Management of Tailings Storage Facilities

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Introduction

1. BACKGROUND

The Earth Resources Regulation Branch (ERR) of the Victorian Department of Economic Development, Jobs, Transport and Resources - Earth Resources (the department) is responsible for regulating the minerals, petroleum and extractive industries in Victoria and its offshore waters, including Commonwealth waters. It manages the administration of the Mineral Resources Development Act 1990 (MRD Act) and the Extractive Industry Development Act 1995 (EID Act).1

This document sets out departmental policies and provides guidelines for the management of tailings from mining or extractive industries in Victoria. Appendix I summarises the guidelines, Appendix II outlines the administrative process for obtaining a Work Authority and Appendix III lists the main documentation required by the department for the approval and operation of a Tailings Storage Facility (TSF).

Tailings comprise deposits of fine-grained residues from mining, processing and extractive operations. Management of tailings is one of the main environmental issues to be addressed by the mining and extractive industries, particularly the goldmining sector where the tailings often contain cyanide.

Most tailings dams in Victoria are relatively small and significant environmental incidents associated with the management of tailings have been rare. However, in recent years a number of serious environmental incidents have occurred at mines in other parts of the world. The lessons learned from these incidents highlight the need for a clear regulatory framework to ensure the ongoing safe and environmentally responsible management of tailings.

The department is of the view that, wherever possible, the management of tailings should be objective based. It recognises, however, that the community must have confidence in the regulatory system and would expect prescriptive measures for a number of key areas to ensure that risks have been addressed. In addition, for objective based measures to be acceptable, they must be subject to periodical audit by the department or another independent expert.

Wherever possible, the guidelines enable flexibility in approaches to allow innovation in tailings management and to accommodate variations between sites in the physical, technical and social environments. The overall aim is to encourage the adoption of the best industry standards and practice in tailings management and to minimise the cost of the operations to current and future generations.

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.

Early planning and development of an appropriate tailings management strategy is essential to the success of the overall project. In particular, proponents for tailings dams will be required to demonstrate that other options have been fully considered. Proponents are therefore encouraged to discuss their proposals at an early stage with the Minerals and Petroleum Regulation Branch.

2. TAILINGS

Tailings from the mining and extractive industries are most commonly fine-grained or finely ground materials left over from such processes as:

- the crushing of ore or other processes for extraction of metals or other valuable minerals;
- upgrading of ore or coal by removing unwanted materials;
- washing of sand, clay and coal;
- burning of coal or blast furnace operation (ash or fume);
- chemical reactions as part of a process (as for gypsum) and

- preparation of construction materials.

In Australia, tailings are usually transported to, and discharged into, a TSF as slurry. The impoundment structure of a TSF, or tailings dam, has many similarities to a conventional water-holding dam although there are important differences in terms of the way the dam is constructed and its contents.

Tailings are chemically similar to the parent material, but the presence of process reagents, evaporation of water and weathering after deposition may significantly change their properties. All tailings have been subjected in some way to physical and/or chemical separation processes, such as flotation, cyanidation or acid leaching.

A TSF may therefore contain constituents that require careful environmental management, particularly as the pore fluid may include a variety of metals, chemicals, salts or radioactive materials. In arid regions the process water may also be saline or hypersaline. Further information on the nature of tailings can be found in ANCOLD (1999) and Environment Australia (1995).

The most common adverse characteristics of deposited tailings in Victoria are likely to be:

- remnant cyanide;
- high pH;
- sulphide minerals which, through oxidation, have the potential to generate acid and consequently mobilise heavy metals;
- elevated arsenic levels;
- highly saline pore water and
- colloidal clays.

Deposition of tailings in a TSF may be subaqueous (below water) or sub-aerial (above the water line on the ground or on a 'beach' formed by tailings). Other techniques include the production of pastes and disposal in-pit or underground. Tailings can also be deposited in conjunction with waste rock or other materials; a technique referred to as codisposal. Another technique is dry stacking. Appendix VI discusses the nature and construction of TSFs.

3. APPLICATION OF THE GUIDELINES

These guidelines aim to ensure that tailings management in Victoria is environmentally sensitive and safe. To that end, they seek to ensure that a TSF is:

- safe, both during its operating life and after closure;
- managed to minimise waste generation;
- managed to minimise environmental pollution and
- rehabilitated and revegetated after closure to minimise long-term risks to the environment, social impacts, future land use and visual amenity.

Although separate Acts and Regulations govern mining and extractive activities in Victoria, the administrative requirements and processes are similar. Accordingly, while the focus of these guidelines is on tailings from the mining sector, it is intended that many aspects of the guidelines should also be applied by the extractive industries.

TSFs are not relevant to oil or gas production. Further, although coal extraction is governed by the MRD Act, the tailings-like waste stream (ash) from coal burning for power generation is not. Ash disposal is subject to licence under the Environment Protection Act 1970 (EP Act).

The various Acts and Regulations relevant to tailings management in Victoria are set out in Appendix VIII.

The discharge of mining wastes to land contained within an approved mine or quarry site is regulated under the EID Act and MRD Act and is exempt from Works Approval and Licensing under the Environment Protection (Schedule Premises and Exemptions) Regulation 1996, Appendix VIII). However, any external discharges from a mine or quarry is regulated by the EP Act (1970).

A range of approaches to the management of tailings has been adopted around the world in response to jurisdictional legislation, climatic and geomorphological constraints and historical experience. These guidelines are framed in the light of contemporary methods of tailings management in Victoria. They are not intended to constrain innovative proposals and are intended to encourage best practice and continual improvement. However, disposal techniques involving the submarine placement of tailings, or any uncontrolled placement of tailings in natural waterways, are considered unsuitable and the department cannot foresee the circumstances in which this would be permitted in Victorian waters. Accordingly, these guidelines do not address such activities.

The guidelines are intended to apply to TSFs of all sizes. However, for the purpose of application of the policy requirements set out in the following sections, the guidelines discriminate in a number of cases between 'small' and 'large' TSFs. These are categorised as follows.

Large TSFs are those:

- with an embankment of 5 m or higher and a storage capacity of 50 ML or more;
- with an embankment of 10 m or higher and a storage capacity of 20 ML or more;
- with an embankment of 15 m or higher, regardless of storage capacity or
- where the combined storage capacity of all TSFs on the site is greater than 50 ML.

The height of the embankment should be determined from its maximum height above natural surface.

Small TSFs are those which do not meet or exceed the above criteria.

TSFs storing contaminated tailings must meet the same requirements as large TSFs.

For the purpose of these guidelines, tailings are classified as contaminated if they contain, or are predicted to contain, concentrations of contaminants exceeding those levels specified in *Definitions and Acronyms*. Tailings that do not exceed these criteria may exhibit low level contamination.

Departmental Policies and Requirements for Tailings Management

A. GENERAL

4. WORK PLAN

Both the MRD Act and the EID Act require a Work Plan to be lodged and approved before construction or operation of a TSF can commence. Where a TSF is part of a larger mining or quarrying proposal, the Work Plan requirements described in these guidelines may be addressed as part of the Work Plan for the overall project. However, where a TSF is proposed as supplementary work on an existing site, outside the provisions of the current work plan, the operator must submit an appropriate Work Plan variation. Proponents should also ensure that appropriate planning approval is obtained where required.

Appendix II sets out the application and approval process.

A Work Plan should include plans for:

- the development of the proposed operation
- and associated infrastructure;
- occupational health and safety;
- environmental management and closure and rehabilitation works.

The Work Plan documentation for a TSF should include:

- the design plan;
- details about the proposed management of the tailings and water;
- plans for the minimisation of impacts on native vegetation;
- plans for environmental monitoring and for managing rehabilitation, risks and emergencies, and
- plans for the intended end-use of the TSF site.

Appendix III describes the site information usually required in a Work Plan for a TSF.

The **Environmental Management Plan** is part of the Work Plan. For a TSF, it should include proposals and processes for monitoring standard environmental parameters, principally the groundwater and nearby surface water, and show compliance with the Acts and Regulations relevant to water management at the site. It may also require elements to address other significant risks identified for the particular site, such as impacts on flora and fauna or the generation of dust or odour. Monitoring is discussed in Section 16 of these guidelines.

The Risk Assessment and Emergency Response Plan are also important elements of the Work Plan for a TSF. These are discussed in Sections 7 and 8 of these guidelines.

Work Plan

Proponents should ensure that the Work Plan for a TSF contains the details required by either the *Mineral Resources Development Regulations* 2002 (for a mine) or the *Extractive Industry Development Regulations* 1996 (for a quarry), and those set out in these guidelines and Appendix III.

5. PLANNING APPROVAL

In addition to the departmental Work Plan requirements, the proponent for a TSF may also need to apply to the Responsible Authority (usually the local municipality) for planning approval under the Planning and Environment Act 1987.

Where a proposed TSF represents a minor variation to a pre-existing operation, the proponent should confirm with the Responsible Authority whether further planning approval is required.

Where a proposed TSF has the potential for significant environmental impacts, approval via an Environment Effects Statement (EES) in accordance with the *Environment Effects Act* 1978 may be required.

For mining projects, approval via an EES precludes the need to seek approval by way of a Planning Permit.

The approval process is set out in Appendix II and the provisions of the Acts are summarised in Appendix VIII. Proponents requiring further information about planning permits or EES requirements should consult MPD.

In addition to work plan and planning approval, a project may require approval under the *Commonwealth Environment Protection and Biodiversity Conservation Act* (1999).

This Act protects matters of 'national environmental significance'. A proponent is required to determine whether the Act applies to their proposal. Proponents who are seeking approval, or who are unsure about whether approval is required, should contact the Department of the Environment and Heritage.

Planning approval

The Proponent for a TSF should ensure that appropriate planning approval is in place.

Where a proposed TSF has the potential for significant environmental impacts, approval via an EES may be required.

6. CONSULTATION

Consultation is a process in which the proponent and the public are able to exchange information and views about a project, its potential hazards and approaches to address them.

The principal aspects of effective consultation include:

- identification of key stakeholders and other interested parties, and provision of information that is appropriate and timely for their needs and to facilitate their meaningful participation in the process;
- establishment of consultative processes to ensure ongoing engagement with the community and
- responding to community concerns in a transparent and effective manner.

Consultation before and during the design and operation of the TSF should be part of the broader consultative process associated with the mining or extractive venture. Structured community participation should also be undertaken should a major variation to a project be proposed. Effective consultation is an integral part of risk management and can provide benefits if it is undertaken in conjunction with monitoring and auditing.

It is also likely that Planning Permit or EES processes will require any project of significant scale to undertake consultation activities with local communities potentially affected by a proposed facility and other stakeholders.

Where a proposed TSF represents a minor variation to a pre-existing operation, consultation may not be necessary. However, proponents are advised to seek confirmation from MPD about this issue.

Consultation The proponent of a new TSF should undertake adequate consultation with the community and interested stakeholders.

Where a proposed TSF represents a minor variation to a pre-existing operation consultation may not be necessary. However proponents are advised to seek confirmation from MPD about this issue.

7. RISK MANAGEMENT

Risk management is about minimising safety, health, environmental and financial risks associated with the transportation and storage of tailings. Although, for the most part, they cannot be entirely eliminated without affecting the technical or economical viability of the overall operation, the risks must be managed to remain within acceptable limits.

Hazards associated with operation of a TSF may arise through:

- inadequate site security;
- structural failure;
- operational failure;
- equipment failure, and
- unforseen circumstances or consequences.

Deficiencies in design, management or operational practice, inadequate controls, unauthorised access, climatic events or geotechnical instability can reduce the safety margin.

For instance, the main threats to the stability of an artificial embankment are (EPA, 1995):

- overtopping by flood waters;
- Slope instability caused by high piezometric pressures;
- piping of fine-grained material during seepage and
- liquefaction of saturated fines during seismic activity or other vibration.

The more serious potential impacts associated with a TSF include:

- threat to human life, health or infrastructure;
- short-term and long-term pollution of ground and/or surface waters;
- raised groundwater levels resulting in salinisation of the surface and streams;
- the release of a large volume of water and semi-fluid tailings which smother vegetation, blanket the land surface and restrict stream flow with sediment;
- threat to health or life of wildlife, livestock or domestic animals;
- loss of significant native vegetation and
- generation of dust or odour.

It is incumbent upon the proponent or owner of a TSF to demonstrate that the immediate and long-term risks associated with tailings handling and storage are acceptable and to justify the design and operational decisions using conventional risk management techniques. Innovative solutions to the control or elimination of risks are encouraged.

Management of risks involves a structured and systematic approach that enables protective measures to be well targeted rather than either excessive or inadequate.

7.1 Risk assessment

Proponents of large TSFs or those storing contaminated tailings should undertake a formalised Risk Assessment as part of the Work Plan submission.

Risk assessment for a TSF should include a systematic assessment of the likelihood and consequences of identified hazards and encompass all aspects of its design, construction, operation and closure. The assessment should be reviewed regularly, based on the performance of the facility against its design parameters and the outcome of the annual Audit Report. Auditing requirements are outlined in Section 16.5

Key elements in the design of a large TSF or one storing contaminated tailings that require consideration in the Risk Assessment include:

- location;
- containment system;
- type of lift and
- cyanide management.

The responsibilities of the operator of a mine in identifying hazards and assessing the risks to health and safety Regulation 302 are set out in the *Occupational Health and Safety (Mines) Regulations* 2002. Proponents of potentially high risk TSFs in the extractive industries are also encouraged to consider these issues.

Risk assessment planning incorporates the following steps:

Risk analysis

a. Description of every element and phase of the equipment, infrastructure and operation and identification of the associated potential hazards.

b. Establishing the level of risk by a case by case analysis of those hazards to estimate the likelihood of an event occurring and its likely consequences.

Risk assessment

c. Establishment of the criteria under which a level of risk is acceptable.

d. Prioritisation of the hazards and identification of those where the risk exceeds, or has potential to exceed, the levels of acceptability.

Risk treatment

e. Development of response mechanisms to minimise the major risks. These could include accepting the risk or eliminating the hazard, avoiding the risk, reducing the consequences, reducing the likelihood or transferring the risk. Risk control measures should be carefully assessed to prevent unintended consequences.

f. Implementation of the established plan.

Follow-up

g. Monitoring of environmental indicators and the performance of the safeguards, auditing of the implementation process and the risk profile, periodic review and updating of the Risk Assessment.

Risk minimisation also involves:

- adoption of rigorous operational procedures that ensure compliance with the assumptions made in the design and
- correct implementation of performance monitoring procedures.

Risk analysis for a TSF should take into account such factors as the proximity of surface water and groundwater resources and their use.

However, irrespective of Risk Assessment results, TSFs must comply with relevant environmental legislation and policy, such as the State environment protection policy water quality objectives (EPA, 2003).

The processes involved in environmental risk management, and its applicability to the mining industry as a whole, is described more fully in Environment Australia (1999).

Risk Assessment

The proponents of a TSF should adhere to the principles of risk management and ensure that potential risks to the community, workforce and environment are minimised.

Proponents of large TSFs or those storing contaminated tailings should undertake a formalised Risk Assessment as part of the Work Plan submission.

Proponents of large TSFs or those storing contaminated tailings should also demonstrate that the provisions of the Emergency Response Plan are based on a comprehensive Risk Assessment.

Irrespective of Risk Assessment results, TSFs must comply with relevant environmental legislation and policy, such as State environment protection policy (SEPP) water quality objectives.

8. EMERGENCY RESPONSE PLAN

The consequences of a major failure at a TSF could be very serious. These may include contamination of waterways and potable water supplies, impacts on flora and fauna or even the loss of human life. Part of the documentation that is required for approval of any TSF is an ***Emergency Response Plan*** (ERP).

The ERP should be prepared on the basis of a worst case scenario and include procedures describing and prioritising such actions as protection of personnel, notification of emergency services and resource management agencies, advice to neighbours and immediate and longer term remedial actions. Implementation of such a plan could make a significant difference to the outcome of an accident. The ERP should make specific provision for the TSF but may be included as part of the ERP for the overall operation.

The scope and content of each ERP would depend on the size of the particular TSF and the identified hazards. For instance, the proforma safety emergency plan set out in Appendix V may be appropriate for small TSFs and could form the basis for a more comprehensive ERP for large ones.

An ERP should conform to the requirements for 'Emergency planning' as set out in Regulation 322 of the *Occupational Health and Safety (Mines) Regulations* 2002 and include, at a minimum:

- an assessment of persons (such as water diversion and groundwater extraction customers), property and environmental features at risk;

- actions to be taken appropriate to the scale of the emergency, including lines of responsibility (and names and contact details of nominated safety personnel), communications, and involvement of police and emergency services;
- details of any necessary evacuation procedure, including the location of assembly points, in the event of failure or impending failure;
- accessible advice to all personnel on site as to the nature of the emergency warning system or warnings and procedures to be followed and
- training and refreshment programs of safety procedures for all personnel involved.

An ERP should be produced in an appropriate format separate from the main body of the Work Plan for the TSF. The approved ERP should be kept in a prominent and accessible location at the operation centre of the mining or extractive operation and should be available to all staff and emergency services for use in the case of an emergency. A copy should also be forwarded to each of the emergency services likely to attend the facility.

Emergency Response Plan

A documented Emergency Response Plan (ERP) should be prepared specific to the TSF (but which may be included as part of the ERP for the overall operation) and kept in a prominent and readily accessible location at the operation centre.

8.1 Incidents

The safety of tailings storage operations can be enhanced through the sharing of experiences and knowledge about accidents and incidents. Systems already function in Victoria for the notification and dissemination of information on workplace accidents and environmental incidents.

TSF operators should make provision for immediate notification of incidents (including near-miss incidents) to the department for timely and rigorous investigation. The department will then circulate relevant information from the incident reports to other operators and jurisdictions as appropriate.

'Incidents' include:

- injury or death of personnel (whether legitimately on site or otherwise);
- injury or death of fauna (domestic or native) on or near the TSF;
- uncontrolled release of tailings or supernatant water (pipe breaks, overtopping of dam);
- major, unplanned, seepage (discernible impact on vegetation, soil contamination, groundwater accession) and
- defects in the structure of the TSF (cracking, slumping or significant erosion of the wall, faults in the decant system.

Incidents

Incidents and accidents associated with the management of tailings should be reported immediately.

9. WASTE MINIMISATION

Tailings are one of the principal waste streams in the mining and extractive industries. It is acknowledged that, although it may be possible to reduce the volume of tailings waste at some mines and extractive operations, avoidance or elimination of waste is not practicable in many cases.

It is also appreciated that, while drying or stabilisation of tailings can result in lower risks to the environment, they also add cost to the operation and could make some proposed operations uneconomic. Further, some technologies that offer promise for avoidance or elimination of waste, may introduce other environmental risks.

The proponent for a TSF should consider potential waste minimisation programs and reuse opportunities as an integral part of a submission for a tailings storage proposal.

Subject to the practicabilities offered by the nature of the materials involved and economics of the operation, the order of preference for managing waste should be:

1. Avoidance – processes or materials should be changed, where possible, to eliminate the generation of the waste;
2. Reuse – some wastes may be redirected to other uses such as underground backfill and packing sand;
3. Recycle – materials included in the waste may be suitable as feedstock for further processing such as in concrete or shot crete production;
4. Recovery of energy – wastes may be useful as fuel for energy production or substitution;
5. Treatment – it may be possible to make wastes innocuous by further treatment or processing;

6. Containment – secure storage of wastes in facilities that are isolated from the environment is often preferable to disposal and
7. Disposal – discharge of waste to the environment under controlled conditions and in a manner which does not cause environmental harm.

Waste minimisation

The proponent for a large TSF should provide an assessment of appropriate alternative waste management programs based on the principles of waste minimisation. The submission should include a description of the method and should consider practicability, cost and current industry best practice.

Proponents for small TSFs should consider the principles of waste minimisation in development of the TSF proposal. The department may request further analysis where it is considered necessary for the protection of the environment or reduction of risks to the community.

B. DESIGN

10. SITING OF A TAILINGS STORAGE FACILITY

One of the earliest and most important stages in the design of a TSF is the selection of an appropriate site.

Site selection often requires analysis of a number of competing factors, some of which may be subject to regulation. It may, for instance, be influenced by the potential impacts of the TSF on environmental, social,

cultural and landscape values or by local planning issues. Factors related to the site itself, such as the potential for flood or seismic activity, foundation conditions, availability of construction and rehabilitation materials, or the depth to groundwater, would also influence its selection. In turn, the chosen site may affect the overall cost: for example because of wall or lining requirements.

TSFs should be designed and located to have the smallest practical catchment. The advantages and disadvantages of siting a TSF in a valley or away from a waterway are discussed in Appendix VI. It should be noted, however, that it is departmental policy that a TSF with a significant upstream catchment will not be approved unless the proponent can demonstrate that environmental risks are adequately addressed and there are no practicable alternatives.

Matters that will be considered in assessing the proposal include:

- the area and nature of the catchment above the TSF;
- climatic conditions, such as peak flows from critical design storms and wet seasons;
- the long term stability of structures, such as stream diversions;
- location of domestic water supplies;
- effects of drainage works on downstream flow regimes, particularly flooding;
- landscape design and
- the planned rehabilitation outcomes.

Siting of a TSF

The proponent for a TSF should identify and investigate reasonable potential alternative sites and undertake realistic assessments of comparative risks.

Where a valley dam is the only practicable alternative, the proponent should demonstrate that all environmental risks have been identified and are adequately addressed.

TSFs should be designed and located to have the smallest practical catchment.

11. TAILINGS STORAGE FACILITY DESIGN

TSFs are tailored to the particular site, the mineralogy and treatment of the raw material and the desired ultimate landform. The primary design objectives outlined by the

Australian National Committee on Large Dams are (ANCOLD 1999):

- the safe and stable containment of tailings;
- the management of decant and rainfall runoff;

- the minimisation or control of seepage;
- a cost effective storage system and
- a planned system for effective closure.

The design should be adequate for the proposed use, meet contemporary standards and have identified and addressed all the likely risks associated with the site, the nature of the containment materials, the nature, quantity and treatment of the tailings, construction process and closure.

The design of large TSFs should be based on appropriate standards and principles such as those outlined in 'Guidelines on Tailings Dam Design, Construction and Operation' (ANCOLD 1999) and 'Guidelines on Selection of Acceptable Flood Capacity For Dams' (ANCOLD 2000) and subject to adequate Risk Assessment. For small TSFs (not storing contaminated tailings), appropriate design criteria can be found in the guide to managing the safety of farm dams – *Your dam, your responsibility* (NRE 2002).

The Design Plan of large TSFs, and those of any size that will store contaminated tailings, should be undertaken and certified by a suitably qualified and experienced person (*Definitions and acronyms*).

The designers should clearly define the parameters and assumptions that are made in the design process and develop an appropriate design response. The designer should specify any particular requirements for ensuring the ongoing stability of the embankment including monitoring programs. The designer should submit Design Certification to the department that the plans meet appropriate engineering and safety standards and are consistent with these guidelines The design should include a description/specification of what parameters and methods should be used in construction monitoring to verify the design assumptions.

Where a proponent can demonstrate that they meet criteria (b) to (g) of a suitably qualified and experienced person the department may allow for internal design of the TSF. However independent certification of the design, by a person fulfilling all the criteria of the above definition, will be required.

Proponents should demonstrate that the most appropriate disposal method has been selected. Alternatives to wet storage systems for tailings discharge are encouraged. This is particularly important if the nature of the tailings materials may compromise final rehabilitation (such as slimes that will not dry successfully). In such cases proponents of large TSFs will be required to show that alternatives to wet deposition have been examined and to justify its use if no alternative is proposed.

Contemporary types of TSF and their construction are described in Appendix VI. Construction of a conventional dam style TSF usually involves an initial embankment with subsequent lifting of the dam crest as the need arises. Proponents should specify the type and number of lifts at the time of initial design and display control of any risks associated with the design.

Proponents should avoid the use of tailings to construct the dam embankment, because of the nature of tailings and the climate in Victoria. This is particularly important in high rainfall areas or for large TSFs. A Risk Assessment will be required where it is proposed to use tailings for dam embankment construction.

Proponents must submit the design of the TSF to the department for approval. The relevant details of the planned operation should also be entered on the Tailings Storage Facility Data Sheet (Appendix IV), which should be presented with the design.

TSF design

The proponent of a large TSF using wet deposition should demonstrate that this method is the most appropriate for the site and that alternatives have been examined.

Design Plans for large TSFs and those TSFs storing contaminated tailings, should be prepared by a suitably qualified and experienced person who should submit the design as well as Design Certification to the department that the plans meet appropriate engineering and safety standards and are consistent with these guidelines.

Where a proponent can demonstrate that they meet criteria (b) to (g) of a suitably qualified and experienced person the department may allow for internal design of the TSF. However independent certification of the design, by a person, fulfilling all the criteria of the above definition will be required.

11.1 Design for water management

Good water management is critical to the safety of the TSF and the quality of the final outcome. The design of a large TSF should display a quantitative water balance of all gains and losses (Appendix III and VI) and satisfy the 'worst case' combination of risk factors (e.g. full TSF, wave action, design storm, breakdown of decant process).

Water design requirements for TSFs including freeboard and emergency spillways are specified in Appendix VII. These are adapted from criteria outlined by ANCOLD (2000).

Proponents of small TSFs containing benign or low level contaminated tailings and without an external catchment may choose to adopt the requirements outlined in NRE (2001). In this case the TSF must be sufficient to contain the waste inputs and rainwater during a one in ten year wet year and still retain a minimum one metre freeboard.

Large TSFs, TSFs with external catchments or TSFs storing contaminated tailings must provide assessments to demonstrate that the TSF has the capacity to meet the requirements of Appendix VII. To this end, the catchment size should be as small as practicable as runoff from the rain falling on the surrounding land surface as well as that within the TSF are to be accounted for. Runoff calculations should be made in accordance with appropriate methods as outlined in IEA (1998) and Bureau of Meteorology (BOM, 2003).

Most TSFs in Victoria are designed to have no discharge. However, appropriately designed emergency spillways are required for all new large TSFs or any TSFs storing contaminated tailings to deal with the exceptional circumstance where there is a risk of embankment failure.

The spillway should be designed and maintained to the peak flow from the storm event (Appendix VII) without damage to the embankment and infrastructure. The spillway should lead to an emergency overflow dam, which is kept empty during normal operations.

The department and the EPA must be notified prior to the commencement of the emergency discharge and implementation of the ERP may be required.

Where sub-aerial deposition (in which final rehabilitation requires drying of the tailings mass) is proposed in a large TSF, the design should include decant or water recovery facilities to minimise the amount of supernatant water in the dam at any one time.

Alternatively, the proponent should demonstrate why a decant or water recovery facility is not required and that risks have been adequately addressed.

The type of water decant system used and, particularly, the location of any decant pond may influence the stability of the embankment. Where upstream lifts are proposed, the decant pond, should be situated away from the outer wall of the TSF to reduce both the degree of saturation of the embankment materials and the piezometric levels.

Where diversion of clean runoff water around a TSF is required, works should be carefully designed to prevent downstream impacts such as erosion or siltation. Design of diversion works should be based on site specific hydrological data.

Design for water management

The design of a large TSF or one storing contaminated tailings should display a quantitative water balance of all gains and losses.

Large TSFs or ones storing contaminated tailings should comply with the water design requirements specified in Appendix VII.

Emergency spillways are required for all new large TSFs and all new TSFs storing contaminated tailings. The spillway should lead to an emergency overflow dam, kept empty during normal operations. Where sub-aerial deposition is proposed in a large TSF, the design should include decant or water recovery facilities.

Where sub-aerial deposition is proposed in a large TSF, the design should include decant or water recovery facilities.

11.2 Seepage Containment

TSFs must be designed to ensure that the beneficial uses of groundwater and surface water are protected and to prevent other undesirable impacts such as waterlogging and land salinisation.

Although the permeability of deposited tailings sediment is often low and they may have the capacity to quickly attenuate contaminants, some seepage from TSFs, both during the deposition phase and after decommissioning, is inevitable. Where seepage may contain contaminates it must be minimised to levels that will not cause groundwater or surface water pollution.

Seepage may be controlled by the installation of a liner and/or adequate under drains. Proposed under drainage systems should be subject to appropriate Risk Assessment. In some cases, an external seepage collection system may be required.

Where tailings are inert (e.g. small mines and extractive industry) and the underlying substrate provides a firm, low permeability foundation, seepage rates may be of little concern and a liner may not be required. However all proposals for TSFs should demonstrate that the proposed design is appropriate to the particular circumstances. As specified in section 7.1, a documented Risk Assessment is required for the design of a large TSF, or one storing contaminated tailings. This should consider not only the chemical composition of the seepage but also whether the seepage has the potential to cause or exacerbate waterlogging and land salinisation.

In the mining industry where tailings often contain cyanide, heavy metals or other undesirable constituents, seepage rates usually need to be managed by the installation of a suitable liner and often an under drainage system. A number of options for liner construction are available including clay and artificial liners or a combination of both.

Where a liner is required for a large TSF or one storing contaminated tailings, the Risk Assessment process should be used to specify an appropriate design permeability and liner thickness. The Risk Assessment should include consideration of the:

- potential rate of seepage under and through the embankment and the base of the TSF;
- predicted chemical composition of seepage;
- predicted physical and chemical properties of the tailings;
- characteristics of the underlying substrate, and
- potential impacts on the beneficial uses of groundwater and surface water systems.

TSF design proposals incorporating a clay liner should specify a minimum thickness for the liner, taking the following factors into account:

- the thickness required to ensure construction is practicable given the need to compact in layers and minimise the development of preferential pathways;
- the applicability of assumptions about the degree of compaction to be achieved and the extent of homogeneity in the liner material;
- the permeability of the underlying substrate;
- the expected permeability of the emplaced tailings and
- the risk of the liner integrity being compromised by cracking or mechanical damage while tailings are being deposited or prior to commencement of deposition.

As stated above, the primary objective of TSF design is assurance of an appropriate level of containment for tailings. For TSFs storing contaminated tailings (Definitions and Acronyms), the department requires that the standard of containment is at least equivalent to a constructed liner of 0.6m thickness of clay, with a permeability of 10-8m/s.

In some cases, the containment system proposed for a TSF storing contaminated tailings, may include artificial liners or incorporate a low permeability substrate or tailings mass. Where this is the case, the proponent must demonstrate that the proposed system provides the required level of containment. The department may consult other relevant agencies before determining whether to approve such proposals.

Seepage Containment

TSFs must be designed to ensure that the beneficial uses of groundwater and surface water are protected and to prevent other undesirable impacts such as waterlogging and land salinisation.

Where a liner is required for a large TSF or one storing contaminated tailings, the Risk Assessment process as outlined in section 7.1 should be used to specify an appropriate design permeability and liner thickness.

For those TSFs storing contaminated tailings, the standard level of containment should be at least equivalent to 0.6 metre of clay with permeability no greater than 10-8 m/sec.

11.3 Design for closure

Most TSFs require large quantities of cover material for closure. Accordingly, the Work Plan should describe how the TSF is to be closed and the source of the cover material. A preliminary assessment of the geochemistry of the tailings, to identify any constituents with the potential to have an environmental impact, is fundamental to assessing requirements for closure.

The type and depth of cover are also influenced by the desired revegetation outcomes and future activities permitted on the closed TSF. These matters are discussed later in this document.

Design for closure

The Work Plan should describe how the TSF is to be closed and the source of the cover material. The design should account for the end use of the land, the nature of closure and the proposed rehabilitation.

12. MANAGEMENT OF CYANIDE

Sodium cyanide solutions are widely used in the mining industry for the recovery of gold and other non-ferrous metals. Industry favours cyanide because the technology is proven, well understood, and available at reasonable cost. However, cyanide is highly toxic and must be very carefully managed to minimise the associated risks.

Tailings containing toxic chemicals, such as cyanide, can often be treated to neutralise their toxicity. However, the processing costs must be weighed against the benefits. A further consideration is that cyanide compounds degrade rapidly in the environment. Potential technologies to replace cyanide exist but are not in wide use and are, in some cases, considered more hazardous.

The approach to be taken in the management of cyanide at a particular site is best determined by considering the hazards and risks applicable to the location. For example, the operator of a site close to wetlands that support a high waterbird population may consider the risk of bird mortality to be high. In such a case it may be appropriate to consider neutralisation of the cyanide or the erection of physical barriers to exclude the birds.

On the other hand, in a different location where large bird populations are unlikely, the normal operational concentration of cyanide may be considered acceptable. Similarly, the proponent of a TSF within a domestic or any potable water supply catchment would need to consider the risk of contamination of water supplies. In this case it is highly likely that neutralisation of cyanide would be required to adequately reduce the risk.

As indicated above, decisions about the management of cyanide depend on a number of interacting factors. A formal hazard identification and assessment approach is needed to determine the best approach. It is also essential that this assessment be undertaken in conjunction with Risk Assessments (section 7.1) for other elements of TSF design, such as location, water management and permeability, so that the outcomes are complementary.

Factors to be considered in relation to management of cyanide include:

- planned and possible discharge concentration and amounts from the plant to the TSF;
- potential impact on wildlife;
- risks to surface waters;
- risks to groundwater;
- risks to livestock and domestic animals and
- risks to people.

Controls that should be considered to mitigate the risks of cyanide include:

- reduction or elimination of the amount and concentration of cyanide in tailings;
- animal deterrents (acoustic or visible);
- physical barriers to access by animals to the supernatant water, such as fencing, mesh covers or floating barriers;
- decant systems or seepage control to reduce the surface area of the supernatant pond;
- more intensive site supervision and
- amendments to design criteria, such as structural design or deposition method.

In addition to the above requirements, operations that use cyanide must comply with the Occupational Health and Safety (Mines) Regulations 2002 regarding the protection of people in mines against risk.

Cyanide management

The proponent for a TSF shall provide a detailed and operation specific Risk Assessment for the management of cyanide tailings. The TSF design and management approach should ensure risks are adequately addressed.

C. CONSTRUCTION

13. CONSTRUCTION TO DESIGN

It is essential that construction of a TSF accords with the approved design and is carried out to a high standard of workmanship. Adequate supervision of the works is essential to ensure relevant factors are addressed.

A suitably qualified and experienced person should undertake supervision of the construction of large TSFs and those where contaminated tailings are to be stored.

'As Constructed' Reports detailing the construction of each lift should be prepared and retained to assist determination of the overall stability and the future life of the TSF.

The reports should include survey drawings of:

- the original ground surface contours inside and outside the TSF;
- the locations of test boreholes and pits (and details about their backfilling);

- the locations of the drainage system;
- the locations and profiles of any borrow pits inside the facility;
- embankment profiles and
- confirmation that the lining has been constructed to the required specifications.

The retention of Construction Records is essential for the effective monitoring of long term performance (MCMPR and MCA 2002).

Ground conditions should be properly monitored and appropriate remedial works undertaken where zones of higher permeability or lower structural strength are encountered in the substrate. This information should be included in the 'As Constructed' Report.

The embankment walls should be correctly keyed in. Some designs may rely on such technically complex features as grout curtains or geo-membrane liners.

The materials used should be appropriate and compatible with the rest of the design, emplaced to the correct compaction levels and gradient and produce an erosion resistant outer wall.

Where it is necessary to vary the design during construction of a large TSF, the operator should verify that the changes do not compromise the design objectives. The changes should be reviewed and endorsed by a suitably qualified and experienced person (such as the original designer).

The licensee is required to submit a detailed 'As Constructed' Report for each lift of any large TSF or one where contaminated tailings are to be stored, which confirms that construction complies with the design and sets out any modification to the design.

A suitably qualified and experienced person should certify the report.

Where a significant change to the design of a large TSF is necessary a revised design, prepared and certified by suitably qualified and experienced person, must be submitted to the department for approval.

A significant change in the design is one that would affect the Risk Assessment of the TSF.

Construction of a TSF

Upon completion of the initial construction of a large TSF or one that will store contaminated tailings, and upon the completion of each lift, the licensee should:

a) obtain certification from a suitably qualified and experienced person that the construction of the TSF 'as constructed' accords with the certified and approved Design Plans, and

b) submit the 'As Constructed Report' and the Construction Certification to the department.

When it is necessary to modify the design of a large TSF during construction, the licensee should:

a) determine if the modification is significant; b) obtain prior agreement to the modification from the person who certified the original design; c) if a significant change is proposed, submit a revised design to the department for approval certified by suitably qualified and experienced person; d) on completion, obtain certification from a suitably qualified and experienced person that the modification 'as constructed' meets appropriate engineering and safety standards and is consistent with these guidelines and e) submit the Modification Certification to the department.

The licensee of a small TSF should ensure that construction is undertaken in accordance with the design and to professional standards.

D. OPERATION

14. OPERATIONAL PHASE MANAGEMENT

Well planned operational practices can reduce long term costs and minimise risks to the environment. The Work Plan should set out the planned operational phase of the TSF. This should include planning for the systematic deposition of tailings, water and process chemicals in the facility. Although these processes are simple, minor variations in the way they are carried out can significantly impact on the outcomes.

To this end an Operations Manual, for utilisation by operational personnel, should be in place from the time of commissioning of the TSF. This should provide the basis for converting the objectives of the Work Plan into appropriate actions on the site.

The level of detail in an Operations Manual would be determined by the characteristics of the specific site. However, the manual should document all relevant operational procedures such as:

- roles and responsibilities;
- method for tailings deposition;
- water management and maintenance of freeboard (e.g Appendix VI and VII);
- inspection schedule and maintenance;
- dam safety and environmental monitoring;
- record keeping;
- reporting requirements and
- any additional requirements specified by the designer.

TSF personnel should have a detailed understanding of those aspects of the Operations Manual relevant to their day to day functions and responsibilities. The operations manual should be updated as required to reflect any significant changes in site conditions.

Operation An Operations Manual, for utilisation by operational personnel, should be in place from the time of commissioning of a TSF.

The manual should document all relevant operational procedures for the specific site.

TSF personnel should have a detailed understanding of those aspects of the Operations Manual relevant to their day to day functions and responsibilities.

15. PIPELINES

Most tailings management operations involve pumping and conveying of tailings and decant water by pipeline, discharge spigotting and, in some cases, separation or drying processes. All of these activities introduce a risk of accidental discharge as a result of failure of mechanical systems -such as broken pipelines or faulty control devices -or materials. Appropriate maintenance and replacement schedules for mechanical equipment are necessary for safe operation.

Tailings pipelines may be required to have control systems designed to shut the supply pump down if a no-flow condition is detected at the discharge end. This ensures that the tailings supply is stopped if a catastrophic failure occurs in the pipeline. These systems do not, however, eliminate the risk of a discharge event where a pipeline develops a serious leak but does not fail completely.

Most existing pipelines are constructed in trenches or between parallel bunds so that spillage is directed to dedicated catch dams. Escapes may still occur where liquid under pressure escapes as a jet at an elevated trajectory. Mechanisms to minimise the chance of such events include completely encasing the pipeline in a secondary sleeve or constructing covers over pipe joints.

Although the department does not specify particular measures for increased safety for tailings pipelines and other equipment, the proponent and operator should be able to demonstrate that the measures proposed and implemented reduce the risks to an acceptable level.

Procedures for pipeline inspections should form part of the Operations Manual.

Pipelines

Written records of inspection and maintenance of tailings pipelines and other tailings equipment should be maintained and made available for audit.

The proponent and operator should demonstrate that measures proposed and implemented to prevent accidental discharge reduce the risk of a discharge event to an acceptable level.

16. MONITORING, AUDITING AND REPORTING

Monitoring and auditing are essential management tools for the operation of a TSF. Where monitoring or audit indicates deficiencies in the Risk Assessment or risk reduction activities, there should be a clearly defined process for review of those measures.

Monitoring, auditing and reporting

A program for monitoring, auditing and reporting operational and environmental factors appropriate to the nature and scale of the operation should be included in the Work Plan for a TSF. The monitoring and reporting components of the program should be specified in the Operations Manual.

16.1 Monitoring

A site specific monitoring program should be developed for a TSF based on the key risks identified in the Risk Assessment process and on other known issues.

The monitoring program should ensure early detection of any unexpected impacts. It should also enable validation of the assumptions made in the Risk Assessment and indicate aspects of the operation where further risk analysis is warranted.

A program to monitor a large TSF or one storing contaminated tailings should:

- identify the scope of the program;
- define the objectives of the program;
- determine the indicators to be measured;
- select sample collection sites (for example, for surface and groundwater);
- determine the monitoring frequency (daily, weekly, monthly, etc);
- where necessary, establish a site based laboratory and/or select an appropriate testing laboratory (NATA registered);
- report results, particularly any that exceed specified limits and
- ensure that licensees are able to fulfil the requirements of Schedule 15 of the *Mineral Resources Development Regulations* 2002.

Monitoring

The Work Plans for all TSFs should include a site specific monitoring program based on the key risks identified in the Risk Assessment process and on other known issues, and a process for reporting outcomes to the community.

16.2 Safety monitoring of tailings storage facilities

Routine monitoring of a TSF dam is aimed at avoiding failure by giving early warning of any symptom of trouble so that timely maintenance can be carried out.

Further, a TSF is usually designed for particular tailings characteristics. Deviations from these particular characteristics (such as grading, density or chemical constituents) could influence the operating procedures and the performance of the facility.

Depending on the facility, features to be included in a safety monitoring program for a large TSF may include:

- seepage or leakage through the embankment;
- cracking, slips, movement or deformation of the embankment;
- erosion of the embankment;
- pond level;
- pond location (location of the pond against the embankment may pose particular problems);
- piezometric levels in embankments (to this end, knowing the location of the phreatic surface would assist);
- structural defects or obstruction in infrastructure (outlet pipes, spillway, decant system);
- borehole groundwater elevations;
- under-drain flow rates;
- obstruction or erosion of diversion drains and
- characteristics and consolidation behaviour of the tailings (enabling prediction of final settlement and refinement of design to suit the predicted conditions).

In preparing a safety monitoring program, proponents should also consider the provisions of ANCOLD (2003) guidelines on dam safety management.

Simpler but nevertheless systematic and effective monitoring programs can usually be devised for smaller TSFs based on the above features. The guide Your dam, your responsibility (NRE 2002) also provides useful information on safety surveillance of small dams.

Safety Monitoring of TSFs

Monitoring of TSFs should be tailored to the size and nature of the TSF and its contents and the associated risks identified in the Risk Assessment process.

Proponents should include an appropriate TSF safety monitoring program in the work plan including an Annual Audit as required by Section 16.5.

Operators of large TSFs should ensure that an inspection and review of dam safety is undertaken at least annually by a suitably qualified and experienced person.

16.3 Environmental monitoring

Work Plans for all large mining and extractive sites are required to incorporate a monitoring program to address key environmental issues and a process for reporting outcomes to the community. Environmental monitoring may also be required for TSFs at small mine or extractive sites depending upon the size of the TSF, type of tailings and the risks involved.

Properly designed, a monitoring program should assist the operator to run the mining or extractive operation and TSF efficiently and with minimum impact on the environment. The data produced can also help demonstrate performance to the community and should fulfil the reporting requirements of Schedule 15 of the *Mineral Resources Development Regulations* 2002.

The environmental monitoring program for the TSF should be incorporated into the overall Environmental Management Plan for the site.

Environmental aspects that may require monitoring include:

- impacts on surface water;
- impacts on groundwater quality;
- impacts on groundwater level;
- impacts on vegetation;
- impacts on fauna (birds in particular are susceptible to poisoning by drinking tailings supernatant water);
- impacts on aquatic ecosystems;
- generation of dust, noise or odour, and
- spray drift and its effects on the vigour of adjacent vegetation, where aerial sprays are used to enhance evaporation or to reduce dust.

Remedial action should be implemented if conditions are found to be outside the design or predicted parameters.

Groundwater is one of the most commonly monitored environmental aspects. A number of bores are usually installed at selected locations around a TSF to enable monitoring of both the level and quality of groundwater. A good understanding of the local groundwater environment and chemistry is necessary to ensure that bores are located in appropriate places and drilled to the correct depth. In some cases, multiple bores are required to intercept different aquifers.

It is also common to install shallow bores near dam walls to permit detection of any seepage that might occur. Where a TSF is constructed near surface watercourses it is also good practice to monitor upstream and downstream from the facility. Although, in most cases, no discharge is permitted, monitoring allows the operator to verify compliance and ensure that no contamination has occurred by any pathway associated with the TSF. Samples will need to be collected before, during and after the life of the operation.

Additional parameters to be monitored and the nature and detail of the monitoring would depend on the site-by-site Risk Assessment that would identify the critical hazards.

Factors that should be monitored following decommissioning of a TSF, and until the site is resumed by the land owner or land manager, are discussed later in this document.

Environmental monitoring

The monitoring program should address key environmental issues.

16.4 Monitoring of transfers

In accordance with Schedule 15 of the Mineral Resources Development Regulations 2002, the volumes and chemical characteristics of tailings and process water transferred to or from a mining TSF shall be monitored and included in the Annual Report as part of the normal reporting of the operation. Appendix IV Tailings Storage Facility Data Sheet, provides a reporting proforma.

The reports can provide an understanding of the characteristics of the waste stored in the TSF and may be important for future land management decisions. They could also provide the operator some insight into the degree to which application of the principles of waste minimisation has been successful.

Monitoring of transfers

The volumes and chemical characteristics of tailings and process water transferred to or from a mining TSF shall be monitored.

16.5 Auditing and reporting

Regular independent audits ensure that essential systems and procedures are maintained and improved where necessary.

Periodic operational audits also provide a valuable status report of actual performance of the TSF against the design parameters, expectations or assumptions. The records provide an ongoing history of the facility, which is vital on sites where frequent personnel changes occur, and assist with tailings management planning, wall lift scheduling and improvements to the overall operation.

The operator of a large TSF, or one storing contaminated tailings, should ensure that a suitably qualified and experienced person (preferably the original designer) implements an Annual Audit and review of the facility. This should confirm that the operations are consistent with the Work Plan and should assess the adequacy, applicability and implications of the program. The Annual Audit Report should be submitted to the department.

Periodic Audit and Review Reports should include the following:

- updated site plan;
- updated survey plan of the facility including cross-sections and contours of the embankment and tailings beach; including certification from a suitably qualified and experienced person that any construction (since the last report) meets appropriate engineering and safety standards and is consistent with the conditions set out in these guidelines;
- data on the engineering properties (including dispersion/erodibility tests) of any construction and lining materials actually used, comparison of performance against design criteria, and their sources;
- updated data on the properties of the tailings stored in the facility;
- reconciliation of the stored volume and densities of the tailings against the Work Plan;
- calculations of the deposition rate against capacity and of the remaining capacity in terms of time and volume;
- water balance data;
- climatic conditions over the period between reports;
- data from daily (routine inspections) and periodic monitoring during TSF operation for such factors as dust, odour and water management (where not otherwise required in the Schedule 15 report);
- A review of the results of the safety and stability monitoring done in accordance with Section 16.2;
- A review of the results of environmental and tailings transfer monitoring done in accordance with Sections 16.3 and 16.4;
- information on operation of diversion; drains, TSF capacity and freeboard and downstream areas during storms and wetter seasons;
- information on the location and depth of boreholes and the proposed monitoring program for boreholes;
- inspection and maintenance schedules for tailings pipelines and other tailings equipment;
- information on the conduct of the operations in terms of the risk assessment and
- planned operations for the next reconciliation period.

Auditing

The operator of a large TSF or one storing contaminated tailings should implement an Annual Audit and review of the facility to confirm operations are consistent with the Work Plan.

The Annual Audit should be undertaken by suitably qualified and experienced person, preferably the original designer.

For mining TSFs, the report on the Annual Audit should be submitted to the department accompanied by the Tailings Storage Facility Data Sheet (Appendix IV).

E. DECOMMISSIONING

17. OVERVIEW

Tailings material must be securely stored for an indefinite period and present no hazard to public health and safety or the environment. Therefore the closure of a TSF and rehabilitation works must be as inherently stable, as resistant to degradation and as consistent with the surrounding landscape as possible. The design should also seek to minimise maintenance or upkeep.

The nature of the tailings, the process by which they were deposited and the design for water recovery can significantly influence the costs and risks associated with closure of a TSF.

The diversity in materials and objectives makes it impractical to prescribe designs for TSF covers. Operators are encouraged to undertake research into cover designs and to justify the type proposed based on a case –by case analysis of the objectives and risks. Proposed designs will be assessed on their merits.

18. CLOSURE

18.1 Closure strategy

Early planning for closure of a TSF can reduce risks for both the community and operator and minimise costs at the end of the project's life. Most TSFs require large quantities of cover material for closure. Accordingly, a proponent must demonstrate in the initial Work Plan. how the TSF is to be closed and the source of cover material. Sometimes at the end of a project aspects of the initial Rehabilitation Plan will no longer be appropriate. In this situation a revised closure proposal, submitted, as a Work Plan Variation may be required.

Closing a TSF can involve a number of processes. In many cases stored tailings must be dried over a long period to enable the passage of earthmoving equipment. In some, significant engineering works may be required, such as the construction of a spillway and alteration of surface drainage, the provision of a layered dry cover or controls to establish a permanent water cover.

The progressive closure and rehabilitation of individual TSFs, or cells of TSFs, is encouraged, provided this is integrated into the overall closure strategy. Progressive closure provides the opportunity to monitor the success of reclamation strategies and to refine future programs in the light of operational experience (MCMPR and MCA 2002).

The potential environmental impacts of decommissioned TSFs include groundwater contamination, acid drainage and erosion of material by water and wind. While the threat of catastrophic failure is usually reduced due to the de-watered nature of the deposit, under certain circumstances it remains an important consideration.

The final landform design must be compatible with the form of containment or encapsulation of the tailings, the nature of the embankment materials, the needs of the community and the landowner, any legal requirements, climate, local topography and the level of management available after reclamation.

Closure

Plans for the closure of a TSF should be included in the initial Work Plan for the TSF.

The nature of closure of a TSF should be appropriate to the nature of the contents, the desired final landform and accord with community and landowner expectations.

Progressive closure and rehabilitation of individual TSFs, or cells of a TSF, is encouraged, provided this is integrated into the overall closure strategy.

18.2 Cover design

The characteristics of the particular tailings and the topographic, hydrogeological, geotechnical and climatic characteristics of the disposal site usually determine the appropriate cover design. Covers range from complex multilayers of earth and rock to those where only a relatively thin growing medium is required on the surface.

Where the tailings is, for example, sulphitic, it may be essential to exclude oxygen from the substrate, in which case the cover must include an anoxic layer or impermeable barrier. In those circumstances, water covers or designs incorporating an artificially high watertable are often used. Where the tailings are less reactive, impermeable layers may not be required but it may be necessary to install a layer of broken rock to stop capillary rise or to use a large volume of material in order to provide a sufficient depth of soil for root establishment. Typical covers for TSFs are described in EPA (1995).

Cover design

The proponent should demonstrate that the type and depth of cover proposed for closure of a TSF is suitable for the nature of the contained tailings, the proposed revegetation and subsequent management regime.

18.3 Revegetation

The type and depth of cover used in rehabilitation of a TSF are also influenced by the desired revegetation outcomes and future activities permitted on the closed facility.

In some cases large depths of soil and rock may be required to ensure adequate resources for tree growth, while, where the area is expected to return to pasture, less cover would be required. Caution should be exercised in revegetating with trees, however, as the cover or lining may be compromised by roots or when trees fall or are removed.

The potential for erosion of enclosures is also of concern, and the risk increases considerably where the area is used for intensive agriculture (cultivation) and with the steepness of the embankment. Even with less intensive agriculture, such as grazing, potential for erosion exists along frequently used stock routes and during drought.

In Victoria, the vegetative cover of a TSF is likely to be burned by wildfire at some time, potentially exposing the soil surface to erosion.

Revegetation

Performance criteria should be developed for revegetation of a decommissioned TSF. Actual performance should be assessed for an agreed period against expectations and alternative plans implemented in the event that objectives are not being met.

18.4 Post-closure monitoring and management

Unless full scaled pre-closure trials have been carried out, it is unlikely that the success of the method of closure and cover design for a large TSF or one storing contaminated tailings can be demonstrated in less than five years following cessation of operations.

Another consideration in determining the length of the post closure and management programs is the time frame for environmental monitoring programs to detect any impacts. This is particularly important with respect to TSFs containing material with a potential to impact on groundwater. In such cases the migration of a contaminated plume may take several years before it reaches a groundwater monitoring bore.

Broadly, and within the land use objectives set for closure, monitoring of a decommissioned TSF should continue until formal closure and resumption of management by the landowner.

Post-closure monitoring should include:

- revegetation performance;
- flood mitigation and drainage control;
- seepage;
- erosion control;
- control of pest plants and animals (including the establishment of wilding trees in forested or plantation areas) and
- groundwater quality.

The monitoring should be able to demonstrate that (MCMPR and MCA 2002):

- structures are geotechnically stable, and covers are not eroding at unacceptable rates;
- there is a low risk of an uncontrolled release of tailings or contaminants;
- the contaminants or tailings will not result in recognisable detrimental effects on the surface water and groundwater, soil and air surrounding the closed facility and
- required plant growth has been successful and that, over a period of several growing seasons, a self-sustaining community has developed.

Post-closure monitoring

The operator should design a monitoring program to demonstrate that completion criteria have been met and that the site is safe and stable.

19. LONG TERM RESPONSIBILITY

TSFs must be designed for the long term. Ultimately, however, even the best designed facilities will require maintenance or care. Facilities on private land would normally be subject to the requirements of the landowner agreement. It is assumed that landowners will take into account the long term maintenance costs when considering such agreements. However, many such facilities are constructed on Crown land and will therefore be the responsibility of the community in the long term.

Recent amendments to the MRD Act make compensation payable to the Crown for losses associated with the use of land. In addition, Section 26 of the MRD Act allows for the Minister to impose conditions on a licence for an environmental levy.

It is departmental policy that the TSF operator should provide for the long term maintenance and up keep costs associated with such facilities. Where a TSF is located on Crown land, the department will seek to ensure that this is addressed by one or more of the following mechanisms:

- suitable provision in a Crown land compensation agreement;
- establishment of an appropriate environmental levy and
- conclusion of a suitable closure agreement between the operator and the Government.

Long term responsibility

Proponents and operators of a TSF should make provision for the long term costs associated with the up-keep and maintenance of the TSF.

20. FURTHER INFORMATION

For further information on matters discussed in this guideline or to discuss a proposal for a TSF, proponents should initially contact ERR at one of the offices listed in Appendix IX.

Appendices

APPENDIX I: SUMMARY OF DEPARTMENTAL REQUIREMENTS FOR MANAGEMENT OF A TAILINGS STORAGE FACILITY.

	Section	Requirement	Page
4	Work Plan	Proponents should ensure that the Work Plan for a TSF contains the details required by either the *Mineral Resources Development Regulations 2002* (for a mine) or *the Extractive Industry Development Regulations 1996* (for a quarry), and those set out in these guidelines and Appendix III.	**4**
5	Planning approval	The Proponent for a TSF should ensure that appropriate planning approval is in place. Where a proposed TSF has the potential for significant environmental impacts approval via an EES may be required.	**4**
6	Consultation	The proponent for a new TSF should undertake adequate consultation with the community and interested stakeholders. Where a proposed TSF represents a minor variation to a pre-existing operation consultation may not be necessary. However proponents are advised to seek confirmation from MPD about this issue.	**5**
7	Risk Assessment	The proponents of a TSF should adhere to the principles of risk management and ensure that potential risks to the community, workforce and environment are minimised. Proponents of large TSFs or those storing contaminated tailings should undertake a formalised Risk Assessment as part of the Work Plan submission. Proponents of large TSFs or those storing contaminated tailings should also demonstrate that the provisions of the Emergency Response Plan are based on a comprehensive Risk Assessment. Irrespective of Risk Assessment results, TSFs must comply with relevant environmental legislation and policy, such as State environment protection policy (SEPP) water quality objectives.	**7**
8	Emergency Response Plan	A documented Emergency Response Plan (ERP) should be prepared specific to the TSF (but which may be included as part of the ERP for the overall operation) and kept in a prominent and readily accessible location at the operation centre.	**8**
8	Incidents	Incidents and accidents associated with the management of tailings should be reported immediately.	**8**

9	Waste minimisation	The proponent for a large TSF should provide an assessment of appropriate alternative waste management programs based on the principles of waste minimisation. The submission should include a description of the method and should consider practicability, cost and current industry best practice. Proponents for small TSFs should consider the principles of waste minimisation in development of the TSF proposal. The department may request further analysis where it is considered necessary for the protection of the environment or reduction of risks to the community.	**9**

	Section	**Requirement**	**Page**
10	Siting of a TSF	The proponent for a TSF should identify and investigate reasonable potential alternative sites and undertake realistic assessments of comparative risks. Where a valley dam is the only practicable alternative, the proponent should demonstrate that all environmental risks have been identified and are adequately addressed. TSFs should be designed and located to have the smallest practical catchment.	**10**
11	TSF design	The proponent of a large TSF using wet deposition should demonstrate that this method is the most appropriate for the site and that alternatives have been examined. Design Plans for large TSFs and those TSFs storing contaminated tailings, should be prepared by a suitably qualified and experienced person who should submit the design as well as Design Certification to the department that the plans meet appropriate engineering and safety standards and are consistent with these guidelines. Where a proponent can demonstrate that they meet criteria (b) to (g) of a suitably qualified and experienced person the department may allow for internal design of the TSF. However independent certification of the design, by a person, fulfilling all the criteria of the above definition will be required.	**10**
11	Design for water management	The design of a large TSF or one storing contaminated tailings should display a quantitative water balance of all gains and losses. Large TSFs or ones storing contaminated tailings should comply with the water design requirements specified in Appendix VII. Emergency spillways are required for all new large TSFs and all new TSFs storing contaminated tailings. The spillway should lead to an emergency overflow dam, kept empty during normal operations. Where sub-aerial deposition is proposed in a large TSF, the design should include decant or water recovery facilities. Where sub-aerial deposition is proposed in a large TSF, the design should include decant or water recovery facilities.	**11**
11	Seepage Containment	TSFs must be designed to ensure that the beneficial uses of groundwater and surface water are protected and to prevent other undesirable impacts such as waterlogging and land salinisation. Where a liner is required for a large TSF or one storing contaminated tailings, the Risk Assessment process as outlined in section 7.1 should be used to specify an appropriate design permeability and liner thickness. For those TSFs storing contaminated tailings, the standard level of containment should be at least equivalent to 0.6 metre of clay with permeability no greater than 10-8 m/sec.	**12**
11	Design for Closure	The Work Plan should describe how the TSF is to be closed and the source of the cover material. The design should account for the end use of the land, the nature of closure and the proposed rehabilitation.	**14**

	Section	Requirement	Page
12	Cyanide management	The proponent for a TSF shall provide a detailed and operation-specific Risk Assessment for the management of cyanide tailings. The TSF design and management approach should ensure risks are adequately addressed.	**14**
13	Construction of a TSF	Upon completion of the initial construction of a large TSF or one that will store contaminated tailings, and upon the completion of each lift, the licensee should: a) obtain certification from a suitably qualified and experienced person that the construction of the TSF 'as constructed' accords with the certified and approved Design Plans and b) submit the 'As Constructed' Report s and the Construction Certification to the department. When it is necessary to modify the design of a large TSF during construction, the licensee should: a) determine if the modification is significant; b) obtain prior agreement to the modification from the person who certified the original design; c) if a significant change is proposed, submit a revised design to the department for approval, certified by suitably qualified and experienced person; d) on completion, obtain certification from a suitably qualified and experienced person that the modification 'as constructed' meets appropriate engineering and safety standards and is consistent with these guidelines and e) submit the modification certification to the department. The licensee of a small TSF should ensure that construction is undertaken in accordance with the design and to professional standards.	**16**
14	Operation	An Operations Manual, for utilisation by operational personnel, should be in place from the time of commissioning of a TSF. The manual should document all relevant operational procedures for the specific site. TSF personnel should have a detailed understanding of those aspects of the Operations Manual relevant to their day to day functions and responsibilities.	**18**
15	Pipelines	Written records of inspection and maintenance of tailings pipelines and other tailings equipment should be maintained and made available for audit. The proponent and operator should demonstrate that measures proposed and implemented to prevent accidental discharge reduce the risk of a discharge event to an acceptable level.	**18**
16	Monitoring, auditing and reporting	A program for monitoring, auditing and reporting operational and environmental factors appropriate to the nature and scale of the operation should be included in the Work Plan for a TSF. The monitoring and reporting components of the program should be specified in the Operations Manual.	**19**
16	Monitoring	The Work Plans for all TSFs should include a site specific monitoring program based on the key risks identified in the Risk Assessment process and on other known issues, and a process for reporting outcomes to the community.	**19**

	Section	Requirement	Page
16	Safety Monitoring of TSFs	Monitoring of TSFs should be tailored to the size and nature of the TSF and its contents and the associated risks identified in the Risk Assessment process. Proponents should include an appropriate TSF safety monitoring program in the Work Plan including an Annual Audit as required by Section 16.5. Operators of large TSFs should ensure that an inspection and	**19**

		review of dam safety is undertaken at least annually by a suitably qualified and experienced person.	
16	Environmental monitoring	The monitoring program should address key environmental issues.	**20**
16	Monitoring of transfers	The volumes and chemical characteristics of tailings and process water transferred to or from a mining TSF shall be monitored.	**21**
16	Auditing	The operator of a large TSF or one storing contaminated tailings should implement an Annual Audit and review of the facility to confirm operations are consistent with the Work Plan. The Annual Audit should be undertaken by suitably qualified and experienced person, preferably the original designer. For mining TSFs, the report on the Annual Audit should be submitted to the department accompanied by the Tailings Storage Facility Data Sheet (Appendix IV).	**21**
18	Closure	Plans for the closure of a TSF should be included in the initial Work Plan for the TSF. The nature of closure of a TSF should be appropriate to the nature of the contents, the desired final landform and accord with community and landowner expectations. Progressive closure and rehabilitation of individual TSFs, or cells of a TSF, is encouraged, provided this is integrated into the overall closure strategy.	**23**
18	Cover design	The proponent should demonstrate that the type and depth of cover proposed for closure of a TSF is suitable for the nature of the contained tailings, the proposed revegetation and subsequent management regime.	**24**
18	Revegetation	Performance criteria should be developed for revegetation of a decommissioned TSF. Actual performance should be assessed for an agreed period against expectations and alternative plans implemented in the event that objectives are not being met.	**24**
18	Post-closure monitoring	The operator should design a monitoring program to demonstrate that completion criteria have been met and that the site is safe and stable.	**24**
19	Long term responsibility	Proponents and operators of a TSF should make provision for the long term costs associated with the up keep and maintenance of the TSF.	**25**

APPENDIX II: ADMINISTRATIVE PROCESS FOR OBTAINING A WORK AUTHORITY

This appendix sets out the sequential actions required by the proponent and ERR leading to grant of a Work Authority or approval of a Work Plan Variation.

NB: Where a TSF is part of a larger mining proposal, the Work Plan requirements described in these guidelines may be addressed as part of the Work Plan for the overall project. However, where a proposed TSF is outside the provisions of the current work plan, the operator must submit an appropriate Work Plan variation, which may require planning approval.

Proponent	**Earth Resources Regulation**
In consultation with the department, the local municipality and the department managing the Environmental Effects Statement (EES) process, determines if the project requires an EES or planning permit. Where an EES is required, consult with the department and the department managing the EES process regarding the appropriate process to follow.	
Consults with the department, the local municipality, the community and other stakeholders to prepare a satisfactory Work Plan or Work Plan Variation.	
Prepares a draft Work Plan or Work Plan Variation and lodges it with MPD.	

	Endorses draft Work Plan and approves proponent to proceed with application for Planning Permit (if necessary).
Applies to Responsible Authority (usually the local municipality) for a Planning Permit on the basis of the endorsed draft Work Plan. (Note: for an existing project, a pre-existing Planning Permit or EES approval may permit the TSF to proceed without further approval. Proponents should determine whether this is the case.) • Municipality refers application to Referral Authorities (who include ERR) • Municipality makes a determination in the light of comments by the Referral Authorities and grants or refuses a Planning Permit	
Advises ERR that the Planning Permit is approved (and or any conditions).	
Makes any final amendments to the Work Plan and lodges it with ERR.	
	Where appropriate: On receipt of the Work Plan, lodges a copy with Ministers administering the *Crown Land (Reserves) Act* 1978 and/or the *Forests Act* 1958 for comment.
	Approves the Work Plan in consideration of comments and assessment information from the relevant authorities and subject to any required variations or conditions.
	Assesses the appropriate level of rehabilitation bond.
For new projects, applies to ERR for a Work Authority.	
Lodges the rehabilitation bond.	
Satisfies other requirements of relevant Acts of Parliament.	
	Grants the Work Authority (if a new project) Grant may be subject to conditions.
Proceeds with development.	

APPENDIX III: DOCUMENTATION AND INFORMATION TO BE SUPPLIED FOR THE OPERATION OF A TAILINGS STORAGE FACILITY

Documentation and Work Plan requirements referred to throughout this guideline are summarised in the table below. More detailed information on Work Plan requirements is provided in the following parts A (large TSFs) and B (small TSFs).

All mining and extractive industry operations must be detailed in an approved Work Plan. The Work Plan must include at least the information set out in Schedule 13 of the *Mineral Resources Development Regulations* 2002 (for mining) or Schedule 3 of the *Extractive Industry Development Regulations* 1996 (for quarries).

Work Plans for TSFs also must comply with these requirements. However, where the TSF is proposed as an addition to an existing site, much of the required information will be detailed in the Work Plan for that site and need not be reiterated in the TSF submission.

DOCUMENTATION REQUIREMENTS FOR A TAILINGS STORAGE FACILITY

Document	Description	TSF categories	Guideline Section
Approved Work Plan	Key elements include: • Waste Minimisation • Risk Assessment • TSF Design and water management • Environmental Management Plan, monitoring, auditing and reporting • Closure and long term responsibility.	All TSFs	4
Emergency Response Plan	Deals with the worst case scenario and includes procedures describing and prioritising such actions as protection of personnel, notification of emergency services and resource management agencies, advice to neighbours and immediate actions.	All TSFs	8
		All TSFs	8.1

Incident and Accident Reporting	Reports about all accidents, incidents and emergencies affecting health or safety of personnel, fauna, surface and groundwater, vegetation and infrastructure.		
Design Certification	Certification from a suitably qualified and experienced person that the design plans meet appropriate engineering and safety standards and are consistent with the guidelines.	Large TSFs and contaminated tailings TSFs	11
Construction Certification	Certification from a suitably qualified and experienced person that the construction of the TSF 'as constructed' accords with the certified and approved Design Plans	Large TSFs and contaminated tailings TSFs	13
'As Constructed' Reports	As Constructed' Reports detailing the construction of each lift prepared and retained to assist determination of the overall stability and the future life of the TSF.	Large TSFs and contaminated tailings TSFs	13
Operations Manual;	Documents all relevant operational procedures for the systematic deposition of tailings, water and process chemicals in the facility.	All TSFs	14
Annual Report: Monitoring of transfers	Reports on the volumes and chemical characteristics of the tailings and process water transferred to or from a mining TSF. The reporting proforma is provided in Appendix IV *Tailings Storage Facility Data Sheet.*	All mining TSFs	16.4
Annual Audit Reports	Reports the results of the annual audit to ensure that essential systems are maintained and improved where necessary.	Large TSFs and contaminated tailings TSFs	16.5

A. INFORMATION TO BE SUPPLIED IN A WORK PLAN FOR A LARGE TSF OR A TSF STORING CONTAMINATED TAILINGS

The following schedule lists detailed information required by the department in relation to proposals for construction, operation and closure of large TSFs (see Size of TSFs in Definitions and Acronyms for the criteria that determine a large TSF) and those storing contaminated tailings. These are additional to the basic requirements set out in the *Mineral Resources Development Regulations* 2002 or the *Extractive Industry Development Regulations* 1996.

Where possible, information should be displayed on a suitably scaled and referenced maps and plans.

Introduction

- objectives;
- general description of method of raw material processing and tailings storage;
- overview of the proposal, including commencement and expected closure dates, and the relationship with any existing (if relevant) or proposed operation and
- location map with AMG coordinates.

Environmental Features of the Site

- site Geology;
- potential for seismic activity;
- load bearing ability of TSF foundation;
- permeability of foundation/substrate;
- regional topography including the nature and extent of catchment to the TSF (the size of catchment should be the smallest practicable);
- site topography (contour plan), including surface drainage;
- proximity of surface water resources and their uses;
- flooding potential;
- depth and nature of the groundwater and its uses;
- sources of materials for construction of the embankment, liners and closure (if the borrow pits are located outside the area subject to the mining licence, an extractive licence may be required under the *Extractive Industry Development Act* 1995);
- location, extent and conservation status of potentially affected natural values at or near the site(extant native vegetation, rare or endangered flora or fauna wetlands, etc) and

- where removal of native vegetation is proposed an assessment in accordance with the *Native Vegetation Management Framework*, 2003.

Cultural Features of the site

- location of other infrastructure (built-up areas, dwellings and other buildings, storage sites, mine sites, access roads and ramps) on the site and on adjoining land;
- location and nature of cultural features (aboriginal, historic, recreational or landscape) and
- nature of adjacent agricultural activities, and local planning features.

Tailings Deposition Methodology and Waste Minimisation

- analysis of appropriate alternative waste management programs based on the principles of waste minimisation and justification of the selected method of waste management based on practicability, cost and current industry best practice (section 9 of guidelines);
- source of the tailings including process throughput rate (dry tonnes/year);
- tailings production rates (dry tonnes/year), rates of rise of the tailings surface within the TSF, expected changes with time and the potential for unplanned changes;
- details of the geotechnical (density and consolidation behaviour) and chemical properties of the tailings, reagents, process and return waters and residual process chemicals; expected changes with time;
- how deposition and drying is to be managed: expected changes with time and the potential for unplanned changes and
- design, location and operation (movement) of delivery system: to include pipe-break contingency plans.

Risk Assessment (section 7 of guidelines)

- identification of significant hazards to the environment, people and infrastructure;
- evaluation of the location of the TSF;
- evaluation of the type of lift to be used;
- identification appropriate design features or actions required to eliminate or reduce risks to an acceptable level;
- determination of the appropriate level of cyanide in the tailings and
- identification of matters to be addressed in the Emergency Response Plan.

TSF Design

- description of site preparation;
- plan of the TSF site itself showing details and total area of structure, working area and ultimate tailings capacity (volume to include allowance for non-recovered water content); to include conditions at start-up, during production and at close of operations;
- data on the engineering properties (including dispersion/erodibility tests) of construction materials;
- construction method – for initial embankment and type and number of lifts;
- engineering designs of the initial embankment and each lift. The design to show a section through the long axis of the embankment and cross sections (including final outer wall angle);
- 'As Constructed' Report to be provided when dam is completed;
- erosion control measures for the embankment and toe;
- stability computations for the embankment, both for static and for the 'expected' seismic events and
- design details and comparative assessments as required by Sections 10, 11 and 12 of the guidelines.

TSF Design for Water Management

- data on the source and engineering properties (including permeability and dispersion tests) of liner materials (if used);
- seepage (permeability) analyses for the TSF, both downward and through the embankment;
- design, location and Risk Assessment of any under-drainage (filter drains), catch drains, sumps and outfall pipes to intersect seepage and details of blanket drains;
- design, location and operation of any de-watering bores;
- determination of appropriate extreme rainfall events (see section 11.1 and Appendix VII of guidelines);

- analysis of the runoff into the TSF catchment for rainfall both on the storage itself and on the surrounding catchment (if applicable);
- design, location and operation of pond control and water decant facilities;
- quantified water balance model for all gains and losses;
- design, location and operation of return pipelines;
- design, location and materials of diversion drains and
- information to show that the design of the TSF and diversion drains satisfies the 'worst case' combination of factors (e.g. full TSF, overflow of tailings delivery system, failure of decant/recovery facilities, wave action, design storm); this to include the impact on surrounding areas of the combined effect of the design storm runoff and the diverted waters, and detailed information on the management of cyanide (where relevant) and to show that the management is in accordance with an operation-specific Risk Assessment.

Environmental Management Plan

- identification of the key environmental issues based on the environmental features of the site and the Risk Assessment;
- proposals for the management and reduction of environmental impacts and
- a program for monitoring, auditing and reporting environmental factors appropriate to the nature and scale of the operation as required by Section 16 of the guidelines.

Safety Monitoring Program

- a program for monitoring, auditing and reporting safety and operational aspects appropriate to the nature and scale of the operation as required by Section 16 of the guidelines.

Incident management:

- plans for recording and reporting all accidents, incidents and emergencies affecting health or safety of personnel, fauna, surface and ground water, vegetation, infrastructure (Section 8.1).

Closure and rehabilitation:

- information on how closure is to be achieved in accordance with Section 18 of the guidelines;
- data on the source and engineering properties (including dispersion tests) of cover materials;
- detailed design of the cover, including demonstration that the proposed design will be suitable for the proposed vegetation type;
- details on erosion management and
- a revegetation program.

B. INFORMATION TO BE SUPPLIED IN A WORK PLAN FOR A SMALL TSF

(NB – Proposals for small TSFs where storage of contaminated tailings is proposed should submit information in accordance with Schedule A)

The following schedule lists detailed information required by the department in relation to proposals for construction, operation and closure of small TSFs. These are additional to the basic requirements set out in the *Mineral Resources Development Regulations* 2002 or the *Extractive Industry Development Regulations* 1996.

Introduction:

- general description of method of raw material processing and tailings storage;
- brief summary of the proposal, including commencement and expected closure dates, and the relationship with any existing (if relevant) or proposed operation, and
- location map with AMG coordinates.

Environmental features of the site:

- geology of the area to be covered by the TSF (especially any features that might effect the water tightness of the TSF;
- topography of the site and immediate surrounding area, particularly to indicate the nature and extent of catchment and surface drainage pattern (the size of catchment should be the smallest practicable);

- details of any watercourses or water supply dams likely to be affected in the event of an accidental discharge from the site;
- the potential for flooding;
- sources of materials for construction of the embankment, liners and closure (if the borrow pits are located outside the area subject to the mining licence, an extractive licence may be required under the Extractive Industry Development Act 1995);
- location, extent and conservation status of any known potentially affected natural values (extant native vegetation, wetlands, groundwater, etc);
- where removal of native vegetation is proposed an assessment in accordance with the Native Vegetation Management Framework, 2003 and
- location or indications of any known rare or endangered flora or fauna at or near the site.

Cultural features of the site:

- location and nature of cultural features (aboriginal, historic, recreational or landscape).

Tailings Deposition methodology and Waste Minimisation:

- consideration of the principles of Waste Minimisation (section 9 of guidelines)
- source of the tailings including approximate process throughput rate (dry tonnes/year),
- details of the chemical properties of the tailings, reagents, process and return waters and residual process chemicals.

TSF Design:

- design parameters used (these may derive from approved small dam design manuals);
- plan of the TSF site itself showing details and total area of structure, working area and ultimate tailings capacity (volume to include allowance for non-recovered water content) and
- erosion control measures for the embankment and toe.

TSF Design for water management:

- for TSFs with external catchments, determination of appropriate extreme rainfall events (see section 11.1 and Appendix VII of guidelines);
- for TSFs with external catchments, analysis of the runoff into the TSF catchment for rainfall both on the storage itself and on the surrounding catchment (if applicable);
- design, location and operation of discharge and return pipelines and
- design, location and materials of diversion drains.

Monitoring:

- a program for monitoring, auditing and reporting safety, operational and environmental factors appropriate to the nature and scale of the operation as required by Section 16 of the guidelines.

Incident management:

- plans for recording and reporting all accidents, incidents and emergencies affecting health or safety of personnel, fauna, surface and ground water, vegetation, infrastructure (section 8.1 of guidelines).

Closure and rehabilitation:

- information on how closure is to be achieved in accordance with Section 18 of the guidelines;
- details on erosion management and
- revegetation program.

APPENDIX IV: TAILINGS STORAGE FACILITY DATA SHEET

The following proforma is to be used for providing basic data about the proposed TSF for the initial Work Plan (supplemented with the balance of the required information as set out in Appendix III) and for annual reporting.

- Tailings Storage Data Sheet

- Explanatory Notes for Completing Tailings Storage Data Sheet

APPENDIX V: SMALL TAILINGS STORAGE FACILITY EMERGENCY PROCEDURES

The following procedures should be followed by the operator of a small Tailings Storage Facility in the case of a major event or incident occurring at the facility. Procedures for larger facilities could follow this format but should be more detailed.

EMERGENCY EVENTS

high rainfall, storm, earthquake

EMERGENCY INCIDENTS

overtopping, wave damage, cracking, slips, structural failure, slides, slumping, increased or new seepage, piping, pipeline leakage or other abnormal signs or behaviour

Priority of action

saving life
protecting highly significant environmental values
saving property
dam structure damage control

Failure to apply due diligence under circumstances that could result in injury or damage to public or private property may constitute a liability against the TSF operator

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Be alert to potential developments and maintain close vigilance during extreme events or perceived abnormal behaviour of the TSF

↓

Maintain safety requirements at all times during response actions

↓

Take actions as outlined in the following pages

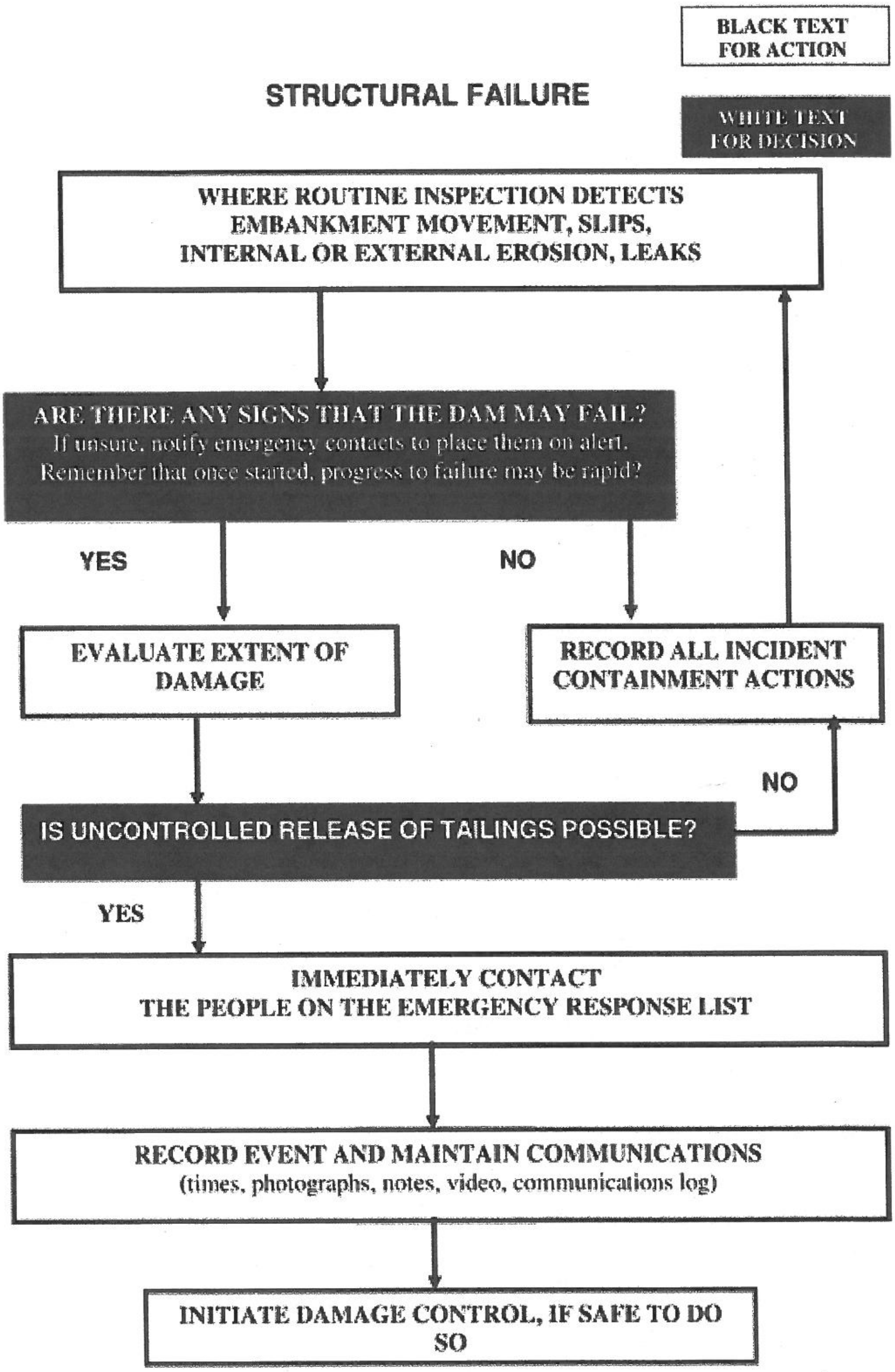
Appendix V cont: Small tailings storage facility emergency procedures.

EMERGENCY RESPONSE CONTACTS

Contact	Phone Number
POLICE	Office
	After hours
STATE EMERGENCY SERVICE	Office
	After hours
ENGINEER	Office
	After hours
MINERALS & PETROLEUM	Office
	After hours
ENVIRONMENT PROTECTION AUTHORITY	Office
	After hours
BUREAU of METEROLOGY(weather reports)	Office
	After hours
DOWNSTREAM NEIGHBOURS (eg. surface water diversion and groundwater extraction customers)	
WATER AUTHORITY (where operation is in water supply catchment)	

Having made initial contact, the TSF operator shall make arrangements to maintain continuous contact and provide timely advice on changes of conditions

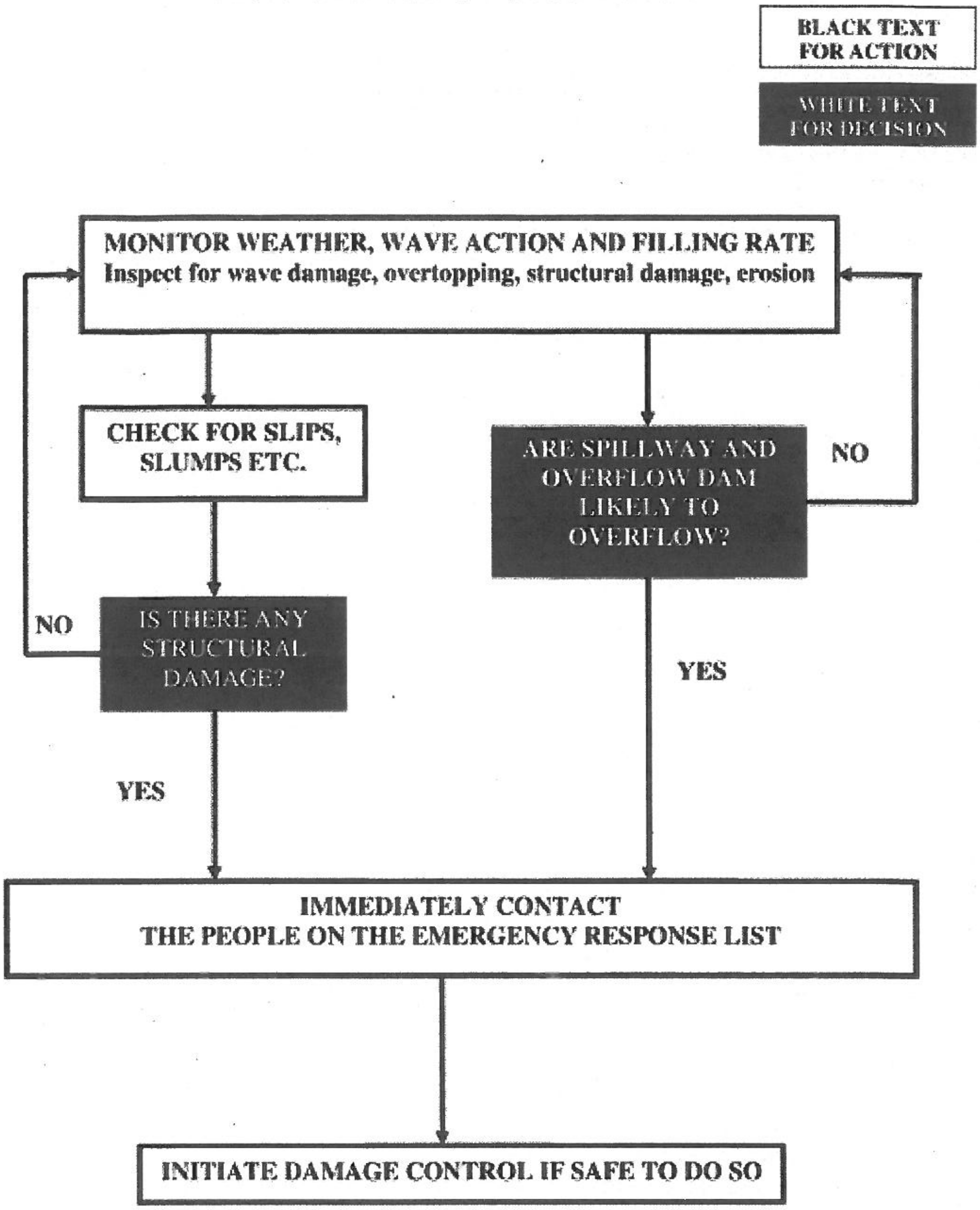
Appendix V cont: Small tailings storage facility emergency procedures.



Appendix V cont: Small tailings storage facility emergency procedures.

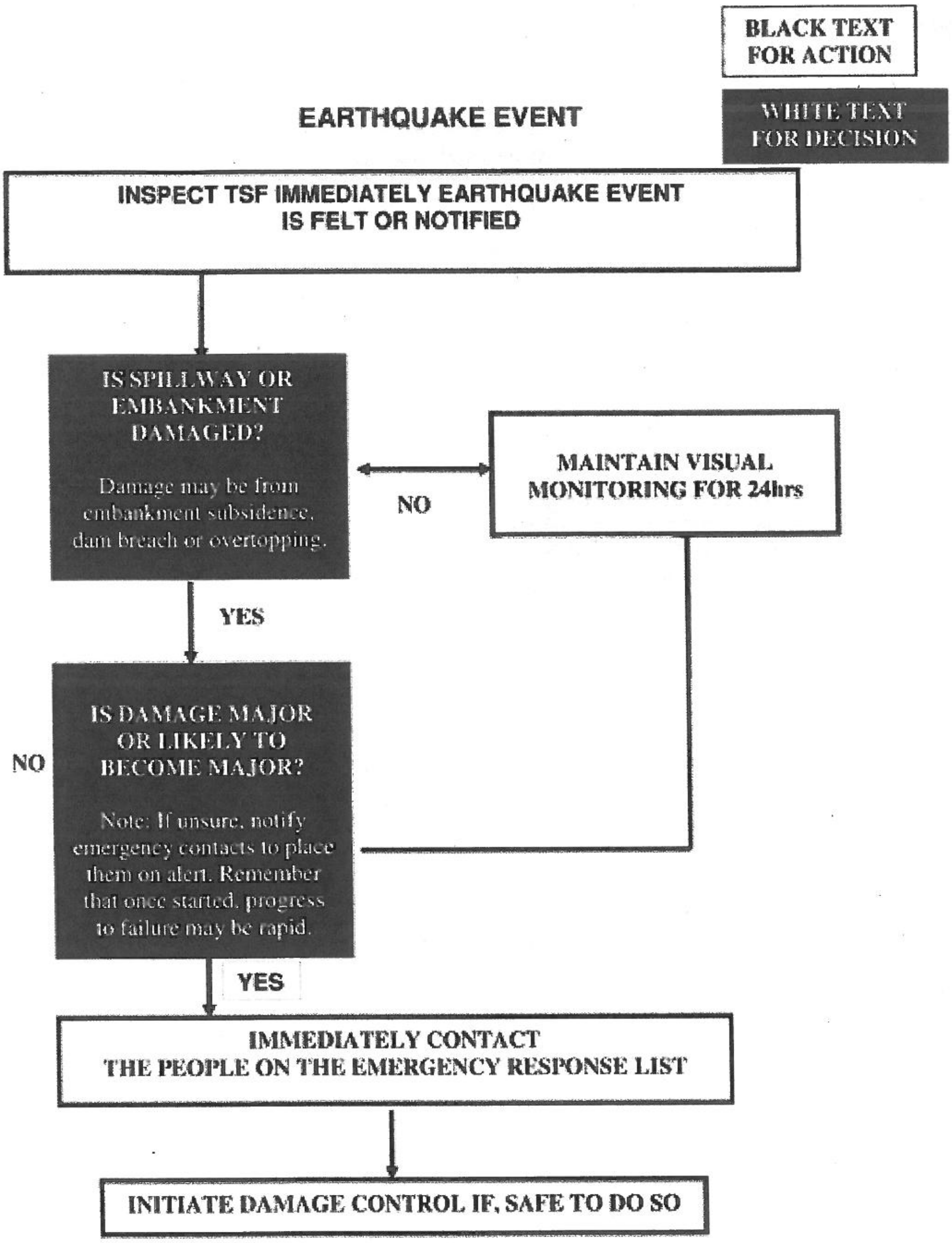
HIGH RAINFALL OR STORM EVENT

HIGH RAINFALL OR STORM EVENT



Appendix V cont: Small tailings storage facility emergency procedures.

EARTHQUAKE EVENT

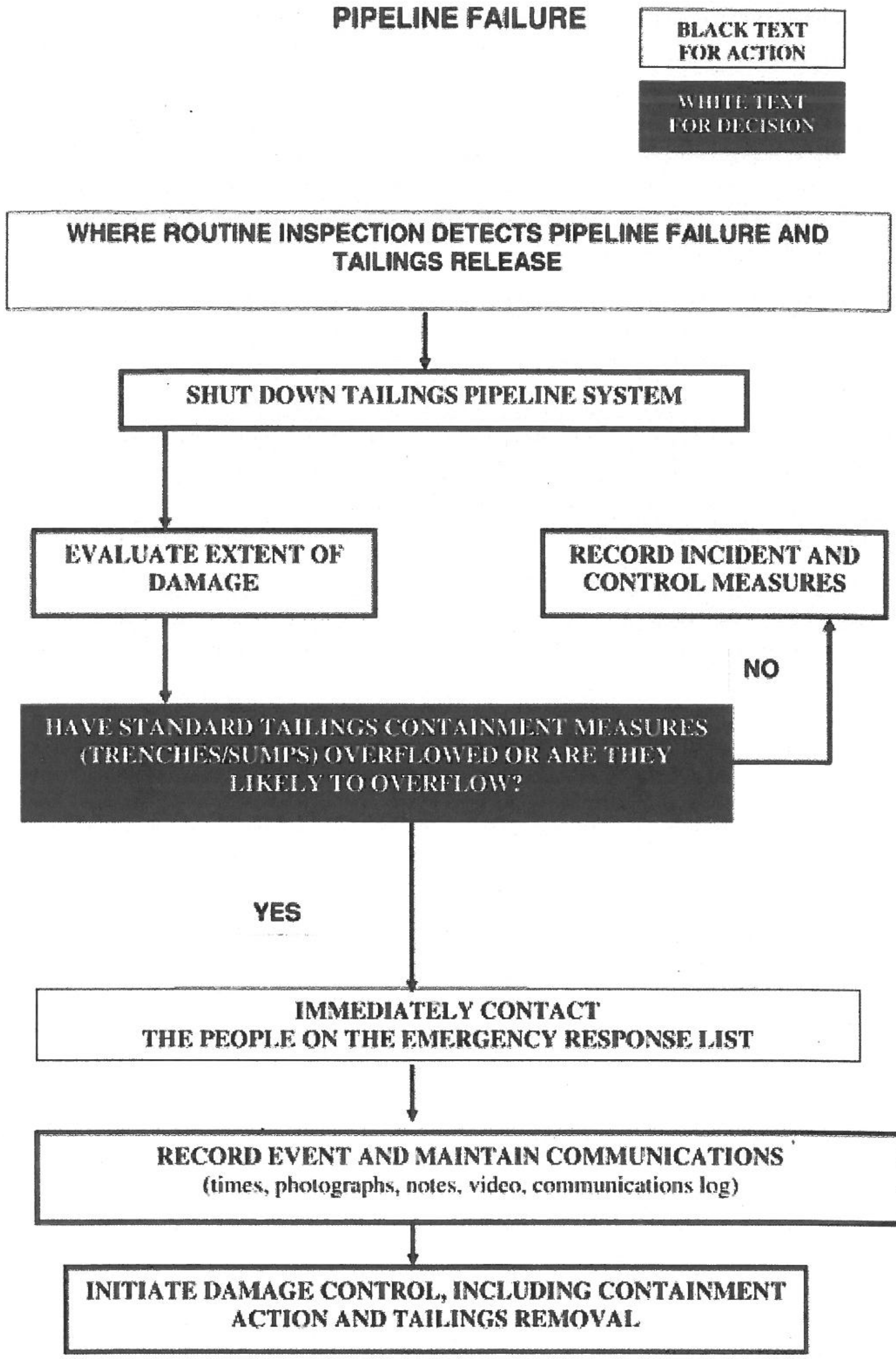


Note: If the initial inspection was at night, follow-up inspections should be carried out in daylight.

Note: If the initial inspection was at night, follow-up inspections should be carried out in daylight.

Appendix V cont: Small tailings storage facility emergency procedures.

PIPELINE FAILURE



APPENDIX VI: TAILINGS STORAGE FACILITIES

Tailings storage facilities (TSF) are designed essentially as dams to retain tailings slurry, to enable the reclamation of water and for the permanent storage of the contained effluents and solids.

The retaining embankment(s) of a tailings dam can be built in a single stage, as for conventional water dams, or built progressively in raises or lifts (Figure 1). These methods are described below and discussed in further detail in EPA 1995.

- **Single-stage embankment construction to full height.** This option is usually adopted for facilities of relatively low height (less than 5 m), where sufficient capital is available at the outset or where it is impracticable to effect future lifts.
- **Downstream lifting of the embankment**, whereby the embankment crest moves progressively downstream, or outwards from the stored tailings. It is the most inherently safe means of construction and its adoption is mandatory in some countries due to seismic loading conditions. It is by far the most expensive means of lifting an embankment due to the large volume of material required in its construction and the greater incidental impacts generated through expansion of the footprint of the TSF during operation.
- **Centreline lifting of the embankment**, whereby the embankment crest remains in the same plan position as the embankment is lifted. This system is a compromise between the upstream and downstream techniques and offers

some of the advantages of both. It offers greater stability than upstream construction and is not as costly as downstream construction. It is usually used where the embankment would tend to be unstable under the upstream-lift method.

- **Upstream lifting of the embankment**, whereby the embankment crest moves progressively upstream, or partially over previously deposited tailings. This is usually the least expensive option, but is less inherently safe than the other methods and necessitates careful consideration of stability and potential for settlement, as well as the practicability of construction and the potential for seepage. It is a system commonly (and safely) employed in arid environments that have low seismic activity, such as occurs over large tracts of Australia.

These methods can be used together, in a variety of combinations, and some relatively elaborate schemes have been developed to minimise costs while achieving an acceptable level of risk. Each situation needs to be considered on its particular merits, with particular emphasis on the factors that influence the stability of the embankment.

The long term stability of a tailings dam is vital. The main factors influencing its stability are the height and slope of the embankment and the nature, strength and degree of compaction of foundation and embankment materials. Depending on circumstances, the retaining embankment may be constructed of mine wastes, imported materials or desiccated mill tailings sourced from the adjacent tailings beach. Although tailings usually increase the stability of the structure and, once settled, are often relatively impervious, the extent to which this occurs depends on their unique chemical and physical properties.

In arid areas of Australia dried tailings may be used in the construction of TSF walls. A segregated slurry is spigotted onto a beach and then the coarse fraction, after drying by evaporation, is reclaimed for use in embankment construction. Because of the nature of tailings materials and the climate, however, it is generally inappropriate to use tailings for the construction of embankments in Victoria.

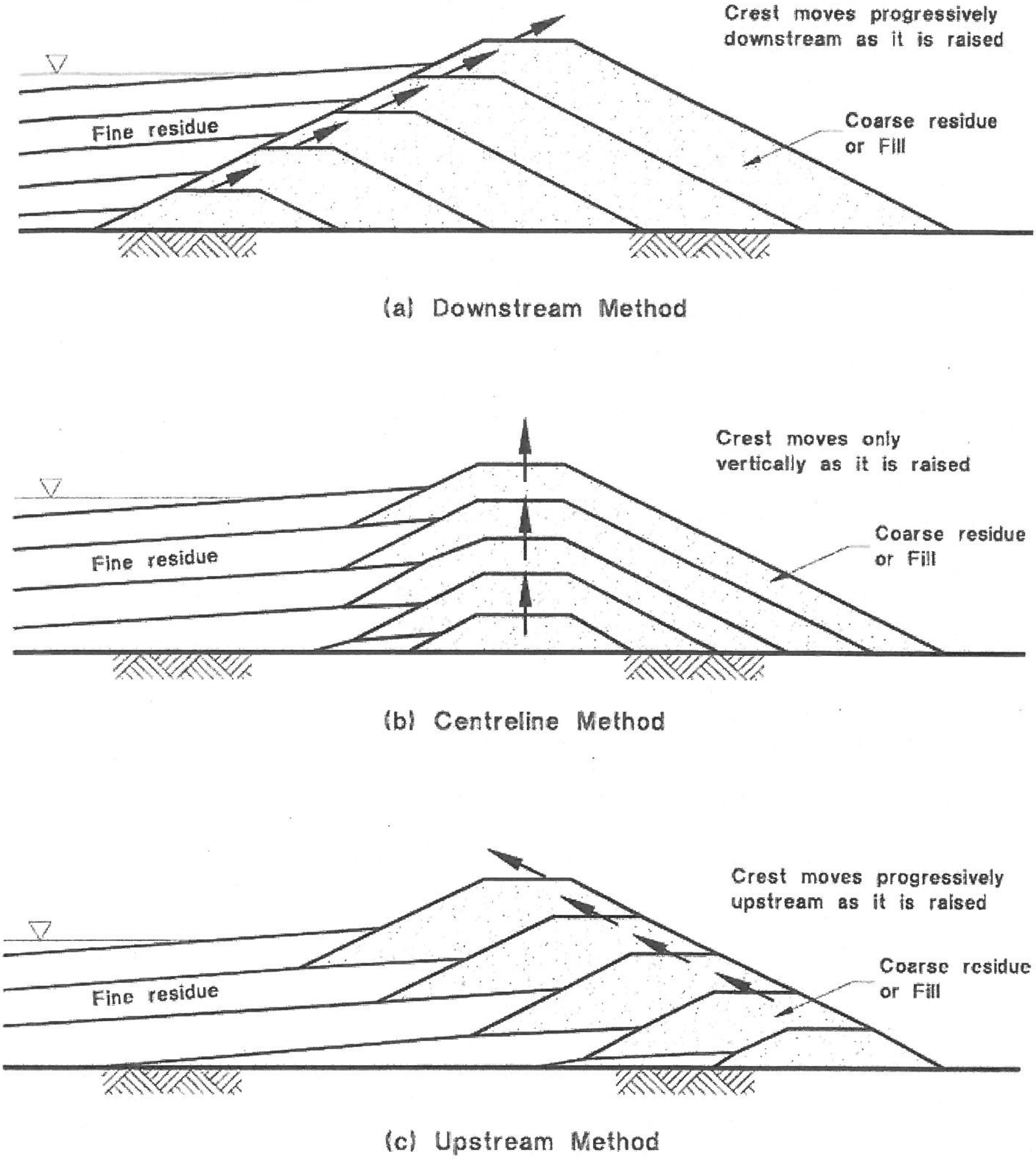


Figure 1: Methods of lifting TSF perimeter embankments
(After Chamber of Mines of South Africa, 1996)

Location of TSFs

TSFs can be constructed across a valley in the landscape or off-valley:

- **Cross-valley storage**, whereby a dam wall is constructed across a natural valley. This has the principal advantage of requiring a relatively small amount of earthworks for the volume of tailings that can be contained. In addition, any escape or seepage of tailings or supernatant water can be expected to occur along the drainage line and backup structures or systems can be emplaced there for greater security. The main disadvantages are the initial capital costs, the need to permanently divert the stream and probably construct substantial spillways, the risks of failure of the diversion system causing erosion of the embankment and escape of tailings materials, and the environmental impacts may be high. Further, diversion of a watercourse may represent negligible risk if rainfalls are low but may be a difficult engineering problem in high-rainfall areas.
- **Off-valley storage**, which can be located on land ranging from near horizontal to the side slope of a gentle valley. This approach requires the construction of confining embankments on either the downhill side(s) or around the full perimeter to form an impoundment ('ring dyke' or 'turkey nest'). The advantages of this approach over a cross-valley storage are that runoff management is simpler and impacts on groundwater and surface waters are likely to be lower.

Variations of the above exist and, in some instances, a combination of cross-valley and side-valley configurations may be adopted. In Australia, off-valley storage is preferred for environmental reasons. Moreover, the cross-valley option is not often technically viable due to the typically flat terrain of many mine sites.

Management of water in a TSF

The Work Plan for a TSF should include a quantitative water balance that accommodates all gains and losses.

Gains to a TSF include:

- water forming the slurry;
- rainfall (direct onto the TSF and as runoff from its catchment) and
- water as waste from the operation and from flushing of facilities.

Losses from a TSF include:

- decanted supernatant water;
- evaporation;
- drainage water;
- water retained in the pores of the tailings (interstitial losses) and
- seepage water.

Many TSFs are used to store water as well as tailings, but should be managed to minimise the quantity of water retained. Most TSFs in Victoria to date have been managed to recover water and contained process chemicals from the TSF and re-use them in the treatment plant. Water can be removed using a variety of methods, including floating or submerged pumps, decant towers or syphons.

Where sub-aerial deposition is used, it is often important to minimise the amount of water held by the TSF to aid drying and ensure consolidation of the tailings mass. In some cases water is continually drained from the TSF into a separate water recovery dam (or decant dam). Some TSFs are constructed with pre-installed drainage pipes under the tailings. This feature has been successful in some cases in improving the consolidation of tailings but is expensive and can fail quickly if the consolidated tailings material is low in permeability.

TSFs must be large enough to accommodate water from the slurry, rainwater falling on the storage catchment as well as the volume of tailings deposited. In the past, TSFs in Victoria have been designed with no allowance for the discharge of water as it is assumed that the designs account for the highest likely rainfall events and discharge will never be required.

Based on the concern that design information may be imperfect or an unprecedented rainfall event might compromise the capacity of the facility, Victoria and some other jurisdictions require large tailings storages to include discharge spillways and overflow dams. This enables controlled discharge via an engineered spillway rather than an uncontrolled overtopping of a dam which, although unlikely, could have very serious consequences, including structural failure of the TSF.

TSFs containing potentially acid-forming tailings materials are often designed to have a permanent water cover (ie sub-aqueous deposition). In such cases the above discussion clearly does not apply. Management of such storage facilities introduces a range of additional issues. To ensure permanent cover, water recovery, losses and rainfall must be carefully balanced. This is most critical after rehabilitation when the facility must be safe with a minimum of management intervention.

APPENDIX VII: TAILINGS STORAGE FACILITIES WATER DESIGN CRITERIA

Table 1: Minimum TSF freeboard and design requirements for water management, applicable to individual TSFs (refer also to figure 2 below).

TSF Category	**Flood Capacity** (AEP 72 hour rainfall event)	**Additional freeboard** (m)	**Emergency Spillway** (AEP 1 hour rainfall event, TSF full at the beginning of the storm)
Small TSF: Benign to low level contaminated Tailings	1×10^{-2}	0.6	1×10^{-2}
Large TSF: Benign to low level contaminated Tailings or Small TSF: Contaminated Tailings	1×10^{-3} to 1 x 10-4	0.6	1 x 10-3 to 1×10^{-4}
Large TSF: Contaminated Tailings	1×10^{-5} to PMP	0.6	1×10^{-5} to PMP
All TSFs	Capacity to contain the waste inputs and rainwater during a one in ten wet		

	year as well as meet the above Flood Capacity and Additional Freeboard Requirements
All TSFs	Where tailings are against the embankment, specify and maintain an appropriate minimum vertical distance between the top of the tailings beach and the lowest point of the embankment.

Definitions:

AEP: Annual exceedence probability: The probability that the rainfall event occurs in any one year.

Additional freeboard: the vertical height between the lowest point of the emergency spillway and the TSF pond water level after the AEP 72 hour rainfall event.

PMP: The theoretical greatest depth of precipitation for a given duration that is physically possible over a particular catchment area. (ANCOLD 2000, IEA 1998 and BOM 2003).

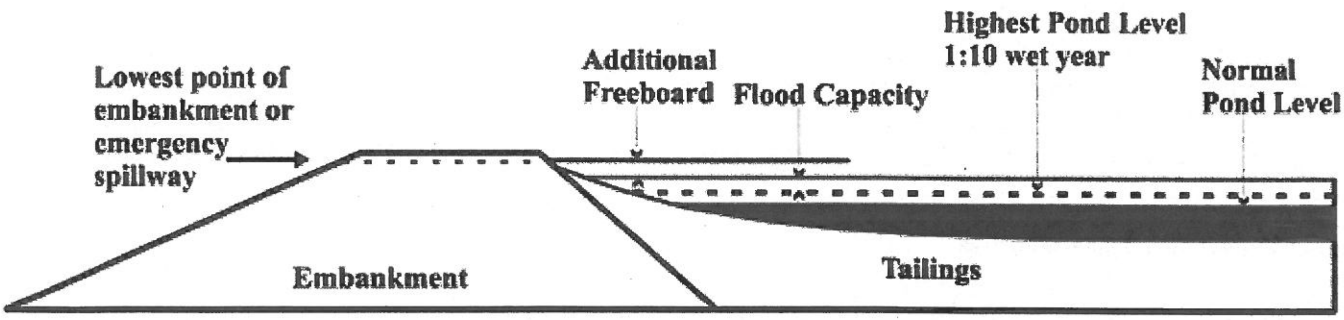
Notes:

1. Where a range has been given for the AEP the lower probability shall be initially adopted. However the proponent may submit a detailed Risk Assessment and hydrological analysis consistent with recognised methodologies (eg ANCOLD 2000) justifying the adoption of a higher probability AEP for the department's consideration.
2. The department may require lower probability AEPs than above where a TSF poses a particularly high risk, such as a downstream threat to life.

Example:

A small TSF storing contaminated tailings must have the capacity to:

1. Contain the waste inputs and rainfall during a 1 in 10 wet year;
2. Store the inputs from a 1 x 10-4 AEP 72 hour rainfall event and retain a minimum additional freeboard of 0.6 m and
3. In an exceptional circumstance where there is a risk of embankment failure pass a 1 x 10-4 AEP 1 hour rainfall event (storm) via an appropriately constructed emergency spillway.



(a) Pond located away from embankment.

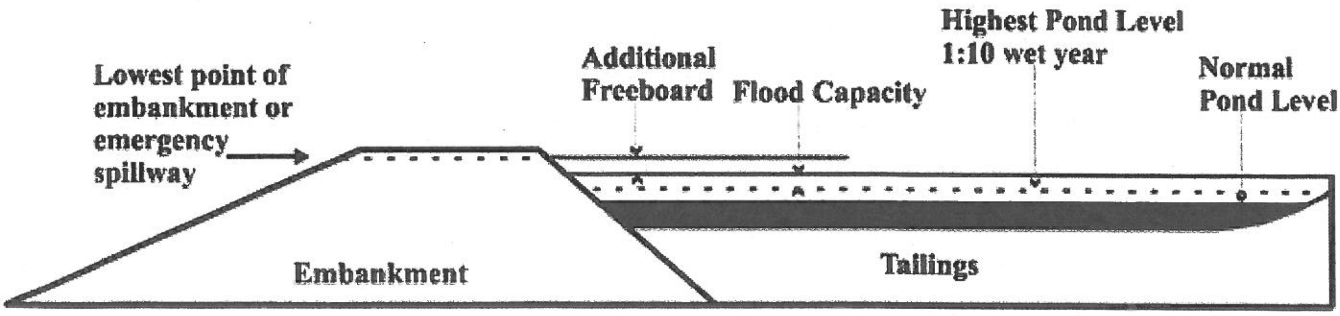


Figure 2. TSF minimum freeboard and water design criteria.

APPENDIX VIII: RELEVANT LEGISLATION AND POLICIES

Mineral Resources Development Act 1990 **(MRD Act)**

The purpose of the MRD Act is, among other things, to encourage an economically viable mining industry that operates in a way that is compatible with environmental, social and economic objectives of the State. Its objectives include encouraging and facilitating exploration for minerals and establishing a legal framework that ensures that mineral resources are developed in ways that minimise impacts on the environment.

The MRD Act establishes a two-stage process for the approval of mining work:

- the granting of a licence and
- the approval of a Work Plan and the granting of a Work Authority.

Prior to issuing a Work Authority, the head of the department administering the MRD Act must be satisfied that the applicant has an approved Work Plan. The contents of a Work Plan are prescribed under Schedule 13 of the *Mineral Resources Development Regulations* 2002.

***Extractive Industry Development Act* 1995 (EID Act)**
The purpose of this Act is, among other things, to ensure that extractive industry operations are carried out with safe operating standards and in a manner that ensures the rehabilitation of quarried land to a safe and stable landform.

The EID Act establishes the following staged process for the approval of extractive operations:

1. proponent prepares a proposal or Work Plan
2. proponent applies to local municipality for a Planning Permit
3. local municipality refers application to Referral Authorities (which includes ERR)
4. local municipality makes a determination
5. ERR approves the Work Plan in consideration of comments by local municipality and others
6. ERR grants the Work Authority subject to any conditions.

The EID Act also sets out the procedure for notification of proposed extractive industries to holders of licences under the MRD Act.

Occupational Health and Safety (Mines) Regulation 2001
The purpose of these regulations is to protect people in mines against risk to their health and safety. All operations which use cyanide must comply with these regulations. Additional duties are required for prescribed mines. Prescribed mines include mines that use cyanide and have inventories of more than 5 tonnes of cyanide, including solutions of inorganic cyanides with total cyanide ion content greater than 3 %.

Environment Effects Act 1978
This Act provides for the Minister administering the Act to decide whether any proposed development requires an Environment Effects Statement (EES). Where an EES is required for a mining project, approval procedures are coordinated as closely as possible and the proponent is not required to obtain further planning approvals for the activity assessed in the EES.

Planning and Environment Act 1987
This Act provides a framework for planning the use, development and protection of land in Victoria. It has a number of aims related to environmental protection, social equity and facilitation of appropriate development.

The Act provides the overarching process for responsible authorities (RA) to consider and approve or refuse to approve applications by mining and extractive industries. In most instances the RA is the relevant municipality. The RA utilises the approved local municipality Planning Scheme, including the State Planning Policy Framework, in support of its considerations. The RA is required to refer all applications to the appropriate Referral Authorities. ERR is a Referral Authority for mining and extractive industries although the respective water management authority may be the Referral Authority with respect to a proposal for any on-stream construction. Approval takes the form of a Planning Permit.

The holder of a mining licence may be granted a Planning Permit regardless of the provisions of the approved planning scheme. Further, even if a Planning Scheme requires a permit to be issued for mining on land covered by a mining licence, the MRD Act exempts the licensee from having to obtain the permit if an Environment Effects Statement for the work has been prepared and assessed in accordance with the Environment Effects Act 1978, and a Work Authority granted in the light of that assessment.

Victoria's Native Vegetation Management - a Framework For Action, 2003
The framework is a whole of government policy applicable to the mining and extractive industries through Earth Resources's approvals process. The framework establishes the strategic direction for the protection, enhancement and revegetation of native vegetation across the State and identifies 'net gain' as the primary goal for native vegetation management. At the on-ground level it expresses the principle that where losses are unavoidable and permitted requirements for offsets must be met. DELWP has released 'Native Vegetation Operational Guidelines' to provide tools to consistently apply the framework.

ERR is currently working with DELWP to ensure the guidelines reflect the nature of rehabilitation in the mining and extractive industries. Where a proposal involves clearing native vegetation, the proponent should contact ERR about current requirements.

Environment Protection Act 1970
This Act is concerned with all aspects of the environment and makes provision for the establishment of environmental objectives as well as management of waste discharges. The EP Act aims to:

- encourage waste avoidance, reduction and re-use;
- control emissions of waste into the atmosphere and on land and water and
- impose sanctions against those who have polluted.

Industrial Waste Management Policies
Section 16(1A) of EP Act requires the management of industrial waste to be in accordance with the provisions of Industrial Waste Management Policies (IWMP).

IWMP (*Waste Minimisation*) 1990 and IWMP (*Prescribed Industrial Waste*) 2000 require the adoption wherever possible of a waste management hierarchy. This hierarchy of preferred waste avoidance, reuse and recycling to waste treatment or disposal. Specifically, the policies require the use of commonly available technology to minimise the volume of material from waste streams containing defined wastes.

State Environment Protection Policies
The EP Act provides for the preparation of State Environment Protection Policies (SEPP) which set quality objectives for segments of the environment (air, water and land and noise emissions) and seek to protect their beneficial uses. Being statutory instruments, the provisions of SEPPs are legally enforceable and apply to government departments, agencies and private companies. They provide a basis for the application of Works Approvals, licences, pollution abatement notices and regulations.

SEPP (*Waters of Victoria*) determines the beneficial uses of the water environment to be protected, water quality indicators and objectives for specific segments of the water environment.

SEPP (*Groundwaters of Victoria*) aims to maintain and, where necessary, improve groundwater quality sufficient to protect existing and potential beneficial uses.

If an operator proposes to discharge water to the environment, it is likely that a Works Approval and Waste Discharge Licence will be required under the EP Act. Works Approvals permit work to be undertaken which will result in a discharge of waste to the environment or an increase in, or alteration to, an existing discharge, a change in the way waste is treated or a change in the way waste is stored.

Premises requiring Works Approval and licences under the EP Act are described as 'scheduled premises' and listed in the *Environment Protection (Scheduled Premises and Exemptions) Regulations* 1996. Under these regulations disposal of wastewater to land within a mine or quarry site in accordance with an approval under the MRD Act or EID Act does not also require a Works Approval or licence under the EP Act. This situation applies where water is discharged to a TSF, an evaporation pond or to some other system that ensures no offsite discharge occurs.

Catchment and Land Protection Act 1994
This Act aims to:

- establish a framework for integrated management and protection of catchments;
- encourage community participation in the management of land and water resources and
- set up a system of controls on pest plants and animals. Catchment Management Authorities (CMA), established under the Act, are responsible for the development and coordination of approved regional catchment management strategies, which may include Catchment Management Plans.

These Plans cover land use and regional development issues and set out management strategies for a particular catchment or sub-catchment. The process aims to maximise community involvement in decision-making about development of detailed work programs within a catchment. The main priorities of CMAs include salinity, pest plants and animals, nutrient inflows to streams and declining biodiversity.

Where off-site discharge of mine or quarry waters is proposed it is likely that the respective CMA will be consulted.

Water Act 1989
This Act applies to all surface water in Victoria, including river management, water supply, irrigation and sewerage.

Any construction on a waterway, and any works to deviate a waterway; requires a Construction Licence issued under Section 67 of the Water Act 1989. Issue of Construction Licences is the responsibility of the respective CMA.

Flora and Fauna Guarantee Act 1988
This Act establishes a legal and administrative structure to enable and promote the conservation of Victoria's native flora and fauna and to manage potentially threatening processes. It also provides a list of species and communities of flora and fauna which are threatened and mechanisms for their protection.

Forest Act 1958
This Act provides for the management and protection of State forests, defines the powers of the Director and the power to issue leases and licences, places restrictions on the cutting or removing of timber or forest produce, and makes provision for other forest related matters.

Crown Land (Reserves) Act 1978
Amongst other matters, this Act provides for the reservation of Crown lands for certain purposes and for the management of such reserved lands.

Archaeological and Aboriginal Relics Preservation Act 1972*, and the *Aboriginal and Torres Strait Islander Heritage Protection Act 1984 (Cth)
These Acts provide for the protection of Aboriginal places and objects. The Commonwealth Act also requires that protection of the places and objects be in consultation with the Aboriginal communities with an interest in them.

Environment Protection and Biodiversity Conservation Act 1999
This Act deals with Commonwealth environmental assessment and approval, biodiversity conservation and reporting/enforcing mechanisms. Under this framework, unless a person has Commonwealth approval, they must not take an action that has, will have, or is likely to have, a significant impact on a " matter of national environmental significance." The Act lists species and communities of national environmental significance.

APPENDIX IX: MINERALS AND PETROLEUM DIVISION CONTACTS

Cnr Mair and Doveton Streets
BALLARAT 3350

Tel. (03) 5333 6727

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35 Sydney Road
BENALLA 3672

Tel. (03) 5761 1502

Cnr Midland Hwy & Taylor Street
EPSOM 3551

Tel. (03) 5430 4444

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1 Spring Street
MELBOURNE 3001

Tel. (03) 9658 4400

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55 Grey Street
TRARALGON 3844

Tel. (03) 5172 2111

Definitions and acronyms

Bentonite – a species of clay used as an absorbent or filler

CMA -Catchment Management Authority

Contaminated tailings –

(1) tailings solids with contaminant concentrations (or predicted concentrations) above any of the levels specified in table 2, and/or sulphidic tailings with the potential to cause acid generation. Current methods for determining acid generation potential are provided in Environmental Australia (1997) and EPA (1999);
and/or

(2) tailings liquor (or predicted tailings liquor) with a total cyanide concentration exceeding 1 mg/l or a pH outside the range 5 to 9.

Tailings with these characteristics require higher standards of TSF design, construction and management.

Table 2: Maximum contaminant concentrations and elutriable fractions allowed in soil to be disposed of as contaminated soils (low level), based on EPA Victoria's classification of contaminated soils (EPA, 2004)

Contaminant	Maximum Concentration (total) mg/kg dry weight	Elutriable Fraction (pH 5.0 extract) g/m3
Arsenic	300	5.0
Cadmium	50	0.5
Chromium	2500	5.0
Copper	1000	10
Cobalt	500	-
Lead	3000	5.0
Mercury 1	2	0.1
Molybdenum	400	-
Nickel	1000	-
Tin	500	-
Selenium	100	1.0
Zinc	5000	50
Cyanide	500	10
Fluoride	4500	150
Phenols	10	-
Monocyclic Aromatic Hydrocarbons	70	-
Polycyclic Aromatic Hydrocarbons	200	-
Total Petroleum Hydrocarbons (C6 to C9)	1000	-
Total Petroleum Hydrocarbons (>C9)	10000	-
Organochlorine Compounds	10	

Department – the Victorian State Department for the time responsible for the administration of the Mineral Resources Development Act 1990 and the Extractive Industry Development Act 1995

DELWP – Department of Environment, Land, Water & Planning

EID Act – *Extractive Industry Development Act 1995*

EP Act – *Environment Protection Act 1970*

ERP – Emergency Response Plan

ERR – Earth Resources Regulation Branch of the Department of for Economic Development, Jobs, Transport and Resources

Freeboard – the vertical distance between the operating or predicted water level in a storage and the crest level where water would flow over the dam Hazard – a source of potential harm or a situation with potential for harm and its potential consequences

Likelihood – a qualitative term encompassing both probability and frequency

MRD Act – *Mineral Resources Development Act 1990*

Phreatic surface – the position at which soil water is saturated; essentially the water table

Piezometric level - the level that groundwater rises to in a piezometer. This is a measure of groundwater pressure

Pore water – water in the spaces between particles (of sand, rock, tailings materials, etc)

Rheological – flow characteristics of liquids with suspended particles

Risk – the likelihood of particular event or set of circumstances being realised as compounded by its consequences

Risk analysis – the systematic use of available information to identify hazards and to estimate, quantitatively or qualitatively, the likelihood and consequences of those hazards being realised (how often a specific event may occur and its magnitude)

Risk assessment – the evaluation of the results of risk analysis against predetermined standards, target risk levels or other criteria to determine acceptability or tolerability of the levels of risk remaining after control measures have been implemented, or to determine risk management priorities (or the effectiveness or cost-effectiveness of alternative risk management options and strategies)

Risk management – the systematic application of policies, procedures and practices to the task of identifying hazards; analysing the consequences and likelihoods associated with those hazards; estimating risk levels (quantitatively or qualitatively); assessing those levels of risk against relevant criteria and targets; making decisions and acting to reduce risk levels. Actions involve consideration of legal, economic and behavioural factors.

Size of TSFs - 'Large' TSFs are generally classified as having:

- an embankment of 5 m or higher and a capacity of 50 ML or more;
- an embankment of 10 m or higher and a capacity of 20 ML or more;
- an embankment of 15 m or higher regardless of capacity
- (the above three criteria derive from Section 67(1A) of the Water Act 1989) or
- a combined storage capacity of all TSFs on the site greater than 50 ML.

The height of the embankment should be determined from its maximum height above natural surface.

Slime – silt- or clay-sized material; usually with high water content

Suitably qualified and experienced person – a person who:

a) is independent of the TSF proponent and operator.

b) has qualifications sufficient for eligibility for membership of The Institution of Engineers, Australia or The Australasian Institute of Mining and Metallurgy.

c) has appropriate professional indemnity insurance (adapted from Ministerial Guidelines 2002).

d) has knowledge of engineering principles related to the structures, geomechanics, hydrology, hydraulics, chemistry and environmental impact of TSFs.

e) has a total of at least five years of suitable experience and demonstrated expertise in at least four of the following areas:

- investigation, design or construction of TSFs;
- operation and maintenance of TSFs;
- geomechanics with particular emphasis on stability, geology and geochemistry;
- hydrology with particular reference to flooding, estimation of extreme storms, water management or meteorology;
- hydraulics with particular reference to sediment transport and deposition, erosion control and beach processes;
- hydrogeology with particular reference to seepage, groundwater, solute transport processes and monitoring thereof;
- safety of TSFs and
- safety and environmental audits of TSFs.

f) where appropriate has experience in forming and managing multi-disciplinary teams with the relevant expertise for complex projects and

g) can provide evidence of the arrangements that will be in place to provide technical expertise on areas in which the suitably qualified and experienced person is not an expert.

Supernatant Water – free water that has collected on the surface of deposited tailings or slurry.

Tailings – a solid waste product or residue from a process. The residue or waste that comes out of the 'tail' end of a processing plant. In the context of mining, the term is used as a singular noun and refers to the fine-grained waste material remaining after the economically recoverable metals and minerals have been extracted from the raw material.

Tailings dam – an artificial barrier or embankment, together with appurtenant works, constructed for storage, control or diversion of water, other liquids, silt, debris or other liquid-borne material associated with tailings.

TSF - Tailings storage facility – an area used to confine tailings and includes the tailings dam or other structure and associated infrastructure. It refers to the overall facility, and may include one or more tailings (or water) dams.

Waterway – defined under the *Water Act 1989* to be any river, creek, stream or watercourse in which water regularly (but not necessarily continuously) flows and a channel resulting from the alteration or relocation of a waterway.