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

Guide to the preparation of a design report for tailings storage facilities (TSFs)

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Foreword

This guide has been provided to assist tailings storage facilities (TSFs) designers with preparing the design report for a TSF. It describes the preferred structure of the design report for tailings storage facilities (TSFs) that should be submitted to the Department of Mines and Petroleum (DMP) in accordance with section 4 of the Mining Proposal guidelines as required by the *Mining Act 1978* and the *Tailings storage facilities in Western Australia – code of practice*.

As necessary, this guide will be updated to present required changes to the design report. Refer to the latest online guide to ensure essential requirements are covered in submitted design reports.

Notes:

1. *It is the responsibility of the Principal Employer, Mine Manager and tenement holder to comply with obligations that exist under the Mines Safety and Inspection Act 1994 and the Mines Safety and Inspection Regulations 1995 (e.g. contaminated sites, Environment Protection Act).*
2. *Authorised versions of the Act and regulations are available from the State Law Publisher (www.slp.wa.gov.au), the official publisher of Western Australian legislation and statutory information.*
3. *A competent person means a person who is appointed or designated by the responsible person to perform specified duties which the person is qualified to perform by knowledge, training and experience (see the Mines Safety and Inspection Act 1994).*
4. *While ANCOLD Guidelines on Tailings Dams 2012 is referenced for further information in a number of sections in this guide, regulatory requirements in Western Australia may supersede some guidance contained within ANCOLD.*

3rd party independent technical reviewer

It is the responsibility of the Registered Manager and the competent person(s) involved in the TSF design to determine the level of geotechnical and other professional assistance required.

The option exists for the Registered Manager to allow a 3rd party independent reviewer to verify the TSF design report. This option should assist with expediting the approvals process.

The requirement is that a competent reviewer certifies that the design report has been prepared in accordance with the *Tailings storage facilities in Western Australia – code of practice* and this guide. It is required that this 3rd party technical reviewer is:

- independent of the proponent and the company preparing the design report
- technically competent with tailings experience.

If this process is followed, it will remove the need for DMP Geotechnical Engineers to review the TSF design before recommending environmental approval under the *Mining Act 1978* administered by the Executive Director Environment Division, DMP. However, as part of DMP's commitment to continually improve safety and environmental management, the design may still be audited before or subsequent to the granting of environmental approval, and additional information may be requested by DMP, if required.

Please note that the usual environmental assessment under the provisions of the *Mining Act 1978* is required to be undertaken.

Design reports received without 3rd party independent certification will be processed in the normal manner and will require DMP Geotechnical Engineers to verify the design report before approval will be issued.

Submission of a design report

The design report is to be submitted online through the DMP website at www.dmp.wa.gov.au/8266.aspx.

After approval of the mining proposal, the design report — excluding confidential information designated by the proponent — will be available online for public review.

Introduction – TSF design justification

The tailings storage facility (TSF) design report presents an analysis of the background conditions and investigations undertaken. It outlines the basis of the design and justifies the parameters adopted for the engineering design, construction, operation, rehabilitation and after closure of the TSF.

Supporting evidence within the design report will indicate that the structure will meet the design objectives — safe, stable, non-polluting, erosion-resistant and self-sustaining — during construction, operation, rehabilitation and after closure.

The scope and extent of the design report and supporting data required to justify the design of a TSF will vary depending on the:

- proposed TSF retaining structure (e.g. type, size) and the corresponding hazard rating
- tailings physical properties, mineralogy and geochemistry
- complexity and spatial variability of local topographic and geotechnical conditions
- availability of quality data from previous or similar TSFs
- presence of any private or public infrastructure and properties, including the population at risk
- environmental attributes and aesthetics of the TSF site.

Note: Tailings, referred to in this guide, comprise solids and liquids as a result of mineral processing. For design purposes these may be addressed separately or in combination.

The preparation of the design report should be seen as a basis for the initial identification of potential hazards of the proposed TSF and associated mining operations, and a starting point for developing ongoing strategies to manage the associated risks. Therefore, the design report should be considered by the Principal Employer and Mine Manager as an important tool in their due diligence process to develop an appropriate site-specific occupational health, safety and environment management system.

The design report needs to consider the risks associated with the various stages of the TSF's life cycle, including development, construction, operations and closure. The levels of risks involved depend on the site characteristics, including site topography, chosen method of storage and properties of tailings material and, therefore, site selection is integral to the design process and cannot be treated separately.

The design report is expected to evaluate:

- variations in the surface and sub-surface profile, and their impact on physical and engineering properties
- specified design and operational parameters, including relevant tolerances and their impact on the integrity and performance of the TSF
- monitoring and inspection requirements
- the proposed closure approach to be adopted.

It is important that the contents of the TSF proposal be given careful consideration to streamline the approvals process and avoid the need for amendments.

The design report should include a description of all investigations undertaken (e.g. sampling from drill holes and test pits, geophysical interpretation) and an analysis and interpretation of the test results for each soil and bedrock stratigraphic unit. This description should include supportive information, such as location, depths and logs of boreholes, probes and test pits, clearly marked on plans and sections.

In Western Australia, TSFs are classified as Category 1, 2 or 3 facilities based on their hazard rating and height of the TSF retaining structure (see *Tailings storage facilities in Western Australia – code of practice*) and, in some circumstances, the location and depositional method.

The TSF category will determine the degree of investigation, design input, construction supervision, and ongoing assessment and review necessary to assure it is safe, stable, erosion-resistant and non-polluting throughout its life cycle, as well as the level of detail required when making submissions or reporting to the Department of Mines and Petroleum (DMP). As a guide, the greater the hazard rating and the larger the area of the TSF, the greater the need for extensive site investigation to understand the ground conditions.

The structure of the TSF design report should take the form as presented by this guide and include:

- TSF proposal summary (see Chapter 1)
- input parameters used to develop the TSF model (see Chapter 2)
- details of the TSF design process (see Chapter 3)
- operational requirements (see Chapter 4)
- closure considerations (see Chapter 5)

Appendix 1 provides a TSF data sheet template, while Appendix 2 and 3 provides a certificate of compliance and a third party technical reviewer declaration. Appendix 4 and 5 provide details of further reference material and a definition of freeboard.

Note: Throughout this guide, the term retaining structures also refers to embankments and containment structures.

1 TSF proposal summary

All proposals for TSF construction and operation in Western Australia submitted to DMP should contain a summary of the proposal that includes:

- description of the project and TSF
- location — suitably scaled Geo-Datum Australia 94 (GDA 94) survey plan showing mine and non-mine infrastructure, labelled tenement boundaries, relevant cadastral and topographical data
- completed tailings storage data sheet (see Appendix 1)
- rehabilitation and closure objectives
- lists of commitments to
  - safeguard the TSF, site personnel and the environment
  - ensure the TSF is constructed, operated, maintained, rehabilitated, monitored and closed according to the approved design.

Where required, include:

- reference to an environmental study as carried out by the proponent
- confirmation by the proponent that relevant stakeholders have been consulted and resolutions reached.

Note: Stakeholder consultation, by the proponent, is a key component to the TSF planning, design, operation and closure process. Early engagement with stakeholders enables operators to better understand and manage stakeholder expectations and the potential risks associated with the TSF. This process should be part of the consultation process for project approvals. Therefore, the design report will need to consider the social environment of the area, including:

- *items or sites of State, National or Aboriginal heritage*
- *land ownership and use such as tourism, recreation, farming, reserve land, town sites and local Aboriginal communities.*

2 TSF design considerations

2.1 Introduction

TSF design should consider factors that may impact the TSF during construction and its operational life and after closure. These include:

- storage capacity
- tenure and site conditions
- retaining structure
- tailings properties.

The TSF should be designed to contain anticipated tailings volumes from the process plant and rates of deposition of tailings over the expected life of the project.

2.2 Storage capacity

TSFs should be designed to ensure sufficient storage capacity for expected quantity of tailings taking into account the potential for early closure or extended mine life. The factors that need to be considered include:

- method of ore processing
- annual rate of discharge
- quantity of tailings produced over the life of the project.

The TSF should have adequate capacity to cater for operational and safety requirements over the life of the TSF.

2.3 Tenure and site conditions

Appropriate tenure must be in place for the proposed TSF. The designer needs to confirm that the TSF, including the final closed state with associated infrastructure, fits within the tenure boundaries.

Supporting data for the design and the geotechnical model should be included in the design report. This commonly includes:

- climate
  - rainfall records, including intensity, duration, volume and probability
  - evaporation
  - humidity
  - wind speed and direction
- surface
  - landforms, soil units, and rock outcrops identified during investigations at the proposed TSF site *
  - geomorphological origin
  - sites for obtaining construction material *
  - surrounding infrastructure (existing and proposed) *
  - potential source of dust generation

- current and after closure land use
  - hydrology
    - catchment size, drainage paths, flood patterns and levels *
    - short- and long-term design rainfall events
    - run-off coefficients
    - effects of vegetation on flow
    - water management areas (e.g. water reserves, declared or proposed water supply catchment areas or groundwater protection areas) *
    - nearby water bodies, wetlands or groundwater dependent ecosystems *

** depict on suitably scaled, contoured, topography drawings showing the TSF outline*

- sub-surface and foundations
  - interpreted stratigraphic boundaries and units ++
  - material types (e.g. top soil, rehabilitation mediums, construction materials) ++
    - physical characteristics
    - geochemical characteristics
    - availability
    - volume
    - engineering properties as relevant, including
      - *in situ* density
      - particle size distribution
      - shear strength
      - Atterberg limits
      - consolidation
      - erosion resistance
      - dispersion characteristics and piping potential
      - static and dynamic liquefaction resistance
      - slake durability
      - hydraulic conductivity
      - geological structures (e.g. contacts, faults, shears) ++
  - hydrogeology
    - interpreted hydrogeological boundaries and units (e.g. aquifers, aquicludes, aquitards) ++
    - measured or interpreted hydraulic conductivity
    - measured or interpreted phreatic surfaces and piezometric surfaces ++
    - groundwater quality

- where applicable, a certified copy of groundwater quality analysis from a registered laboratory (e.g. SO_4, HCO_3, Mg, TDS, TSS and pH)
- groundwater flow directions and hydraulic gradient. ++

++ *where applicable, depict on suitably scaled plans and sections showing the TSF outline*

Locations of test pits, probes, seismic traverses and drill-holes used to obtain the parameters listed above should be provided on suitably scaled drawings. Suitably scaled logs showing the sampling methods and intervals, sections showing geological and geotechnical units, and seismic surveys across the TSF site, where used, and proposed borrow areas should also be provided.

Results of laboratory tests should be summarised and presented in a suitable format, with individual test data sheets appended to the report. Standard testing carried out as part of investigations needs to be certified by a registered laboratory or testing facility. Other testing methods used should be supported by suitable documentation.

If any drill-holes are located within the footprint of the TSF, their locations, depths, azimuth, and method and confirmation of sealing should be provided.

The final design parameters adopted for each characteristic need to be justified. Typically, the design parameters are likely to be the result of iterative investigations undertaken. Spatial and time-based variations to design values should also be described in the design report.

Note: Determining the mineralogy and geochemistry of the foundation materials, as part of the geochemical study for the project, will assist in understanding the reaction that may occur if inundated, exposed to oxygen or interacting with seepage from the TSF.

2.4 Retaining structure properties

Where purpose-built structures are used for tailings containment, the design report should present an analysis of the physical, chemical and engineering properties of material to be used for construction. The list of items included in the previous section under the heading subsurface and foundations applies here as well.

Design properties adopted for each of the TSF retaining structures should be included in the design report. For in-pit TSFs and cross-valley TSFs the permeability of the natural ground forming lateral containment should be considered.

The following topics should also be addressed:

- effect of construction and process water on relevant engineering properties
- effect of repeated shrink and swell on physical and engineering properties
- degradation or durability of materials, and resistance to erosion and piping
- permeability of compacted materials
- saturated and unsaturated peak and residual strengths, and moduli
- consolidation properties
- resistance to liquefaction (dynamic and static)
  - dynamic loading
  - naturally occurring seismicity
  - mining induced seismicity
  - blast induced vibration.

2.5 Tailings properties

Tailings properties are important considerations to determine the type of structure, and the operational and closure strategies suitable for any project. These properties also influence the scope and extent of the design report.

Where sites have existing TSFs, data should be obtained from stored tailings or from the processing plant detailing the quantities, range and composition of material delivered to the TSF. New mining projects will require laboratory or pilot plant assessments to obtain expected tailings parameters.

Changes in tailings properties that may result from any projected variations in ore types, processing method and discharge strategies also need to be assessed. These investigations and the associated testing of tailings should verify:

- physical and engineering characteristics
- mineralogy, geochemistry and composition
- process water geochemistry and residual process chemicals
- tailings rheology.

Where the initial evaluation is based on limited validated tailings properties, the designer should adopt a conservative design relevant to the degree of uncertainty and potential consequences.

For more information on tailings properties see section 4.0 of *ANCOLD Guidelines on Tailings Dams 2012*.

Physical and engineering characteristics of tailings solids

The design report should evaluate and describe the characteristics of tailings that may occur in response to any anticipated variations in ore, discharge properties, processing methods and depositional methods, depositional location, depth and time of year.

Examples of tailings material characteristics to be presented include:

- particle size distribution
- Atterberg limits
- shrinkage limits
- percentage solids
- slurry density
- bulk and dry density across the beach profile
- dust generation potential
- beach angle relevant to deposition strategies
- drained and undrained shear strengths
- consolidation behaviour during and after operation
- erodibility, collapsibility and piping potential
- elastic properties
- hydraulic conductivity
- static and dynamic liquefaction resistance
- post liquefaction strength

- “runout” potential.

Note: some of the above characteristics can be based on assessment of the physical properties of the tailings (e.g. dust generation potential under various climatic and operating conditions can be assessed using particle size distribution).

Mineralogy and geochemistry of tailings solids

The design report should evaluate and describe the potential ranges in tailings mineralogy and geochemistry, including:

- environmentally sensitive metal contents (e.g. Cu, Pb, Zn, Ni, As, Cd, Na)
- organic contents
- acid generating potential of tailings compounds (e.g. total sulfur, net acid production potential and NAG testing)
- radioactive or rare earth minerals
- potentially harmful fibrous minerals, dust, and metalliferous or neutral drainage.

Properties of process and return liquor

The design report should evaluate and describe the range of possible variations in physical and chemical properties of tailings liquor, including:

- suspended solids and settlement rates
- total cyanide ex-plant
- total cyanide in tailings return water
- weak acid dissociable (WAD) cyanide ex-plant
- WAD cyanide in tailings return water
- residual process chemicals and organic solvents
- salinity of process and tailings return water
- pH of slurry or paste ex-plant
- pH of tailings return water
- total dissolved salts (TDS)
- radioactivity of tailings return water.

Tailings rheology

Rheology of tailings should be considered as part of investigations and presented in the design report, as it affects the delivery and discharge of tailings. For example, rheology of the tailings is particularly relevant to thickened tailings systems.

In situations where tailings are pumped into disused open pits or underground voids, the design report should present an assessment of the flow characteristics of the tailings slurry. Depending on the mine closure strategies, the dewatering measures to be developed to maximise the tailings consolidation after deposition should be described and verified.

For more information on rheology and tailings flow see section 4.4 and 4.5 of *ANCOLD Guidelines on Tailings Dams 2012*.

3 TSF design

3.1 Introduction

The structural design of the TSF needs to consider all relevant input parameters and design options to ensure the TSF meets the design and operational objectives.

The greater the hazards associated with a TSF, the greater the level of detail required in investigation and parameter verification. For a consistent approach to hazard identification and management, TSFs are defined as a Category 1, 2 or 3 facility where the classifications are derived from the TSF retaining structure hazard rating and height (see the *Tailings storage facility in Western Australia – code of practice*) and documented in the proposal.

Table 1 presents reporting requirements for each TSF category for design, construction, operation and closure. Reporting requirements may change in certain circumstances.

Table 1 Guide to reporting requirements for TSFs

	CATEGORY 1	CATEGORY 2	CATEGORY 3
Design (including site investigation)	Report prepared in detail by geotechnically competent person	Report prepared in detail by geotechnically competent person	Report prepared by competent person
Construction	Supervised by geotechnically competent person Detailed construction report with as-built drawings	Supervised by geotechnically competent person Detailed construction report with as-built drawings	Constructed by a competent person As-built drawings provided
Operations	Annual inspection and audit by competent person	Inspection and audit every 2 years by competent person	Inspection and audit every 3 years by competent person *
Pre-closure	Inspection report by competent person confirming current status and intended decommissioning, rehabilitation and monitoring strategies with as-built drawings	Inspection report by competent person confirming current status and intended decommissioning, rehabilitation and monitoring strategies with as-built drawings	Inspection report by competent person confirming current status and intended decommissioning, rehabilitation and monitoring strategies with as-built drawings
Relinquishment	Final report by competent person confirming closure objectives have been achieved	Final report by competent person confirming closure objectives have been achieved	Final report by competent person confirming closure objectives have been achieved

** For in-pit TSFs a risk assessment must be undertaken to determine frequency of audits regardless of its category.*

Note: An operating manual should be maintained on site for all three TSF categories to ensure acceptable operations to meet regulatory expectations.

If a change in mining operations occurs (e.g. development of an underground mine adjacent to a previously mined open pit and existing TSF), the potential effect to the hazard rating of the structure must be reassessed, the design updated and approval sought.

The design report should also present evidence to verify the suitability of the tailings delivery system and TSF design to ensure no adverse impact on safety or on the environment. This process involves an iterative interrogation of the TSF model, which uses input parameters that are selected through site investigations and laboratory testing.

3.2 Modelling and design studies

Several methods may be used to model and design a TSF. Effective design requires a good understanding of the relationship between each method and their limitations with respect to the prevailing conditions and expected modes of failure. Design approaches include:

- empirical methods
- deterministic methods
- numerical methods
- kinematic, stereographic and block analyses (for in-pit TSFs)
- physical scale-modelling.

The design report presents justification of the methods used to design the TSF and presents results from the following modelling:

- tailings deposition and staged TSF development
- structural stability, including
  - dynamic stability
  - liquefaction
- seepage
- surface water flows
- groundwater flows
- water balance.

A competent person should determine which design method(s) best suits the site's geotechnical and mining conditions in order to achieve the required TSF objectives.

Structural stability

Factors to consider when analysing the stability of any TSF retaining structure (e.g. embankment, levee, pit wall, land bridge) associated with the full life-cycle of the TSF include:

- methods of testing and correlations used to determine the material design parameters, with justification for selection of the resultant design values
- internal and external flood effects during operations (e.g. 1-in-100-year 72-hour rainfall event)
- internal and external flood effects after closure (e.g. PMP or PMF event)
- variations in material parameters
- static and dynamic loading

- liquefaction potential
- surcharge loading
- variations in construction and testing tolerances.

For more information on TSF structural stability analysis see section 6.1 of *ANCOLD Guidelines on Tailings Dams 2012*.

Static and dynamic stability analyses assess the potential for deformation of foundations, retaining structure and tailings materials, which would result in TSF retaining structure instability or insufficient freeboard.

The dynamic stability of the TSF and associated structures should be assessed against relevant design earthquake events. These events also provide the basis for determining the design ground motions, response spectra, and peak ground accelerations.

The site investigation should undertake adequate in situ and laboratory testing to ascertain the potential for liquefaction, and the potential deformation characteristics of the TSF retaining structure and tailings material under dynamic loading.

Where tailings are determined as potentially liquefiable, the tailings should be modelled as a liquefied fluid with no shear strength if pseudo-static analyses is carried out as part of stability assessment of the TSF retaining structure. If other values are used they need to be justified.

Where relevant, the design report should evaluate the potential for lateral spreading, static or cyclic liquefaction of the foundation and TSF retaining materials or tailings.

The designer should be aware of the assumptions and history underlying the development of correlations used for the assessment of material parameters (e.g. shear strength, liquefaction potential), and the limitations on their use. The methods used to calculate the factor of safety against liquefaction should be described and justified in the design report.

Where a layer of foundation material is identified to be potentially liquefiable, and thus may impact on the TSF integrity, measures to prevent liquefaction or maintain stability during and following liquefaction should be presented and their application justified in the design report.

For more information on dynamic stability see section 6.15 of *ANCOLD Guidelines on Tailings Dams 2012* and *ANCOLD Guidelines on Design of Dams for Earthquake*.

Design acceptance criteria

Design acceptance criteria, such as factors of safety or probabilities of failure, should be developed and documented by a competent person to demonstrate that the design follows a justifiable process. This should be developed as an iterative process from the results of the modelling and stability analysis. The design acceptance criteria used for each design method may differ depending on:

- the consequence of any type of failure (as identified in a dambreak study)
- the degree of inherent uncertainty of the geotechnical model
- the degree of suitability against potential modes of failure
- consideration of applicable worst case conditions
- reliability and sensitivity to relevant input parameters.

For example, TSFs located near public infrastructure, sensitive environmental receptors or near tenement boundaries, should adopt design acceptance criteria that have a degree of conservatism.

A dambreak study needs to be presented in the proposal to show the impact of the tailings retaining structure failure. It also examines the case of storage to the maximum design level. The scope of the dambreak study should consider:

- the volume, extent and depth of potential tailings flow slides and likely flow travel times and velocities
- potential impacts on people, livestock, infrastructure and environment.

Erosion control

The design report should define the methods of erosion control and the criteria by which erosion will be managed. The allowable operational tolerances should be described and included in the operational specification.

To achieve DMP's objectives of the landform being safe, stable and non-polluting, the design report should clearly define the erosion control measures to minimise adverse impacts on the integrity of the TSF and environment. The design report should define:

- erosion mechanisms and rates (e.g. water, wind, biological activities)
- mitigating measures
- operational tolerances
- instrumentation and ongoing monitoring of erosion during operation and decommissioning.

Tailings that form a crust due to a high salt content may have reduced dust problems, unless disturbed. However, the long-term breakdown of salt crusts should be considered and may require a cover of benign material.

Seepage

The potential seepage from the decant pond and tailings beaches into the underlying tailings and foundations of the TSF from commencement of tailings deposition through to closure should be considered. The seepage into the TSF floor, through or under any retaining structure, levee, bund, pit walls or waste dumps associated with the TSF should be determined and presented in the design report.

The seepage associated with each reporting period during operation, decommissioning and after closure phases should be quantified in terms of volume, rate and quality. It should be demonstrated that the projected seepage will not compromise the integrity of any structures, or result in environmental harm.

The allowable operational tolerances should be described and included in the operational specification. The design report should define and justify the methods by which seepage will be managed. Examples of seepage control measures include:

- underdrainage systems, sumps and pumps
- cut off keyways, slurry walls and grout curtains
- interception drains and trenches with collection and recovery systems
- under-drainage
- seepage recovery wells
- low permeability or artificial liners.

During the decommissioning the seepage control measures, such as under-drainage outlets and sumps, are required to be removed or decommissioned if their continued presence compromises successful closure.

For more information on assessing and designing for seepage see section 5.8 of *ANCOLD Guidelines on Tailings Dams 2012*.

Surface water flow and storage

Rainfall in Western Australia may be extremely heavy at times, and this should be accounted for at all stages of the TSF development. The impact of storm flooding throughout the operating life of the TSF should be taken into account in terms of external toe erosion as well as internal flooding. The catchment response time is critical to emergency planning and assessment of potential impacts, and should be utilised in design assessments.

The design report should document:

- estimated maximum flood levels
- estimated surface water flow velocities and volume
- methods proposed to prevent ponding against TSF retaining structures
- an assessment of the requirement for flood protection armouring of any retaining structures, levee, bund, or diversion structure.

In general, there is limited hydrological data in remote mining areas of Western Australia that can be used as a basis for the direct estimation of probable extreme flood levels. Correlation with records from nearby areas with similar characteristics may be made, but care should be exercised with this approach and estimates checked through specific field measurements, including runoff and previous flood marks. Alternatively in critical cases, theoretical flood levels can be obtained by application of rainfall runoff models in conjunction with stream flow modelling.

If diversion of natural drainage channels becomes necessary for the construction of a TSF, safety issues arising from water diversion measures should be addressed at the design stage. It is important to give special attention to minimise the potential for flooding operating mines, residential areas and access roads due to combined effects of extreme rainfall events and natural drainage diversion measures associated with the TSF.

The design report should consider 1-in-100-year rainfall/flood events for storage and drainage during the operating life of the TSF — PMF and PMP events are relevant when considering TSF closure. This design approach applies to all relevant water management structures both internal and external to the TSF.

Note: water management structures installed while the TSF was operational may not be adequate for closure and additional drainage or storage structures may be required.

Water balance

It is important to develop a dynamic water balance model for the TSF. This will help to understand how water may affect the design and subsequent operational limitations and risks, and should be presented in the design report. The water balance model allows the mine operator to monitor water management during operation for comparison with design predictions. Figure 1 shows key components of a water balance model for a TSF with a central decant pond.

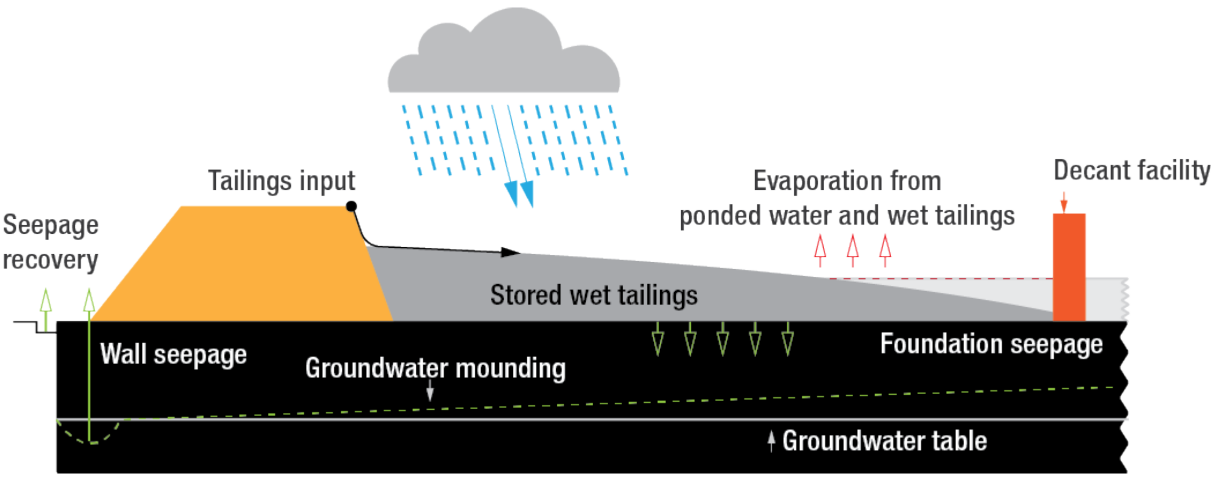

Figure 1 Illustration of TSF water balance

For more information on TSF water balance see section 5.2 of *ANCOLD Guidelines on Tailings Dams 2012*.

Settlement

Potential settlement during construction, operation, rehabilitation and closure of the TSF should be considered for the following:

- tailings
- foundations of retaining structures
- levees, bunds
- associated waste dumps.

It should be shown that settlement will not have a detrimental impact on the structural integrity or operational performance of the TSF retaining structure and associated infrastructure, or on the post closure landform.

For more information on assessment methods and the expected tailings settlement issues to be addressed see section 6.2 of *ANCOLD Guidelines on Tailings Dams 2012*.

Other factors

The potential interaction between adjacent infrastructures and environmental factors with TSFs should be analysed and, where the stability or integrity of the TSF or infrastructure is affected, a quantitative engineering assessment of the potential impact on the design should be included in the design report. Examples include:

- dust generation
- biological impacts, such as burrowing animals and large tree growth
- changing surface water flow
- rising phreatic surface.

Special requirements for radioactive tailings

When processing ore contains radioactive minerals, the likely concentrations of such minerals in the tailings should be determined, and suitable impoundment liners and covers considered to reduce health and environmental impacts (e.g. radiation, gas release, seepage, dust generation).

Additional attention is required for tailings from processing of uranium ores and for tailings from downstream processing of heavy mineral sands. In these cases an additional radioactive waste management plan is usually necessary.

3.3 Design and construction details

The final design parameters adopted for the TSF need to be justified. The construction material characteristics and tolerances should be established based on specified ranges of physical and geochemical properties, and construction methods.

The design report should clearly document and technically justify all input parameters and steps taken to arrive at the preferred design of the TSF. Technical aspects to be documented in the design report include:

- engineering properties of materials in each zone of the TSF retaining structure and the foundation adopted for stability analyses and seepage control (e.g. density, shear strength, hydraulic conductivity)
- engineering properties of impounded tailings where any contribution towards TSF retaining structure stability is assumed
- details of the methods of stability analyses used, formulae used in the analyses or references thereto in technical literature, the upstream and downstream water levels considered, and the phreatic surfaces used in the analysis
- locations of the critical failure surfaces identified for different loading conditions (e.g. TSF under static and dynamic loading conditions with minimum factors of safety immediately after construction and at full storage level).

Assuming a sound design, the success of a TSF retaining structure will depend critically on the manner in which it is constructed. Construction strategies, management, technical supervision and quality control are essential for the successful construction of a TSF.

Details of the construction methods and procedures, and materials to be used in the construction should be provided, including method statements and drawings addressing:

- details of each component of the TSF
- compaction specifications (e.g. lift height, moisture content, compacted density)
- quality assurance methods
- allowable traffic loadings and bearing pressures on foundation and structure
- temporary works (where relevant)
- armouring materials and sizes
- volumes of materials required
- monitoring instrumentation (e.g. phreatic surface, seepage, settlement)
- design features for preventing drainage control measures becoming unserviceable during the life of the TSF.

The design report should consider the requirements for ongoing maintenance, monitoring and verification of geotechnical and hydrogeological characteristics of the TSF.

If applicable, the design report should also describe implications of methods for harvesting tailings for construction or mine fill production (e.g. the effect of weak saturated materials, deposited in trenches excavated adjacent to retaining structures, on future TSF retaining structure raises).

Furthermore, designs proposing upstream construction with tailings materials for wall lifts should technically justify any proposed use of open-ended pipe discharge techniques over multi-point discharge techniques.

3.4 Tailings discharge and water management

The design report should provide details of tailings discharge and water management methods, including:

- tailings delivery and discharge arrangements
- decant systems and target water recovery
- size and location of free water pond
- tailings segregation and anticipated beach profile
- rate of rise of the tailings surface
- return water holding ponds.

Decant water and tailings pipelines should be located in a suitably bunded easement capable of containing any spill with appropriately designed catch pits or sumps.

When decant pipes are to be located within or beneath a retaining structure, the report should present the design details on how the risk of structural failure or internal erosion of the structure along the wall at the decant pipe would be minimised.

Where relevant, any water holding ponds should be designed in such a way that there are no adverse effects on the environment or nearby infrastructure. The design report should provide details of the design of the water holding ponds, criteria applied in sizing the pond, and how the pond levels will be managed.

If decant water is not to be re-used in the processing plant, the design report should present details on how the decant water will be managed.

3.5 Covers and liners

While most TSFs require a vegetated cover at closure (see chapter 5), some may require a special-needs cover or liner to mitigate specific high risk issues. For example:

- permeable foundations leading to groundwater mounding and surface expression of seepage
- sensitive environmental receptors
- tailings containing high salt concentrations, metals, highly acidic or alkaline material, toxic chemicals or radioactive material
- tailings that may liberate toxic dust, fibrous materials or gases.

Contingency temporary covers should also be developed where required (e.g. potential for significant dust generation during operation or if the TSF remains unused for an extended period). The selection of material(s) for liners and covers should be aligned to project specific conditions and circumstances (e.g. effect of root growth, durability post closure).

In these instances, provided design details and justifications should include physical and chemical characteristics of liner and cover materials, and volumes and location of materials available.

3.6 Quality assurance

Quality assurance to verify that the technical specification is being met in the course of construction is an important control that is applicable throughout the construction phase. Procedures and quality control tests should verify the TSF retaining structure has been constructed in accordance with specifications.

For example, the method of compaction control for TSF retaining structure construction should be specified to ensure that there are no weaknesses within the retaining structure, and confirm compliance with the design intent.

Strategies to rectify any areas not meeting the design specifications should be set out in the technical specifications and summarised in the design report.

3.7 Spillways

In Western Australia, the use of spillways is not encouraged, particularly for paddock or ring-dyke type facilities with perimeter retaining structures constructed using tailings.

However, in certain circumstances (e.g. cross-valley TSFs) where a secure structure can be achieved, a spillway may be considered as an additional safety measure. When spillways are proposed as part of the TSF, they should be designed and built to meet operational and closure objectives.

Where spillways are planned, they should be designed to have sufficient capacity to prevent surges and resultant overtopping of the retaining structure. Discharge from the spillway should not have an adverse effect on safety or the receiving environment. Spillways should be designed assuming a higher density of vegetation exists relative to the surrounding environment, which may reduce their capacity over time.

Where possible, spillways should be located and constructed within natural ground, away from retaining structures.

4 Operational requirements

4.1 Management of tailings deposition and water

The design report should provide an outline and expected performance of the tailings discharge and decant systems. These specific details should be provided in the Operating Manual.

Discharge management

The design report should provide details of the tailings discharge method used. These methods may include:

- single and multiple spigot discharge of tailings slurries
- vertical risers and end of pipe outlets for thickened and paste tailings
- hydrocyclone discharge
- stacking of dewatered (or dried) tailings by mechanical methods.

Correct operation of the selected discharge method is required to ensure that TSFs are managed to meet design expectations such as:

- uniform separation of coarse and fine tailings fractions
- formation of designed tailings beach
- tailings rate of rise
- operational freeboard
- reduced risk of erosion of the upstream retaining structure face
- decant pond location.

For example, issues to consider for slurry discharge, include:

- discharge sequencing
- selection of rate and period of discharge per spigot
- use of energy dissipaters and extender pipes at spigots
- operation of spigot outlets, normal to retaining structures and towards the decant pond
- selection of optimal tailings slurry density.

Decant control

The design report should provide details of the method of decanting the tailings water pond and the criteria by which the pond levels will be maintained within design tolerances. The selected method should be capable of maximising water recovery and tailings density to ensure efficient performance can be maintained (i.e. lower phreatic surface, reduced seepage, faster settlement of tailings, improved evaporative drying). Details provided should include:

- decant capacity, pond location, allowable pond size and elevation, and design tolerances (ponds should be kept to a minimum for environmental and engineering purposes)
- management of water recovery systems
- methods of control of suspended solids in decant pond
- performance monitoring of decant.

Freeboard

The purpose of freeboard is to provide a safety margin for storage of potential inflows from extreme natural events and unforeseen operational situations. In this way the risk of overtopping, leading to erosion and catastrophic failure of TSF retaining structures, is minimised. Freeboard definitions are given in Appendix 5.

The maintenance of adequate freeboard on a TSF is critical, particularly when the deposited tailings level approaches the TSF retaining structure crest level.

Where relevant, the following information should be provided within the design report:

- a topographic map of the catchment and description of the terrain including elevations
- the area of the catchment and of each sub-area controlled by other TSFs or lakes
- summary of stream and flood flow, or rainfall records on which the hydrological analyses are based
- tables or curves of reservoir area and storage capacity versus water surface level
- summaries, as applicable, of hydrological analyses leading to the determination of flood frequencies, probable maximum flood, reservoir capacity, outlet capacity, and freeboard above maximum flood level and capacity of flood diversion measures
- estimated rates of production of tailings or industrial wastes to be stored
- details of any proposal for reclaiming water from storage
- capacity of return water pond(s) and automatic shut-off valves and mechanisms for decant outfall pipe and under-drainage collection pipes
- details of any proposal for pumping or otherwise discharging excess water
- assumptions as to loss of water by evaporation
- the minimum freeboard to be maintained at relevant stages of the tailings deposition cycle to minimise the potential for tailings spills.

4.2 Seepage management

The methods by which seepage control measures would be maintained during the operating life of the TSF should consider the following:

- the tolerable seepage rates (e.g. impacts on the receiving environment)
- how it will be managed
- how impacts to the receiving environment will be negated
- instrumentation and ongoing monitoring of all seepage discharges during operation and decommissioning.

4.3 Erosion control

The design report should describe the allowable tolerances for wind and water erosion. Uncontrolled erosion of the TSF is likely to have significantly different consequences depending on the stage of the TSF. For example, erosion that may be insignificant during operation could become a potential pathway for large-scale failure after closure. Any damage to the retaining structure or tailings surface could accelerate wind and water erosion.

Dust generated from the surface of TSFs may be a nuisance, cause a health risk (e.g. fibrous materials, silica, heavy metals) and cause environmental impacts from airborne particulates and contaminants. Unbound silty or sandy tailings are likely to cause dust problems during periods of high wind. The design report should specify how dust will be controlled. For example:

- spraying with dust-suppressants
- suitable capping of the TSF during periods of suspension and decommissioning
- using windbreaks and silt traps
- maintaining moist tailings surface.

4.4 Performance monitoring and instrumentation

It is mandatory to conduct routine daily inspections during periods of tailings deposition. Other visual monitoring requirements will be required for specific events, such as extreme weather, earthquakes and periods of prolonged inactivity.

The design report should specify monitoring and instrumentation requirements, such as:

- sampling and testing procedures to be adopted
- minimum frequencies for testing and monitoring
- *in situ* and laboratory tests required to verify the design parameters on an ongoing basis
- corrective procedures for non-compliance with monitoring specification
- procedures for validation of the design using monitoring data
- procedures for identifying and rectifying non-compliance with the design
- instrumentation to monitor tailings and water transport, groundwater level and quality, seepage, evaporation and rainfall, dust emissions and landform stability, for example:
  - automatic cut-outs in the event of pipe failure
  - warning system to alert plant operators of possible overflow
  - leak detection system
  - piezometers
  - weather station.

Ongoing monitoring and instrumentation of seepage discharges is expected, and should be included in the monitoring specification. Monitoring specifications should be derived in accordance with trigger levels for specific issues of concern (e.g. phreatic surface, water quality, size of supernatant pond).

While the design of the TSF should address measures to be taken to mitigate the extent of contamination, the monitoring program should provide the means to assess the effectiveness of the measures taken. The aims of monitoring are to provide a measure of actual performance against expected performance as described in the mining proposal for the TSF.

It is a requirement that all native fauna deaths and any technical malfunction resulting in tailings or water escaping from the retaining system be reported to the Director Environment Division, Department of Mines and Petroleum.

The design report should describe all proposed monitoring procedures for the TSF. Details of sampling locations, frequency and parameters should be provided.

In addition, the report should also describe how to monitor other relevant aspects such as:

- achieved tailings densities and properties
- available storage volumes
- deposition time remaining
- results of environmental trials for final rehabilitation.

5 Closure considerations

5.1 Overview

TSF closure planning needs to be integrated into mine development and operations planning and, as such, the level of information required will correspond to the life span of the TSF and reflect the various stages of the project. Decommissioning and closure of TSFs is a complex process that requires specialised ongoing consideration and management.

TSF closure objectives are to create a safe, stable, non-polluting landform. TSF closure should be viewed as a whole-of-life process that includes:

- decommissioning, which is a process that begins near, or at, the cessation of deposition of tailings into a TSF and ends with removal of all unwanted infrastructure and services
- rehabilitation, which is the return of disturbed land to a self-sustaining condition — consistent with post-mining land use and relevant stakeholder expectations — it is recommended that records of the stakeholder consultation process are maintained
- performance monitoring to demonstrate that agreed outcomes can be achieved — an extended monitoring period may be required to demonstrate closure objectives are achieved.

The TSF closure plan should include details of:

- final landforms and drainage structures (e.g. surface drainage works, covers, encapsulation cells, armouring)
- progressive rehabilitation including materials handling, placement (e.g. topsoil and vegetative material)
- monitoring and validation against agreed closure criteria
- monitoring and maintenance program until relinquishment
- unplanned or contingency closure plan.

5.2 Decommissioning

Detail on the strategy and activities for decommissioning TSF-related plant and infrastructure should be provided in the design report, including:

- demolition and decommissioning of the TSF-related plant and infrastructure (e.g. decant and under-drainage systems fully decommissioned and made safe so as not impact on stability of the retaining structure and function of the TSF and surrounding ecosystems)
- compliance with the requirements of other relevant legislation including the *Contaminated Sites Act 2003* and the remediation of contaminated areas
- ongoing consultation with stakeholders
- handover of infrastructure requested by other parties.

5.3 Rehabilitation

It needs to be demonstrated in the design report that closure optimises rehabilitation outcomes, consistent with the proposed post-mining land use. Suitable land forms, soil profiles and soil characteristics should be reinstated consistent with the proposed final land use. Evidence to support the long-term objectives being achievable may include:

- integrity of the TSF retaining structural (e.g. no slumping, piping, gullying, or undercutting)
- no overtopping
- no adverse effects to the ground water or surface water on receiving environment (e.g. contaminants leaching from the structure)
- no adverse effects from the ground or surface water to the TSF (e.g. flood waters)
- minimising, to an acceptable level, adverse impacts to the ecosystem on the rehabilitated TSF surface
- erosion rates not detrimental to the stability of the TSF retaining structure, and function of the TSF and surrounding ecosystems
- a self-sustaining, functioning ecosystem
- managing any risk of uptake of toxic materials by vegetation or pasture to avoid harm to the vegetation, native animals or stock which may feed on the vegetation or pasture.

5.4 Performance monitoring against closure criteria

The aim of performance monitoring is to provide a measure of actual performance of the rehabilitation program against expected performance as described in the mining proposal and TSF design report.

The design report should provide a summary of rehabilitation monitoring requirements for the TSF to verify expected performance. Details of sampling locations, frequency and parameters should be provided, such as:

- surface drainage works (e.g. concentration of flows, erosion, construction and ongoing maintenance)
- physical and chemical stability of the tailings, including dust generation, and wind and water erosion
- sedimentation and its influence on receiving environment
- consequences of extreme environmental conditions (e.g. drought, flood, fire, earthquake)
- groundwater
- structural integrity
- on-going settlement of the TSF retaining structure and rehabilitated surface
- rehabilitation and ecological function.

It is recommended that completion of environmental trials for final rehabilitation should be considered part of the TSF monitoring to aid rehabilitation and closure planning.

Appendix 1 – Tailings storage data sheet

Project operator			
Project name		Date	
TSF name		Commodity	
Name of data provider		Phone	
TSF centre co-ordinates (GDA 94)	m North		m East
Mining Tenement and Holder(s) details			
TSF data			
TSF status: Proposed ☐ Active ☐ Non Active ☐ Decommissioned ☐ Rehabilitated ☐ Closed ☐			
Type of TSF: [1]		Number of cells: [2]	
Hazard rating: [3]		TSF category: [4]	
Catchment area: [5]		Nearest water course:	
Date deposition started (mm/yy):		Date deposition completed (mm/yy):	
Tailings discharge method: [6]		Water recovery method: [7]	
Bottom of facility sealed or lined?	Y / N	Type of seal or liner: [8]	
Depth to original groundwater level Current groundwater level	m m	Original groundwater TDS/pH	mg/l
Ore process: [9]		Tailings Deposition rate: [10]	
Impoundment volume (present)	m^3	Expected maximum	m^3
Mass of solids stored (present)	tonnes	Expected maximum	tonnes
Above ground facilities			
Foundation soils		Foundation rocks	
Starter bund construction materials: [11]		Wall lifting by: Upstream ☐ Downstream ☐ Centre line ☐	
Wall construction method/materials:		Wall lifting material: [12] mechanically ☐ hydraulically ☐	
Present maximum wall height agl: [13]	m	Expected maximum	m
Crest length (present)	m	Expected maximum	m
Impoundment area (present)	ha	Expected maximum	ha
Below ground (in-pit) facilities			
Initial pit depth (maximum)	m	Area of pit base	ha
Thickness of tailings (present)	m	Expected maximum	m
Current surface area of tailings	ha	Final surface area of tailings	ha
Properties of tailings and return water			
TDS mg/l	pH	Solids content	Deposited density t/m^3
Potentially hazardous substances: [14]		WAD CN	Total CN mg/l
		Any other NPI listed substances in the TSF? [15] Y / N	

Explanatory notes for completing tailings storage data sheet

The following notes are provided to assist the proponent to complete the tailings storage data sheet.

1 Paddock (ring-dyke), cross-valley, side-hill, in-pit, depression, waste fill, central thickened discharge, stacked tailings

2 Number of cells operated using the same decant arrangement

3 See Table 1 – Hazard rating system in the Code of practice

4 See Table 2 – Matrix of hazard ratings in the Code of practice

5 Internal for paddock (ring-dyke) type, internal plus external catchment for other facilities

6 End of pipe, (fixed), end of pipe (movable) single spigot, multi-spigots, cyclone, central thickened discharge (CTD)

7 Gravity feed decant, pumped central decant, floating pump, wall/side mounted pump

8 Clay, synthetic

9 See list below for ore process method

10 Tonnes of solids per year

11 Record only the main material(s) used for construction, e.g. clay, sand, silt, gravel, laterite, fresh rock, weathered rock, tailings, clayey sand, clayey gravel, sandy clay, silty clay, gravelly clay or any combination of these materials

12 Any one or combination of the materials listed under item 11 above

13 Maximum wall height above the ground level (not AHD or RL)

14 Arsenic, Asbestos, Caustic soda, Copper sulphide, Cyanide, Iron sulphide, Lead, Mercury, Nickel sulphide, Sulphuric acid, Xanthates, radioactive elements

15 NPI – National pollution inventory
(contact Department of Environmental Protection for information on NPI listed substances)

Ore process methods

The ore process methods may be recorded as follows:

Acid leaching (Atmospheric)

Acid leaching (Pressure)

Alkali leaching (Atmospheric)

Alkali leaching (Pressure)

Bayer process

Becher process

BIOX

Crushing and screening

CIL/CIP

Flotation

Gravity separation

Heap leaching

Magnetic separation

Ore sorters

Pyromet

SX/EW (Solvent extraction/Electro wining)

Vat leaching

Washing and screening

Appendix 2 – Certificate of compliance

CERTIFICATION OF COMPLIANCE

Tailings storage facility design report

For and on behalf of ....
I, ...
being a duly authorised officer of the above company and a qualified geotechnical engineer holding professional registration by a professional body, do hereby certify and confirm that the .... tailings storage facility at the ....
mine site has been designed in accordance with the current edition of the *Tailings storage facilities in Western Australia – code of practice* issued by the Department of Mines and Petroleum, Western Australia and the design is referenced

as..

dated ....

Signature of above person: ....

Signature of witness: ....

Name of witness: ....

Date: ....

Appendix 3 – Third party independent technical reviewer

DECLARATION BY
3RD PARTY INDEPENDENT TECHNICAL REVIEWER
Tailings storage facility design report

I,..,
being a qualified engineer, registration number ……………………………………………….
(with relevant experience and competence in tailings management to verify the tailings storage facility design) holding professional registration through

☐ The Institution of Engineers Australia, or

☐ Australasian Institute of Mining and Metallurgy

being independent of the applicant, do hereby declare and confirm that I have reviewed the design report for the ....
tailings storage facility at the ....
mine site, and hereby verify that the design report provides the required information, and demonstrates the current best practice engineering investigation and analysis. The information contained in the design report meets the design, operation and closure objectives stipulated in the current edition of the Tailings storage facilities in Western Australia – code of practice issued by the Department of Mines and Petroleum, Western Australia.

I acknowledge that the Department of Mines and Petroleum may rely on this declaration.

The design report is referenced as...

dated.............................

Name of 3rd party technical reviewer: ....

Signature of 3rd party technical reviewer: ....

Date: ……...

Note: The 3rd party technical reviewer and applicant must have public liability insurance to the minimum value of $50,000,000.

I hereby confirm my opinion that the above-mentioned 3rd party independent technical reviewer is suitably qualified with relevant experience and competence in tailings design and management, and verify that the reviewer is truly independent of the applicant.

Name of applicant: ....

Signature of applicant: ....

Date: ....

Appendix 4 – Further information

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

- Department of Mines and Petroleum, www.dmp.wa.gov.au
  - *Tailings storage facilities in Western Australia – code of practice*
  - *Safe design of buildings and structures – code of practice*
  - *Development of an operating manual for tailings storage – guideline*
  - *Tailings dams – HIF audit guideline and template*
  - *Mines survey – code of practice*

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

  Guidance includes:
  - *Guidelines for Geotechnical considerations in open pit mines*
  - *Guidelines for mining proposals in Western Australia*
  - *Guidelines for preparing mine closure plans*
- The Australian National Committee on Large Dams Inc. (ANCOLD), www.ancold.org.au
  - *Guidelines on tailing dams: Planning, design, construction, operations and closure (2012)*
  - *Guidelines for Design of Dams for Earthquakes (1998)*
- Department of Industry Tourism and Resources, www.ret.gov.au
  - *Leading practice sustainable development program for the mining industry – Tailings management – guidelines (2007)*
- Federal Emergency Management Agency, USA, www.fema.gov
  - *Federal Guidelines for dam safety: Earthquake analyses and design of dams*

Appendix 5 – Freeboard

Importance of freeboard

The freeboard should be sufficient to contain unforeseen increases in the level and movement of fluid within the TSF caused by:

- tailings spills or overflow from spigot malfunctioning
- back flow and overtopping as a result of mounding of tailings at discharge points
- outlet or recovery system failures
- uncertainties in design rainfall estimates
- uncertainties in design catchment and runoff estimates
- extreme wind effects such as wave run-up and wind setup
- other effects, such as seismicity and land slips, that may generate waves.

In the post-decommissioning phase, the requirement for PMP discharges should be considered. Seasonal conditions and floods need to be examined when paddock type TSF are assessed. Individual storm events may not cause problems in terms of storage capacity, but the possibility of successive events in wet seasons, when evaporation rates are low, will need to be considered.

Definition

The purpose of freeboard is to provide a minimum safety margin, over and above the estimated inflows of fluids from extreme natural events and operational situations, so that the risk of overtopping leading to TSF retaining structure erosion and ultimate failure of an above ground TSF is minimised.

For TSFs with retaining structures the freeboard is defined as shown in Figure A1.

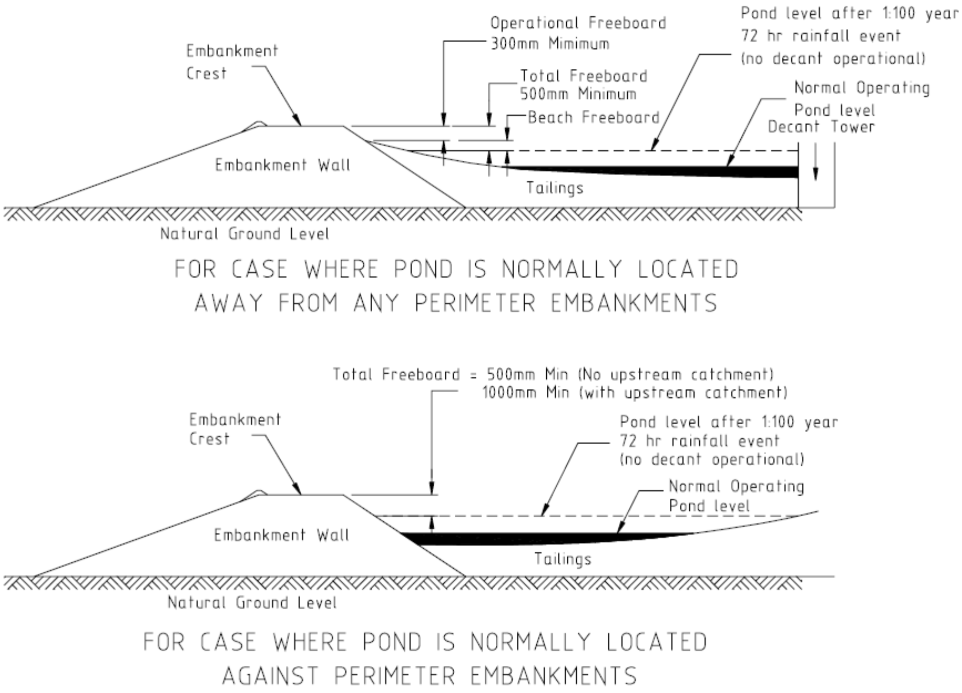

Figure A1 Illustration of freeboard

- For a TSF with a water pond normally located away from any perimeter retaining structure:

  Total freeboard = operational freeboard + beach freeboard

  = 500 mm with a sub-minimum of 300 mm operational freeboard.

- For a TSF with a water pond normally located against a perimeter retaining structure but with no upstream catchment apart from the storage itself:

  Total freeboard = operational freeboard = 500 mm.

- For a TSF with a water pond normally located against a perimeter retaining structure but with an upstream catchment in addition to the storage itself:

  Total freeboard = operational freeboard = 1,000 mm.

Total freeboard is the vertical height between the lowest point on the crest of the perimeter retaining structure of the TSF and the normal operating pond level plus an allowance for an inflow corresponding to the 1-in-100-year 72-hour ARI rainfall event falling in the catchment of the pond, assuming that no decant recovery takes place for the duration of the rainfall event.

Operational freeboard is the vertical height between the lowest elevation of the perimeter retaining structure and the tailings beach immediately inside the retaining structure. The operational freeboard varies over the course of a deposition cycle as the storage is raised and fills with tailings. The operational freeboard becomes critically important at the end of a deposition cycle, particularly to minimise the potential for back flow and overtopping as a result of mounding of tailings at discharge points.

Beach Freeboard is the vertical height between the normal operating pond level plus an allowance for an inflow corresponding to the 1-in-100-year 72-hour ARI rainfall event falling in the catchment of the pond, assuming that no uncontrolled discharge takes place for the duration of the rainfall event, and the point on the beach where the wall freeboard is measured. The beach freeboard may vary significantly during the life of the storage and depends upon beach length, slurry or tailings characteristics and deposition methodology. Beach freeboard is not applicable where the pond is normally located against a perimeter retaining structure.

Note: the total freeboard also corresponds to the sum of the operational freeboard and the beach freeboard as defined below.