Water Quality Protection Guidelines No. 2

Mining and Mineral Processing

Tailings facilities

2000

1. Introduction

Tailings facilities contain waste products from processing operations. They are engineered and managed to optimise the amount of tailings stored while minimising potential environmental impacts. Tailings facilities should not be used for anything other than its intended purpose.

Tailings facilities often act as interim storage ponds in an effort to maximise the recycling of process water. Exceeding the design slurry deposition rate may increase the water being held, leading to reduced tailings consolidation, dam wall integrity problems or increased seepage.

Leakage or seepage from tailings facilities may compromise the beneficial use of water resources in an area. Seepage of some process water from storage facilities is inevitable. Problems arise where excess seepage impacts on groundwater, surface water and vegetation or where seepage causes failure in the structural integrity of the tailings dam.

Tailings facilities should be located, designed and managed to reduce the risk of short-term and long-term environmental problems. This includes maintenance of pipes, pumps and motors associated with these structures.

2. Purpose

These guidelines are designed to be used to manage the impact of tailings containment facilities on the quality of the region's water resources.

3. Scope

These guidelines apply to mining or mineral processing operations where the disposal of tailings occurs. Tailings are considered to be the finely ground material produced as a waste slurry from mineral processing activities. These guidelines do not apply to overburden dumps and mineral leaching facilities.

4. Regulatory requirements

The Department of Minerals and Energy (DME), through administering the *Mining Act 1978, Mining Act Regulations 1981, Mines Safety and Inspection Act 1994* and *Mine Safety and Inspection Regulations 1995*, governs safety and environmental aspects of tailings disposal in Western Australia. All tailings storage facility proposals should be documented and the facility constructed as per DME *Guidelines on the Safe Design and Operating Standards for Tailings Storages* (March 1996) and submitted to DME for review. The submission should include aerial photographs showing the location of surrounding land uses and land features.

DME initially reviews tailings dam proposals and refers them to the Department of Environmental Protection (DEP) for assessment. DEP may then refer the proposal to the Environmental Protection Authority for formal assessment and/or require a Works Approval (to construct) and a Licence (to operate) a storage facility. The DEP may also require a works approval for subsequent raising of tailings dams. Appropriate environmental conditions are attached to Works Approvals. The DEP or DME may seek advice from the Commission on projects that pose a threat to water resource quality.

Further advice can be obtained by contacting the DEP or DME.

5. Guidelines

5.1 Tailings disposal containment facility design and site assessment

a. Tailings are commonly disposed of in purpose-built containment dams, mined-out voids, valleys in overburden stripping or underground mined areas. Where possible a site should be selected where the natural ground exhibits a permeability of less than 10^{-9} m/s. Where this is not possible, an engineered lining system may be required to protect underlying groundwater resources. A hydrogeological and geochemical assessment should be conducted prior to disposal of the material to ensure that groundwater or void water quality will not be adversely affected.

b. Tailings facilities should not be constructed over watercourses, as these drainage pathways are often underlain by fractured rock zones that provide porous seepage paths to the external environment. To minimise unnecessary impacts on neighboring leases, the facilities should not be constructed on the boundaries of leases.

c. Tailings facilities may be above or below the ground surface. They may be paddock, plain, cross-valley, side-of-hill type structures or in-pit, depression type or complex structures. They are normally constructed with perimeter embankments to a maximum height dictated by ore reserves, geotechnical stability, local topographical constraints and rehabilitation requirements.

d. A water balance and hydrological assessment should be conducted to ensure that tailings containment and process water ponds provide:

- sufficient storage to handle incident rainfall runoff and other discharges from mine workings within their catchment without overtopping (for further information, see DME *Guidelines on the Safe Design and Operating Standards for Tailings Storages*);
- adequate protection of watercourses and groundwater from unacceptable contamination;
- freeboards and decants that are of adequate capacity (a 0.5 metre freeboard should be used except where facilities have been built on natural catchments, where 1.0 metre should be used);
- the interim storage of water does not compromise the stability of the storage facility.

e. The basic water balance calculation is:

Storage capacity = inflow – outflow

Items that should be included in the inflow calculations include:

- incident rainfall;
- catchment runoff;
- groundwater seepage;
- tailings volume;
- process water;
- other process wastes and liquid inputs.

Items that are considered in the outflow include:

- evaporation;
- seepage through walls or base of the facility;
- controlled water drainage
  - underdrains
  - retained pore water in tailings
  - reclaim to process plant
  - decant.

The difference must be taken up by storage within the containment. The storage must provide for:

- tailings;
- process water in circuit;
- design storm or wet season floodwater.

f. It is important when determining the water balance that consideration be given to climatic variations. A wet-season water balance can differ markedly from water balances conducted at other times of the year.

g. The containment facility should be designed to account for potential adverse chemical reactions within the tailings mass.

h. Tailings infrastructure (e.g. pipelines, pumps, decant ponds, bunding) should be designed so that any spillages are contained, vegetation is protected and the beneficial use of water resources is not compromised.

i. The need for suitable lining or drainage to manage leachate should be assessed after hydrogeological studies have been conducted at the initial planning stage.

j. Underdrainage structures incorporating perforated pipework, filter sock and coarse graded rock surround should be considered to assist tailings consolidation.

k. Detailed design should be carried out by suitably qualified and experienced engineers. The Department of Minerals and Energy, Western Australia, (DME) provides guidance on the design, construction and operation of tailings storage in their publication *Guidelines on the Safe Design and Operating Standards for Tailings Storages*.

5.2 Operation

a. Operation planning should ensure that:

- all uncontaminated stormwater runoff not incident on the tailings facility is diverted away from the area;
- rainfall incident on the tailings facility is safely managed;
- there is efficient filling to maximise consolidation and storage of tailings;
- the transfer and reclaim of process water is optimised;
- regular monitoring and maintenance of the facility is conducted and logged;
- competent material is used for any sequential raising of the dam wall.

b. Commitments on the above should be contained within an environmental management plan and operational procedures for the site.

c. To facilitate quick stabilisation of tailings, management of tailings should involve:

- separating process water from tailings as soon as possible;
- allowing tailings the opportunity to dry before the next application;
- allowing tailings to consolidate;
- preventing the forming of thick deposits of unconsolidated slime or salt crust.

d. Tailings pipelines not equipped with automatic cut-outs in the event of pipe failure should be suitably bunded and capable of containing any spill for a period equal to the time between routine inspections. The pipelines should not be buried, as this precludes visual inspection.

e. Decant or return water ponds should be lined with a low permeability liner, e.g. high-density polyethylene (HDPE), with an alarm system that will alert plant operators to any potential overflow.

f. Uncontrolled seepage through external embankments or beneath the base layer should be minimised. This can be achieved by:

- use of clay cores within embankments, compacted clay or synthetic liners in base;
- foundation grouting and the use of cut-off trenches under embankments;
- controlled placement of tailings;
- inclusion of toe drains and underdrains to collect, treat and recycle seepage;
- sealing all exploration drill holes with grout or bentonite;
- preventing accumulation of water near the embankment by controlling the top water level of the tailings facility.

g. Seepage through designed permeable walls and bunds should be captured by perimeter drains that feed containment dams that have been sized accordingly.

h. The land area (footprint) covered by tailings should be minimised by ensuring that such land has been used to its reasonable maximum capacity for tailings disposal before rehabilitation.

i. Coarse tailings should be deposited against embankment walls to minimise the likelihood of erosion through wave action. Coarse tailings can also be used as a foundation for increasing the height of the upstream embankment. Tailings slurries should be managed to drain via shallow beaches to a decant structure remote from dam walls.

j. Tailings facilities should not be used as standby 'water storages' for process water or balancing storages. Water from rainfall and tailings slurries should be decanted as soon as possible.

k. Fines (slimes) should be removed from the process water by sedimentation and/or filtering prior to re-use or discharge of water.

5.3 Accidents and Emergencies

There should be a contingency plan for accidents and emergencies. The plan should allow alternative storage arrangements for substances harmful to the environment. It should include:

- Defined chain of responsibility for dealing with abnormal operating events;
- Plan for installing and maintaining a warning system;
- Process for minimising adverse impact of emergency events on the environment;

- Allow for process of back up equipment to deal with emergencies;
- Plan to train staff to deal with emergency events;
- Protocol for alerting response personnel and key external agencies of details of the emergency and the remedial steps planned.

5.4 Monitoring

a. The operation of tailings disposal facilities should be monitored for seepage. Monitoring should cover all elements that are critical to the operation and safety of the facility. An effective monitoring system requires geotechnical understanding of the tailings being stored, the design of the facility, seepage migration potential, groundwater flow conditions, potential interaction of the leachate with the soils, and the most probable and significant pathways of potential migration of leachates. **For comparative purposes sampling should be conducted at baseline points before tailings deposition occurs** and at background points in areas not expected to be affected by leachates. Monitoring may include:

   - Piezometers to monitor water levels to assess dam stability;
   - Bores for monitoring groundwater quality (for further information see the Commission's *Water Quality Protection Guidelines No. 4 – Installation of groundwater monitoring bores* and *Water Quality Protection Guidelines No. 5 – Minesite water quality monitoring)*;
   - Bores to allow early detection of unacceptable seepage (bores should be constructed at an appropriate distance and spacing from the facility wall);
   - Interceptor drains along the downstream toe to monitor seepage and leakage rates;
   - Subsoil drainage systems (where installed).

b. The frequency of monitoring will vary depending on the situation of each tailings dam. As a general guide:

   - The dam wall and associated pipework should be routinely inspected for leakage/seepage and its integrity checked on a daily basis.
   - Monitoring bores should be sampled at least quarterly for key water quality indicators associated with a particular mineral process.
   - Where anomalous analytical results occur, the site should be immediately retested/resampled to confirm the validity of the result.
   - The DEP requires vegetation monitoring around tailings storage facilities. Monitoring should be undertaken quarterly using techniques such as photography, aerial surveys and vegetation mapping.

5.5 Reporting

The DEP and DME require annual reports on the performance of the tailings facility. A single report may meet the requirements of both agencies.

5.6 Decommissioning

Tailings storage facilities should be rehabilitated in such a way that they are able to be:

- non-polluting;
- structurally stable;
- resistant to erosion;
- revegetated.

6. Useful references

Some components of these guidelines have been based on work already undertaken and reported in the following publications:

1. Department of Minerals and Energy (1996). *Guidelines on the Safe Design and Operating Standards for Tailings Storages*, DME, Perth.
2. Department of Minerals and Energy (Queensland) (1995). *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland*, DME, Brisbane.
3. Department of Minerals and Energy. (1997). *Draft Guidelines for the Development of an Operating Manual for Tailings, Storage*, November 1997, Perth.
4. Environment Protection Agency (1995). *Best Practice Management in Mining - Tailings Containment Module*, Commonwealth of Australia, Canberra.

Glossary and Abbreviations

1.	Beneficial use	Existing or proposed use of any portion of the environment which is: (a) conducive to the benefit, convenience, welfare, amenity, safety, health or aesthetic enjoyment of the public and which requires protection; (b) so declared under an approved policy.
2.	Bentonite	A clay-type material which is usually highly colloidal and plastic which swells and shrinks with changes in water content. Used to reduce seepage in mines and channels and also is a major component of drilling mud.
3.	Decant water	Water removed from the surface of tailings storage facilities after the solids have settled.
4.	Freeboard	The vertical distance between the maximum level in a dam and the top of the side walls, provided to prevent the contents of the dam from being blown over the walls in a high wind.
5.	Geochemistry	The determination of the earth and its parts and the laws which control the distribution of its individual elements.
6.	Geotechnical stability	Engineering properties of soil, incoherent rock and tailings materials that determine the stability of a tailings dam.
7.	Grout	A fluid mixture of cement and water of a consistency that can be forced through a pipe and placed as required. Various additives such as sand, bentonite and hydrated lime, may be included in the mixture to meet certain requirements.
8.	Grouting	The operation by which grout is placed between the casing and the sides of the well bore to a predetermined height above the bottom of the well. This secures the casing in place and excludes water and other fluids from the well bore.
9.	Hydrogeology	The geological science associated with the occurrence, distribution, movement and quality of groundwater.
10.	Hydrology	The characteristics, occurrence, movement and utilisation of water on and below the earth's surface and within the atmosphere.
11.	Leachate	Groundwater that contains material removed from the soil through the percolating process.
12.	Liner	A synthetic or non-synthetic material used to contain hazardous substances which might otherwise degrade water resources.
13.	Permeability	The capacity of a porous rock, sediment or soil for transmitting a fluid when subjected to unequal pressure.
14.	Piezometer	A tube or pipe used to measure water-level variations in a aquifer.
15.	Rehabilitation	The restoration of disturbed ground to a condition which applied prior to development of the site or as agreed with regulatory authorities.
16.	Topography	The description or representation on a map of all the surface features of an area, natural and artificial.

Further enquiries

Any project where the proponent/operator is unable to comply with these guidelines, or where site conditions prevent their application, should be submitted to the Commission as early as possible in the development of the proposal so that the matter may be resolved.

Any queries relating to the **content of these guidelines** should be directed to:

Program Manager Assessment and Advice
Water Quality Protection Branch
Water and Rivers Commission
Level 2, Hyatt Centre
3 Plain Street
EAST PERTH, WESTERN AUSTRALIA 6004
Phone (08) 9278 0300
Fax (08) 9278 0585

For further enquiries on any matter relating to the **management of water resources**, please contact the Water and Rivers Commission's regional offices.

Swan-Goldfields-Agricultural Regional Office
849 Albany Highway
VICTORIA PARK WA 6100 Phone (08) 9362 0555 Fax (08) 9362 0500

Or
254 Fitzgerald St
NORTHAM WA 6401 Phone (08) 9690 2821 Fax (08) 9622 7155

North West Regional Office
Chiratta Road
KARRATHA WA 6714 Phone (08) 9144 2000 Fax (08) 9144 2610

South West Regional Office
U2 Leschenault Quays,
Austral Parade
BUNBURY WA 6230 Phone (08) 9721 0666 Fax (08) 9721 0600

Or
'Sholl House'
21 Sholl St
MANDURAH WA 6210 Phone (08) 9535 3411 Fax (08) 9581 4560

Mid-West Gascoyne Regional Office
Pass Street
Geraldton WA 6530 Phone (08) 9964 5978 Fax (08) 9964 5983

South Coast Regional Office
5 Bevan Street
ALBANY WA 6330 Phone (08) 9842 5760 Fax (08) 9842 1204

These guidelines are also available from the Water and Rivers Commission's web page at:
http://www.wrc.wa.gov.au/protect/policy/

Other related guidelines in this series include:

WATER QUALITY PROTECTION GUIDELINES NO. 1
Water quality management in mining and mineral processing: An overview

WATER QUALITY PROTECTION GUIDELINES NO. 3
Liners for waste containment

WATER QUALITY PROTECTION GUIDELINES NO. 4
Installation of minesite groundwater monitoring bores

WATER QUALITY PROTECTION GUIDELINES NO. 5
Minesite water quality monitoring

WATER QUALITY PROTECTION GUIDELINES NO. 6
Minesite stormwater

WATER QUALITY PROTECTION GUIDELINES NO. 7
Mechanical servicing and workshop facilities

WATER QUALITY PROTECTION GUIDELINES NO. 8
Laboratory waste discharge

WATER QUALITY PROTECTION GUIDELINES NO. 9
Acid mine drainage

WATER QUALITY PROTECTION GUIDELINES NO. 10
Above-ground fuel and chemical storage

WATER QUALITY PROTECTION GUIDELINES NO. 11
Mine dewatering