

CODE OF PRACTICE

Tailings storage facilities in Western Australia



Government of **Western Australia**
Department of **Mines and Petroleum**
Resources Safety and Environment Divisions

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Further details of publications produced by Resources Safety can be obtained by contacting:

Resources Safety

Department of Mines and Petroleum
100 Plain Street
EAST PERTH WA 6004

Telephone: + 61 8 9358 8002 (general queries)
+ 61 8 9358 8154 (publication orders)

NRS: 13 36 77

Facsimile: + 61 8 9358 8000

Email: ResourcesSafety@dmp.wa.gov.au
(general queries)

RSDComms@dmp.wa.gov.au
(publication orders)

Foreword

Basis for code of practice

This code of practice is issued by the Department of Mines and Petroleum under the *Mines Safety and Inspection Act 1994* and the *Mining Act 1978*, with the endorsement of the Mining Industry Advisory Committee (MIAC) and approval from the Minister for Mines and Petroleum.

A code of practice is a guide to achieving the standards required under legislation. It applies to anyone who has a duty of care or responsibility in the circumstances described in the code. In most cases, following a code of practice would achieve compliance with the duties or requirements under the legislation in relation to the subject matter of the code. However, like regulations, codes of practice deal with particular issues and do not cover all situations that may arise.

Codes of practice are admissible in court proceedings. Courts may regard a code of practice as evidence of what is known about a hazard, risk or control and may rely on the code in determining what is reasonably practicable in the circumstances to which the code relates.

Compliance with the legislation may be achieved by following another method, such as a technical or an industry standard, if it provides an equivalent or higher standard of work health and safety than the code.

An inspector may refer to an approved code of practice when issuing an improvement or prohibition notice.

Scope and application

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*.

Tailings storage facilities are reservoirs that store mine tailings, which is waste material discharged from an ore processing plant or coal preparation plant. A TSF includes pits, dams, ponds, integrated waste landforms, erosion protection bunds, levee banks, diversion channels, spillways and seepage collection trenches associated with the storage of tailings.

The code does not apply to waste rock landforms (e.g. waste dumps), heap or vat leaching facilities, flood protection bunding, surface water diversions, or underground mine fill using tailings.

Due to the varying nature of potential hazards and control measures when managing TSFs, this Code has been prepared as a performance-based standard that states the outcome to be achieved rather than providing a detailed prescriptive methodology for achieving the outcome. In line with a performance-based approach, this Code focuses on the factors to be considered rather than specific control measures. However, more detailed guidance is available from the Departmental website to assist with the submission of:

- mining proposals
- design report
- project management plans prior to construction
- construction reports
- operating manual
- periodic environmental reports
- periodic audit reports
- decommissioning plans
- radiation management plans

involving TSFs, as required by the tenement conditions applied under the *Mining Act 1978*, and requirements of the *Mines Safety and Inspection Act 1994*.

Who should use this code?

You should use this code if you have functions and responsibilities for site selection, design, construction, operation, monitoring and surveillance, emergency response planning, management or rehabilitation of TSFs. The code may also be useful for supervisors, TSF personnel, and safety and health representatives who need to understand the hazards and environmental requirements associated with constructing, operating and decommissioning TSFs.

How to use this code of practice

The code includes references to both mandatory and non-mandatory actions.

The words “must” or “requires” indicate that legal requirements exist, which must be complied with. The word “should” indicates a recommended course of action.



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1 Introduction

1.1 Aims

The aims of this code of practice are to describe:

- a set of outcomes for tailings storage facilities (TSFs) to meet the approval requirements of the project management plan under the *Mines Safety and Inspection Act 1994* and Mines Safety and Inspections Regulations 1995, the mining proposal under the *Mining Act 1978* and Mining Regulations 1981, and the review report under tenement conditions
- the variables to be considered to demonstrate that a TSF is safe, stable, erosion-resistant and non-polluting
- the role of the competent person in the hazard management process for TSFs
- the broader occupational health and safety requirements for operating in accordance with the *Mines Safety and Inspection Act 1994* and Mines Safety and Inspection Regulations 1995.

The code promotes a proactive approach to monitoring and surveillance during construction, operation, and prior to decommissioning so it is possible to predict a TSF's long-term performance and potential environmental impact after a tenement is relinquished.

1.2 Structure of code

Chapter 2 describes the hazards-based approach to categorising TSFs in Western Australia. The level of TSF management needs to be commensurate with the potential impacts of TSF loss of integrity or failure during operation and decommissioning, and after tenement relinquishment.

Chapters 3 to 8 are structured to support a hazard management approach that follows the life cycle of a TSF, including:

- site selection
- design
- construction
- operation
- emergency planning
- decommissioning planning and rehabilitation
- decommissioning monitoring and maintenance.

Chapter 9 summarises the requirements for information, instruction, training and supervision to ensure the integrity of the TSF and occupational safety and health of affected personnel.

Other resources and useful links are listed in Appendix 1.

1.3 Roles of competent persons

To assure a safe, stable, erosion-resistant and non-polluting TSF at the end of the life cycle, competent persons should:

- select an appropriate site
- certify the design
- certify that construction meets design specifications and tolerances
- ensure performance is within operational tolerances
- provide training and assess the competency of TSF personnel
- conduct monitoring and surveillance
- conduct reviews and prepare reports.

Note: A competent person is considered to be someone who is appointed or designated by the employer or tenement holder to perform specified duties that the person is qualified to perform by knowledge, training and experience.

2 Classification

2.1 Introduction

The primary function of a TSF is the safe and economical storage of tailings in an erosion-resistant, non-polluting structure that minimises environmental impacts.

TSFs need to be individually tailored to the site, ore mineralogy, plant process and desired long-term landform and, therefore, will have a variety of designs and construction techniques. The design approach, construction method and decommissioning process should be selected to suit the local conditions and potential consequences should the TSF lose integrity or fail.

2.2 Hazard ratings

The TSF hazard rating is an assessment of the potential impacts in scenarios such as:

- seepage of tailings liquor
- overflow or leakage of tailings liquor
- dust generation
- release of tailings material or liquor
- an abrupt failure of the TSF.

The hazard rating assigned to an individual TSF will be high, medium or low depending on the potential consequences.

A dambreak study should be completed to show the impact of a failure of the embankment or other retaining structure. The scope of the study should determine the extent, travel times and velocities of potential flooding or tailings flow slides, and any safety, health and environmental effects on the downstream area.

The dambreak study should consider the worst-case scenarios, which are the release of tailings and water contained in the TSF at the maximum design tailings storage level during:

- probable maximum precipitation
- probable maximum flood.

Note: Probable maximum precipitation and flood are defined within the 2012 guidelines published by The Australian National Committee on Large Dams (ANCOLD) [see Appendix 1].

Since the hazard rating is a function of the potential impact of loss of integrity or failure, a well designed and constructed embankment or a well-operated TSF may still have a high or medium hazard rating.

The hazard rating is derived for the whole life of the TSF (including future raises) by considering the potential consequences of the scenarios on:

- the safety and health of people
- the environment
- property
- infrastructure
- mining developments.

Table 1 shows the hazard rating system that applies to TSFs in Western Australia.

Note: For TSFs with no embankments, only Part I of Table 1 should be used. However, there may be exceptions. For example, for an in-pit TSF located adjacent to an operating open-pit mine separated by a narrow land bridge or waste dump, Part II of Table 1 is applicable, with the land bridge and waste dump treated as an embankment.

Table 1 Hazard rating system applicable to TSFs in Western Australia

Hazard rating is derived by considering the potential adverse impacts or damage from:			
(a) embankment or structural failure, and			
(b) controlled or uncontrolled release of tailings/water, or seepage.			
Type of impact or damage	Hazard rating		
	High	Medium	Low
	Extent or severity of impact or damage		
Loss of human life or personal injury	Loss of life or injury is possible	Loss of life or injury is possible although not expected	No potential for loss of life or injury
Adverse human health due to direct physical impact or contamination of the environment (e.g. chemical or radiation denigration of water, soil, air)	Long-term human exposure is possible, and permanent or prolonged adverse health effects are expected	The potential for human exposure is limited, and temporary adverse health effects are possible	No potential for human exposure
Loss of assets due to direct physical impact or contamination of the environment (e.g. chemical or radioactive pollution of water, soil or air)	Loss of numerous livestock is possible	Loss of some livestock is possible	Limited or no potential for loss of livestock
	Permanent loss of assets (e.g. commercial, industrial, agricultural and pastoral assets, public utilities and infrastructure, mine infrastructure) is possible and no economic repairs can be made	Temporary loss of assets is possible and economic repairs can be made	Limited or no potential for destruction or loss of assets
	Loss of TSF storage capacity is possible and repair is not practicable	Loss of TSF storage capacity is possible and repair is practicable	Insignificant loss of TSF storage capacity is possible
Damage to items of environmental, heritage or historical value due to direct physical impact or contamination of the environment (e.g. chemical or radioactive pollution of water, soil or air)	Permanent or prolonged damage to the natural environment (including soil, and surface and ground water resources) is possible	Temporary damage to the natural environment is possible	Limited or no potential for damage to the natural environment
	Permanent or prolonged adverse effects on flora and fauna are possible	Temporary adverse effects on flora and fauna are possible	Limited or no potential for adverse effects on flora and fauna
	Permanent damage or loss of items of heritage or historical value is possible	Temporary damage of items of heritage or historical value is possible	Limited or no potential for damage of items of heritage or historical value

2.3 TSF categories

For a consistent approach to hazard identification and management in Western Australia, TSFs are classified as a Category 1, 2 or 3 facility based on their hazard rating and embankment height (Table 2), and, in some circumstances, location and depositional method.

A TSF's category will determine the degree of investigation, design input, construction supervision, and ongoing

assessment and review necessary to assure it is safe, stable, erosion-resistant and non-polluting throughout its life cycle, as well as the level of detail when making submissions or reporting to the Department of Mines and Petroleum.

Further information is provided in online departmental guidance for submitting mining proposals, plans and reports involving TSFs.

Table 2 Matrix of hazard ratings and heights used to derive TSF categories in Western Australia

Maximum embankment or structure height	Hazard rating		
	High	Medium	Low
> 15 m	Category 1	Category 1	Category 1
5 - 15 m	Category 1	Category 2	Category 2
< 5 m	Category 1	Category 2	Category 3

Notes:

- Cross-valley TSFs or those that block or significantly impede flow in natural drainage paths should be treated as Category 1 TSFs, regardless of the embankment height.
- In-pit TSFs are categorised assuming an embankment height of less than 5 m. In-pit TSFs extended by constructing a perimeter embankment are categorised based on the embankment height.
- For thickened discharge facilities and "dry" stacked tailings, the maximum stack height is used in lieu of embankment height.
- Integrated landforms should be classified according to the height of the retained tailings.

3 Site selection

Using the hierarchy of control (e.g. elimination, substitution, isolation, engineering), the site for a TSF should be selected to eliminate hazards or minimise the potential impact of the facility on people, infrastructure and the environment, particularly in the event of:

- seepage
- dust generation
- exposure to radionuclides, chemicals or particulates
- erosion
- overtopping
- abrupt failure of retaining structure
- pollution
- impediment of surface water flows

during operations and decommissioning, and after tenement relinquishment.

Physical factors that should be considered during site selection include:

- hydrology (e.g. potential for flooding, catchment area characteristics)
- topography (e.g. influence of watershed, streams, creek systems)
- foundation material (e.g. water tightness, strength, liquefaction potential)
- construction materials (e.g. suitability, availability, proximity)

- climate (e.g. rainfall patterns, evaporation rates, prevailing winds)
- geology (e.g. faults, fractures, shear zones, areas of instability)
- geomorphology (e.g. depositional processes and properties)
- hydrogeology (e.g. potential impact on ground water resources).

Other factors to be considered include:

- proposed construction methods (e.g. upstream, centreline or downstream raising)
- surrounding area (e.g. proximity to public infrastructure, centres of population, operational mine sites, camps, areas of environmental or heritage significance, aquifers of significance and high value)
- underground workings
- sterilisation of potential resources (e.g. mineralisation, water)
- tailings deposition approach (e.g. aerial, subaerial)
- tailings deposition method (e.g. co-disposal, central discharge, thickened discharge, perimeter spigotting, paste discharge, “dry” stacking)
- water management
- current and final land-use
- closure requirements, including decommissioning.

4 Design

4.1 Design needs

The objective of the design process is, so far as is practicable, to ensure the TSF's integrity and safety during:

- normal operation
- abnormal operation (e.g. decant pump failure, pipe breakouts)
- extreme events (e.g. seismic loading, extreme weather)
- decommissioning

and that it is safe, stable, erosion-resistant and non-polluting after tenement relinquishment.

The design must satisfy the safety requirements of the *Mines Safety and Inspection Act 1994* and regulations, the environmental requirements of the *Mining Act 1978* and regulations and *Environmental Protection Act 1986*, and other State and national legislation as applicable.

Where the TSF is used to store wastes potentially containing radionuclides, the facility's design and management must also be consistent with the applicable State and national legislation and safety standards of the International Atomic Energy Agency (IAEA).

4.2 Design factors

The following criteria influence the design of a TSF, and their assessment and the basis for parameter selection should be documented during the design and construction phases:

- hazard rating
- environmental requirements (e.g. rehabilitate to safe, stable, erosion-resistant and non-polluting landforms)
- decommissioning standards and objectives
- site conditions
 - geology (e.g. bedrock, structure)
 - geomorphology
 - foundation conditions (e.g. physical, geochemical and geotechnical properties)
 - hydrogeology
 - terrain
 - climate
 - seismicity
 - surface hydrology (e.g. drainage patterns, flood volumes)
- minimum freeboard
- decant pond design

- characteristics of tailings and construction materials (e.g. physical, geochemical, rheological and geotechnical properties)
- seepage control measures
- availability of suitable construction material
- construction method (e.g. upstream, centreline or downstream raising)
- characteristics of embankment or other retaining structures (e.g. stability, erosion resistance, resistance to dynamic or static liquefaction; integrated waste landform)
- operating strategy
- requirements for access
- characteristics and availability of cover and rehabilitation materials.

Note: When considering the option of upstream raising to a TSF, there may be increased risks associated with potential dynamic and static liquefaction of constituent materials. Suitable screening criteria should be applied to determine whether further quantitative evaluation of the liquefaction potential is required.

Decommissioning and tenement relinquishment must be considered during the design stage to ensure post-decommissioning performance will meet stakeholder expectations and regulatory requirements. Relinquishment and rehabilitation planning should ensure that the tailings disposal area is left such that it is able to:

- maintain an acceptable impact on the environment
- remain structurally stable
- resist deterioration through erosion or decay
- prevent loss of containment
- be functionally compatible with the agreed post-mining land use.

4.3 Design submission

The competent person responsible for the design submission should:

- certify that the design achieves the occupational safety and health, and environmental outcomes required under applicable legislation, and
- specify the:
 - ongoing design verification and validation methods
 - construction, operational and maintenance principles
 - conceptual design for decommissioning.

5 Construction

5.1 Construction plan

The mine operator should develop and implement a construction plan with quality assurance procedures to ensure that the TSF construction meets design specifications and tolerances. The plan should also contain systems of work and procedures to ensure the proposed construction can be carried out safely.

5.2 Construction report submission

A competent person should certify that the construction of the TSF meets design specifications and tolerances, and prepare a report that:

- documents the conditions encountered during construction (including field and laboratory testing) and verifies them against those assumed in the design
- includes a non-compliance report with documented remedial measures if the conditions encountered did not meet the original design or specifications

- includes a variance report if the construction was required to deviate from the original design
- demonstrates that the testing and measurement regime was appropriate and sufficient to validate the design parameters
- includes survey drawings of the TSF showing the true positions of features such as borrow pits, embankments, drains, topsoil stockpiles, capping material sources, process water and return water ponds, seepage trenches, monitoring instrumentation, decant towers, and buried pipework and cables (see Resources Safety's code of practice on mines survey).

The construction records, together with monitoring data, form the basis of the design of subsequent stages. Where construction is staged, a separate construction report should be prepared for each stage.

6 Operation

6.1 Operation and maintenance manual

An employer is required to provide information so that workers can undertake their tasks safely. Competent persons should develop and maintain an operating manual for TSF operations that documents:

- procedures for the safe and efficient storage of tailings in line with the specifications and principles adopted by the designer to minimise environmental impacts
- processes that comply with legislation and public expectations, and can be used as a reference during auditing of the facility.

The operating manual should be current, describe the roles and responsibilities for tailings management on site, and contain procedures, specifications and tolerances for:

- key health, safety and environmental risks for the mine and community with respect to operation, monitoring and maintenance
- depositional and operational methods
- instrumentation, monitoring and inspection requirements and schedules
- maintenance requirements and schedules
- ongoing verification requirements and schedules
- audit criteria and schedules
- an operational stage hazard register
- training requirements and schedules
- monitoring triggers and initiating appropriate responses
- emergency response
- rehabilitation trials, plans and schedules
- tenement conditions.

6.2 Operational record

A TSF and its surrounds require ongoing monitoring and surveillance to provide a measure of actual performance against expected performance as described in the mining proposal for the project. Where applicable, the following should be recorded:

- incidents and responses
- occupational exposure results
- environmental monitoring results and rehabilitation trials
- concentrations of residual contaminants in the tailings
- piezometric levels within the tailings body, embankments and other retaining structures, and surrounds

- deposition rates and quantities of tailings
- physical, geochemical, rheological and geotechnical properties of in situ tailings
- storage volumes, and capacity and deposition time remaining
- reconciliation of inflows and outflows (water balance)
- physical conditions of embankments
- TSF's performance during significant seasonal events
- results of inspections
- results of operational reviews.

6.3 Operational review

Periodic technical reviews should be undertaken by a competent person to assure the TSF is operating in accordance with the design intent and that regulatory requirements are being met. Inspections and audits form part of this review process and should be conducted by a competent person using input parameters derived from site measurements, observations and testing.

For Category 1 TSFs, it is prudent for operational reviews to be conducted by a third party (i.e. not the designer or operator). This is consistent with ANCOLD's 2012 guideline.

Technical reviews:

- check that the recommendations of previous reviews have been actioned
- confirm that appropriate responses have been made to any incidents or issues arising
- verify compliance with specifications (e.g. inspection, monitoring, quality control)
- verify compliance with legislative requirements and tenement conditions
- validate the continued use of the TSF design
- recommend any necessary operational or design modifications.

The type and level of information provided in the competent person's review reports should be commensurate with the TSF's category.

A record of review outcomes should be maintained by the mine operator, including any actions recommended and details of how they were addressed or implemented.

7 Emergency preparedness and planning

The emergency response strategy for the TSF forms part of the mine's emergency response plan, and should be referenced in the TSF's operating procedures. The plan should address the potential emergency scenarios defined in the TSF hazard register, assess the potential for such an emergency, and consider how it might be prevented or dealt with.

The emergency response plan should:

- assign roles and responsibilities
- describe any warning or emergency alarm systems
- describe the emergency procedures
- list the contacts arrangements and actions for local emergency authorities, local and State governments, neighbours and the community including specific evacuation advice where required
- describe impact prevention and mitigation measures.

The TSF emergency action plan should:

- be written in plain English
- be compiled and laid out to facilitate quick access to important information
- include appropriate use of illustrations such as maps
- be available to all affected personnel on site.

The plan should be regularly tested to ensure its effectiveness. Both "desk-top" tests and emergency response drills involving onsite personnel should be used to evaluate how people respond.

Debriefings should be conducted as soon as practicable after an emergency or drill to identify any modifications needed to improve the TSF emergency response.

8 Closure

8.1 Planning for closure

As TSFs are a critical mine closure issue, the TSF decommissioning plan must be developed in line with the overall mine closure plan required under the *Mining Act 1978*. The plan will be conceptual at the design stage, becoming more detailed during the operation of the mine as it accommodates relevant operational change, new regulations and new technology.

The initial TSF design should include ongoing survey, monitoring and instrumentation so that some decommissioning assumptions can be verified prior to tenement relinquishment, or data obtained to increase the reliability of post-relinquishment performance predictions.

The broad objective when closing a TSF is to leave the facility safe, stable, erosion-resistant and non-polluting with no requirement for ongoing maintenance. Factors to be considered when planning the final landform include:

- environmental setting
- leaching of contaminants into ground and surface waters
- dust generation
- erosion material decay and degradation
- underdrainage and pipework
- climate.

The mine closure plan should also consider premature or temporary closure of the TSF due to unplanned suspension of mining operations.

Proposed TSF decommissioning designs should be tested and evaluated during the operational phase using rehabilitation or closure trials.

8.2 Decommissioning review

When a TSF is scheduled for decommissioning, a competent person should conduct a review and prepare a detailed assessment of the current condition of the TSF. This decommissioning review will detail further investigation and work required to decommission the TSF and allow for tenement relinquishment.

During TSF decommissioning, and before tenement relinquishment, continued monitoring is required to demonstrate progress towards assuring:

- a self-sustaining ecosystem, as described in the approved mine closure plan
- a safe, stable, erosion-resistant and non-polluting landform.

9 Information, instruction, training and supervision

9.1 Introduction

The provision of information, instruction, training and supervision is an essential component of any safe system of work.

9.2 Information

Personnel must have the information necessary to complete tasks safely and to the environmental standard required. Such information will include:

- manuals and specifications provided by the TSF designer
- manuals and operating instructions provided by original equipment manufacturers (OEMs)
- the operation's policies, procedures and plans
- applicable legislation, Australian and industry standards, and other guidance material.

9.3 Instruction

Personnel must be instructed about specific tasks to be undertaken, including the hazards and risks, the controls to be applied, and the job steps necessary to complete the tasks safely and correctly.

Instructional tools such as job safety or hazard analyses (JSAs or JHAs), safe work instructions or procedures (SWIs or SWPs) and standard operating procedures (SOPs) may be used to document the process, but should be reviewed and amended if equipment or conditions change.

Instructions must be approved by the supervisor or management.

9.4 Training

People must be competent in the tasks they are assigned. This means they must have the knowledge and skills necessary to perform the task safely and correctly. Competency is gained through training and experience while being supervised or mentored.

The risk management training provided must be appropriate to the assigned roles and responsibilities. It must provide information on:

- the risk management process
- task-specific safe work methods, including the safe use of tools and equipment and safe systems of work.

All personnel should understand the implications that their activities during construction, operation and decommissioning

may have for the eventual closure of the mine and relinquishment of the tenement.

Assessment of competency should be evidence based and verified before work commences. Competency may be verified:

- by recognition of prior learning
- by on-site recognition or validation of current competency
- using the operation's training and development program.

Verifications of competency must include a documented assessment.

Whenever systems of work or plant and equipment change, or new systems of work or plant and equipment are introduced, there must be a system to ensure affected personnel are consulted, retrained as necessary and reassessed.

9.5 Supervision

Supervisors are responsible for the quantity and quality of the output of others, and contribute to the development of technical solutions to non-routine problems.

They help achieve the operation's safety and environmental goals by:

- confirming that workers (including contractors) are trained and competent for the task undertaken
- providing clear work instructions
- inspecting and monitoring workplace conditions
- continuously evaluating worker performance and correcting acts that are unsafe or would compromise environmental strategies
- reporting and rectifying hazards
- assuring implementation of the company's health, safety and environmental systems
- demanding compliance with site rules and procedures.

Supervision of TSFs includes:

- ensuring work is carried out in accordance with approved documentation
- managing assigned work areas and crews
- communicating regularly with others
- diagnosing and solving routine and non-routine problems
- controlling work programs to ensure objectives are met
- reporting and recording performance issues (e.g. fauna entrapment, pipeline failures, variances to approved construction diagrams)
- escalating any issues they are unable to address
- maintaining operating records.

Appendix 1 Resources and useful links

This list is provided for general reference but is not exhaustive.

- Department of Mines and Petroleum, www.dmp.wa.gov.au
 - *Safe design of buildings and structures – code of practice*
 - *Development of an operating manual for tailings storage – guideline*
 - *Tailings dams – HIF audit guideline and template*
 - *Managing naturally occurring radioactive material (NORM) in mining and mineral processing – guideline*
 - *Mines survey – code of practice*

Information is available online to assist with the submission of mining proposals, plans and reports involving TSFs as required by legislation and the tenement conditions applied under the *Mining Act 1978*. Guidance includes:

- *Guidelines for mining proposals in Western Australia*
- *Guidelines for preparing mine closure plans*
- The Australian National Committee on Large Dams Inc. (ANCOLD), www.ancold.org.au
 - *Guidelines in tailings dam: Planning, design, construction, operations and closure (2012)*

- International Commission on Large Dams (ICOLD), www.icold-cigb.org
- International Council on Mining and Metals (ICMM), www.icmm.com/page/746/emergency-response
- International Cyanide Management Institute (ICMI), www.cyanidecode.org
- Australian Department of Resources, Energy and Tourism, www.ret.gov.au
- Department of Environment and Conservation, www.dec.wa.gov.au
 - *Application to transfer or amend a licence, works approval or registration*
- Department of Water, www.water.wa.gov.au

Information on water resource protection is available online to guide land use activities that may affect the quality of water resources.
- International Atomic Energy Agency (IAEA), www.iaea.org

Specific guidance is available for handling tailings that potentially contain radionuclides.



Government of **Western Australia**
Department of **Mines and Petroleum**
Resources Safety and Environment Divisions

Department of Mines and Petroleum
100 Plain Street
EAST PERTH WA 6004

Resources Safety Division

Telephone: + 61 8 9358 8002
NRS: 13 36 77
Facsimile: + 61 8 9358 8000
Email: ResourcesSafety@dmp.wa.gov.au
Website: www.dmp.wa.gov.au/ResourcesSafety

Environment Division

Telephone: + 61 8 9222 3333
NRS: 13 36 77
Facsimile: + 61 8 9222 3862
Email: dmp@dmp.wa.gov.au
Website: www.dmp.wa.gov.au/Environment