, Land, Water and Planning
http://www.depi.vic.gov.au/environment-and-wildlife/biodiversity/native-vegetation/native-vegetation-permitted-clearing-regulations
The guidelines outline how impacts on Victoria's biodiversity are assessed when an application to remove native vegetation is lodged. In particular they include native vegetation offset requirements.

2.8 Western Australia

2.8.1 Exploration

Guideline: Complete a Rehabilitation Report (Exploration)
Department of Mine, Industry Regulation and Safety
http://www.dmp.wa.gov.au/Environment/Complete-a-rehabilitation-20029.aspx
"It is a requirement that all rehabilitation is undertaken within six months of completion of ground disturbance activities. It is best practice in rehabilitation reporting to submit both before and after photographs (including a significant landmark) with captions detailing location, date and a brief description of the content of the photograph."

Code of Environmental Practice for Mineral Exploration
Association of Mining and Exploration Companies (AMEC), 2010
https://www.amec.org.au/Public/Media/AMEC_Publications/Code_of_Environmental_Practice_for_Mineral_Exploration.aspx
"The purpose of the code is to provide practical guidance to assist mineral explorers to identify and meet their environmental obligations and to maintain a high standard of environmental performance. The Code does not replace existing statutory and guiding mechanisms."

2.8.2 Mining

Guideline: Guidelines for Preparing Mine Closure Plans
Department of Mine, Industry regulation and Safety and Environmental Protection Authority, 2015
http://www.dmp.wa.gov.au/Documents/Environment/ENV-MEB-121.pdf
"The purpose of these guidelines is to provide guidance on the preparation of Mine Closure Plans to meet Western Australian regulatory requirements." Appendix G provides an outline of specific mine closure issues including Rehabilitation.

Guideline: Mine Rehabilitation Fund – Guidance
Department of Mines and Petroleum (now Department of Mine, Industry Regulation and Safety), July 2013
http://www.dmp.wa.gov.au/Documents/Environment/ENV-MEB-382.pdf
This Guidance assists in how to lodge the annual Mine Rehabilitation Fund Report. "The Mine Rehabilitation Fund (MRF) provides a pooled fund, levied annually according to the environmental disturbance existing on a tenement at the annual reporting date. Participation into the MRF is compulsory."

Guideline: A Guide to Preparing Revegetation Plans for Clearing Permits (Draft)
Department of Water and Environmental Regulation, Nov 2016
https://www.der.wa.gov.au/images/documents/our-work/consultation/Revegetation-plan/Consultation_Draft_Reveg_Guide_v0-3.pdf
"This guide sets out the Department of Environment Regulation's (DER) recommended approach to preparing a revegetation plan, where land revegetation is proposed as an offset or required as a condition of a clearing permit granted under the Environmental Protection Act 1986 (EP Act). It provides guidance to key stakeholders including landowners, consultants, local government authorities and state government

agencies, regarding the minimum information requirements that must be provided to DER. This is to ensure that an assessment of the adequacy of a revegetation plan can be made."

2.9 International

Good Practice Guidance for Mining and Biodiversity
International Council on Mining and Metals, 2006
http://www.icmm.com/website/publications/pdfs/biodiversity/good-practice-mining-and-biodiversity
"This Good Practice Guidance has been prepared in response to that commitment. It is aimed at providing the mining industry with the steps required to improve biodiversity management throughout the mining cycle." Section 7. Mitigation, Rehabilitation and Enhancement Tools pg. 90 – 103 specifically relates to rehabilitation

3 Key Rehabilitation Aspects

3.1 Material Characterisation

Waste Characterisation studies are essential for understanding the physical and geochemical properties of the soil and waste rock material present at a mine site. The information obtained from these studies feeds into Stage 2 - Planning (refer to Figure 1); essential for designing safe, stable and non-polluting landforms. This section includes references on materials characterisation, and more specific geochemical issues; namely Acid and Metalliferous Drainage and Radiation.

Guideline: Materials Characterisation Baseline Data Requirements for Mining Proposals
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Department of Mines, Industry Regulation and Safety, 2016

http://www.dmp.wa.gov.au/Documents/Environment/ENV-MEB-213.pdf

This guidance outlines the Materials Characterisation Baseline Data Requirements for Mining Proposals in Western Australia. Materials characterisation identifies the physical and geochemical properties of materials to see if they have the potential to cause environmental harm or impact on the success of rehabilitation and closure. Effective materials characterisation helps ensure that the environmental risk assessment is appropriately informed and assists in the cost-effective operation and closure of a mine. The draft guidance provides examples of how suitable materials characterisation can be achieved.

Manual: Dispersive Soils and their Management
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Sustainable Land Use: Department of Primary Industries and Water, 2009
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http://dpiwwe.tas.gov.au/Documents/DPIW_DSM_Manual_April2009.pdf

"This document seeks to provide a summary of the available science and experience gained with the management of dispersive soils and tunnel erosion in Tasmania. It is expected this document will have relevance for a range of stakeholders including professionals in the building, construction, local government, affected landholders and natural resource managers."

Report: Identification and Management of Dispersive Mine Spoils
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Australian Centre for Mining Environmental Research, 2004

https://eprints.usq.edu.au/1311/1/Dispersive_spoils_report_final_June2004b.pdf

"This report details a project that has focused heavily on soil properties and the infiltrating water on both soil properties and soil behaviour." Included with the report is a review of literature covering aspects of soil chemistry, structure, clay dispersion and tunnel erosion.
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3.1.1 Acid and Metalliferous Drainage

Guideline: Global Acid Rock Drainage Guide (GARD Guide)
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International Network on Acid Production (INAP) and the Mining Association of Canada (MAC). 2009
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http://www.gardguide.com/images/5/5f/TheGlobalAcidRockDrainageGuide.pdf

"This Guide deals with the prediction, prevention and management of drainage produced from sulphide mineral oxidation, often termed 'acid rock drainage'. It also addresses metal leaching caused by sulphide mineral oxidation. The GARD Guide is intended as a state-of-the-art summary of the best practices and technology to assist mine operators and regulators to address issues related to sulphide mineral oxidation."
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Handbook: Preventing Acid and Metalliferous Drainage – Leading Practice Sustainable Development Program for the Mining Industry

Department of Industry, Innovation and Science (DIIS) & Department of Foreign Affairs and Trade (DFAT), 2016

<https://industry.gov.au/resource/Documents/LPSDP/LPSDP-AcidHandbook.pdf>

This handbook addresses the topic of acid and metalliferous drainage (AMD). The emphasis in this handbook is on preventing the production of AMD from exposed sulfidic materials, followed by managing existing AMD, followed by treating AMD. This approach is consistent with the contemporary hierarchy for risk reduction.

This handbook covers all phases of a mining project, from exploration and feasibility studies through to operations and closure. It is applicable to exploration properties, operating and decommissioned mines and brownfield and legacy sites.

Handbook: ARD Test Handbook – Prediction and Kinetic Control of Acid Mine Drainage

AMIRA International, 2002, Melbourne

<http://www.amira.com.au/documents/downloads/P387AProtocolBooklet.pdf>

A guide to assist in the prediction and kinetic control of AMD through static and kinetic testing procedures. The AMIRA handbook provides a sequential approach to testing for acid forming potential of mine waste materials.

Guidelines: Acid Sulphate Soils: Laboratory Methods Guidelines

Department of Natural Resources, Mines and Energy, 2004, Indooroopilly, Queensland

<http://www.environment.nsw.gov.au/resources/soils/acid-sulfate-soils-laboratory-methods-guidelines.pdf>

This Guideline sets out the standard methods for routine laboratory analysis of existing acidity and of the potential acid production from oxidation of iron sulfides that should be used to provide information for the assessment and management of acid sulfate soils (ASS).

Manual: Prediction Method for Drainage Chemistry from Sulphidic Geologic Materials

CANET – Mining and Mineral Sciences Laboratories, (Price WA), 2009, Canada

<http://www.abandoned-mines.org/pdfs/MENDPredictionManual-Jan05.pdf>

This manual provides a comprehensive in-depth level of understanding needed to conduct a prediction program and then review the results.

Article: Predicting Water Quality at Hardrock Mines Methods and Models, Uncertainties, and State-of-the-Art

Maest et.al, 2005, USA

http://www.ceaa-acee.gc.ca/050/documents_staticpost/cearref_3394/hearings/SM09.pdf

"This report identifies various techniques for the geochemical characterisation of mine wastes, including conventional geochemical and mineralogical analyses, static tests, short-term dissolution tests and kinetic tests. For each technique, the report addresses advantages, limitations and sources of uncertainty and makes concise recommendations for improvements."

Environmental Notes: Acid Mine Drainage

Department of Mines and Petroleum (now Department of Mining, Industry Regulation and Safety), 2006; updated 2009

<http://www.dmp.wa.gov.au/Documents/Environment/ENV-MEB-220.pdf>

This document outlines strategies available to prevent or mitigate the impact of acid mine drainage.

Guidelines: Acid and Metalliferous Drainage – Environmental Impact Statement Guidelines

Northern Territory Environmental Protection Authority, 2013

https://ntepa.nt.gov.au/_data/assets/pdf_file/0011/287426/guideline_assessment_acid_metalliferous_drainage.pdf

"The purpose of this Guideline is to assist Proponents to define the information requirements of an Environmental Impact Statement (EIS) relating to assessment of potential Acid and Metalliferous Drainage (AMD) from mining and mineral processing materials including waste rock, tailings, low grade ore stockpiles and open pits."

Report: Development of ARD Assessment for Coal Process Wastes

Stuart Miller, Environmental Geochemistry International, Levey and Co Environmental Services, ACeSSS - University of SA, 2008

<https://www.acarp.com.au/abstracts.aspx?repld=C15034>

"The overall objective of the project was to develop a set of tests for reliably predicting acid rock drainage (ARD) potential of coal rejects and tailings. Standard test methods for predicting their ARD potential are unreliable due to interferences associated with organic matter and mineralogy common in these types of materials. The project involved three main components:

- Geochemical characterisation and kinetic testing of coal and coal washery samples from a variety of coal operations and projects;
- Modified net acid generation (NAG) test development; and
- Sulphur speciation test evaluation and development."

3.1.2 Radiation

Guideline: Managing Naturally Occurring Radioactive Material (NORM) in Mining and Mineral Processing Guideline - NORM 4.2 Controlling NORM Management of Radioactive Waste

Department of Mines and Petroleum (now Department of Mining, Industry Regulation and Safety), 2010

http://dmp.wa.gov.au/Documents/Safety/MSH_G_NORM-4.2.pdf

This guideline provides recommendations on the safe management of radioactive waste that results from the mining and processing of minerals.

Guideline: Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing, Radiation Protection Series

Australian Radiation Protection and Nuclear Safety Agency, 2005

<https://www.arpsa.gov.au/sites/g/files/net3086/f/legacy/pubs/rps/rps9.pdf>

"A Code of Practice for the mining and mineral processing industries which sets out the mandatory requirements necessary for the control of occupational and public radiation exposures; and the management of radioactive waste arising from these industries. Schedule 1 specifies additional requirements that form

part of the Code of Practice and is therefore part of the material that may be referenced by regulatory authorities."

3.2 Community Engagement

There is an increasing focus on social licence to operate, hence community engagement is an important practice to ensure community values are considered during rehabilitation planning (Stage 2 of Figure 1). Companies should seek contribution from local communities regarding rehabilitation outcomes and incorporate (where practical) into rehabilitation techniques such as landform design and species selection. This section includes references on community engagement, development and Indigenous landscape values.

Note that social closure (ie management of the impacts of mine closure on communities) is another component of mine closure and is not comprehensively included in this Rehabilitation Reference Library (however is referred to in some references). This section intends to address consultation and community engagement activities specifically related to rehabilitation.

Handbook: Leading Practice Sustainable Development Program - Community Engagement and Development
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Department of Industry, Innovation and Science (DIIS) & Department of Foreign Affairs and Trade (DFAT), 2016
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https://industry.gov.au/resource/Documents/LPSDP/LPSDP-CommunityEngagement.pdf

"This handbook examines what is meant by the 'social licence' and its ongoing relevance to successful mining projects. It also discusses the challenges involved in establishing a business case for investment in good community engagement and development. This handbook provides guidance to mining industry participants on how these higher-level policy commitments can be translated into improved practices at the mine site. It focuses on the challenges that companies may encounter as they engage with local communities and seek to contribute to their long-term development, using case studies to illustrate how these challenges have been addressed in particular contexts. It concerns itself primarily with relationships between mining projects and their local communities, although other stakeholders are also referred to as sometimes engagement with broader communities, such as at the state or national level, is also relevant."
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Article: Seeing the Landscape Through New Eyes: Identifying and Incorporating Indigenous Landscape Values Into Regional Planning Processes

Low Choy, Darryl, Wadsworth, Jenny, Burns, Darren, 2010, Queensland

https://research-repository.griffith.edu.au/bitstream/handle/10072/37664/67160_1.pdf%3bsequence=1

"This paper outlines the beginnings of a process to address this deficiency and identify indigenous landscape values for the purposes of accounting for them in statutory planning at the regional scale within a value-led planning process. It describes the current outputs from a pilot study of indigenous landscape values for the South East Queensland (SEQ) region ¹ . The research question that guided this study was: <i>Can indigenous landscape values be identified and represented in ways that respect indigenous culture and represent their interest in conventional regional planning processes?</i> "

Article: Nourishing Terrains, Australian Aboriginal Views of Landscape and Wilderness
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Deborah Bird Rose, 1996, Canberra

http://webarchive.nla.gov.au/gov/20170224230034/http://www.environment.gov.au/heritage/ahc/publications/nourishing-terrains

This article was commissioned by the Australian Heritage Commission explore Aboriginal Australians' views of landscape and their relationships with the land. It provides an overview of Indigenous perspectives and captures the spiritual and emotional significance of the land to Aboriginal people.
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Biodiversity: Science and Solutions for Australia - Chapter 6. Indigenous Perspectives on Biodiversity

CSIRO, 2014

<https://www.csiro.au/en/Research/Environment/Biodiversity/Biodiversity-book/Chapter-6>

The book describes the ancient origins and unique features of Australia's species, as well as the current status of our biodiversity. It outlines tools for management and planning, highlights Indigenous perspectives on biodiversity and looks at how Australia's biodiversity interacts with agriculture, the resources sector, cities and our changing global environment.

This chapter looks at the perspectives of Aboriginal and Torres Strait Islander peoples on Australia's biodiversity, its importance and management.

Article: The integration of Indigenous Knowledge Into Mine Site Rehabilitation and Closure Planning At Ok Tedi, Papua New Guinea

A.R. Butler, I. Toh, D. Wagambie, 2012, Perth

https://papers.acg.uwa.edu.au/p/1208_52_Butler/

"In developing the rehabilitation strategy for Bige, information was gathered from local communities on goods and services provided by the surrounding forest, traditional vegetation and land management practices, and recognised cycles of clearing and forest regeneration. This paper describes how the information provided by customary landholders was integrated into the rehabilitation strategy and completion criteria for this part of the Ok Tedi operation."

Guidelines: Community Consultative Committee Guidelines – State Significant Projects

NSW Planning and Environment, 2016

<http://www.planning.nsw.gov.au/CommunityConsultativeCommittees>

"Community Consultative Committees play an important role in ensuring proponents engage with the community and stakeholder groups on State significant projects. The NSW Planning and Environment Department has developed guidelines to clarify the roles and responsibilities of Community Consultative Committees, and to help these committees operate effectively."

3.3 Landform Design and Construction

Despite suggestions that reconstructed mined landforms should, wherever possible, mimic natural landforms within the region of the operation, most waste landforms are essentially large mounds of unconsolidated materials that may—in their properties—bear little, if any, relationship to the rock and weathered material making up nearby natural landforms (DIIS and DFAT 2016). Consequently, mimicking natural landforms without any consideration of material properties has a very high probability of failure, particularly where erosion risk is high. Site specific information from waste characterisation studies (Section 3.1) must be incorporated into Stage 3 - Rehabilitation Techniques: Landform Design and Construction (Figure 1).

This section includes information and articles on the design of waste rock dumps, creek diversions/reinstatements and tailings storage facilities.

3.3.1 Waste Rock Landforms

Information Sheet: Waste Rock Dumps
Department of Mine, Industry Regulation and Safety, 2009
http://www.dmp.wa.gov.au/Documents/Environment/ENV-MEB-223.pdf
This document outlines planning before and during construction to produce cost efficient and effective rehabilitation of waste rock dumps.

Article: Evolution of Landform Design Concepts
Howard, EJ, Loch, RJ, Vacher, CA, 2011 Trans. Inst. Mining and Metallurgy, 120:112–117.
https://www.researchgate.net/publication/233683937_Evolution_of_landform_design_concepts
"This paper briefly outlines the approach applied for design of final waste dump shapes and the management of their rehabilitation, and discusses its limitations and successes, using examples from a number of mine sites. It then considers alternative approaches to landform design that have been advanced, including use of generic guidelines, attempts to mimic natural landscapes and attempts to simply mimic advanced design methodologies. Conceptual weaknesses of those alternative approaches are reviewed and potential for further refinement is discussed, again, using data from various sites."

Article: Evaluation of the Water Erosion Prediction Project (WEPP) Model: Validation Data From Sites in Western Australia
Howard, EJ, Roddy, BP (2012). in AB Fourie and M Tibbett (eds), Mine closure 2012, Australian Centre for Geomechanics, Perth, ISBN 978-0-9870937-0-7.
https://papers.acg.uwa.edu.au/d/1208_09_Howard/09_Howard.pdf
"Computer simulations of runoff and erosion are a key element in the design of stable waste dump outer batter profiles. The Water Erosion Prediction Project (WEPP) model is used to develop erosion-stable landform batter surfaces. Although the WEPP model has been widely validated elsewhere, there is a perceived need to similarly validate the model for mine site conditions. Erosion monitoring data collected on landforms for which model parameters are known can be used for two primary purposes: a) to demonstrate that erosion rates are consistent with site targets; and b) to validate and more precisely calibrate the erosion model used in landform design, enabling continuous improvement in the design process. Model validation techniques are discussed and validation data for several landforms are presented. In general, cumulative erosion rates measured since completion of construction show good agreement with predicted erosion rates. The data have provided validation of the landform design process used; confidence in the surface stability of existing landforms that have been constructed; refinement and improvement in the design process; and a means for continual improvement in landform rehabilitation methods."

Article: The Design of Post-Mining Landscapes Using Geomorphic Principles
Hancock, GR, Loch, RJ, Willgoose, GR 2003, Earth Surface Processes and Landforms, 28:1097–1110.
http://onlinelibrary.wiley.com/doi/10.1002/esp.518/abstract
"Nature can provide analogues for post-mining landscapes in terms of landscape stability and also in terms of the rehabilitated structure 'blending in' with the surrounding undisturbed landscape. In soil-mantled landscapes, hillslopes typically have a characteristic profile that has a convex upper hillslope profile with a concave profile lower down the slope. In this paper hillslope characteristic form is derived using the area-slope relationship from pre-mining topography at two sites in Western Australia. Using this relationship, concave hillslope profiles are constructed and compared to linear hillslopes in terms of sediment loss using the SIBERIA erosion model. It is found that concave hillslopes can reduce sediment loss by up to five times that of linear slopes. Concave slopes can therefore provide an alternative method for the construction of post-mining landscapes."

Article: Sustainable Landscape Design for Coal Mine Rehabilitation
Loch, RJ (2010). ACARP project C18024 report.
https://acarp.com.au/abstracts.aspx?repld=C18024
"This project compared waste dump landform design outputs using (a) existing landform guidelines; (b) the Water Erosion Prediction Program (WEPP) runoff and erosion model; and (c) dedicated landform design software (Geofluv). The three landform design approaches were applied at two mine sites in the NSW Hunter coalfield, for landforms sheeted with local topsoil. Landforms developed using the three design methods were then assessed for erosion risk using the SIBERIA landform evolution model, with the impacts of varying vegetation cover for each landform design also being evaluated to assess the importance of cover in ensuring the stability of the designed waste dumps."

3.3.2 Surface Water Diversions/Re-instatements

Article: Criteria for Functioning River Landscape Units in Mining and Post Mining Landscapes
Karen White, Darcy Moar, Ross Hardie, Dom Blackham & Rohan Lucas, 2014
https://www.acarp.com.au/abstracts.aspx?repld=C20017
"The objective of this research has been to further develop an understanding of the requirements for successful design, operation, management and approvals relinquishment for constructed watercourse diversions at mine sites in the Queensland coal mining industry. This has been undertaken through a series of investigations and reviews."

3.3.3 Tailings Storage Facilities

Handbook: Tailings Management - Leading Practice Sustainable Development Program for the Mining Industry
Department of Industry, Innovation and Science (DIIS) & Department of Foreign Affairs and Trade (DFAT), 2016
https://industry.gov.au/resource/Documents/LPSDP/LPSDP-TailingsHandbook.pdf
This handbook addresses the theme of tailings management in the Leading Practice Sustainable Development Program. The aims of the program are to identify the key issues affecting sustainable development in the mining industry and to generate information and case studies that illustrate a more sustainable basis for mining operations.
Tailings Storage Facilities (TSFs) need to be designed, constructed and operated to the highest standards, taking into account the eventual need for closure and rehabilitation. Closure and rehabilitation plans are increasingly influencing the location of TSFs and the selection of tailings disposal methods, so as to minimise

the costs of closure, the future risks to the environment and the legacy for future generations. As described in Section 3, the design of the TSF should be integrated with the life-of-mine (LoM) plan so that the most cost-effective and acceptable risk solution for closure can be developed. Section 8 specifically addresses rehabilitation and aftercare.

Guideline: Management of Tailings Storage Facilities

Department of Economic Development, Jobs, Transport and Resources, Earth Resources Regulation

<http://earthresources.vic.gov.au/earth-resources-regulation/licensing-and-approvals/minerals/guidelines-and-codes-of-practice/management-of-tailings-storage-facilities>

"The guidelines aim to ensure that tailings management in Victoria is environmentally sensitive and safe. Tailings storage operations embrace four main stages – design, construction, operation and decommissioning. However, these stages are not discrete as decisions and actions at each stage impact on the subsequent ones, and the planned decommissioning processes have implications for the earlier stages. Appendix E details decommissioning, including cover design and revegetation."

Code of Practise: Tailings Storage Facilities in Western Australia

Department of Mine, Industry Regulations and Safety, 2013

http://www.dmp.wa.gov.au/Documents/Environment/MSH_COP_TailingsStorageFacilities.pdf

"This Code will assist those involved with tailings storage facilities (TSFs) to meet their legislative obligations for work health and safety under the Mines Safety and Inspection Act 1994 and environmental matters under the Mining Act 1978. Section 8 details closure/rehabilitation of a TSF."

Guidelines: Guidelines in Tailings Dam: Planning, Design, Construction, Operations and Closure (hardcopy only)

The Australian National Committee on Large Dams Inc (ANCOLD), 2012

https://www.ancold.org.au/?page_id=334

"ANCOLD has prepared these new guidelines to provide a single base document that supports the DITR publication and others like it, with engineering detail that can be accepted by all relevant government authorities, and national and international companies involved in tailings dam development, allowing them to undertake design and construction consistent with leading industry practice. The new guidelines include much of the original guidelines but with appropriate updating. There is considerable new information on designing for closure and on the use of risk assessment techniques to assist in design and management."

Code of Practice: Guide to Departmental Requirements for the Management and Closure of Tailings Storage Facilities (TSFs)

Department of Mine, Industry Regulation and Safety (formally Department of Mines and Petroleum), August 2015

http://www.dmp.wa.gov.au/Documents/Safety/MSH_G_TSFs_DeptRequirementsManagementClosure.pdf

"This guide has been prepared by the Department of Mines and Petroleum of Western Australia (DMP) (now DMIRS) to provide information for the consistent preparation of reports for tailings storage facilities (TSFs) in Western Australia. It provides both the technical basis and administrative framework that meets the legislative requirements currently covering the mining industry in Western Australia."

3.4 Reconstruction of the Soil Profile

The growth medium placed in areas to be rehabilitated must be capable of supporting a self-sustaining vegetative cover (DIIR and DFAT 2016). It should:

- have adequate infiltration capacity;
- have an adequate available water capacity;
- have adequate aeration;
- provide an adequate rooting depth, not restricted by mechanical impedance or by hostile subsoil conditions;
- be capable of supplying adequate plant nutrients;
- be free from excessive salinity, acidity and alkalinity; and
- provide the microbial associations necessary for plant growth.

Suitable growth mediums can be created by topsoil placement, physical amelioration such as ripping and rock armouring, chemical amelioration such as addition of fertiliser and gypsum and biological amelioration (vegetation establishment – see Section 3.5). The references included in this section include articles on different topsoil management techniques.

Handbook: Leading Practice Sustainable Development Program - Mine Rehabilitation
Department of Industry, Innovation and Science (DIIS) & Department of Foreign Affairs and Trade (DFAT), 2016
http://www.industry.gov.au/resource/Documents/LPSDP/LPSDP-MineRehabilitationHandbook.pdf
Refer to section 5 – Rehabilitation implementation

Article: Effect of Different Stockpiling Operations on Topsoil Characteristics for Rehabilitation in the Hunter Valley
Nardia Keipert, Carl Grant, John Duggin and Peter Lockwood, 2004 Victoria
http://www.acarp.com.au/abstracts.aspx?repld=C9029
"The major objective of this study was to examine the effect of increasing stockpile heights on the physical, chemical and biological components of topsoil used to rehabilitate open cut coal mines in the Hunter Valley."

Article: Topsoil Handling and Storage Effects on Woodland Restoration in Western Australia
Rokich, DP, Dixon, KW, Sivasithamparam, K and Meney, 2000, Restoration Ecology, vol. 8, pp. 196-208
http://onlinelibrary.wiley.com/doi/10.1046/j.1526-100x.2000.80027.x/abstract
"An analysis of the effects of topsoil handling and storage methods was undertaken to optimize the potential rehabilitation of southwest Western Australian <i>Banksia</i> woodland species present before site disturbance."

Article: Waterproofing Topsoil Stockpiles Minimizes Viability Decline in the Soil Seed Bank in an Arid Environment
Peter J. Golos, Kingsley W. Dixon Restoration Ecology Volume 22, Issue 4, pages 495-501, July 2014
http://onlinelibrary.wiley.com/wol1/doi/10.1111/rec.12090/full
"Topsoil is a valuable resource for revegetation of mine sites as it contains seeds of plant species indigenous to the local environment. As mine site restoration is undertaken after the completion of mining, it is a common practice to stockpile topsoil in preparation for restoration activities. While many studies have found

a decrease in seedling emergence with increasing stockpile age in temperate regions around the world, a few examine the effect of stockpile age on topsoil seed bank and seedling recruitment in arid environments. Seed longevity is promoted under dry conditions whereas viability loss is increased under warm and moist conditions. Here in a study in Australia's Great Sandy Desert, the effect of topsoil storage age and method of storing topsoil (under-cover and exposed) on seedling recruitment was examined for a major gold mining site."

3.5 Vegetation Establishment & Fauna Recolonisation

The selection of plant species to be used in rehabilitated areas is influenced by rehabilitation objectives, success criteria and the intended land use. In some instances, particular vegetation forms and species may be needed to achieve specific ecosystem functions, such as critical levels of surface contact cover, nutrient cycling or fixation, and impacts on infiltration and deep drainage (DIIR and DFAT 2016). Vegetation establishment can be undertaken using many techniques including the use of topsoil seed bank, direct seeding and planting of tubestock.

Animals will usually colonise rehabilitated areas if the composition and structure of the rehabilitated vegetation are similar to surrounding areas. Experience has shown that some key components of fauna species' habitat requirements might not be present in rehabilitation areas for many decades.

This section includes guidelines and articles that form part of Stage 3 – rehabilitation techniques (Figure 1) focusing specifically on revegetation issues including species selection, establishment of vegetation and creation of fauna habitats.

Handbook: Leading Practice Sustainable Development Program - Mine Rehabilitation
Department of Industry, Innovation and Science (DIIS) & Department of Foreign Affairs and Trade (DFAT), 2016
http://www.industry.gov.au/resource/Documents/LPSDP/LPSDP-MineRehabilitationHandbook.pdf
Refer to section 5 – Rehabilitation implementation

Biodiversity: Science and Solutions for Australia - Chapter 11: Mining and biodiversity
CSIRO, 2014
https://www.csiro.au/en/Research/Environment/Biodiversity/Biodiversity-book/Chapter-11
"The book describes the ancient origins and unique features of Australia's species, as well as the current status of our biodiversity. It outlines tools for management and planning, highlights Indigenous perspectives on biodiversity and looks at how Australia's biodiversity interacts with agriculture, the resources sector, cities and our changing global environment.
This chapter looks at the main impacts of mining on biodiversity and how these can be appropriately managed through processes like strategic regional assessments, use of bioindicators in rehabilitation, and biodiversity offsets."

3.5.1 Vegetation

Guidelines: Rehabilitation of Open Cut Coal Mines Using Native Grasses: Management Guidelines
Huxtable C. New South Wales Government, Department of Sustainable Natural Resources (2003)
http://www.environment.nsw.gov.au/resources/soils/coalminerehab.pdf
"These guidelines provide a brief summary of the species of Australian native grasses and their management that are recommended for rehabilitation of open cut coal mines in the Hunter Valley. The information is based on the results of five years of research carried out on mine sites during 1994–1999."

Guidelines: Florabank guidelines for best practice for seed collection and use
Florabank, 1999
http://www.florabank.org.au/default.asp?V_DOC_ID=755

"First published in 1999 and 2000, the ten Florabank guidelines are the Australian benchmark for best practice for seed collection and use."

- Florabank Guidelines 1: Native Seed Storage for Revegetation
- Florabank Guidelines 2 - Basic Methods for Drying, Extraction and Cleaning Native Plant Seed
- Florabank Guidelines 3 - Improving on Basic Native Seed Storage
- Florabank Guidelines 4 - Keeping Records on Native Seed
- Florabank Guidelines 5 - Seed Collection from Woody Plants for Local Revegetation
- Florabank Guidelines 6 - Native Seed Collection Methods
- Florabank Guidelines 7 - Seed Production Areas for Woody Native Plants
- Florabank Guidelines 8 - Basic Germination and Viability Tests for Native Plant Seed
- Florabank Guidelines 9 - Using Native Grass Seed in Revegetation
- Florabank Guidelines 10 - Seed Collection Ranges for Revegetation.

Article: Plant Propagation from Seed

Australian Native Plants Society, updated Feb 2017

<http://anpsa.org.au/seed.html>

This website provides information regarding native seed dormancy treatments. "Not all seed germinates easily. Some seeds have a physical or chemical inhibitor to germination designed so that the seed will only germinate in natural habitats when conditions are favourable. In some cases the inhibitor can be overcome by pre-treatment of the seed before sowing but with others, successful germination has defied all attempts." <http://anpsa.org.au/propinfo.html> includes more references on the germination of native seed.

Book: Pilbara Seed Atlas and Field Guide (Hardcopy only)

Todd E. Erickson, Russell L. Barrett, David J. Merritt and Kinsley W. Dixon, 2016

<http://www.publish.csiro.au/book/7527/>

"The Pilbara seed atlas provides plant identification along with robust scientific cost-effective seed-based rehabilitation. It describes 103 regional plant taxa and provides guidelines for effective seed collection, cleaning, storage and germination of their seeds."

3.5.2 Fauna

Guidelines: Habitat Restoration Planning Guide for Natural Resource Mangers

Department of Environment and Natural Resources, South Australia 2010

http://www.environment.sa.gov.au/Knowledge_Bank/Science_research/Seascapes_landscapes_and_communities/Landscape_restoration/Publications?BestBetMatch=restoration|720cd45f-5fec-4627-9f29-24303b5b894c|1771538a-419d-4c71-bd57-9e0e00fd8c25

"Effective restoration planning requires a good understanding of ecological concepts and practical considerations. This guide provides land managers with tools to assess the state of a site and make the right decisions about which approach to take in restoring a site. It can be used as a planning checklist and provides many sources of further information."

Article: A Review of Fauna in Mine Rehabilitation in Australia: Current State and Future Directions

Cristescu, RH, Frère, C, Banks, PB (2012). 'A review of fauna in mine rehabilitation in Australia: current state and future directions', *Biological Conservation*, 149(1):60–72.

<http://www.sciencedirect.com/science/article/pii/S000632071200095X>

"Fauna plays a critical role in the re-establishment of a functional ecosystem, yet fauna recolonization of restored areas is less studied than flora. The article reviews the findings of 71 publications on fauna recolonization, through the example of mining rehabilitation in the Australian continent, a global stronghold of large-scale mining."

3.6 Rehabilitation Monitoring

Monitoring is the gathering, analysis and interpretation of information for the assessment of the progress and completion of rehabilitation. Monitoring commonly used in the rehabilitation context includes monitoring of surface and groundwater; soil surface stability and erosion; the development of vegetation; colonisation by fauna; and the extent to which rehabilitation and final land-use objectives are being met (DIIR and DFAT 2016).

Techniques used to collect data on those attributes typically consist of field sampling units or measurements such as plots, transects and points to determine the success of the rehabilitation. Monitoring using remote sensing techniques is increasingly playing a role in the assessment of mine-site rehabilitation. The monitoring will also determine if any remedial work is required and may include:

- replanting or reseeding areas that may not have regenerated;
- repairing any erosion problems; and / or
- weed control.

This section includes references for different sampling and monitoring techniques that can be utilised as part of Stage 5 – Rehabilitation Monitoring (Figure 1).

Handbook: Leading Practice Sustainable Development Program- Evaluating Performance: Monitoring and Auditing
Department of Industry, Innovation and Science (DIIS) & Department of Foreign Affairs and Trade (DFAT), 2016
http://www.industry.gov.au/resource/Documents/LPSDP/EvaluatingPerformanceMonitoringAuditing_web.pdf
"This handbook addresses the theme of evaluating performance through monitoring and auditing, which are key elements in the Leading Practice Sustainable Development Program for the Mining Industry. The aims of the program are to identify the key issues affecting sustainable development in the mining industry and provide information and case studies that illustrate how to establish a more sustainable basis for the mining industry. This handbook addresses the ongoing assessment of impacts at all stages of a resource project, from pre-feasibility through planning, environmental and social impact assessment, development, operation rehabilitation, decommissioning and closure."
Manual: A Technical Manual for Vegetation Monitoring, Resource Management and Conservation
Department of Primary Industries, Water and Environment, Hobart 2001
http://dpiwve.tas.gov.au/Documents/Manual_screen.pdf
"Effective monitoring involves a commitment to conducting reliable and systematic measurements and responding to those measurements with appropriate management actions. This can only be achieved if the design of the monitoring project is relevant and scientifically rigorous. Therefore, the purpose of this manual is to equip you with the understanding and skills necessary to design and carry out simple but scientifically rigorous monitoring projects."
Book: Effective Ecological Monitoring
Lindenmayer, DB, Likens, GE (2010). Effective ecological monitoring, CSIRO Publishing and Earthscan, Melbourne and London. Updated May 2018.
http://www.publish.csiro.au/book/7812
"The book first outlines why long-term monitoring is important, then discusses why long-term monitoring programs often fail. The authors then highlight what makes good and effective monitoring. These good and bad aspects of long-term monitoring programs are further illustrated in the fourth chapter of the book. The

final chapter sums up the future of long-term monitoring programs and how to make them better, more effective and better targeted."

Procedure: Landscape Function Analysis: Procedures for Monitoring and Assessing Landscapes

CSIRO, 2004

https://www.researchgate.net/publication/238748160_Landscape_Function_Analysis_Procedures_for_Monitoring_and_Assessing_Landscapes_-_with_Special_Reference_to_Minesites_and_Rangelands

"EFA is a field monitoring process that uses simple indicators to assess how well a landscape is working as an ecological system. It is based on recent research that has been extensively tested and implemented throughout Australia, Africa, the Middle East, southern Europe and Asia. It is a scientifically verified method that can be used to monitor mine rehabilitation in a much more quantitative way than in the past. It can also be used for early detection of rehabilitation failure, hence allowing a change in remediation technique.

The EFA model has three interrelating parts designed for joint implementation:

- landscape function analysis (LFA)
- vegetation and structure composition
- habitat complexity."

Guideline: Wildlife Notes: Photographic monitoring of Vegetation

Hussey B.M.J, 2001

https://www.dpaw.wa.gov.au/images/documents/conservation-management/off-road-conservation/LFW/Photographic_Monitoring_of_Vegetation.pdf

Information notes on vegetation photo point monitoring methodology.

Article: Opportunities and Constraints of Functional Assessment of Mined Land Rehabilitation

Erskine, P, Fletcher, A, Seaborn, B (2013). ' , in M Tibbett, A Fourie, C Digby (eds), Mine closure 2013, Perth, Australian Centre for Geomechanics.

<https://espace.library.uq.edu.au/view/UQ:315127>

"This paper presents a general overview of the functional attributes of rehabilitated open-cut coal mine lands. It provides an evaluation of how classical soil analysis techniques and landscape function analysis (LFA) have been applied to ecosystems on heavily modified mined landscapes. It also compares the landscape position and placement of LFA transects to high-resolution imagery captured by an unmanned aerial vehicle."

Article: Incorporating Remote Sensing as a Tool to Assist Rehabilitation Monitoring in a Dolomite Mining Operation in South Australia

Naveen KARIYAWASAM, Simitkumar RAVAL and Ali SHAMSODDINI, June 2014

http://www.fig.net/resources/proceedings/fig_proceedings/fig2014/papers/ts08b/TS08B_kariyawasam_raval_et_al_6966.pdf

"Monitoring for rehabilitation success in the mining industry has grown in use and relevance in recent years. Remotely sensed data are considered as a reliable alternative for the field-based monitoring methods which are usually expensive and time-consuming. This study, conducted at the Ardrossan Dolomite Operation (ADM) in South Australia, utilises a time series of freely available Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper (ETM+) satellite images to monitor and assess the status of permanent re-vegetation using different spectral derivatives."

Article: Rehabilitation Closure Criteria Assessment Using High Resolution Photogrammetrically Derived Surface Models

Fletcher, A, Erskine, P (2013). 'Rehabilitation closure criteria assessment using high resolution photogrammetrically derived surface models', in G Grenzdörffer, R Bill (eds), UAV-g2013, Rostock, Germany, International Society for Photogrammetry and Remote Sensing.

<https://espace.library.uq.edu.au/view/UQ:407286>

"Relinquishment of mined land is unlikely to occur without compelling evidence that post mine landforms have a sustainable vegetation cover and represent a minimal liability to subsequent land users. Gully and rill erosion result in unstable landforms create unsafe landscapes for commonly targeted post mine land uses, such as grazing. The photogrammetric products of two small Unmanned Aerial Vehicle (UAV) platforms were compared in this study as a means of delineating erosion gullies and comparing vegetation in rehabilitation at an open cut coal mine in the Bowen Basin, Queensland."

Article: The Use of Ground Based LiDAR in Rehabilitation Performance and Landform Stability Monitoring

Pratt, AS, Mangan, CM (2013). 'The use of ground based LiDAR in rehabilitation performance and landform stability monitoring', in M Tibbett (ed.), Mine closure 2013, Australian Centre for Geomechanics, Perth.

https://papers.acg.uwa.edu.au/p/1352_32_Pratt/

"This paper presents an alternative rehabilitation monitoring technique that allows for the quantitative measurement of key rehabilitation performance measures and provides additional landform information that can be used to effectively plan and direct future rehabilitation and mine closure activities. This monitoring technique utilizes a ground-based LiDAR (Light Detecting and Ranging) system, which is similar to that often used to assess pit wall stability, to accurately capture quantitative data on floristic parameters (e.g. plant height and growth rate, foliage cover, plant density), surface soil parameters (e.g. percentage of rock and exposed soil cover) and landform attributes (eg slope shape, angle and length, berm / setback width). Unlike existing monitoring techniques, whereby the data is captured at specific locations on the post-mine landform, the LiDAR technique can rapidly and accurately measure these parameters over the entire landform, thus removing the subjectivity in selecting sites for monitoring."