Banpu Public Company Limited

Waste Management - Mineral Waste

Management Standard

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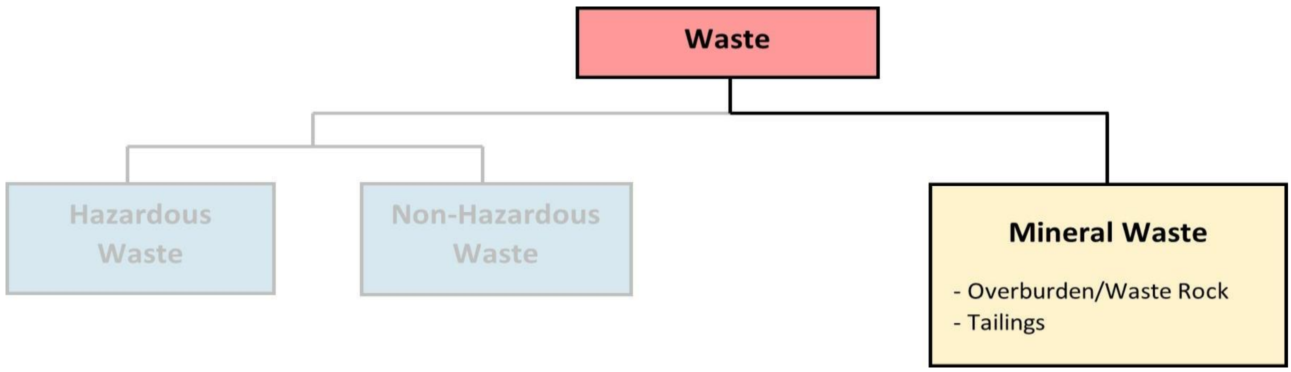
Introduction

Waste management is an integral component of Banpu's environmental management system. Waste management practices aim to reduce waste generated from business operations through prevention, minimization, reuse, recycling and effective utilization of resources. In case that disposal of wastes is inevitable, the Company expects everyone to strictly adhere to regulations or industry best practices whichever are more stringent for both on- and off-site disposals.

The standard practice manual of waste management covers management practices of
(1) all waste streams associated with business operations, and
(2) potential impacts on existing environmental values.

Waste can be structured as below:



● Hazardous and non-hazardous wastes are the waste generated from operational processes, supporting facilities such as ports and train loading facilities, and offices.
● Mineral waste consists of overburden/waste rock and tailings from extraction, beneficiation and/or processing of mining business, which is not included in hazardous and non-hazardous waste categories. The generated volume of this waste is basically much higher than hazardous and non-hazardous waste. Therefore, it is needed to closely monitor and manage in proper way so as to minimize negative environmental impacts and risks that might occur in the future.

This standard practice manual (Waste Management – Mineral Waste) has been developed from Banpu Waste Management Policy. The document focuses only on the management details of mineral waste, while the management details of hazardous and non-hazardous waste are detailed in the Standard Practice Manual of Waste Management – Hazardous and Non-hazardous Waste separately.

Objective

The objectives of this standard practice manual are:
• To outline framework and broad principle of mineral waste management
• To provide information and guideline for the sites to establish their work procedure (WP) and/or work instruction (WI) (if applicable), and waste management plan as well as implement waste management program for mineral waste

Scope

This standard practice manual shall be integrated and applied to Banpu and its subsidiaries where we have management control including employees, contractors and suppliers, and will also be applied for internal consideration during due diligence and/or mergers and acquisition processes where appropriate.

In implementing this manual, we establish measurable indicators and an assurance system to monitor and review performance to ensure that this manual is implemented effectively. Global Corporate Sustainability (GCS) will conduct assurance with the country and/or operations as required by the Sustainability Assurance Division.

Definitions

Overburden/Waste rock:
Comprises rock that has uneconomic mineral content and which is removed to access ore during mining activities. Overburden typically results from the development of surface mines, while waste rock is a byproduct of mineral extraction in underground mines.

Tailings:
Material remaining after minerals have been removed from ore, and which comprise finely ground rock mixed with process water.

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

Process / Content

Mineral Waste Management Principle
The standard practice manual provides guidance for mineral waste management through mineral waste management principles of overburden/waste rock and tailings, and tailings storage facilities (TSFs) as details below:

Overburden/Waste Rock and Tailings Management Principle
The principles of leading practice for overburden/waste rock and tailings management are:
- Prevention, minimization or proper management of mineral waste generation quantities both overburden/waste rock and tailings
- Reuse overburden/waste rock and tailings
- Disposal with all measures and appropriate technology that avoid potential impacts to human health and the environment as well as to comply with national and/or local regulations

In order to prevent/minimize the production of overburden/waste rock and tailings as well as the potential risks associated with storages, mineral waste management plan shall be integrated to the mine plan since pre-mining stage throughout entire mine life. Any potentials to reprocess the overburden/waste rock and tailings should be exploited, and alternative uses should be found wherever possible. Overburden/waste rock generated by mining operations can be used for land forming including road base aggregate, footings or for landscape restoration.

While, tailings volumes which are a function of the run-of-mine (ROM) ore throughput can be recovered and reprocessed to be economic products to mines and processes in the future. There are opportunities to use some tailings for industrial or the environmental purposes, thus reducing the storage requirement, including:
- Coal tailings used as a low-grade fuel

● Some tailings used as a construction material (for example, for upstream raises of TSFs)

Tailings Storage Facilities Management Principle

The principles of leading practice for tailings storage facilities management are underpinned by a risk- based approach to the planning, design, construction, operation, closure and aftercare of TSFs together with surveillance and monitoring systems to manage risks in all phases. In this approach, plans need to be tailored to manage the TSFs effectively over their full life cycle, with sufficient details to manage the potential risks within acceptable limits.

The design of the TSFs should be integrated with the life-of-mine (LoM) plan so that the most cost- effective and acceptable risk solutions for closure can be developed. TSFs with higher risk ratings require more rigor at the design phase, greater quality control during construction, and closer attention to risk management, emergency action planning systems and documentation during the operational and closure phases.

The TSFs locations, disposal methods, approaches to water management and long-term closure objectives need to be clearly defined in accordance with global standards, such as Global Industry Standard on Tailings Management (GISTM), leading internal standards and best practices throughout the life of TSFs. Financial and technical analysis of options must accommodate social and community concerns about the environmental, aesthetic and cultural issues.

Mineral Waste Management

Mineral waste is a type of waste generated during the extraction, beneficiation, and processing of ore. Overburden/Waste rock is the material removed to access the ore, while tailings consist of ground rock and wastewater that are generated during processing of the ore.

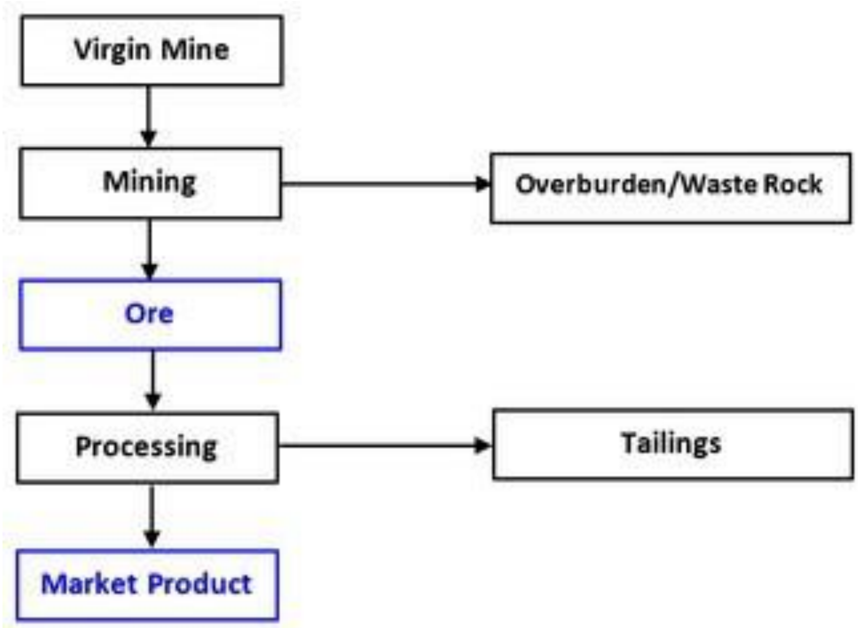


Figure 1: Mineral Waste Types (BRGM, 2001)

Mineral waste, which does not pose exposure risks, does not require special treatment or geochemical monitoring. The waste can be used for landform reconstruction, road and dam construction, and may be suitable substrates for vegetation covers and similar rehabilitation measures upon mine closure.

However, some types of mineral waste contain, or may result in the generation of, hazardous substances and require monitoring, treatment and secure disposal to avoid the environmental impacts which might be occurred. See the management details in the Standard Practice Manual of Acid Mine Drainage Management.

Potential environmental impacts of mineral waste can be managed by:
● Comprehensively characterizing the wastes
● Segregating reactive from non-reactive mineral wastes
● Designing the repositories to minimize environmental impacts
● Monitoring surface water, groundwater and other medias to verify performance and identify failures in design or practice at the outset
● Undertaking progressive rehabilitation program
● Implementing risk assessment programs
● Networking externally and internally to share best practices and develop best practice control technologies

Mineral waste may be managed in a variety of ways, depending on their physical and chemical maturity, the site topography, climatic condition, national regulation and the socio-economic context in which the mine operations and processing plants are located.

1. Overburden/Waste rock

Overburden/Waste rock may even contain very low grades of ore which cannot be processed profitably. This is generally stored permanently on-site where it can be used as in-pit backfill or placed in engineered repositories. The most common methods for managing overburden/waste rock are to filling or constructing roads and other infrastructures.

2. Tailings

Tailings consist of ground rock and process water that are generated in a mine processing plant. Mechanical and chemical processes are used to extract the desired product from the run of the mine ore and produce a waste stream known as tailings. This process of product extraction is never 100% efficient, nor is it possible to reclaim all reusable and expended processing reagents and chemicals. The unrecoverable and uneconomic metals, minerals, chemicals, organics and process water are discharged, normally as slurry, to a final storage area commonly known as a Tailings Management Facility (TMF) or Tailings Storage Facility (TSF). The most common methods for managing tailings include the following:

1) Slurry Disposal

Tailings are commonly pumped as a slurry in a pipeline and discharged sub-aerially into a surface TSF. The consistency of the slurry (% solid by mass) depends on the type of tailings, the particle size distribution and specific gravity, and the extent of thickening at the processing plant. Tailings slurries are typically pumped at 25% solids (for low specific gravity coal tailings) to over 50% (for hard rock metalliferous tailings). At low solids concentrations, slurried tailings disposal into a surface TSF has the potential, if it is not well controlled and managed, to produce incrementally greater water losses through evaporation and seepage. Seepage to the underlying foundation and through the TSF wall can potentially be much greater than occurs naturally due to rainfall, particularly in a dry climate.

Slurry disposal may be from a single or, preferably, from multiple discharge points. Nevertheless, multiple discharge points have advantages over single one, including:
● Production of a more even tailings beach
● Achievement of greater control over the direction of the tailings beach, supernatant water and surface run-off towards the decant
● Deposition of the thin and controllable lifts of tailings, and the cycling of tailings deposition to facilitate consolidation and drying throughout the depth of the stored tailings
● Facilitation of upstream and wall raising resulted from coarse-grained tailings deposition

Figure 2: Conventional Tailings Slurry Disposal (Australian Government, 2016)

2) Thickened and Paste Disposal

Thickening of tailings in the processing plant before disposal enables process water to be recycled directly back to the plant, reducing water losses and reducing plant raw water demand. The most commonly applied are outlined in table below.

Tailings Consistency	Thickening Equipment Requirements
Slurry	Conventional or high-rate thickener
Thickened	High-compression thickener
High-slump paste	Deep bed thickener
Low-slump paste or filter cake	Filters

Thickening tailings can reduce the quantity of water delivered to the TSF, minimize risks of overtopping, and reduce seepage and evaporation losses. Moreover, it can reduce the risk of failure of the TSF embankment by lowering the pond level and reducing water table within the embankment.

Thicker tailings discharge also has better control of the decant pond and water return system. Where tailings are discharged into surface storage facilities, they are discharged at a thicker consistency and steepen as beach angles that reduce moisture and containment risk.

3) Dry Stacking

Dry stacking usually requires flocculated tailings to be filtered under pressure or vacuum in order to produce a dry product that is transportable and stackable using dry material transportation and disposal techniques. The term “dry stack” is sometimes misused when referring to thickened and/or paste disposal techniques that do not move the tailings in a dry state.

Drums, horizontally or vertically stacked plates and horizontal belts, are the most common pressure filtration methods. Both the gradation of the tailings and their mineralogy are important determinants in filtration design. Also, high proportions of some minerals such as clay tend to limit effective filtration. Therefore, it is important to anticipate mineralogical and grind changes that could occur over the life of mine.

Filter tailings are transportable by truck or conveyor and may then be placed, spread and compacted to form an unsaturated, dense and stable tailings dry stack. In some cases, geochemically benign tailings require no dam for retention and no associated tailings pond.

Figure 3: Dry-Stacked, Filtered Tailings Transported by Conveyor and Compacted by Dozer
(Australian Government, 2016)

Filtration and stacking of tailings are typically considered in very arid regions where water conservation is crucial, or the handling of tailings is very difficult in the frozen winter. Filtration enhances the recovery of process reagents, and dry stacking provides enhanced seismic stability over wet tailings deposition method. Dry stacking may also overcome difficult site topography and foundation conditions, or very constrained sites which make conventional tailings dams very difficult to construct. Dry stacking also facilitates rehabilitation, thereby reducing closure risks and liabilities.

4) Co-Disposal of Coarse Wastes and Tailings

The co-disposal of coarse wastes and tailings can reduce the volume of waste storage since tailings can fill the void space between the coarse wastes. A key challenge of co-disposal is to find a safe, practical and economic method of mixing the two waste streams. One successful co-disposal operation involved the filling of a completed open pit by dumping of waste rock from the crest and depositing thicken tailings from the others.

Figure 4: Co-Disposed Waste Rock and Thickened Tailings in a Completed Open Pit
(Australian Government, 2016)

5) Integrated Disposal of Coarse Waste and Tailings

An integrated mixture of water rock and paste tailings can potentially be used as a sealing material in covers over potentially contaminating mine wastes. For this application, the tailings and waste rock selected must be geochemically benign. The waste rock is typically limited to 100 mm top size by crushing and screening. This size restriction facilitates mixing and ensures a good mixture consistency. The waste rock can be combined with tailings slurry, dried tailings or paste tailings. Integrated coarse and fine wastes achieve a high density and low hydraulic conductivity, making the mix well suited for use as a sealing material. It has particular application at mine sites where supplies of natural clays for sealing purposes are limited or absent, and achieves a hydraulic conductivity at least equal or lower than compacted natural clay.

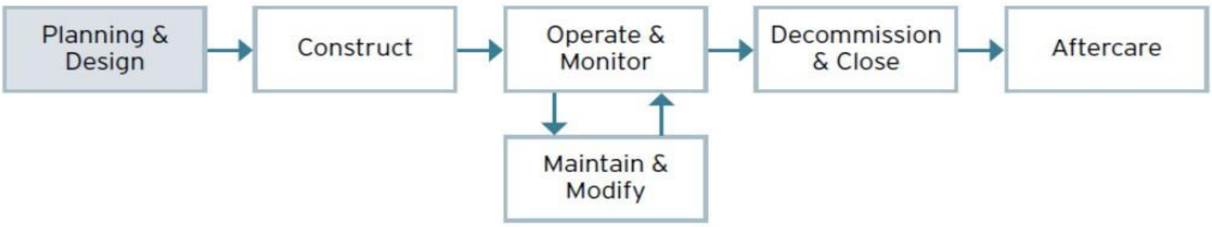
Figure 5: Integrated Coarse and Fine Wastes in the Laboratory
(Australian Government, 2016)

Overburden/waste rock is often used as a TSF embankment construction material. The overburden/waste rock is used to form a wide encapsulation into which the tailings are disposed. The tailings may be dewatered to limit the loss of water to the coarse-grained waste rock encapsulation, and the waste rock may be pushed progressively into the tailings to facilitate capping. It may be advantageous to submerge potentially acid-forming waste rock beneath slurried tailings to limit oxidation.

<u>**Tailings Storage Facilities Management System**</u>

The principles underlying responsible and effective tailings management are to plan, design, construct and operate a TSF in order to achieve effective closure and aftercare. There are five consecutive stages called “Life of a TSF” to be considered as planning & design, construct, operate & monitor, decommission & close, and aftercare.

1. Planning and Design



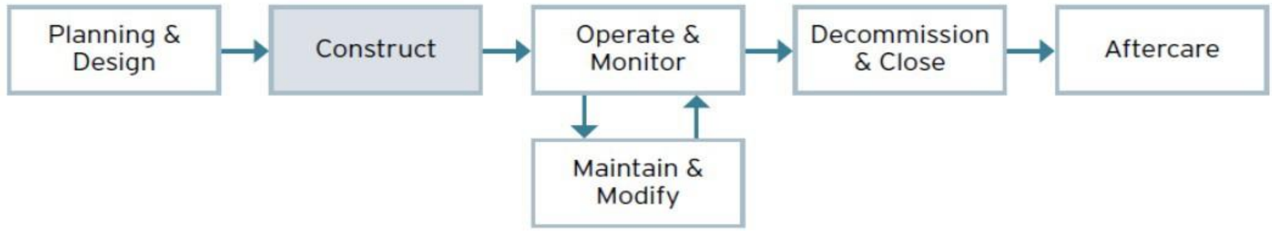
A good practice requires alignment between the TSF planning and the mine plan to be "Life-of-mine tailings storage facility plan" which its details depending on each site. The TSF plan must also be reviewed in response to any changes to the mine plan, and revised, if necessary. This will ensure that any staging or sequential raising requirements are adequately financed and scheduled, and that operation and management activities strive to achieve closure objectives throughout the project life.

In the planning stage, consideration should be given respectively to:
- Integration with the mine plan and schedule in developing the tailings disposal methodology
- Geochemical characterization of tailings to assess their potential for acidic mine drainage during operation and after closure. The selection of tailings placement method and the type of embankment construction can both be influenced by the level of geochemical risk. Samples for characterization can be obtained from the metallurgical test typically carried out as part of the economic pre-feasibility phase of a new mining project
- Location of the TSF to avoid degrading the quality of coal resources or contaminating natural resources (especially water bodies and soil)
- Availability of suitable embankment construction materials, liners, and surface capping materials. For example, utilizing topsoil or waste rock, identified as non-acid forming (NAF) for construction of embankment and/or liners, caps and covers

In the design stage, key factors should be defined and provided as follows:
- Background and baseline conditions i.e.
    - Surface water quality
    - Groundwater level and quality
    - Air quality i.e. Total Suspended Particulate (TSP)
    - Fauna and flora population and density
- Geotechnical and geochemical investigations i.e. geochemistry of foundation soils and rocks, seepage analysis, characteristics of tailings, in order to assess the potential of acid drainage during operation and closure phases
- Tailings generation rates and entire life-of operation tailings generation
- Water balance, including reuse water rates and pipeline system
- Change management — increases in processing plant throughput impact storage requirements for tailings and water. The rate of rise of the tailings surface can also have implications for tailings strength and stability.
- Reprocessing of tailings — some tailings may contain valuable minerals, and therefore a management objective may be to provide interim storage until economic recovery becomes feasible. However, this should not be used as a justification for leaving tailings in a geochemically unstable or reactive state for prolonged periods of time.
- Public health and safety, and environmental compliance targets, including rehabilitation and closure requirements

As part of the TSF planning and design process, formal environmental impact and risk assessments are required to identify and, where appropriate, quantify the risks that need to be prevented, mitigated and managed, including change management and closure. A tailings storage facility and associated components must be designed by experienced persons.

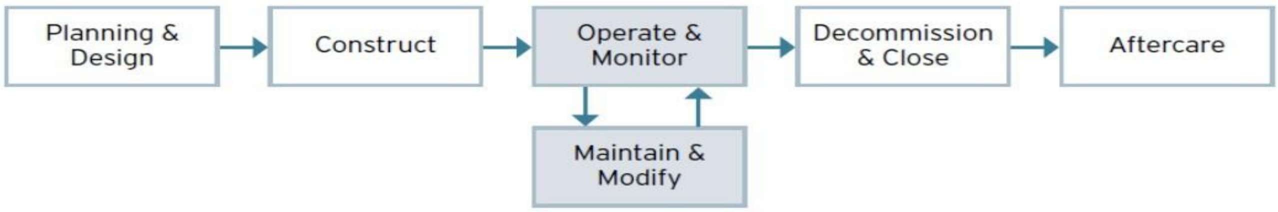
2.Construction



Successful TSF operation depends heavily on the construction quality of all aspects of the TSF. It is important that TSF construction management, technical supervision and QA/QC are all undertaken by competent practitioners who understand the dependence of the successful operation of the TSF on good construction practices and who are capable of ensuring that the construction is carried out in accordance with the specifications and the design intent. The construction report shall be provided to maintain an accurate record of the construction work in order to:

- Ensure the TSF was constructed by a competent contractor, with an appropriate level of supervision and quality control of construction materials, and techniques to show they were in accordance with the design drawings and specifications
- Provide a detailed record and description of geo-technically critical aspects such as the preparation of foundations, treatment of cracks in key and cut-off trenches, or the compaction of backfill around outlet works. This record assists in the design and construction of remedial works if any post-construction issues occur.
- Provide as-constructed drawings that:
    - Provide an accurate representation of the detailed construction works
    - Particularly where design changes may have occurred during construction phase
    - Assist in improved designs for further stages
    - Provide details and dimensions for remedial works so that these do not impact the integrity of existing structures
    - Provide details for back-analyses should these be required

3. Operation and Monitoring



In the operation stage, both normal and emergency circumstances should be taken into account. Leading practice of tailings management demonstrates clear operational accountability at operational mine management, with a thorough understanding of the design, operating and closure objectives. The implications of not operating in accordance with the design intent and design criteria must be clearly understood.

A tailings operating manual or standard operating procedure (SOP) is required for each TSF. This manual must be aligned with the design objectives of the facility, and the key engineering and operational risk controls. Its intention is to guide and assist the TSF operators with the daily operation, as well as with forward planning of the facility's operation and maintenance. Using suitable reference drawings and sketches to illustrate important operating features, principles and limitations, the operating manual should describe the following aspects, and the operators should receive related training program in those that contribute to leading practice:

- Principles of good tailings deposition and beach development — thin layers with maximum drying to maximize strength and minimize seepage
- Correct management of the decant pond and efficient water recovery to maximize stability
- Examples of poor tailings management practices, and their negative impacts
- The facility's daily operation and the frequency and correct method of changeovers
- Operational procedures which require specific precautionary measures, such as the correct order of valve opening/closing to avoid blockage of tailings pipelines
- Procedures for changing and flushing tailings pipelines

● The key lead indicators used to monitor the facility's successful operation, and each operator's role and responsibilities in support of the tailings management plan
● Scheduled and preventative maintenance to keep critical equipment operational
● The importance of recording and storing monitoring and performance data
● The intended closure strategy and how the TSF can be effectively managed for its ultimate closure
● The need to report any exceptional, untoward or unexpected observations, particularly TSF embankment seeps, cracking and erosion, to a supervisor
● The need to follow through with early responses to prevent the escalation of minor issues
● Ultimately, if and where necessary, emergency and risk management actions are required to ensure that all people who may be affected are safely evacuated before the anticipated failure of a TSF.

Safety Management and Emergency Preparedness

A safety management plan should exist for any TSFs where there is a potential for loss of life in the event of a TSF failure.

The TSF safety management plan relates to:
● Risks identified for the facility
● Public health and safety, community and environmental risks, and necessary mitigation measures and controls to ensure the integrity of the operation
● The surveillance and maintenance program to ensure the ongoing integrity of the various structural components
● Communication of identified risks and controls implementation to related people or functions

The emergency response plan:
● Identifies conditions that could result in an emergency, such as severe storms
● Describes procedures to isolate people from hazards, including the warning and evacuation of downstream communities
● Identifies recovery plans to mitigate impacts, such as monitoring and clean-up plans
● Identifies the resources required to implement the emergency action and response plans
● Identifies emergency response training requirements for key people
● Documents the location of emergency warning alarms and their maintenance requirements to ensure serviceability at all times
● Identifies emergency drill plan
● Through the effective implementation of the safety management plan in the event of a failure, ensures that appropriate actions are taken to minimize the safety risk to people on- and off-site, and that impacts are minimized by an organized and systematic response to the incident.

Containment Wall Inspections and Monitoring

All TSFs and associated pumping and pipeline systems should be inspected on regular basis. Observations should be recorded. Any extraordinary observations or maintenance requirements must be documented which the appropriate correction and corrective actions are required to perform, including reporting to regulators and the community. The inspections should include assessments of:
● The position of the decant pond and observations relating to freeboard requirements (the water level compared to the dam crest height)
● Lead indicators, such as damp patches, seepage and erosion, by visual and operating checks
● The status of leak detection systems
● The status of secondary containment systems
● The status of automatic flow measurement and fault alarms

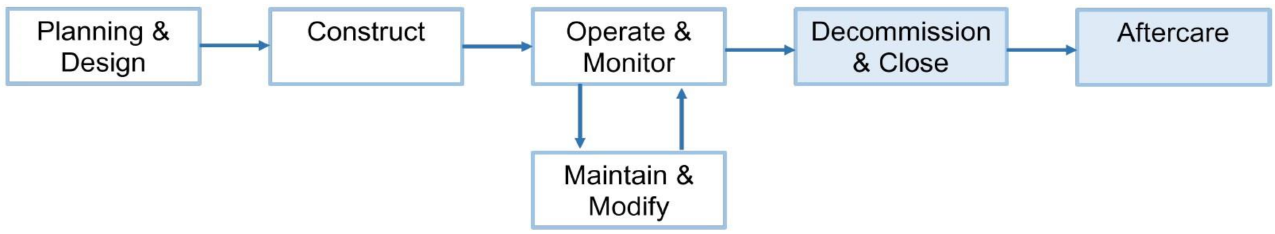
● The condition of pump and pipeline systems
● Impacts on birds, wildlife or livestock, particularly birds that may be affected by tailings water consumption

The monitoring of TSFs should include:
● Piezometers and bores to monitor groundwater mounding and outward movement beneath and surrounding the facility
● Surface water and groundwater quality sampling both upstream and downstream of the facility to check against agreed trigger levels
● Rehabilitation trials and monitoring of closure strategies, including slope treatments and covers, and revegetation performance

Monitoring reports should be prepared annually, and reporting should be accessible, easily understood and transparent to stakeholders. Provision needs to be made for the containment of tailings along delivery pipelines and within the TSF at all times, supported by timely and appropriate maintenance in response to inspections.

To ensure optimal performance, the TSF should be reviewed throughout the year, using a risk-based approach, by an appropriately qualified geotechnical engineer experienced in tailings management and TSF design which the independent audit and assessment are required.

4. Closure and Aftercare



The closure of the TSF should be carefully considered as part of the mine closure plan, to ensure that appropriate public health and safety, community, and environmental criteria can be established for the design. Closure criteria for the TSF should be reviewed in consultation with the community during the operating phase, and the tailings management plan revised (including design modifications) accordingly and obviously specified in procedures of decommissioning and closure TSF.

The leading practice approach of TSF closure planning clearly defines, at the earliest possible stage in the design, the post-closure land use and the final closure landform, and then demonstrates the commitment to achieve these goals, through regular transparent reporting against lead indicator criteria and community consultation. Leading practice also demonstrates a commitment to achieving stable and self-sustaining landforms by testing closure engineering and revegetation concepts well before closure occurs, so that the closure design can be confidently and cost-effectively engineered.

Critical closure-related design considerations relate to geotechnical and landform surface stability and pollution control through the design and construction of effective surface covers and treatments.

Careful consideration must be given to:
● Post-closure land use and final landform — consideration must start in the design stage, and continue throughout the life cycle through to stakeholder consultation during closure planning.
● Characterization and inventory of the materials required to complete the closure – considering materials available, their physical and geochemical characteristics and an understanding of their attributes with regard to infiltration control, armoring potential and suitability as a revegetation substrate
● Financial provisioning — which may be an appropriate probabilistic financial model to fully consider possible ranges of closure costs, footprint size and cover thickness (including sourcing acceptable and sufficient cover materials), events (such as storms and earthquakes), scheduling (design, construction, and post-closure monitoring and maintenance), on and off facility drainage measures, project risks (for example, more stringent criteria than those assumed), and the costs of trials to avoid significant underestimation of the required financial provision
● Aftercare monitoring and maintenance plan — listing all post-closure criteria, and scheduling tasks and activities required to measure key post-closure impact and sustainability indicators. This may include quantities and rates of release of solutes and vegetation regrowth (species, density and weed management). The post-closure monitoring period is site dependent but is determined by the period required to confirm that no unacceptable detrimental impacts are occurring, or could occur after completion. The plan must also detail post-closure accountabilities, responsibilities, schedules and financial provisioning for monitoring activities, reporting, consultation and maintenance, if required.

A post-closure aftercare monitoring and maintenance plan must be prepared. The purpose of the plan is to ensure that the agreed post-closure objectives and completion criteria are achieved. The aftercare period can demand greater resources and attention than is sometimes expected, but good-quality monitoring, maintenance, repair and refinements to improve the plan can increase the likelihood of the agreed post-closure objectives being met. This also enables progressive engagement with stakeholders where completion criteria require review and adjustment based on actual performance. The extent and duration of the aftercare period depend on the conditions at the particular site and therefore on the complexity of the closed site and its completion objectives and criteria, and in the case of closed TSFs is likely to last for at least 10 years.

Mineral Waste Performance Reporting

To recognize and improve performance of mineral waste management, recording and reporting of mineral waste and TSF data in the existing sites shall be proceeded to Corporate on monthly basis as details below:

Mineral Waste & TSF	Data Requested
Overburden/Waste rock	- Actual generated amount - Actual in-pit backfilling amount - Plan in-pit backfilling amount
Tailings	- Actual generated amount
Tailings storage facility	- Number of active and closed - Risk level

Direct weight or systematic calculation can be accepted for generated and in-pit backfilling amount of overburden/waste rock and tailings.

Reference

● Australian Government: Department of Industry, Tourism and Resources, Tailings Management: Leading Practice Sustainable Development Program for the Mining Industry, February, 2007.
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● Global Reporting Initiative, GRI12 – Coal Sector 2022, January, 2024.
● Government of Western Australia: Department of Mines and Petroleum, Code of Practice: Tailings Storage Facilities in Western Australia, 2013.