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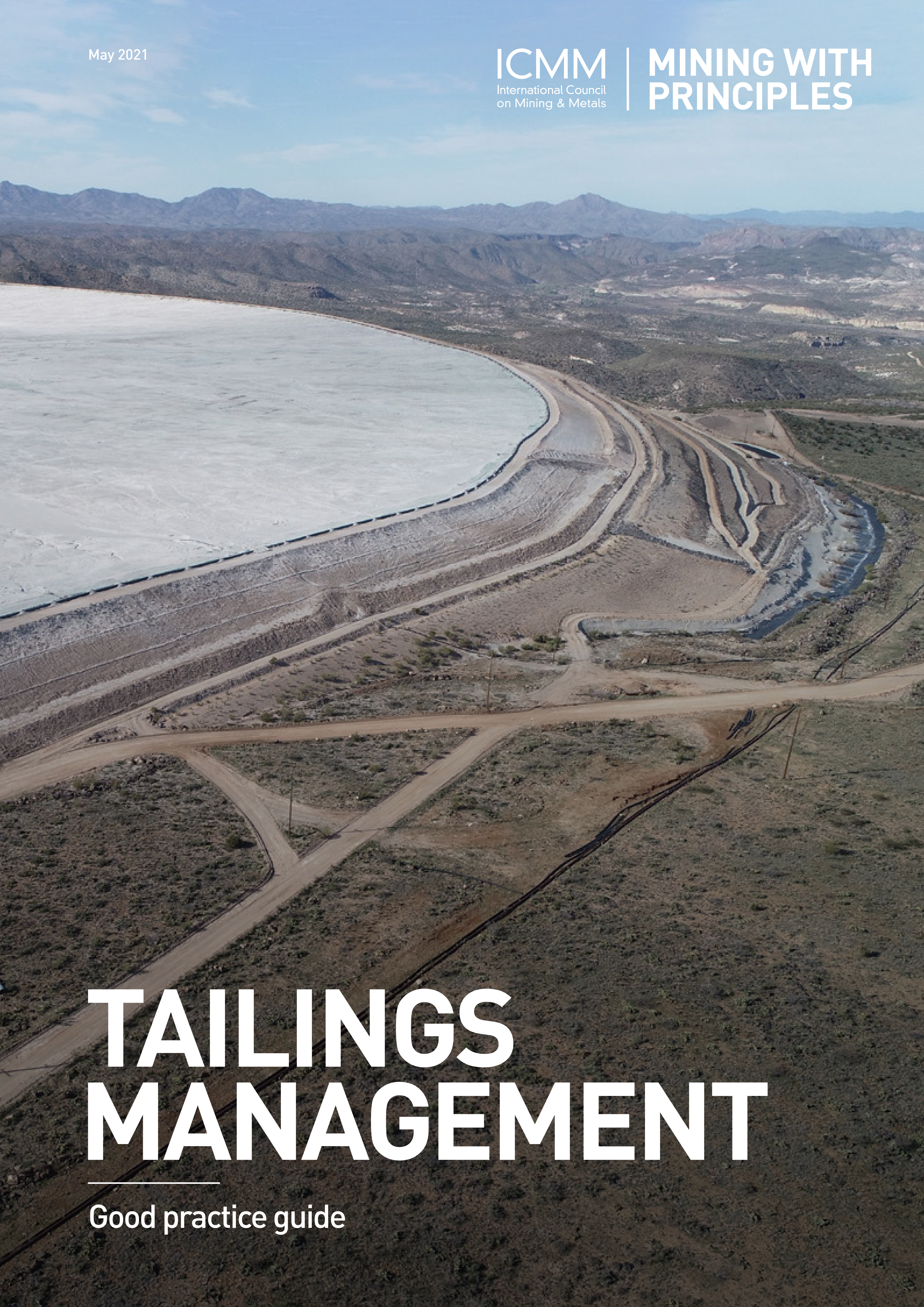

TAILINGS MANAGEMENT

Good practice guide

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Writing team

Unusually for an ICMM publication, no external consultant was contracted to support the report writing process. In practice, this meant that the writing team solely comprised representatives of member companies or associations. Some of these individuals invested very significant amounts of time and energy to ensuring the delivery of a high-quality product that was responsive to the views and perspectives of other members. ICMM is indebted to them for their exceptional contributions and service.

The report was drafted by a writing team led by Tamara Johndrow (Freeport-McMoRan) and Charles Dumaresq (Mining Association of Canada (MAC)). Their commitment to this work represented a significant investment on their part as well as a substantial in-kind contribution from their respective employers, which ICMM greatly appreciates.

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Content contributors

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Member representatives

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The photographs provided in this document were compiled by our members over many years and are used to illustrate tailings facilities and related tailings management activities. In the majority of cases, these images were taken prior to the COVID-19 pandemic and therefore do not show employees wearing masks.

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FOREWORD

Professor (Emeritus)
Norbert R Morgenstern

'Tailings dams are complex systems that have evolved over the years. They are also unforgiving systems, in terms of the number of things that have to go right. Their reliability is contingent on consistently flawless execution in planning, in subsurface investigation, in analysis, in construction quality in operational diligence, in monitoring, in regulatory action, and in risk management at every level. All of these activities are subject to human error.'

Mount Polley Independent Expert Engineering Investigation and Review Panel (2015)

Assuring safety or otherwise is not achieved by a set of calculations alone or by observations alone, unless they reveal that performance as flawed, or by adopting a pre-conceived list of safety indicators that reduces the confirmation of safety to checking the items off in a box. As revealed by the quotation above, the construction and operation of a tailings storage facility incorporating a dam, is a highly dynamic process, more so than is common for water dams where there is usually a clearer separation between the Design and Construction phases and the Operations phase. Therefore, reliable confirmation of safety requires an equally dynamic process applied to the full lifecycle of the facility so that it can, in turn, reassure all stakeholders.

Progress in this regard has already been made by the publication of the *Global Industry Standard on Tailings Management*, and its recommendations will be integrated into ICMM's industry member commitments. The Standard makes recommendations both with regard to Environmental, Social and Governance issues and technical issues. The Standard might be regarded as requirements of what has to be done. ICMM has developed this Guide, which is aligned with the Standard, but focuses primarily on technical issues and recommends good practice for design, construction, operation and closure.

From my perspective, this Guide is built upon the following core elements:

- Of overarching significance is the safety culture expressed by the Operator. It is common to declare a goal of zero fatalities, occupational disease and catastrophic events. Hence, a common denominator for all Operators that share this goal is that tailings facilities should be designed, constructed, operated and closed to such high standards that 'failure is not an option'.
- A governance framework to support the aspirational goals of the safety culture is recommended, incorporating roles and responsibilities from the Board of Directors to the Engineer of Record and the Design Team.
- In recognition of the phases associated with tailings management, from Project Conception through to Design, Construction, Operations, Closure and Post-Closure, ensure that tailings management is continually integrated within a sitewide integrated mine, tailings, water and closure plan.
- Informed by the integrated planning, develop a tailings management system.
- Engage external Independent Review for technical matters early in the lifecycle and throughout all of its phases.
- Manage uncertainty through all phases of the lifecycle by risk-informed decision-making that assesses uncertainty, conducts risk assessments at appropriate stages, and carries a risk register throughout the lifecycle of the facility.
- Adopt the technical recommendations put forward for the safe design, construction, operation, and closure of tailings storage facilities. This should recognise the enhanced responsibilities of the Engineer of Record for declaring design criteria as opposed to relying on prescriptive values. Where conditions are complex, recognize the value of adopting performance-based design. Always respect regulatory requirements as a minimum.
- Maintain comprehensive documentation of construction and quality assurance through all phases of the lifecycle, with special emphasis on confirming or adjusting the site characterization model as new information is obtained.
- As part of the Tailings Management System, determine what documentation related to safety could enter the public domain in order to enhance transparency and trust.

While the task of determining the cause of failure is simpler after the event, I have evaluated this Guide in terms of my experience with a significant number of tailings dam failures and related serious incidents and concluded that had this Guide been available and adopted, these incidents should not have occurred.

Norbert R Morgenstern
Distinguished University Professor (Emeritus),
University of Alberta (Canada) and Consulting Engineer

The *ICMM Tailings Management: Good Practice Guide* represents the culmination of years of work by ICMM member companies and external experts to develop guidance for safely and responsibly constructing and managing mine tailings facilities. Inspired by the pathbreaking work of Dr Norbert R Morgenstern, as set forth in the Sixth Victor de Mello Lecture in 2018, ICMM embarked on an undertaking to improve safety and management of tailings storage facilities.

ICMM served as the industry representative in the development of the *Global Industry Standard on Tailings Management*, a multi-stakeholder effort designed to elevate the standard of practice for tailings storage facilities worldwide. ICMM is committed to leading the mining industry in the safe and responsible design, construction, operation and closure of tailings facilities. This is a critical issue at every mine, which must be viewed as such by every mine operator.

In the *Good Practice Guide*, ICMM member company experts build on the Standard promulgated by the multi-stakeholder initiative. The Good Practice Guide supports the requirements of the Standard and provides guidance on good governance and engineering practices.

The *Good Practice Guide* is important in achieving the aspirational goal of eliminating fatalities and catastrophic failures at tailings facilities. We strongly encourage all mining companies worldwide, whether or not they are ICMM members, to incorporate the Standard and *Good Practice Guide* into their practices to improve mine tailings facility performance and to achieve these safety goals.

Richard C Adkerson
Chairman of the Board, and Chief Executive Officer
Freeport-McMoRan and Chair of ICMM

PART 1: OVERVIEW

1.1 INTRODUCTION

1.1.1 Context

Tailings are a by-product of mining, consisting of the processed rock or soil left over from the separation of the commodities of value from the rock or soil within which they occur. If they are not managed in a safe, responsible manner, tailings can pose risks to the environment, human health and infrastructure. In cases where tailings are managed in purpose built (ie engineered) facilities, management of the integrity of these facilities is critically important. The failures that have occurred over the last 30 to 40 years illustrate these potential risks. These failures have included fatalities, displacement of communities, damage to infrastructure, and loss of ecosystems and habitat. They have cost the mining industry billions of dollars.

Most tailings facilities are planned, designed, constructed, operated and closed in a safe and responsible manner. However, as recent failure incidents clearly indicate, the physical stability of tailings facilities has not been universal. Global performance needs to improve.

This guidance is intended to facilitate continual improvement across the global mining sector, leading to the safe, responsible management of tailings worldwide. The guidance presents a comprehensive, holistic approach to tailings management that describes good engineering practices and is informed by lessons learned from past failures. It is intended to improve performance across all the aspects that underpin safe tailings management. While no guidance document is perfect, this Guide is intended to be part of the continual improvement process of the mining industry.

The guidance is ultimately aimed at mitigating what can perhaps be the greatest risk factor: the human element. Individuals, however professional and qualified, make judgements and decisions based on their own experiences and biases. Embedded ignorance, which we all have, results from a lack of knowledge, or a failure to recognise internal weaknesses or limitations. Complacency, over-confidence, competing priorities and the loss of corporate knowledge over time can be compounding factors.

A systematic, comprehensive approach to tailings management, with checks and balances, helps to reduce the risk that the human element can ultimately lead to ineffective tailings management, or worse, the failure of a tailings facility. The implementation of a systematic approach will help to prevent human error.

1.1.2 Mining Industry Safety Culture

Protecting the health and safety of employees, contractors and communities has become ingrained in the mining industry's culture. Mining operations, like all types of heavy industry, can pose many health and safety hazards, and the adoption of a safety culture was in response to the high numbers of fatalities and injuries.

As stated on the ICMM website:

'Responsible mining companies have an unwavering commitment to the health and safety of workers and their families, local communities and wider society. Health and safety has to be at the heart of all operations and processes. Mining presents various hazards that can be of significant consequence, but through effective risk management strategies neither safety incidents nor the onset of occupational diseases are inevitable. ICMM members are progressing towards a goal of zero fatalities, occupational disease and catastrophic events. People have a right to go home safe and healthy to their families and their communities at the end of every day.'

However, the failures of tailings facilities around the world, resulting in hundreds of fatalities over the last three decades, point to the imperative that the mining industry's safety culture be applied to tailings management.

Beyond driving improvements in practice, the guidance is aimed at fostering and strengthening the safety culture associated with tailings management and provides a roadmap to the continual improvement of tailings safety at both new and existing facilities. To be consistent with this safety culture, tailings facilities should be designed, constructed, operated and closed to such high standards that the goal of eliminating fatalities and catastrophic events is achieved.

Although regulators, investors, communities and others have a role in this cultural shift, the responsibility resides primarily with the Operators of mines and the associated tailings facilities.

1.1.3 Objectives

This Guide is intended to support the safe and responsible management of tailings across the global mining industry, with the ultimate goal of eliminating fatalities and catastrophic events.

It provides guidance on good governance and good engineering practices that will support continual improvement in the management of tailings facilities and help to foster and strengthen a corporate safety culture.

The Guide:

- Is informed by the requirements of the *Global Industry Standard on Tailings Management* (the Standard) and the commitments in ICMM's *Tailings Governance Framework Position Statement*. It will help Operators work through how to integrate these into their own programmes.
- Promotes good engineering practices for tailings management, including a performance-based approach where appropriate.
- Provides an overview of good practices and, as such, does not generate additional requirements beyond those within the Standard.
- Should not be used to assess conformance against the Standard, which is the purpose of the Conformance Protocols. Some examples in the Conformance Protocols draw upon and refer to related sections of the Guide.

In keeping with these objectives, the Guide presents recommendations, not requirements. The use of the word 'should' is intended to mean 'recommended' not 'must'.

1.1.4 Scope of Application of the Guide

The Guide describes good governance and good engineering practices for tailings management and may be applied to:

- The management of tailings facilities worldwide, including those operated or maintained by State agencies.
- New and existing tailings facilities throughout all phases and activities of the lifecycle (Section 1.2.1), from the Project Conception phase for future tailings facilities, to facilities that have been inactive for many years, and to those which have been closed.

While the objective is focused primarily on preventing catastrophic failures, the guidance is equally applicable to a wide range of other potential risks associated with the management of tailings facilities.

In Detail

A tailings facility is a facility that is designed and managed to contain the tailings produced by a mine. A tailings facility includes the collective engineered structures, components and equipment involved in the management of tailings solids, other mine waste managed with tailings (eg waste rock, water treatment residues), and any water managed in the facility, including pore fluid, any ponds, and surface water inflows and discharges.

The guidance is applicable to tailings facilities as a whole, not just tailings embankments, excluding riverine systems and other types of facilities such as fresh and process water dams, stockpiles, etc. This distinction is important because while the design, construction and operation of embankments is a very important factor in influencing the safety of tailings facilities, it is not the only factor. For example, aspects related to water management (eg seepage, surface water) can be very important in ensuring safe tailings management.

1.1.5 Intended Audience

The audience for the Guide is broad, in keeping with the breadth of the objective and scope of application of the Guide.

As a document prepared by ICMM, the primary audience of the Guide is ICMM member companies. However, this Guide is intended to facilitate safe tailings management worldwide. Thus, it is intended to support all Operators in improving their practices to meet the goal of eliminating fatalities and catastrophic events.

In addition to ICMM member companies, and consistent with the Standard, the audience includes:

- Operators of all tailings facilities, including non-ICMM Operators, and their employees and contractors across the organisation with roles and responsibilities related to tailings management, from senior management/board level leadership to personnel at the site level.
- Consultants and others providing services (eg tailings facility design) to Operators related to tailings management.
- Investors, insurers and others with the ability to directly influence improved industry performance through access to funding or other means.

This Guide may also be of interest to community organisations, non-government organisations and other stakeholders that may be affected by tailings management, providing them with information on leading practices in tailings management so that they are better informed in their engagement with Operators.

This guidance does not replace professional expertise or jurisdictionally specific legal requirements. Operators should obtain qualified professional advice throughout the lifecycle to be sure that each tailings facility's specific conditions are understood and addressed, and that the facility is planned, designed, constructed, operated and closed in a safe and responsible manner.

1.1.6 Basis for the Guide

In 2016, ICMM released a *Position Statement on Preventing Catastrophic Failure of Tailings Storage Facilities* that included a Tailings Governance Framework (the Framework). The Position Statement committed ICMM members to implement practices consistent with the Framework.

The Framework focuses on six elements of tailings management and governance that are key to minimising the likelihood of a catastrophic tailings failure happening:

1. Accountability, Responsibility and Competency.
2. Planning and Resourcing.
3. Risk Management.
4. Change Management.
5. Emergency Preparedness and Response.
6. Review and Assurance.

While this guidance builds upon the Framework it is more comprehensive in scope and is intended to be applied site-specifically. In developing this guidance, ICMM used existing, well-established external resources as a starting point. Thus, while this Guide represents a new level of detail for guidance prepared by ICMM, it reflects more than 20 years of experience in the development and implementation of other external resources to support tailings management (eg Mining Association of Canada (MAC)).

The Tailings Governance Framework and existing guidance from MAC are focused primarily on tailings management governance and do not address design and other technical elements related to tailings management. Technical resources for tailings facilities are available from several sources (eg International Commission on Large Dams, Canadian Dam Association, Australian National Committee on Large Dams).

In delivering the Sixth Victor de Mello Lecture, in Brazil in 2018, Prof Norbert Morgenstern, a highly esteemed expert on tailings facility safety, identified significant shortcomings in current practices related to tailings management. While he identified good practices related to the governance of tailings management (ie MAC guidance), he identified an urgent need for improved technical and engineering practice, integrated with stronger governance, in order to improve tailings safety across the industry. A key component of his lecture was an outline of a tailings management system (TMS) for Performance-Based Risk-Informed, Safe Design, Construction, Operation and Closure of tailings facilities (PBRISD). He recommended that 'ICMM support the tailings management system based on PBRISD, as outlined here, and fund the development and publication of a guidance document that would facilitate its adoption in mining practice'.

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1.2.1 Tailings Management Lifecycle

Having a common understanding of the lifecycle of tailings management is important for applying this guidance and the requirements of the Standard. The lifecycle of a tailings facility encompasses all the activities across the life of a tailings facility, from the earliest stages of the Project Conception phase through to the Closure and Post-Closure phases. It is determined on a site-specific basis by a wide range of factors and is always subject to change. The lifecycle consists of six phases or activities:

1. Project Conception[1]
2. Design
3. Construction
4. Operations
5. Closure
6. Post-Closure.

The relationship between these phases or activities is dynamic and rarely linear. In addition, the lifecycle of a tailings facility can last for many decades to reach the end of the Operating phase, and centuries beyond for the Post-Closure phase.

Throughout the lifecycle, change can be a key source of risk for tailings facilities and needs to be effectively managed (Section 2.3.2). Consequently, it is important that Operators recognise and plan for a dynamic lifecycle and implement a TMS throughout the lifecycle (Sections 1.2.2.1 and 2.3).

Tailings management does not occur in isolation from the other activities that occur at mine sites. Tailings production is 'downstream' of many steps in the mining process and a wide range of decisions related to the overall process that can impact tailings management are often made without sufficient consideration of those potential impacts. For example, decisions about waste rock management, ore processing and water management often have significant implications for tailings management. Similarly, decisions related to tailings management are sometimes taken without adequate consideration of other plans. A failure to recognise these relationships and potential impacts and to plan accordingly can compromise the objective of safe tailings management.

Throughout the lifecycle, an integrated approach to mine planning is essential to safe tailings management. This involves integrating the planning of all aspects of the mine that can impact tailings management (Section 3.2.2), such as ore extraction and processing, sitewide water management and the management of waste rock. For new tailings facilities and proposed mine life extensions, this includes integrating planning for tailings management into the development of Pre-Scoping, Scoping, Pre-Feasibility and Feasibility Studies.

Such an integrated approach should be adopted for both new facilities and existing facilities, to help to ensure that decisions are aligned with the short-, medium- and long-term objectives of tailings management.

In Detail

Project Conception: A recurring lifecycle activity that is the first step in the planning and design of:

- Construction and Operations phases of new tailings facilities.
- Closure and Post-Closure phases of tailings facilities.
- Any material changes to the design or operation of tailings facilities.
- Re-commissioning of an existing tailings facility for a mine re-opening.

Project Conception consists of the analysis of a range of alternatives (eg location of a new tailings facility, technologies to be applied) to select a preferred alternative to advance to the Design phase. Lifecycle cost estimates are developed as per the Operator's corporate guidelines.

Design: A recurring lifecycle activity that builds upon the decisions made during the Project Conception phase. Once a preferred alternative has been selected, all aspects of that alternative are designed in detail, based on the design intent and defined performance objectives. More detailed lifecycle cost estimates are developed as per the Operator's corporate guidelines.

1. For new tailings facilities, the Project Conception and Design phases encompass key steps in the mine planning process: Pre-Scoping Study, Scoping Study, Pre-Feasibility Study, and Feasibility. Thus, just as conceptual mine planning begins at the pre-scoping and scoping steps, planning for tailings management should also begin at these steps. However, for Project Conception and Design activities related to proposed material changes or closure planning, there may not be corresponding Pre-Scoping, Scoping, Pre-Feasibility and Feasibility studies for the broader mine planning process.

Construction: A recurring lifecycle activity that includes:

- Initial construction prior to the start-up of a new tailings facility (eg starter embankment, pipelines for tailings transport, water management infrastructure).
- Ongoing construction through the Operations phase to increase the capacity of the tailings facility (eg facility raises).

Construction may also include:

- Construction for any material changes (eg increase capacity beyond original design intent, buttress to strengthen an embankment).
- Construction during the Closure phase (eg installation of covers, water management infrastructure).

Operations: The period in the lifecycle when tailings are transported to and deposited in the tailings facility, inclusive of any periods of inactivity prior to the commencement of implementation of the closure plan. Construction is typically ongoing throughout the Operations phase. In addition, progressive reclamation in preparation for closure and consistent with the closure plan may occur during the Operations phase. In some cases, after the end of the active deposition of tailings, tailings may be removed from the tailings facility for reprocessing or other uses. Such activity would also be considered Operations.

Temporary suspension of mine operations: A period in the lifecycle when mine operations have been suspended and tailings are not being deposited into the tailings facility. The suspension may be short-term (eg temporary suspension due to wildfires, labour disruption) or of a longer, indeterminate duration (eg due to low commodity prices).

During temporary suspension, maintenance and surveillance continue and some operation activities (eg active water management) may also continue. The closure plan is not implemented. However, temporary suspension may lead to closure in some cases.

Closure: This lifecycle phase begins when deposition of tailings into the tailings facility ceases permanently and the closure plan is implemented, including:

- Transitioning from the Operations phase to the Closure phase and the Post-Closure phase.
- Removal of infrastructure such as pipelines.
- Changes to water management or treatment.
- Construction of covers, recontouring or revegetation of tailings and any embankments or other structural elements.
- Other reclamation and decommissioning activities.

While Closure is a discrete lifecycle phase, closure planning is part of an integrated approach to mine planning. It is a lifecycle activity that should begin as early as possible and be conducted iteratively throughout the lifecycle. The project conception and design process should be used to develop the closure plan and an executable design for closure.

Post-Closure: This lifecycle phase begins when the closure plan has been implemented and the tailings facility has transitioned to long-term maintenance and surveillance. The Post-Closure phase has to address all the aspects of safety and environmental compliance related to long-term stability and legal requirements.

During the Closure or Post-Closure phases, tailings facilities could return to the Operations phase. In addition, tailings could be removed for reprocessing to recover additional commodities of value, or to be used for other purposes (eg construction material).

In some jurisdictions, during the Post-Closure phase, responsibility for a tailings facility may transfer from the Operator to jurisdictional control.

The tailings management lifecycle is illustrated in **Figure 1**.

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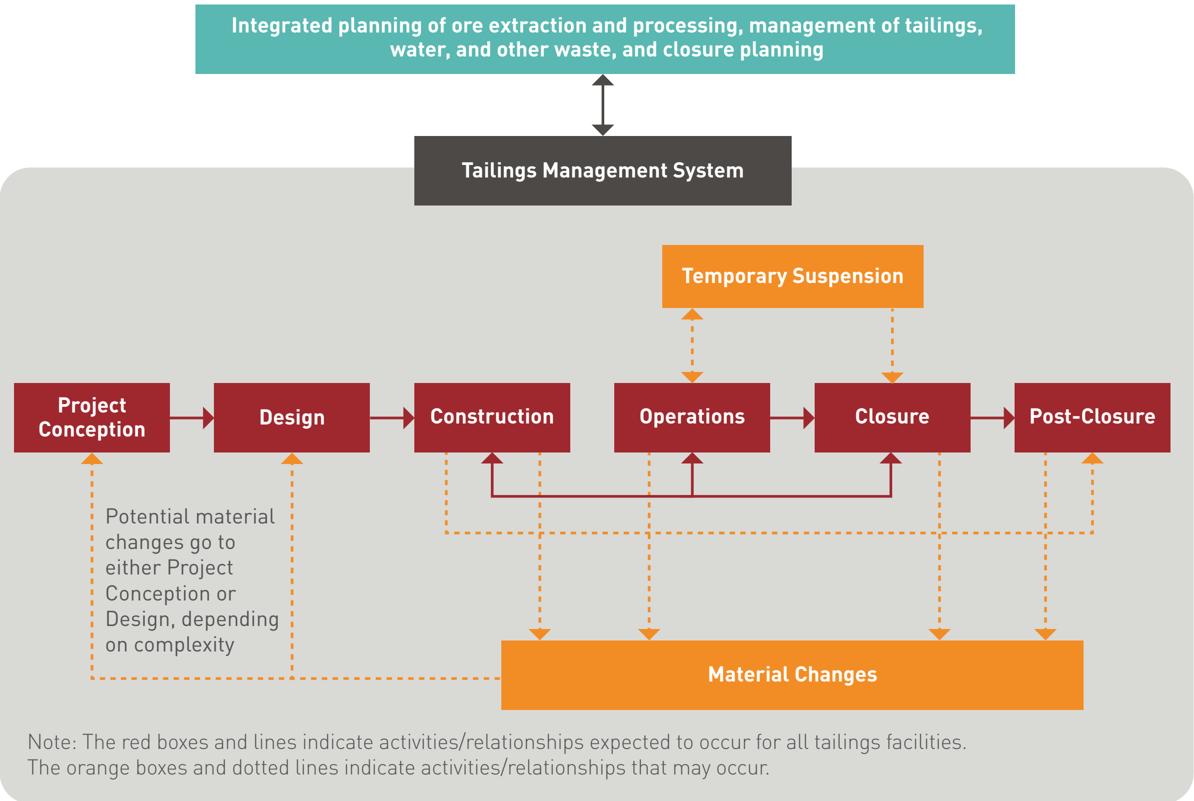

Figure 1: The tailings management lifecycle

1.2.2 Core Elements of Safe Tailings Management

A comprehensive, holistic approach is needed across the lifecycle for the safe and responsible management of tailings. This encompasses two inter-related core elements:

- Governance of tailings management (further described in Part 2).
- Implementation of good engineering practices for tailings management across the lifecycle (further described in Part 3).

These elements are equally vital to the safe and responsible management of tailings and should be implemented together in a fully integrated manner throughout all the phases of the lifecycle. They each fulfil a different but essential role:

- Effective governance of tailings management ensures accountability for decisions, provides a management structure with checks and balances for decision-making, provides the means to effectively manage tailings on a day-to-day basis, and provides input to mechanisms to respond effectively if an emergency occurs.
- Good engineering practices, including a risk-informed approach throughout the lifecycle, are needed to improve the safety of tailings facilities. In some cases, improvement can be achieved through enhancing current practices. In other cases, the adoption of a performance-based approach will provide a more rigorous technical basis for decision-making across the lifecycle.

Implementing these elements together helps to achieve the best outcomes for tailings management and helps to ensure effective communication. Most importantly, this approach helps to mitigate the human element in tailings management and reduce the likelihood that human error will lead to ineffective tailings management, or worse, the failure of a tailings facility.

1.2.2.1 Governance of Tailings Management

Governance of tailings management refers to the organisational structures, processes, procedures and communication channels that a company puts in place to ensure the effective management, oversight and accountability for tailings.

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Effective governance provides an essential foundation for all activities and decisions related to tailings management, and ultimately for managing risk.

Governance of tailings management is inclusive of the following elements:

Accountability and responsibility: Operators should assign and deliver on accountability and responsibility for tailings management to provide the foundation for good governance and decision-making (Section 2.2.2). The Operator should designate one or more Accountable Executive(s) who is/are directly answerable to the Chief Executive Officer (CEO), communicate(s) with the Board of Directors (BoD), and who is/are accountable for the safety of tailings facilities and for minimising the social and environmental consequences of a potential tailings facility failure. The Accountable Executive(s) may delegate responsibilities but not accountability. Conversely, delegation of responsibility to competent personnel is essential to the effective delivery of all tasks and activities related to tailings management. Personnel with accountability, responsibility or authority related to tailings management should have the necessary competencies and experience, commensurate to their level of accountability and responsibility.

Corporate policy on tailings management: Operators should develop a corporate policy on tailings management that is aligned with the declaration of a corporate safety culture, providing a basis and overall direction for safe tailings management (Section 2.2.3). Recognising that safe tailings management is a core business function, the planning of which should be closely integrated with related activities such as ore extraction and processing, the corporate policy on tailings management should be recognised in the overall business case for the mine and integrated into sitewide policies, objectives and plans.

Tailings Management System (TMS): Operators should develop and implement site-specific TMSs and apply them across the lifecycle (Section 2.3). Based on the Plan-Do-Check-Act cycle of management systems, a TMS is a comprehensive framework to integrate the people, resources, processes and practices related to tailings management to help Operators achieve their performance objectives, manage risk and ensure safe, responsible management of tailings. The TMS should be aligned and integrated with other relevant site-level systems, such as a sitewide environmental and social management system (ESMS) and systems related to water management.

A TMS:

- Encompasses governance and decision-making related to tailings management.
- Provides a mechanism to systematically and rigorously implement the other elements described in this guidance to implement good engineering practice.

Operation, maintenance and surveillance (OMS) activities are essential to the day-to-day implementation of the TMS and engineering practices for safe tailings management (Section 2.4). Without OMS, an Operator has no effective control of tailings management.

Managing information: Good information is essential to good governance and decision-making (Section 2.5). Preparing, maintaining and updating documentation of information on all aspects of tailings management is critical to providing a basis for current and future decisions, managing change, and for fully understanding and effectively managing risks. This includes documentation describing key aspects related to:

- Tailings management governance.
- Planning, design, construction, operation and closure of a tailings facility.

Programme for reviewing tailings safety: Operators should implement a programme for reviewing the safety of tailings facilities that provides expert oversight of tailings management activities and the safety of a tailings facility (Section 2.6). Such a programme, including Independent Review, should be applied throughout the lifecycle.

Emergency preparedness: Notwithstanding the obligation to design and operate safe tailings facilities, Operators need to be prepared in the event that an emergency occurs related to tailings management. As part of sitewide plans for emergency preparedness, Operators should develop and test plans for potential emergencies related to tailings to help to ensure a timely and effective response if an emergency occurs (Section 2.7).

1.2.2.2 Implementation of Good Engineering Practices for Tailings Management

There are many facets to engineering practices related to tailings management, including:

- Recognising and managing uncertainty.
- Project conception and design.
- Integrated mine planning.
- Designing and operating for closure.

Recognising and Managing Uncertainty
Understanding and managing risk is fundamental to the safe management of tailings but subject to significant uncertainty.

Risk is a frequently used but often misunderstood concept. It is important to emphasise that assessing risk involves the consideration of both the potential consequences of an event and the probability or likelihood of that event occurring. Risk should not be confused with consequence, nor should these terms be used interchangeably.

Risk assessment involves a process of risk identification, risk analysis and risk evaluation. Available information is first used to identify and describe the risks (risk identification) and estimate the magnitude of the risks to individuals or populations, property or the environment (risk analysis). The acceptability of the risks is then evaluated considering the potential consequences for health and safety, social, environmental, financial and other factors that may occur (risk evaluation). Once the risks have been assessed, risk management plans are developed to eliminate, reduce or mitigate, and communicate the risks.

Uncertainty is inherent in the analysis and evaluation of risks related to tailings facilities. Uncertainty may be related to many factors, such as the natural variability of the foundation and construction materials for a proposed tailings facility, design parameters, the accuracy of predictions of future climate conditions, and the challenge of estimating the likelihood of highly improbable events. As tailings facilities are reliant on natural materials and processes, uncertainty in risk assessment may be greater than in other sectors (eg chemical industry) for which the variability and uncertainty regarding feedstock materials may be significantly less.

An essential characteristic of managing risk is recognising and acknowledging uncertainty, managing risk within the limitations of that uncertainty and working to reduce uncertainty. Implementing a risk-informed approach is key to managing this uncertainty.

A risk-informed approach involves planning, designing, operating and closing tailings facilities in a manner that is:

- Informed by the results of the risk assessment. Potential risks and related uncertainties associated with tailings management are identified, analysed and evaluated during the Project Conception phase, re-assessed during the Design phase, and re-assessed periodically throughout the lifecycle.
- Intended to prevent or eliminate risks to the extent possible and to effectively manage those risks that remain by developing a robust tailings facility design with less uncertainty in design criteria.
- Informed by improved site characterisation, the results of surveillance, input from the programme for reviewing facility safety (Section 2.6), and updates to the risk assessment process, all of which help to reduce uncertainty. Site-specific surveillance programmes should be designed and implemented (Section 2.4.3.4) to provide the information (eg data, observations, results of inspections) needed to accurately assess on an ongoing basis whether the risk management plan is effective. Results from surveillance and input from reviews, together with updates to the risk assessment process, should be used to identify:
  - Variances from performance criteria indicative of potential upset or emergency conditions.
  - Deficiencies in performance or practice that should be addressed.
  - Opportunities for continual improvement.

A risk-informed approach may include the use of:

- Surveillance results to verify whether the tailings facility is behaving as per the design and adjusting accordingly.
- Numerical models of tailings facility performance based on surveillance and site characterisation data to validate assumptions about the facility design and predict future performance. Outputs from these models can be used to inform changes to the design or operating practices to improve performance and reduce risk.

Project Conception and Design of Tailings Facilities

The project conception and design of new tailings facilities, material changes, and the closure of tailings facilities build upon a risk-informed approach (Sections 3.3 and 3.4). For new facilities, the Project Conception phase is the first stage in the lifecycle for the potential elimination of risks. Once a tailings facility has been designed and built, it may be much more difficult to eliminate the risks that exist, than if they had been avoided in the Project Conception phase.

During the Project Conception phase, site characterisation (Section 3.3.2) and risk assessment are used to inform a process of identifying potential alternatives for the conceptual design of a tailings facility, and rigorously evaluate those alternatives (eg using multiple accounts analysis (MAA)) to select the preferred alternative (Section 3.3.4). For example, for new tailings facilities, this would include the alternative locations for a tailings facility and the alternative technologies to be used. Both the location and the technology selected can have a strong influence on the risks that will need to be managed. Thus, decisions made during the Project Conception phase may prove to be some of the most important in the entire lifecycle of a tailings facility. The importance of this phase cannot be overstated.

The preferred alternative is then designed in detail, taking into account factors including:

- Site-specifically appropriate design criteria (Section 3.4.3).

1.2 OVERVIEW OF THE GUIDE

- Site-specific performance objectives and indicators (Section 3.3.3).
- Credible failure modes identified through the risk assessment process and means to address those failure modes in the design (Section 3.4.3.10).
- Continued improvements in site characterisation information and models.
- Where appropriate, the application of a performance-based approach to design that uses the results of numerical modelling of various aspects of the tailings facility performance to inform and refine the design (Section 3.4.3.6).
- Refinements to the risk assessment, including reducing uncertainty associated with the risk assessment (Section 3.4.2).

Designing and Operating for Closure
Tailings facilities may continue to pose risks long after the Operations phase has ended, and after the closure plan has been implemented. The development and implementation of closure plans is critical to mitigating these risks. However, relying solely on the implementation of the closure plan to achieve closure objectives may limit the capacity to reduce long-term risks and liabilities in the Closure and Post-Closure phases.

Alternatively, designing tailings facilities with the objectives of closure in mind from the outset, and incorporating those objectives in the performance objectives for the tailings facility, can help to reduce long-term risks and reduce the liabilities associated with closure. This includes designing, operating and closing tailings facilities in a manner that results in them becoming engineered landforms – structures that mimic natural landforms – to increase their long-term stability and make them more resilient not only to the risk of failure, but also more resilient to gradual deterioration due to erosion. An engineered landform also has much lower long-term maintenance and surveillance requirements.

Designing for closure builds upon integrated mine planning, as a holistic approach to mine planning, design and operation may be needed to achieve the objectives of designing for closure. This should be recognised early in the Project Conception phase.

For existing tailings facilities that were not originally designed with closure in mind, Operators may consider changes to the design or practices that can be implemented during the Operations phase to reduce risk and better position the tailings facility for closure.

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1.3 RELATIONSHIP TO THE GLOBAL INDUSTRY STANDARD ON TAILINGS MANAGEMENT, THE CONFORMANCE PROTOCOLS & THE TAILINGS GOVERNANCE FRAMEWORK

1.3.1 Relationship to the *Global Industry Standard on Tailings Management* and ICMM Conformance Protocols for the Global Industry Standard on Tailings Management

As noted earlier (Section 1.1.3), this Guide has been informed by the Standard and will help Operators to work through how to integrate the related requirements or commitments into their own programmes. The Guide should not be used to assess conformance against the Standard, which is the purpose of the ICMM Conformance Protocols for the Global Industry Standard on Tailings Management (The Conformance Protocols).

The Conformance Protocols have been developed to enable conformance to be assessed and to support the integration of the Standard into ICMM's existing assurance processes for its member commitments. The Conformance Protocols support either self-assessments or independent third-party assessments of progress with implementing the Standard and ultimately conformance. It details clearly and concisely criteria that assessors expect to see evidenced for conformance to be assessed, with illustrative examples of evidence and explanatory notes as appropriate. It is available to be used by company members (or non-members) or suitably qualified independent third parties and maps to the Standard and its 77 requirements.

The social and environmental requirements of the Standard are referred to within this Guide, but the intention is that these are largely addressed by reference to existing guidance from ICMM. Where appropriate, these other sources of guidance are referred to within this Guide and within the Conformance Protocols.

For example, Principle 1 of the Standard includes requirements relating to: respect for human rights and related due diligence; working to obtain and maintain the Free, Prior and Informed Consent (FPIC) of indigenous or tribal peoples; meaningful engagement of project-affected peoples; and the establishment of effective grievance mechanisms to address the complaints and grievances of project-affected people. All of these are adequately covered by existing sources of ICMM guidance.

Two principles from the Standard that require some further explanation are Principles 2 and 3 that deal with the development and use of an integrated knowledge base. The concept of a 'knowledge base' is addressed in ICMM's Integrated Mine Closure: Good Practice Guide, and the basic approach is transferrable to tailings management. It involves developing, documenting and periodically updating information about the social, environmental and local economic context of the tailings facility, to support informed decision-making across the tailings facility lifecycle. This should be undertaken using approaches aligned with international good practice and designed to capture uncertainties due to climate change. In terms of updating the knowledge base, this should be revisited at least every five years, and whenever there is a material change to the tailings facility or to the social, environmental and local economic context.

Other aspects of the knowledge base such as developing, documenting and updating detailed site characterisations of tailings facility sites for a range of criteria or the conduct and periodic updating of breach analysis are addressed in this Guide.

1.3.2 Implementation of the ICMM Tailings Governance Framework

This Guide builds upon the ICMM Tailings Governance Framework Position Statement (the Framework) and will support implementation of the Framework. The Position Statement commits members to implement practices consistent with the Framework, which consists of six elements of tailings management and governance. These elements are described below, together with corresponding sections of the Guide that support implementation.

1.3 RELATIONSHIP TO THE GLOBAL INDUSTRY STANDARD ON TAILINGS MANAGEMENT, THE CONFORMANCE PROTOCOLS & THE TAILINGS GOVERNANCE FRAMEWORK

<table>
<tr><th>ICMM Tailings Governance Framework</th><th>Corresponding Sections in the ICMM Good Practice Guide</th></tr>
<tr><td>Accountability, Responsibility and Competency:
Accountabilities, responsibilities and associated competencies are defined to support appropriate identification and management of tailings facility risks.
• Accountability for the overall governance of tailings facilities resides with the owners and operators.*
• Organisational structures and roles are established to support management of tailings facility risks and governance accountability.
• Communication processes are maintained to ensure that personnel understand their responsibilities. Training is conducted to maintain currency of knowledge and skills.
• Role competency and experience requirements are defined for critical roles within the established organisational structures.

* The ICMM Position Statement uses the terms owners and operators. This Guide uses the term Operators. As defined in the Glossary, Operators is inclusive of owners and operators as described in the Position Statement.</td><td>Section 2.2.2: Accountability and Responsibility
Section 2.2.4: Competency and Promoting Continual Learning
Section 2.2.6: Communication
Section 2.3: Tailings Management System
Section 2.4: Operation, Maintenance and Surveillance</td></tr>
<tr><td>Planning and Resourcing:
The financial and human resources needed to support continued tailings facility management and governance are maintained throughout a facility's lifecycle.
• Tailings facility operating and capital costs, and human resource needs, are included in relevant business planning processes.
• Resources necessary to implement and maintain activities within this governance Framework are provided.</td><td>Section 2.2.3: Corporate Policy on Tailings Management
Section 2.3.2.3: Resources</td></tr>
<tr><td>Risk Management:
Risk management associated with tailings facilities includes risk identification, an appropriate control regime and the verification of control performance.
• Risk controls and their associated verification activities are identified based on failure modes and their associated consequences and evaluated on a tailings facility-specific basis considering all phases of the tailings facility lifecycle.
• Suitably qualified and experienced experts are involved in tailings facility risk identification and analysis, as well as in the development and review of effectiveness of the associated controls.
• Performance criteria are established for risk controls and their associated monitoring, internal reporting and verification activities.</td><td>Section 1.2.2: Core Elements of Safe Tailings Management
Section 2.2.2: Accountability and Responsibility
Section 2.2.4: Competency and Promoting Continual Learning
Section 2.3: Tailings Management System
Section 2.4: Operation, Maintenance and Surveillance
Section 2.7.2: Assessing Credible Potential Consequences
Section 3.2.4: Managing Uncertainty and Risk
Section 3.3: Projection Conception
Section 3.4: Design
Section 3.6: Operations
Section 3.7: Closure and Post-Closure</td></tr>
</table>

<table>
<tr><th>ICMM Tailings Governance Framework</th><th>Corresponding Sections in the ICMM Good Practice Guide</th></tr>
<tr><td>Change Management:
Risks associated with potential changes are assessed, controlled and communicated to avoid inadvertently compromising tailings facility integrity.
• Processes are applied that involve the identification, assessment, control and communication of risks to tailings facility integrity arising from both internally-driven and externally-driven change, to avoid introducing uncertain, unacceptable, and/or unmanaged risks.
• Documents and records that support tailings facility planning, design, construction, operation, surveillance, management and governance are maintained and kept suitably current and accessible.</td><td>Section 2.2.2: Accountability and Responsibility
Section 2.3: Tailings Management System
Section 2.5: Managing Information
Section 3.2.4: Managing Risk and Uncertainty
Section 3.3: Projection Conception
Section 3.4: Design
Section 3.5: Construction
Section 3.6: Operations
Section 3.7: Closure and Post-Closure</td></tr>
<tr><td>Emergency Preparedness and Response:
Processes are in place to recognise and respond to impending failure of tailings facilities and mitigate the potential impacts arising from a potentially catastrophic failure.
• Action thresholds and their corresponding response to early warning signs of potential catastrophic failure are established.
• Emergency preparedness and response plans are established commensurate with potential failure consequences. Such plans specify roles, responsibilities and communication procedures.
• Emergency preparedness and response plans are periodically tested.</td><td>Section 2.4: Operation, Maintenance and Surveillance
Section 2.7: Emergency Preparedness and Response
Section 3.6: Operations</td></tr>
<tr><td>Review and Assurance:
Internal and external review and assurance processes are in place so that controls for tailings facility risks can be comprehensively assessed and continually improved.
• Internal performance monitoring and inspections and internal and external reviews and assurance are conducted commensurate with consequences of tailings facility failure to evaluate and to continually improve the effectiveness of risk controls.
• Outcomes and actions arising from tailings facility review and assurance processes are recorded, reviewed, closed-out and communicated.
• Performance of risk management programmes for tailings facilities is reported to executive management on a regular basis.</td><td>Section 2.3: Tailings Management System
Section 2.4: Operation, Maintenance and Surveillance
Section 2.6: Programme for Reviewing Tailings Safety</td></tr>
</table>

1.3 RELATIONSHIP TO THE GLOBAL INDUSTRY STANDARD ON TAILINGS MANAGEMENT, THE CONFORMANCE PROTOCOLS & THE TAILINGS GOVERNANCE FRAMEWORK

1.3.3 Relationship between the Guide, the Standard, the Conformance Protocols and the Tailings Governance Framework

The relationship between the Standard and ICMM's tailings-related documents (discussed in Sections 1.3.1 and 1.3.2) is illustrated in **Figure 2** and may be summarised as follows.

The two documents that include the commitments of membership are illustrated on the top of Figure 2. The six commitments in the *Tailings Governance Framework Position Statement* on tailings management and governance (see top left of Figure 2) pre-date the requirements of the Standard which adequately addresses them. More broadly, the Standard (top right of Figure 2) outlines seventy-seven Requirements for responsible tailings management, under fifteen Principles that cover six Topic areas. The Standard has helped to inform the development of this Guide (top right of Figure 2).

In turn, this Guide supports the interpretation and implementation of many requirements within the Standard. It also supports the implementation of the commitments within the *Tailings Governance Framework Position Statement*. In addition, the Guide also refers to other sources of ICMM guidance that help to support implementation of some of the environmental and social requirements of the Standard (primarily under Principles 1–3 of the Standard).

Lastly, the ICMM Conformance Protocols (bottom left of Figure 2) support either self-assessments or independent third-party assessments of progress with implementing the Standard (as described in Section 1.3.1 above). Where appropriate, the Protocols refer to related sections of the Guide.

The relationship between the Standard, supporting guidance from ICMM (and other authoritative sources of guidance by organisations such as MAC) and technical guidelines produced by reputable technical organisations such as those focused on dams is shown in **Figure 3**.

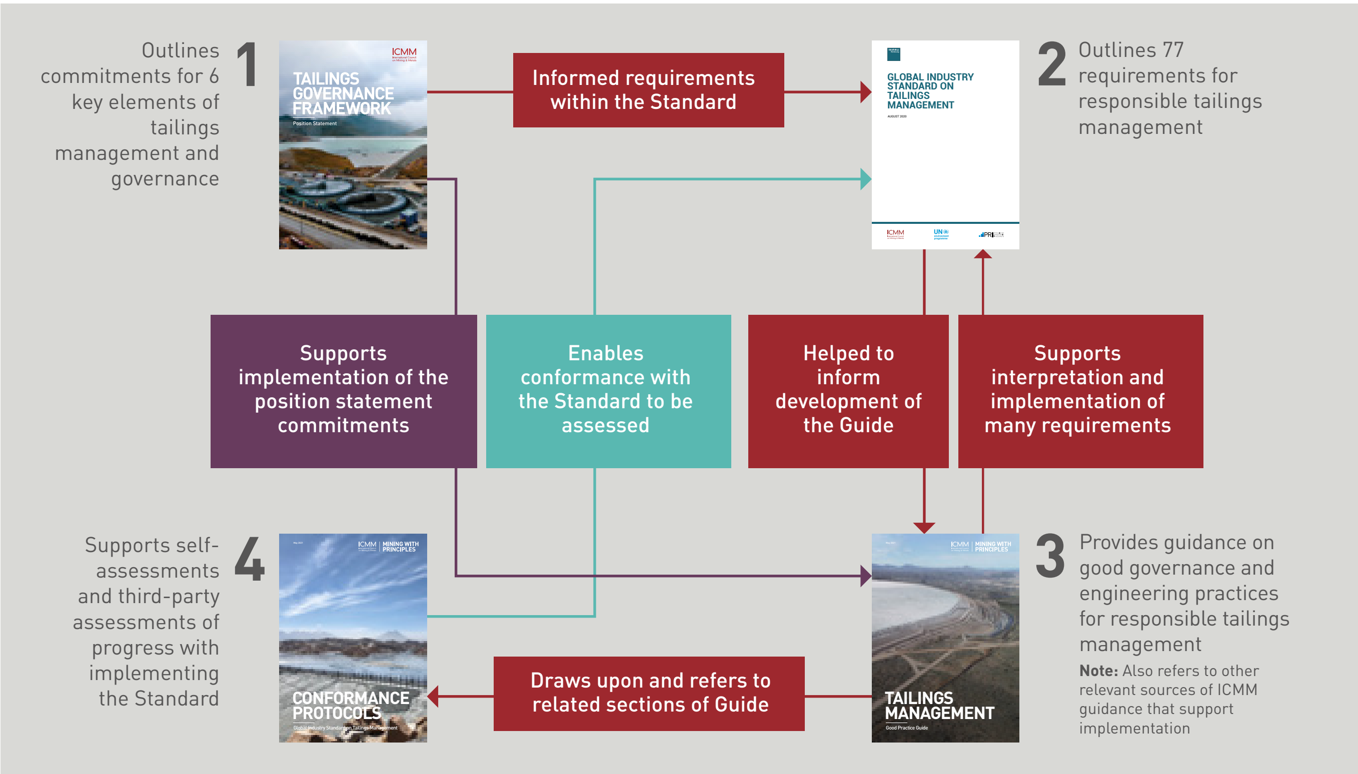

Figure 2: Relationship between key documents

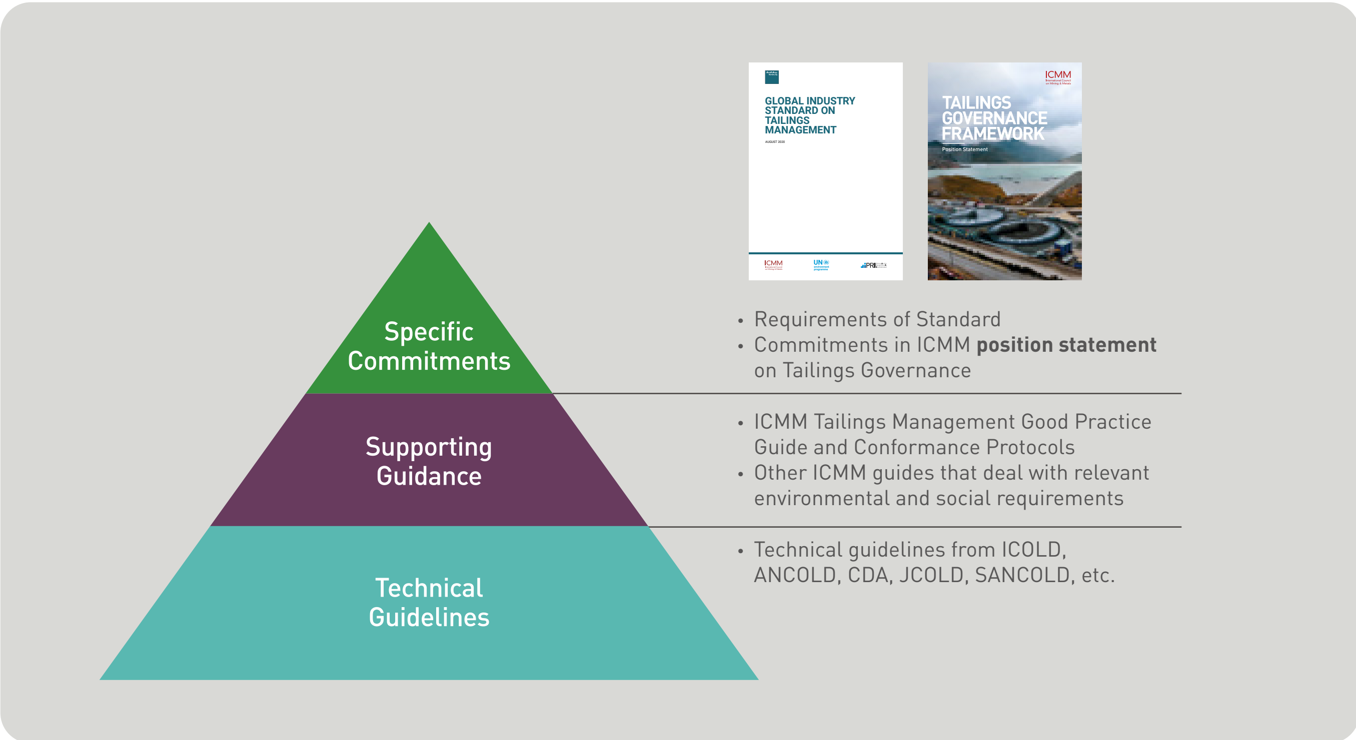

Figure 3: Increasing levels of detail between specific commitments, supporting guidance and technical guidelines

PART 2: GOVERNANCE OF TAILINGS MANAGEMENT

2.1 OVERVIEW

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The governance of tailings management as described in this Guide is consistent with the Standard and refers to the organisational structures. Governance refers to the processes, procedures and communication channels that a company puts in place to ensure the effective management, oversight and accountability for tailings.

Effective governance is essential to safe and responsible tailings management. Elements of governance include:

- Accountability, a corporate policy and related elements:
  - Competency and training
  - Community engagement
  - Communication
- Tailings management system (TMS)
- Operation, maintenance, and surveillance (OMS) activities
- Managing information
- Programme for reviewing tailings safety
- Emergency preparedness and response planning (EPRP).

These governance elements provide an essential framework within which all other activities related to tailings management are conducted. To be effective, the governance of tailings management must come first, with all other activities conducted within that framework.

2.2 ACCOUNTABILITY, POLICY & RELATED ELEMENTS

2.2.1 Introduction

Role clarity is critical to the safe management of tailings. From defining policy at the corporate level to implementing regular measurements in the field at the technician's level, and for every task in between, clear roles and responsibilities enhance individual ownership of assigned scope.

Accountability, which cannot be delegated, should be underpinned by the Operator's commitment to the safe management of tailings, including providing the resources (eg financial, personnel) needed to support both the short- and long-term objectives for safe and responsible tailings management.

The circumstances of each Operator and tailings facility vary, and the governance and organisational structure should be appropriately tailored to suit each facility. At a minimum, the Operator should:

- Define and document accountabilities and responsibilities related to tailings management for the:
  - BoD.
  - Accountable Executive.
  - Responsible Tailings Facility Engineer (RTFE).
  - Engineer of Record (EOR) and Design Team (Section 2.2.2).
- Establish and maintain a corporate policy on tailings management through the BoD.
- Understand the competencies required for tailings management and ensure that relevant personnel (employees, contractors and consultants) have those competencies.
- Engage local communities on matters related to tailings management, including potential risks to those communities.
- Integrate activities and communicate effectively, both internally (eg between different business units) and externally, on matters related to tailings management.
- Share information about tailings management with regulators, communities, investors and other external parties.

2.2.2 Accountability and Responsibility

Accountability, responsibility and authority are closely related concepts. The difference between them is critical but is sometimes not clearly understood. The usage of these terms in this Guide is defined as follows:

Accountability: The answerability of an individual for their own performance and that of any personnel they direct, and for the completion of specified deliverables or tasks in accordance with defined expectations. An accountable person may delegate responsibility for the completion of the deliverable or task but not the accountability.

Responsibility: The duty or obligation of an individual or organisation to perform an assigned duty or task in accordance with defined expectations, and which has a consequence if the expectations are not met. An individual or organisation with responsibility is accountable to the person that delegated that responsibility to them.

Authority: The power to make decisions, assign responsibilities, or delegate some or all authority, as appropriate. The ability to act on behalf of the Operator.

Personnel with accountability and responsibility for all decisions related to tailings management should be identified and in place. Decisions should be made by persons who have clear accountability or responsibility and who are appropriately qualified and experienced. Those persons with defined accountability and responsibility should also have the authority to make decisions commensurate with their level of responsibility. The Accountable Executive should have clear authority commensurate with their accountability and in cases where they need funding authorisations beyond their authority, they should have access to and communication with those who can provide authorisation in a timely manner.

Persons with accountability, responsibility and authority for tailings management should have an understanding – appropriate to their accountability, responsibility and authority level – of how the tailings facility is planned, designed, constructed and operated and how it will be closed. This includes the risks posed by the tailings, the risk management process and operational constraints.

For persons with accountability, responsibility and authority for tailings management, incentive payments or performance reviews should at least in part be based on public safety and the integrity of tailings facilities. Incentive payments should reflect the degree to which public safety and the integrity of the tailings facility are part of the role. Long-term incentives for relevant executive managers should also take tailings management into account.

To enhance clarity of roles and responsibilities, an Operator may elect to use a tool such as a RACI (responsible, accountable, consult and inform) matrix or a RASCI (responsible, accountable, support, consult and inform) matrix to describe roles and relationships between employees and with contractors and consultants, including the Engineer of Record (EOR) and the Design Team.

2.2.2.1 Board of Directors

While companies may be organised in different ways, this Guide adopts the Standard's definition of BoD. The ultimate governing body of the Operator is the BoD, which is typically elected by the shareholders of the Operator. The BoD is the entity with the final decision-making authority for the Operator and holds the authority to, among other things, set the Operator's policies, objectives and overall direction, and oversee the firm's executives. As the term is used here, it encompasses any individual or entity with control over the Operator, including, for example, the owner or owners. Where the State serves as the Operator, the BoD is understood to mean the government official with ultimate responsibility for the final decisions of the Operator.

Accordingly, the Standard requires that the BoD adopt and publish a policy on or commitment to the safety management of tailings facilities, to emergency preparedness and response, and to recovery after failure.

2.2.2.2 Accountable Executive

The BoD or CEO should designate one or more executive-level person(s) to be the Accountable Executive(s), who is/are accountable for the safety of tailings facilities and for minimising the social and environmental consequences of a potential tailings facility failure. The Accountable Executive(s) may delegate responsibilities for tailings management and the development and implementation of the systems needed for safe, responsible tailings management but accountability cannot be delegated. The Accountable Executive(s) is/are directly answerable to the CEO (or to the BoD in the case that a CEO is the Accountable Executive) on matters related to tailings management and should have regular communication with the BoD (initiated either by the BoD or the Accountable Executive(s)). The mechanism for holding the Accountable Executive(s) accountable should be documented. The role and accountability of the BoD versus the Accountable Executive(s) determined by the Operator and should also be documented.

Responsibilities of the Accountable Executive(s) include:

- Having accountability and responsibility for putting in place an appropriate management structure.
- With authorisation from the BoD, ensures that the necessary resources are in place for tailings management.
- Demonstrating to the BoD whether tailings are managed responsibly and in accordance with applicable legal requirements and standards.
- Delegating responsibility and authority for tailings management and defining the personnel responsibilities, authority and reporting relationships to implement the systems needed for safe, responsible tailings management throughout the lifecycle.
- Delegating responsibility and authority for the development of integrated closure plans to ensure facility integrity post-closure.
- Being aware of the key outcomes of tailings risk assessments and how these risks are being managed.
- Being accountable for a programme of tailings management training and for emergency preparedness and response.
- Establishing a programme for reviewing tailings safety, including Independent Review.
- For new tailings facilities, approving that the design satisfies the as low as reasonably practicable (ALARP) principle and approving additional steps to further reduce potential consequences to people and/or the environment, where appropriate.
- Having scheduled communication with the EOR.
- Encouraging open, transparent communication among all employees and contractors regarding concerns about tailings facility integrity, safety or compliance. Establishing a formal, confidential and written process to receive, investigate and promptly address concerns from employees and contractors about possible permit violations or other matters relating to regulatory compliance, public safety, tailings facility integrity or the environment.

2.2 ACCOUNTABILITY, POLICY, & RELATED ELEMENTS

The Accountable Executive(s) should embrace the use of conservative external loading criteria as a guiding philosophy for tailings facilities. Where appropriate, the Accountable Executive(s) may decide to adopt lower design criteria if recommended by the EOR and endorsed by Independent Review, while maintaining the flexibility to upgrade the design for the highest consequence later in the facility's lifecycle.

The Accountable Executive(s) may be supported by a corporate expert(s) in tailings management to help oversee the Operator's portfolio of tailings facilities and to provide a bridge between the Accountable Executive(s) and the RTFE and EOR for each tailings facility for which the Operator is responsible.

2.2.2.3 Responsible Tailings Facility Engineer

As a minimum, the Operator should designate one RTFE for each tailings facility. The RTFE is accountable for the integrity of that tailings facility. During the Construction and Operations phases, an RTFE should be available at all times (although this person does not necessarily need to be located on site).

Alternatively, there may be an RTFE at the corporate level, with responsibility for more than one tailings facility.

The RTFE liaises with the EOR and has regular communication with the Accountable Executive or their delegate. The RTFE should also liaise with internal teams with direct and indirect responsibilities related to tailings management such as operations, planning, regulatory affairs, social performance and the environment. The RTFE should be familiar with the design, construction, operation and performance of the tailings facility and have experience, knowledge and competencies appropriate to the complexity of the facility and the risks posed.

The RTFE should have clearly defined, delegated responsibilities for tailings management and should have the appropriate competencies to carry out these responsibilities. They should identify the scope of work and budget requirements for all aspects of tailings management, including the EOR. The RTFE should delegate specific tasks and responsibilities for aspects of tailings management to qualified personnel.

In Detail

Examples of the responsibilities of a RTFE include:

- Coordinate their efforts through the Accountable Executive for an aligned approach to tailings governance for the Operator.
- Implement the TMS (Section 2.3).
- Establish, with input from appropriate personnel, a budget for approval by the Accountable Executive or persons with delegated budget authority.
- With input from the Accountable Executive or persons with delegated responsibility, establish an organisational structure with roles and responsibilities that meets the operational needs.
- Establish a formal relationship with the EOR and Design Team to ensure that construction and operation meet the design intent and are compliant with legal requirements (Sections 3.4, 3.5 and 3.6).
- Ensure surveillance is undertaken in accordance with design intent, performance objectives and the risk management plan (Section 2.4).
- Ensure the development of the tailings facility closure plan, implementation of progressive reclamation as practicable during the Operations phase, and implementation of the closure plan at the end of the Operations phase (Section 3.7).
- Maintain records related to design, construction and OMS (Section 2.5).
- Ensure inspections (eg dam safety inspections or DSRs) are completed (Section 2.6).
- Review and update the OMS manual (Section 2.4).
- Ensure that emergency response plans are developed, maintained and tested, either as stand-alone plans or as components of sitewide emergency response plans directly related to tailings management (Section 2.7).
- Implement measures to remedy variances from performance objectives or criteria (Section 3.5, 3.6 and 3.7).
- Implement a programme for reviewing tailings safety, including Independent Review (Section 2.6).
- Identify when/where contemplated operational changes are a potential deviation from the design intent and engage the EOR or Design Team as part of the process to manage change (Sections 2.3, 3.3, 3.4, 3.5, 3.6 and 3.7).
- Participate in or provide input to community engagement activities related to tailings management (Section 2.2.5).

2.2.2.4 Engineer of Record and Design Team

The EOR is a fundamental role in the development and management of safe tailings facilities. While this role can be described using various terminology, at its core, the EOR role:

- Provides assurance to the Operator and relevant regulatory authorities that the tailings facility design conforms with and meets applicable regulations, statutes, guidelines, codes and standards.
- Confirms that the facility has been constructed and is being operated consistent with the design intent presented in the design drawings, specifications and design basis documentation.
- Provides critical, ongoing support during the Operations phase and through the lifespan of the facility, confirming that the facility is being safely operated and performing as planned.

The purpose of the EOR role should be understood as a means to ensure that business and operational decisions made by the Operator are informed by an engineer who understands the design principles and technical limitations of the tailings facility and the impact of changes on its safety and performance.

There are multiple models that can fulfil the role of EOR, and past practices for the engagement of an EOR have varied significantly in different countries and regions of the world. This Guide recognises that a 'one-size-fits-all' approach is impractical and acknowledges two basic models for fulfilling the role of EOR – an external EOR or an internal EOR – and that multiple variations of each model may exist.

It is up to each Operator to determine and document the following:

- EOR model best suited to their needs and their capacity.
- Required qualifications and competencies for the EOR, and the process to ensure that these requirements are met.
- Responsibility, authority and role of the EOR.
- Relationship between the EOR and the RTFE.
- Relationship between the EOR and the Design Team.
- Relationship between the EOR and members of the Operator's technical and functional teams and contractors related to tailings management.
- Relationship between the EOR and the programme for reviewing tailings safety (eg role of the EOR in Independent Review).
- In cases where the Operator has more than one EOR with responsibilities related to different embankments, the roles and responsibilities of each EOR should be clearly defined, together with the relationship between these EORs.

- Mechanisms to ensure that relevant personnel understand the role, responsibilities and authority of the EOR.
- Resources required for the EOR to fulfil the assigned role and responsibilities, including financial resources, support personnel required (and appropriate qualifications) and other resources.
- Specific deliverables to be provided by the EOR and associated schedules.

The EOR shares responsibility with the RTFE for assuring to the Operator and other stakeholders that the facility is constructed, operated, monitored and performing according to the design criteria and intent, applicable design standards, change management processes, risk controls, relevant guidelines and accepted engineering practices. All levels of the Operator's organisation should understand the responsibility and authority held by the EOR. The EOR should have regular, scheduled communication with the Accountable Executive or delegate. In addition, they should have the ability to ultimately raise concerns directly with the Accountable Executive if necessary.

The EOR should have professional attributes aligned with the responsibilities required for the given tailings facility inclusive of that facility's complexity and precedence. Selection of the appropriate person for the EOR role and ensuring this person has adequate support is fundamental to tailings facility safety.

Because the scope of an EOR for most tailings facilities is so broad, implementation of the role typically requires the combined expertise of an individual EOR and a supporting multi-disciplinary team. This multi-disciplinary team should be scaled according to the complexity of each facility. Regardless of how individual responsibilities are delegated among the various members of the team, the overarching responsibility for understanding the design concept and how it applies to the construction and successful operation of the facility resides with the individual appointed as EOR.

The Design Team develops the design of the tailings facility. The work involved may include the initial design for a new tailings facility, planned construction through the Operations phase, and any material changes to the design of the tailings facility. The Operator should define and document the roles and responsibilities and relationship of the EOR relative to the Design Team. As with the EOR, there are different models for the Design Team. The Design Team may be from the same firm as the EOR, which is helpful in terms of facilitating effective communication and collaboration. In some instances, there may be a single or lead designer, sometimes referred to as the Designer of Record. In some cases, the EOR may fulfil the design function. It is up to the Operator, subject to any relevant legal requirements, to determine the most appropriate approach.

Like the EOR, the Design Team members should have professional attributes aligned with the responsibilities required for the given tailings facility inclusive of that facility's complexity and precedence. The role of the EOR with respect to design is further discussed in Section 3.4.

Tailings facilities are long-lived structures that change throughout their lives and may require maintenance and surveillance long after the original EOR has retired from professional practice. Thus, managing change of the EOR is critical to the continuity of safe and responsible tailings management.

Above all, the EOR needs to accept the commitment, be available when required, and communicate effectively with the RTFE and Accountable Executive (or delegate). The EOR needs to gain the confidence of the Independent Reviewer(s) through demonstrated commitment and competent responses to issues as they arise.

In Detail

Examples of normal responsibilities carried by the EOR include:

- Documentation of information on the design, design basis and design intent of the facility (Section 3.4.5).
- Providing guidance and oversight to the investigations and studies needed to adequately characterise the site (Section 3.3.2).
- Identifying and providing oversight to the necessary design analyses as required to develop the design basis for the facility (Section 3.4.3).
- Providing responsible charge for reviewing and approving data analyses and deliverables prepared by Design Team, Operator or third parties.
- Providing engineering analysis in support of the development of the closure plan (Section 3.7).
- Providing input into the OMS manual and implementation of OMS activities (Section 2.4) in accordance with the design.
- Receiving and reviewing tailings facility performance data at a frequency determined based on the risks.
- Participating in periodic risk assessments (Sections 3.2 and 3.4.2).
- Participating in the identification and evaluation of potential failure modes, and the identification of credible failure modes.
- Participating in the development of the risk management plan, including risk controls and critical controls and associated surveillance.
- Overseeing or verifying quality management during construction (Section 3.5).
- Preparing a periodic Deviance Accountability Report (DAR) (Section 3.5.3).
- Confirming that the tailings facility's operation is compliant or identifying variances from performance criteria and advising the Operator with recommendations.
- Notifying the Accountable Executive (or delegate) in the event the EOR identifies any critical concerns or any significant outstanding concerns that have not been adequately addressed by the RTFE or others with relevant responsibility and authority.
- Advising on contemplated changes to the tailings facility's operation.
- Participating in inspections and Independent Review (Section 2.6.4).
- Working with the RTFE, be responsible for preparation of

or review of the Construction Records Report (CRR) ('as-built' report) and updates (Section 3.5.4).

- Developing and maintaining relevant records related to design, construction and operation, maintenance, surveillance and closure (Section 2.5), and handing those records over to the Operator.

With respect to managing a change of the EOR the following should be considered:

- Succession planning for the EOR role is important (Section 2.3.2.1).
- Change for the sake of change should be avoided.
- Decisions to select, retain or change the EOR should never be based on cost alone. The selection of the EOR should be decided by the Accountable Executive with input from the RTFE and informed, but not decided by, procurement personnel.

Where procurement practices place a strong emphasis on competitive costs, this can result in breaking the design into small segments for either economic or other management objectives. This creates an unnecessary risk by not taking a holistic approach to design. Thus, procurement policies that ensure experience is adequately weighted in selecting the EOR and Design Team are helpful to make sure that decisions are not being driven unduly by economics.

All tailings facilities evolve and change throughout their lifecycle. As such, the Operator should review the required qualifications of the EOR periodically (every three to five years for tailings facilities in the Operations, Closure and Post-Closure phases, even more frequently as projects progress from the Project Conception phase through to the Design phase) to ensure the EOR has the experience, knowledge and competencies appropriate to the tailings facility.

2.2.3 Corporate Policy on Tailings Management

Establishing a corporate policy on tailings management provides an important basis for establishing corporate priorities and performance objectives (Section 3.3.3) related to tailings management. A policy is an important tool to demonstrate, both internally and externally, the Operator's commitment to tailings management.

The policy should be aligned with the Operator's commitment to implementing a corporate safety culture: prioritising safe and responsible tailings management with the ultimate goal of zero fatalities and catastrophic events.

The policy should be integrated with corporate policies related to sustainability, health and safety, business ethics and other related elements to ensure that:

- Corporate commitments and goals related to tailings management are integrated with and reflected in other corporate commitments.
- Other corporate commitments and goals are reflected in tailings management.

Operators should develop a policy on tailings management that best meets their needs and corporate management approach while addressing their legal requirements and commitments to local communities. As their portfolio of tailings facilities and associated risks will change with time, the Operator should re-evaluate the adequacy of the policy on a regular basis.

The corporate policy should demonstrate the Operator's commitment to:

- Protection of health and safety of employees, contractors and the public.
- Safe and responsible management of tailings with the objective of zero fatalities and eliminating catastrophic failures.
- Allocation of appropriate resources to support tailings management activities.
- Implementing effective governance of tailings management through the actions of the Operator's employees, contractors and consultants.
- An organisational culture that promotes learning, communication, early problem recognition and early escalation of issues.
- Emergency preparedness and post-incident recovery if a failure occurs.
- Implementing a programme for reviewing tailings safety, including Independent Review.
- Providing adequate resources (financial, personnel, etc) to manage tailings in accordance with the policy.

The corporate policy should be:

- Reviewed and endorsed by the BoD.
- Consistent with applicable legal requirements.
- Communicated to employees.
- Understood to a degree appropriate to their roles and responsibilities by personnel whose activities may affect tailings management either directly or indirectly.
- Publicly available.

Tailings management is a core business function of the mining industry, and as described in Sections 1.2.2.2 and 3.2, planning for tailings management should be integrated into planning related to relevant aspects of mining operations, such as ore extraction and processing, sitewide water management, management of waste rock and other mine wastes, and sitewide closure planning. To facilitate this integrated approach, it is essential that all business units understand the corporate policy on tailings management and their role in implementing the policy, including the importance of integrated mine planning. Furthermore, the corporate policy and site-specific performance objectives for tailings management should be integrated into sitewide policies, objectives and plans.

2.2.4 Competency and Promoting Continual Learning

Tailings management requires the Operator and personnel involved in tailings management to have a level of competence consistent with the requirements of the tailings facility and its risks. The key elements of developing and maintaining competence are qualifications, training and experience.

Competency

Competencies comprise knowledge, skills and abilities and are typically demonstrated through behaviour. Competency is important for effective performance. High level competencies for tailings management may be identified by the Operator and should reflect the Operator's values. Those broader competencies are often supported by role specific competencies, performance indicators, knowledge/skills/abilities and current learning resources for the position.

As tailings personnel progress through their careers, they are naturally expected to gain competency in key practice areas. A competency framework should be developed and used in conjunction with a mentoring and training system to maximise learning and development. When assessing competency, consider such aspects as:

- Purpose of the position
- Nature of the work
- Education/Experience
- Level of interaction
- Autonomy/decision-making capacity and authority
- Budgetary responsibilities
- Managerial responsibilities
- Skill demonstration
- Understanding of and knowledge in relevant practice areas
- Understanding and application of relevant theory and practice
- Execution of the TMS
- Leadership skills and behaviours

Operators should identify appropriate qualifications and experience requirements for all personnel who play safety-critical roles related to tailings management, including, but not limited to the RTFE, the EOR and the Accountable Executive. Operators should ensure that incumbents of these roles have the identified qualifications and experience and develop succession plans for these personnel.

In Detail

Attributes of Key Roles
Further information on competencies for key roles are discussed below.

Accountable Executive
The Accountable Executive does not necessarily need to be an expert in tailings management but should have the competency to:

- Understand the concepts of tailings management and the associated risks.
- Know what key questions to ask of their personnel relative to tailings management.
- Articulate a clear, honest assessment of tailings risks to the BoD.
- Advocate for resources needed for tailings management.

EOR
The EOR should have education, experience, capabilities and knowledge commensurate with the complexity of the facility and potential consequences of a failure in the areas of design, construction, operation and performance evaluation, which are gained through directly related experience. This includes facility-specific knowledge to a sufficient level of detail that the EOR can demonstrate 'responsible charge' for the facility. The EOR should also have additional skills and characteristics that allow them to: effectively and respectfully communicate with a broad audience; convey competence and reliability; and gain trust from clients and peers in the tailings facility safety community.

RTFE
The RTFE should understand the tailings facilities for which they are responsible, the risks, and the manner in which those risks are being managed, including any failures, deficiencies or opportunities for improvement. They should be informed by evaluations of performance and results of reviews conducted as part of the TMS (Section 2.3), the results of the programme for reviewing tailings safety (including Independent Review) (Section 2.6) and be apprised of any significant developments in between these activities.

Independent Review
Independent Review is conducted by one or more appropriately qualified and experienced individuals who have not been directly involved with the design or operation of the particular tailings facility. The qualifications and experience of reviewers should be aligned with the tailings facility's complexity and risk profile. Similar to the EOR, Independent Reviewers should have education, experience, capabilities and knowledge commensurate with the complexity of the facility and potential consequences of a failure in the areas of design, construction, operation and performance evaluation, which are gained through directly-related experience.

Promoting Continual Learning
Training should build skills and expand job knowledge and understanding. A training programme should be developed and implemented that considers:

- Training for new personnel.
- Refresher training at a frequency determined by the Operator, considering the risk profile of the tailings facility.
- Training associated with significant changes such as updates to the OMS manual or emergency preparedness plans.
- Training for competency development.

Training should address:

- General aspects, such as the Operator's policy and commitments related to tailings management, and the overall goals of safe, responsible tailings management for personnel with direct and indirect roles related to tailings management.
- Specific aspects (eg technical, communication, management) related to the roles and responsibilities of personnel with direct roles related to tailings management.

Operators should aim to develop a corporate culture that promotes continual learning, both formally and informally. Formal programmes and materials should be developed to cover essential elements required under the training programme. Additionally, informal learning happens through experience and can be developed through reading relevant publications, engaging with subject matter experts, participation in inspections and reviews, interacting with an industry network, internal knowledge sharing, and exposure to new approaches or technologies.

Promoting continual learning will help to ensure that personnel have the competencies and qualifications necessary for tailings management and can also help to ensure staff retention and reduce turnover by creating more opportunities for career advancement. Better trained personnel can help to facilitate improved tailings management, and reducing turnover reduces risks associated with changes in personnel.

Operators should establish mechanisms that incorporate workers' experience-based knowledge into planning, design and operation for all phases of the tailings facility lifecycle. Operators should also establish mechanisms that promote cross-functional collaboration to ensure effective data and knowledge sharing, communication and implementation of management measures to support public safety and the integrity of the tailings facility.

In Detail

Providing appropriate training to those who are involved in tailings management, including employees, contractors, consultants and suppliers, will require different training at different levels. For example, senior management should receive higher level, conceptual training about the risks of tailings management, while mine managers and others working directly on specific aspects of tailings facilities through various lifecycle phases should receive detailed and relevant training that corresponds to their work. Tailings management may also be improved by better understanding the experiences of others in tailings-related roles. When planning a training programme, consider if there is an opportunity to engage others involved with tailings management.

Training may be carried out using in-house resources but there may be a need to involve external parties such as the Design Team or EOR in development of the training materials. Operators may consider some form of evaluation of personnel on their knowledge relative to their role to demonstrate competency. A tracking mechanism should be in place (eg training needs matrix) to ensure that all relevant personnel receive appropriate training.

2.2.5 Community Engagement

Community engagement helps to build trust and prevent the potential for conflicts with communities. It can help to ensure that communities have an understanding of the risks to them associated with tailings facilities, and how the Operator is managing those risks, including the emergency preparedness measures that are in place. It can also help to inform better decisions about tailings management, including:

- Evaluating alternatives (Section 3.3.4) for a new tailings facility or extending the life of an existing facility.
- Reflecting community concerns and values in performance objectives (Section 3.3.3).
- Identification of post-closure land-use objectives and the development of the closure plan (Section 3.7.2).
- Co-developing community-focused emergency preparedness measures (Section 2.7).

Community engagement related to tailings management should be integrated with broader community engagement activities, although engagement more specifically targeted to tailings management may be appropriate on some topics (eg community input during the Project Conception phase (Section 3.3)). Engagement should be coordinated with and conducted in collaboration with personnel with specific expertise in community engagement, but tailings specialists involved in community engagement should receive appropriate training.

In Detail

The Standard has specific requirements related to respecting the rights of project-affected people which are outside the scope of this Guide and are addressed in other guidance from ICMM (Section 1.3.1).

Community engagement may also extend to providing a direct role in the development and implementation of some surveillance activities (eg downstream water quality monitoring). This can help to:

- Ensure that surveillance programmes include parameters of concern to communities.
- Provide a direct mechanism for communities to share their unique knowledge and understanding of the area (eg traditional knowledge).
- Help to build trust through the direct involvement of trained community members in surveillance, including both data collection and analysis (eg involvement in downstream water quality monitoring).
- Help to build community capacity, developing transferable skills and potentially providing a basis for greater community involvement in surveillance during the Post-Closure phase.

Further Reading:

ICMM: *Stakeholder Research Toolkit*

ICMM: *Community Development Toolkit*

ICMM: *Understanding Company–Community Relations Toolkit*

ICMM: *Indigenous Peoples and Mining: Good Practice Guide*

ICMM: *Integrating human rights due diligence into corporate risk management processes*

ICMM: *Handling and Resolving Local-Level Concerns and Grievances*

ICMM: *International Finance Corporation and International Committee of the Red Cross: Voluntary Principles on Security and Human Rights: Implementation Guidance Tools*

MAC: *Towards Sustainable Mining Indigenous and Community Relationships Protocol (2019)*

2.2 ACCOUNTABILITY, POLICY, & RELATED ELEMENTS

2.2.6 Communication

An Operator should describe expectations for communication as well as lines of communication as they relate to tailings management and related activities. Processes should be established and implemented for two-way communication for personnel who have accountability or responsibility tailings management, including reporting of significant information and decisions to senior management, the EOR, regulators and communities, as appropriate.

While documenting and adhering to processes and lines of communication are important, there are limits to what can be achieved through written policies and procedures. Effective communication is a skill that should be developed and addressed as part of training activities, including providing training on mechanisms for communication, and communication expectations commensurate with the roles of personnel. In addition, to help to improve communication:

- Breakdowns in communication should be investigated to learn from them and improve communication.
- The effectiveness of communication should be assessed regularly, with the aim of identifying deficiencies and opportunities for improvement.

In addition, an Operator should establish mechanisms that recognise, reward and protect from retaliation, employees and contractors who report problems or identify opportunities for improving tailings facility management. An Operator should respond in a timely manner and communicate actions taken and their outcomes.

In accordance with international good practices for whistleblower protection, an Operator should not discharge, discriminate against or otherwise retaliate in any way against a whistleblower who, in good faith, has reported possible permit violations or other matters relating to regulatory compliance, public safety, tailings facility integrity or the environment.

2.2.7 Sharing Information

There is a wide range of information about tailings management, including information about risks and how the Operator is managing those risks, that Operators should plan to share with communities and other stakeholders. In addition, there may be a range of information that the Operator is required to provide to meet legal requirements. However, sharing information should be tailored to the needs and capacity of those with whom it is being shared.

Sharing information with communities about tailings management helps to build trust, increase transparency, and provide evidence to demonstrate safe tailings management. It builds upon community engagement (Section 2.2.5) and communication (Section 2.2.6). Operators may consult with communities to identify:

- Information about tailings management that they want the Operator to share with them.
- Form in which the information should be provided by the Operator (eg language, level of detail).
- Mechanisms for sharing information (eg Operator's website).
- Frequency of sharing of information.

The Operator should consider developing a plan for sharing information with communities based on input from consultations and refine how it shares information as engagement with communities evolves. In developing a plan to share information with communities, an Operator should be cognizant of the detailed requirements for public disclosure in the Standard (see Requirement 15.1).

In addition to communities, there are other stakeholders (eg shareholders, investors) with whom the Operator should consider sharing information about tailings management. The nature of the information shared and the mechanisms for sharing this information may be different than for information shared with communities, depending on the needs and nature of the stakeholder.

Specifically, per the Standard, an Operator is required to publish and regularly update information on its commitment to safe tailings facility management, its governance framework, and its policies, standard or approaches to the design, construction, monitoring and closure of tailings facilities. The Standard also outlines specific elements for Operators to summarise for disclosure.

An Operator may also be required to share a range of information with relevant jurisdictions to meet various legal requirements. An Operator should compile a list of all legal requirements relevant to tailings management, including a description of the information required to meet each legal requirement. This list should also clarify whether the information submitted to meet various legal requirements will be in the public domain. The Operator's plan for managing conformance (Section 2.3.2.2) should include this list, with a plan to ensure that all the relevant legal requirements are met.

There is a wide range of information that an Operator needs to be able to safely manage tailings (Section 2.5). This information provides the basis for what is shared with communities and other stakeholders, but it is up to the Operator to put this information in a form (eg plain language summaries) that is useful to communities and other stakeholders, and constructively contributes to building trust and transparency. In determining the information to be shared and the form in which it will be shared, the Operator should be cognizant of any legal limitations on the sharing in information, specifically if related to securities-related limits on sharing forward-looking information.

In addition, the Operator should respond in a systematic and timely manner to requests from interested and affected stakeholders for additional information material to the public safety and integrity of a tailings facility. When the request for information is denied, the Operator should provide an explanation to the requesting stakeholder.

The Operator should also commit to cooperate in credible global transparency initiatives to create standardised, independent, industry-wide and publicly accessible databases, inventories or other information repositories about the safety and integrity of tailings facilities.

2.3 TAILINGS MANAGEMENT SYSTEMS

2.3.1 Introduction

The development and implementation of a TMS is essential to the effective governance of tailings management, which, as described in Section 1.2.2, is one of the foundations of safe tailings management, together with the implementation of good engineering practice.

A site-specific TMS integrates all of the Operator's systems, information, plans, practices and processes related to the management of a given tailings facility into one comprehensive framework. It provides a:

- Governance structure with checks and balances on decision-making, including third-party oversight (eg Independent Review).
- Mechanism to effectively implement good engineering practices for tailings management.
- Means to facilitate effective communication to address risk and drive action, including communication between:
  - Senior management accountable for tailings management and those responsible for tailings management.
  - Those with direct responsibilities for tailings management and those with indirect responsibilities for tailings management (eg procurement, ore processing operations).
- Mechanism to help to ensure that decisions are made:
  - Consistent with the corporate policy, performance objectives, the design intent and the risk management plan.
  - Informed by risk.
  - Taking into account relevant information (eg surveillance results, Independent Review, community perspectives).
  - At the appropriate level within the organisation, commensurate with the risks associated with the decision.

Implementation of TMSs should align with the corporate policy on tailings management and follow an iterative cycle throughout the lifecycle of a tailings facility (**Figure 4**):

1) **Plan: Developing Plans for Tailings Management**. The Operator uses the corporate policy as a basis for establishing all systems, information and plans relevant to the current lifecycle phase and plans, at an appropriate level of detail, for future lifecycle phases (eg begin development of OMS activities during the Project Conception phase, refine during the Design phase, and implement, review and update as necessary during subsequent phases).

2) **Do: Implementing the TMS**. Systems and plans are implemented as appropriate to the lifecycle phase.

3) **Check: Evaluating Performance**. The performance of the tailings facility and the systems and plans in place to manage the facility are measured (eg surveillance, inspections, Independent Review, audits) to determine whether the performance objectives are being met and to identify potential problems. If the performance objectives are not being met, the need for potential corrective actions is identified. Similarly, opportunities for continual improvement are identified.

4) **Act: Identifying Actions to Improve Performance**: The results of performance evaluations are reviewed by senior management to understand whether the facility and systems, and plans to manage the facility, are effective. Action plans to address deficiencies or opportunities for continual improvement are developed.

The cycle then repeats, beginning with reviews and updates, as appropriate, to all systems, information and plans to improve performance and in accordance with the lifecycle phase. The revised plans are implemented, and performance is evaluated.

The key to the success of implementing a TMS is ensuring that:

- The scope of the TMS is clearly defined.
- The relationships between the TMS and other sitewide systems (eg sitewide ESMS, sitewide water management plan) are understood.
- Elements within the scope of the TMS are deliberately managed within the framework of the management system.

For existing facilities, a TMS can be developed and implemented at any phase of the lifecycle to provide more effective integration and governance of tailings management activities.

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A management system describes the set of procedures an organisation needs to follow in order to meet its objectives. The objective of implementing management systems is to 'help organisations improve their performance by specifying repeatable steps that organisations consciously implement to achieve their goals and objectives, and to create an organisational culture that reflexively engages in a continuous cycle of self-evaluation, correction and improvement of operations and processes through heightened employee awareness and management leadership and commitment' (International Organization for Standardization (ISO)).

TMSs as described in this Guide are aligned with the ISO 14001 definition of an environmental management system which includes: an organisational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining policies.

Further Reading:
MAC (2019): _A Guide to the Management of Tailings Facilities, Version 3.1_
ISO 14001 – _Environmental Management_

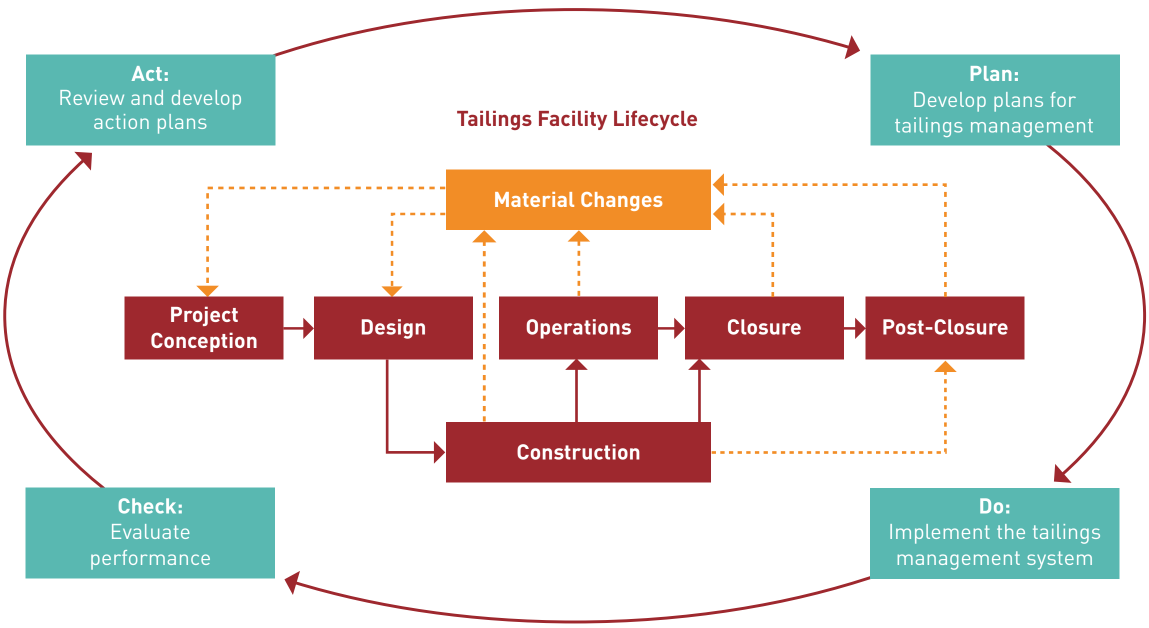

Figure 4: Elements of a tailings management system and application across the lifecycle

2.3.2 Plan: Developing Plans for Tailings Management

Developing Plans for Tailings Management involves developing information and plans related to tailings management and updating the information and plans as appropriate throughout the lifecycle, in alignment with corporate policy. This includes developing and updating as appropriate the following systems, information and plans:

- Site characterisation (Section 3.3.2)
- Risk assessment (Sections 3.2, 3.3, and 3.4)
- Multi-criteria alternatives analysis (Section 3.3.4)
- Performance objectives, indicators and criteria (Sections 3.2 and 3.3)
- Risk management plan (Sections 3.2, 3.4 and 3.6)
- Documentation of the design of the tailings facility, including the design intent and basis (Section 3.4.5)
- Water management plan (Section 3.2.3)
- Tailings transportation and deposition plan (Section 3.4.4)
- Closure plan (Section 3.7.2)
- OMS manual (Section 2.4)
- Emergency preparedness and response plan (EPRP) (Section 2.7)
- Competencies for key roles related to tailings management (Section 2.2.4)
- Plans for managing:
  - Change
  - Conformance
  - Information (Section 2.5)
  - Quality (Section 3.4.5 and 3.5.2)
  - Construction (Section 3.5)
- Resources for tailings management
- Programme for reviewing tailings safety, including Independent Review (Section 2.6).

Aspects to be addressed that are not addressed elsewhere in the Guide are described below.

Developing Plans for Tailings Management should be closely integrated with sitewide mine planning (Section 3.2.2) and should take into account anticipated transitions to different lifecycle phases, anticipated changes and evolution of the tailings facility, and anticipated changes and evolution of the overall mine plan.

For new facilities, the development of the systems, information and plans for a TMS should begin as early as possible in the Project Conception and Design phases of the lifecycle.

For Operators of existing tailings facilities developing a TMS, many of the systems, information and plans items listed above may already exist, while others may not. The objective of the TMS is to bring all systems, information and plans related to tailings management under a single umbrella to help to ensure a consistent, comprehensive, rigorous and systematic approach to tailings management. Operators of existing facilities developing a TMS should conduct a gap analysis and assess the adequacy of existing systems, information and plans. The gap analysis should also consider input from previous reviews (eg Independent Review), audits or other mechanisms to provide internal or external oversight or advice on how the tailings facility is managed. An action plan should be developed and implemented to address gaps, deficiencies or inconsistencies/conflicts between these existing systems, information and plans.

2.3.2.1 Managing Change

Managing change is critical to the safe and responsible management of tailings, and change may be a potential source of risk. Tailings facilities are subject to change throughout their lifecycle. This includes changes in a tailings facility itself (eg increasing the size or height of the facility, implementing progressive reclamation) and changes in the environment in which a tailings facility exists (eg mine plan changes such as a mine life extension, ownership, personnel, legal requirements, communities, climate). In addition, changes to implement continual improvement, such as good engineering practices, also need to be managed appropriately.

Processes to manage change should be documented and implemented to ensure that tailings continue to be managed safely and responsibly.

All potential changes should be carefully considered to ensure that there are no adverse or unintended consequences associated with changes. Further information is provided on three types of changes:

- Potential material changes (Section 3.6.3).
- Changes in personnel in key roles (internal and external) (see below).
- Changes in ownership of a tailings facility (see below).

Changes that are beyond the Operator's control such as changes in legal requirements or changes in nearby communities (eg new downstream social or economic infrastructure) may also be very important but may be more challenging to manage as the Operator may have less latitude for proactive actions. An important aspect of managing such changes is remaining alert to potential developments outside the Operator's control, in order to have as much advance warning as possible of a potential change.

Processes for managing change should address identifying and engaging internal and external stakeholders relevant to the potential change.

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Changes in Personnel in Key Roles
Succession plans should be in place for key roles related to tailings management, including the EOR, RTFE, Accountable Executive and Independent Reviewers. The focus of such planning is not on the staffing or human resources aspects. Rather, it is to ensure that a plan is put in place, proactively, to manage changes in such key roles, whether the changes are expected or unexpected.

Succession plans should include descriptions of the roles and responsibilities, required qualifications, and the process for filling external roles in the event of change. With respect to a change in the EOR the succession plan should also address the transfer of appropriate documentation to the new EOR.

Changes in Ownership
There are two aspects to be considered as part of a change in ownership:

Due diligence of the prospective new Operator in advance of a merger or acquisition
A prospective new Operator should include a thorough review of all tailings facilities that may be included within a merger or acquisition. A review of potential risks and liabilities associated with tailings management is as important as a review of the potential assets, perhaps even more so, to help to ensure that the prospective owner is making an informed decision.

Such a review may be limited by the amount of information available to the prospective new Operator, but to the extent possible such a review should include (Section 2.5):

- Site characterisation
- Risk assessment
- Risk management plan
- Design basis report (DBR)
- Construction versus Design Intent Verification (CDIV)
- Deviance Accountability Report (DAR)
- Construction Records Report (CRR)
- TMS
- OMS manual
- Closure plan
- Assignment of accountability and responsibility
- Competency of personnel in key positions
- Performance of the tailings facility
- Record of conformance, including compliance with legal requirements
- Outcomes of the programme for reviewing tailings safety, including Independent Review.

This review will also help to inform actions taken in the event that the merger or acquisition proceeds.

Hand-over if a merger or acquisition occurs
If a merger or acquisition occurs, then the new Operator should consider the importance of continuity, versus the need for change to improve tailings management and reduce risks. If tailings are being managed in a safe, responsible manner by competent personnel with appropriate systems and documentation in place, then it may be best to avoid undue changes.

Changes, such as changes in key personnel (eg RTFE, EOR) are a risk, given the complexities of tailings management and the time it takes to properly understand how a particular tailings facility is designed and operated.

However, if through the review before the merger or acquisition, or through further assessment after the merger or acquisition, the new Operator concludes that changes are needed to address deficiencies and reduce risks, then these changes should be made.

It is important that the existing Operator ensures the transfer of all relevant information to the new Operator, including:

- Documentation related to all the information listed above for a review prior to a merger or acquisition.
- All relevant archival information.

2.3.2.2 Managing Conformance

The Operator should document and implement conformance management processes to ensure that:

- Applicable legal requirements and commitments (including commitments/conditions associated with environmental assessment and permitting) are identified, documented, understood, effectively communicated and met.
- Operator's policies, guidelines, standards and practices are identified, documented, implemented and met, and are reviewed periodically.
- Those accountable and responsible for conformance understand the conformance management plan and have the necessary training and competence.
- Procedures to assess the state of conformance, including frequencies, have been established, implemented, documented and communicated as required for safe, responsible tailings management.
- Status of conformance is documented and reported internally and externally, as required (eg as required as per legal requirements).

Documentation of conformance management processes should include processes to follow in cases of non-conformance, including:

- Documenting and reporting the non-conformance, internally and externally, as required.
- Initiating investigations to determine the causes of the non-conformance.
- Addressing consequences of the non-conformance.

2.3.2.3 Resources

For effective implementation of a TMS, including eventual decommissioning and closure, and sustained post-closure management, the Operator should identify, secure and regularly review adequacy of:

- Human resources and external contractors and consultants.
- Condition, function and suitability of equipment.
- Financial resources needed to address both operating and capital costs, including expected costs in the Closure and Post-Closure phases.
- Schedules of activities that integrate the required resources related to tailings management. Examples of activities to be scheduled include the timing of construction, access to construction material, reviews, inspections and any other item critical to successfully implementing the TMS.

Measures should be in place for financial control as well as competency and training (Section 2.2.4) and communication (Section 2.2.6).

The Operator should establish and document a budget for tailings management, considering both short-term (eg one to two years) and long-term (eg including the Closure and Post-Closure phases) needs for safe, responsible tailings management throughout the lifecycle.

The Operator should establish and document the associated financial controls, obtain budget approval and track capital and operating costs against the budget. In addition, at a frequency documented and appropriate to the tailings facility and its lifecycle phase, the Operator should re-evaluate the decommissioning and reclamation provision for each facility commensurate with corporate policy, good practices and the applicable legal requirements and commitments.

Further Reading:
ICMM: *Financial Concepts for Mine Closure*

2.3.3 Do: Implementing the Tailings Management System

When fully implemented, a TMS will facilitate continual improvement in safe, responsible tailings management. The objective is to implement all the elements of the TMS in a manner appropriate to the lifecycle phase of the tailings facility, to ensure that:

- Activities relevant to that lifecycle phase are effectively implemented.
- Performance objectives are met, risks are managed, and the tailings facility is performing as expected and as per the design intent for the lifecycle phase of the facility.
- Surveillance programmes and decision-making mechanisms are in place to be able to respond in a timely manner to variances from expected behaviour or performance criteria.
- Conformance requirements relevant to that lifecycle phase are met.
- Change is managed effectively throughout the lifecycle.

Implementing the TMS requires the implementation of relevant plans, including action plans developed in previous iterations of the management system process (Section 2.3.5).

Integral to this for tailings facilities in the Operations, Closure and Post-Closure phases of the lifecycle is the implementation of OMS activities (Section 2.4). OMS activities are essential to the day-to-day implementation of the TMS and all associated plans and operating in conformance with the performance objectives (Sections 3.2 and 3.3) and the design intent of the facility (Section 3.4.5). The conceptual development of OMS activities should begin during the Project Conception phase and be refined during the Design phase.

The development and testing of the EPRP (Section 2.7) should continue throughout the Operations, Closure, and Post-Closure phases, and the Operator should maintain a state of readiness to be able to implement the EPRP if an emergency occurs.

During the Construction phase (Section 3.5), the implementation of the TMS includes constructing in accordance with the design (Section 3.4.5) and the Quality Management Plan (Section 3.5.2). It also includes developing and updating as appropriate the:

- Construction versus Design Intent Verification (CDIV)
- Deviance Accountability Report (DAR)
- Construction Records Report (CRR).

For tailings facilities in the Closure and Post-Closure phases, implementing the TMS includes:

- Implementing the closure plan.
- Conducting long-term OMS activities, as necessary, in accordance with the closure plan.

In cases where changes are made, those changes should be:

- Documented, including incorporation into design or operational documents where relevant.
- Communicated to relevant personnel (proactively when possible).
- Supported with appropriate training, depending on the nature of the change (Section 2.2.4).

2.3.4 Check: Evaluating Performance

Evaluating Performance builds upon the results of surveillance (Section 2.4.3) and the programme for reviewing tailings safety, including Independent Review (Section 2.6). It occurs at a range of time scales and is intended to:

- Assess whether performance objectives (Sections 3.2 and 3.3) are being met.
- Assess whether the design intent is being met (Section 3.4.5).
- Assess the effectiveness of risk management measures, including risk controls (Sections 3.2, 3.4 and 3.6).
- Establish a mechanism to conduct post-incident analyses.
- Inform Identifying Actions to Improve Performance.

Aspects of performance that should be evaluated include:

- Performance of the tailings facility against performance objectives and the design intent (Section 3.4.5).
- Compliance with legal requirements and conformance with plans and commitments.

- Adequacy of the TMS and associated elements, including the systems, information and plans listed in Section 2.3.2.
- Documentation associated with construction activities (Section 3.5):
  - CDIV
  - DAR
  - CRR.
- Adequacy of resources for tailings management.

Evaluating Performance should include the identification of deficiencies and opportunities for improvement.

Evaluating Performance is an ongoing, iterative process that involves two-way communication between a range of personnel involved in tailings management. Through the surveillance of performance criteria associated with risk controls (Section 3.6.4), Evaluating Performance provides essential short-term input to decision-making. The RTFE, EOR and Independent Reviewers all have roles to play including providing input to and receiving outputs from Evaluating Performance, depending on both the information and time scale involved.

Results of Evaluating Performance should be documented in a performance review and reported to the RTFE, the Accountable Executive and, as appropriate, the BoD, at a frequency (at least annual) and level of detail documented in the Operator's policies and procedures. The results of Evaluating Performance may also be reflected in the information provided to project-affected people (Section 2.2.7).

In Detail

As part of Evaluating Performance, the Operator should establish a mechanism to conduct post-incident analyses for incidents related to tailings management that may occur, such as cases of non-conformance, unanticipated upset conditions, or an emergency. This is particularly important for incidents with material impacts (eg business disruption, release of material, non-compliance with legal requirements) and in such cases, post-incident analyses may be conducted in more detail and with more intense scrutiny. It is important to learn from such analyses to help prevent similar incidents from occurring in the future. Post-incident analyses should consider both the technical and governance aspects that potentially contributed to the incident and the Operator's response to the incident. They could also consider a range of questions such as:

- What was the root cause of the incident, and what were the contributing factors?
- How can a similar event be prevented from happening in the future?
- Were any mistakes made that led to the incident, or in responding to the incident? If so, how can those mistakes be avoided in the future?
- What can be done to improve response if a similar incident occurs in the future?
- Are there any recommendations for changes to the TMS, EPRP or OMS manual as an outcome of the post-incident analysis?

If an incident occurs, a post-incident analysis should be initiated as soon as possible afterwards, while the memories of the personnel involved remain fresh. The results of the analysis should be documented and reported to the RTFE, Accountable Executive and BoD, as appropriate. Operators are encouraged to share their analyses and outcomes with the industry more broadly, so that others may learn and subsequently improve their tailings management practices.

2.3.5 Act: Identifying Actions to Improve Performance

Identifying Actions to Improve Performance should be conducted on a regular basis. The objective is to review current performance and future plans, and to drive improvement in tailings facility performance by developing action plans to address deficiencies and opportunities for continual improvement. This element of the TMS integrates and is informed by all available, relevant information including the outcomes of Evaluating Performance and inputs, advice and recommendations from a programme for reviewing tailings safety, including Independent Review (Section 2.6).

Conducted by the RTFE, EOR and other personnel involved in tailings management, this element of the TMS should evaluate:

- Suitability, effectiveness and the need for changes to:
  - The TMS and all associated elements, including the systems, information and plans listed in Section 2.3.2.
  - Controls related to construction (Section 3.5).
- Adequacy of resources committed to tailings management, including adequacy of human resources and competencies required.

If deficiencies or opportunities for continual improvement are identified, then action plans should be developed with input from the EOR and mechanisms implemented as part of a programme for reviewing tailings safety.

Identifying Actions to Improve Performance should also provide an update on the status of the implementation of previously developed and approved action plans, including any deviations from approved action plans.

As part of Identifying Actions to Improve Performance, the Operator should also consider future plans, such as planned future construction, facility expansions or other relevant planned changes. Action plans should be developed accordingly to ensure that the systems, information and plans developed as part of Developing Plans for Tailings Management are revised as needed. This effectively completes the Plan-Do-Check-Act cycle of the TMS, in that the Act stage informs the subsequent Plan stage.

The frequency of Identifying Actions to Improve Performance varies, but is typically annual except during the Post-Closure phase, when a lower frequency may be appropriate.

To ensure that information is communicated to allow the Operator to understand whether tailings are being managed in a safe, responsible manner, the results and action plans developed should be reported, at an appropriate level of detail to:

- RTFE
- EOR
- Accountable Executive (or delegate)
- BoD, where appropriate

These reports can also be provided to other business units (eg management responsible for ore processing) to help ensure the continued coordination of activities directly and indirectly related to tailings management.

In addition, these reports can help to form the basis for the public disclosure of information (Section 2.2.7 and 2.6).

In Detail

Identifying Actions to Improve Performance provides an opportunity for the RTFE, EOR and other personnel involved in tailings management to:

- Reconfirm alignment between design intent, risk management plan, and OMS activities.
- Discuss realised or anticipated changes and their implications/management.
- Identify opportunities for improvement.

As part of Identifying Actions for Improving Performance, changes since the previous review that are relevant to tailings management should be identified and their significance should be evaluated, such as:

- Changes to legal requirements, standards and guidance, industry best practice and commitments to communities.
- Changes in mine operating conditions (eg production rate) or site environmental conditions.
- Changes outside the mine property that may influence the nature and significance of potential impacts resulting from the tailings facility on the external environment or vice versa.
- Changes in the risk profile of the tailings facility.

Identifying Actions to Improve Performance should also provide a summary of any significant issues related to the performance of the tailings facility and TMS, including:

- Conformance with the performance objectives and design intent.
- Compliance with legal requirements, conformance with standards, policies and commitments, and status of corrective actions.
- Tailings facility maintenance and surveillance.
- Input from the programme for reviewing tailings safety ().

The outcomes of Identifying Actions to Improve Performance should be documented and reported to the Accountable Executive, including:

- Conclusions regarding the performance of the tailings facility, the TMS and associated plans, OMS manual and EPRP.
- If needed, action plans to:
- Ensure that performance objectives are met.
- Address non-conformance with requirements, standards, policy or commitments.
- Implement recommendations for continual improvement.
- Any recommendations for modifications to the TMS, OMS manual or EPRP.
- Any recommendations for additional resources for tailings management.

2.4 OPERATION, MAINTENANCE & SURVEILLANCE

2.4.1 Introduction

OMS activities are fundamental to the day-to-day management of tailings facilities. The TMS, performance objectives, risk management plan and design intent provide a framework for safe, responsible tailings management, but OMS activities are needed to implement them on a day-to-day basis. Operators that do not effectively implement OMS activities cannot adequately understand their risks, proactively manage tailings, make informed decisions or have any confidence that tailings and associated risks are being effectively managed.

OMS activities should be documented in an OMS manual, and should be aligned with:

- TMS (Section 2.3) and overall governance structures for tailings management.
- Lifecycle phase of the facility (Section 1.2.1).
- Performance objectives, criteria and indicators to be included in the design of the surveillance programmes that measure performance throughout the tailings facility lifecycle (Section 3.3.3).
- Closure plan and objectives.
- Risk management plan including risks controls and associated performance criteria (Sections 3.6.4 and 3.2.4).
- Design intent (Section 3.4.3).
- Conformance management plan (Section 2.3.2.2).

The OMS manual should also describe the linkages with emergency preparedness and response (Sections 2.4.5 and 2.7).

OMS is applicable across the lifecycle. It is important to emphasise the operation does not just include activities related to the active placement of tailings during the Operations phase of the lifecycle. It also includes activities related to water management, reclamation and, where applicable, the management of other materials (eg residues from water treatment such as lime treatment sludge) that may continue to be deposited into the tailings facility after the end of the Operations phase. Thus, in most cases, operation activities will be necessary in the Closure phase and may also be necessary in the Post-Closure phase.

While the need for operation activities may cease at some point (eg reclamation is complete and there is no longer a need for active water management), the need for maintenance and surveillance activities continues until the tailings facility reaches a point where ongoing maintenance and surveillance are no longer needed to ensure that the facility is safe and that the performance objectives for closure continue to be met.

Further Reading:
MAC (2019): *Developing an Operation, Maintenance, and Surveillance Manual for Tailings and Water Management Facilities*

2.4.2 Development of an OMS Manual

An OMS manual is intended to be a practical, 'hands on' document describing plans and procedures for all aspects of operation, maintenance, and surveillance activities associated with a tailings facility. It can be seen as the 'owner's manual' for a tailings facility.

An OMS manual should be aligned with the performance objectives and risk management plan for the tailings facility to which it is applied, including the closure plan. Linking the facility's risk management plan with OMS activities is at the core of an effective OMS manual. This includes specifying actions to be taken if performance is outside the expected range, indicating upset or potential emergency situations, but also ensuring that OMS activities are planned and implemented in a manner consistent with the design intent, the risk management plan and the closure plan.

To be effective, an OMS manual should:

- Be site specific, not 'off-the-shelf' and should:
  - Address the specific conditions and circumstances of the site.
  - Contain or link to all information needed to conduct OMS activities.
  - Integrate the knowledge and experience of personnel who have worked on the site.
- Define roles, responsibilities and levels of authority for personnel involved in tailings management.

- Be integrated with overall site plans and procedures.
- Be written:
  - By personnel with specific and detailed knowledge of the tailings facility, with input from consultants or other third parties as appropriate.
  - For personnel directly involved in tailings management, and not for other audiences such as regulators, senior management or communities.
  - In a clear, concise, easily understandable manner, and include information regarding how more detailed information can be accessed.
- Be improved over time, reflecting feedback from Performance Evaluation (Section 2.3.4), action plans to address deficiencies or for continual improvement (Section 2.3.5), and lessons learned by personnel involved in tailings management.

An OMS manual should describe the boundaries of its scope of application. The scope should include all operational controls that can influence the performance and risk management of the tailings facility (eg tailings transport, placement of tailings, physical containment of the tailings, water management and seepage management, reclamation activities). The scope is defined on a site-specific basis, taking into account the characteristics and lifecycle stage of the tailings facility and linkages with other relevant plans and procedures.

For new tailings facilities or for material changes such as a mine life extension, planning and development of OMS activities should begin during the Project Conception and Design phases, and some surveillance activities (eg monitoring of meteorological conditions) may begin during these phases. By the end of the Design phase, the surveillance programme should be designed so that relevant instrumentation can be installed during construction. The OMS manual should be refined during the Construction phase so that it is ready for implementation at the beginning of the Operations phase, and reflects the as-built conditions (eg final configuration of the tailings pipeline and pumping system) and any deviations from the design that were implemented during the Construction phase (Section 3.5). The OMS manual also should be updated to reflect the final as-built conditions of the ore processing facility as they relate to characteristics of the tailings that will be produced (eg solids content of the tailings).

The OMS manual should be ready for implementation at the beginning of the Operations phase and should continue to be reviewed and updated as needed throughout the Operations phase. In addition, the OMS manual should address the potential for the temporary suspension of mine operations (Section 3.6.5), including a short-term, emergency suspension or a longer-term suspension of unknown duration. Having an OMS plan for a temporary suspension helps to ensure that risks are appropriately managed during the transition to suspension and during the period of the suspension. OMS activities associated with a transition back to operations should also be described.

The development of OMS activities for the Closure and Post-Closure phases should happen in concert with the development of the closure plan (Section 3.7.2). This is important to ensure that OMS activities during the Operations phase are consistent with the closure plan, lay the foundation for the implementation of the closure plan, and address progressive reclamation activities to be implemented prior to transition to the Closure phase. For existing tailings facilities that do not have an OMS manual, the Operator should develop a manual, informed by:

- Conducting a gap analysis.
- Assessing current OMS activities and the degree to which they are aligned with the performance objectives and risk management plan.

OMS manuals should be regularly reviewed and updated as appropriate to ensure that they are up to date. An out-of-date OMS manual may pose a risk to the safety of the tailings facility.

There are many potential drivers for the need for a review and update of an OMS manual, including:

- Updates to the risk assessment and the risk management plan.
- Planned changes as the tailing facility evolves throughout the Operations phase (eg raising embankment structures to increase capacity).
- Material changes to the design.
- Adoption of new technologies (eg surveillance technology).
- Transitions in the lifecycle phase of the facility.
- Changes in personnel.
- Changes in relevant infrastructure (eg pumping systems for tailings or water).

In conducting reviews, a wide range of information should be considered, including:

- Performance of the facility, including any deficiencies in performance.
- Tailings facility design and any deviations from the design.

- Current constructed conditions (Section 3.5) and construction history.
- Current lifecycle phase of the facility.
- Status of progressive reclamation activities.
- Relevant advice and recommendations from site inspections, and the programme for reviewing tailings safety, including Independent Review.
- Changes since the last review of the OMS manual, such as changes in:
  - Characteristics of the tailings facility (eg increased embankment height since the last review).
  - Performance objectives and indicators.
  - Risk assessment and the risk management plan.
  - Personnel or organisational structure.
  - Legal requirements.
  - Closure plan.
- Plans to address any gaps or deficiencies in performance.
- Plans for continual improvement.
- Future plans for the tailings facility.

As described further in Section 2.5, an OMS manual should be a controlled document. Since OMS manuals are accessible to many people involved in tailings management and are updated frequently, effective document control for the OMS manual is particularly important. The Operator should define mechanisms for:

- Review of the draft OMS manual and proposed updates, including input from the EOR.
- Approval of the OMS manual and subsequent updates, including clarifying who has the authority to approve major revisions (eg new procedures) versus minor revisions (eg updating personnel contact information, reflecting changes in personnel).
- Ensuring that all personnel have access to and are working with the most up-to-date version.

2.4.3 Contents of an OMS Manual

An OMS manual should:

- Address site-specific aspects of OMS governance, building on overall accountability and responsibility for tailings management (Section 2.2.2), and should document site-specific OMS activities.
- Define and describe plans and procedures for implementing activities related to the transport, placement and permanent storage of tailings and, where applicable, water and the recycling of water.
- Define and describe plans for the preventative, predictive and corrective maintenance of tailings infrastructure and all equipment associated with the tailings infrastructure.
- Describe surveillance activities (inspection and monitoring) associated with the tailings infrastructure including the documentation, analysis and communication of results.

2.4.3.1 OMS Governance

An OMS manual should describe:

- Tasks and functions related to OMS activities.
- Roles, responsibilities and level of authority of personnel or groups that assume these tasks and functions, including the RTFE(s) and the EOR (Section 2.2.2) and other key personnel involved in tailings management.
- Competencies required for various roles.
- Functional relationships and lines of communication:
  - Between personnel and groups involved in OMS activities.
  - With groups outside the scope of the OMS manual and involved in activities that may affect tailings management.
  - With external parties, including reviewers, regulators and communities.

An OMS manual should also describe:

- Reporting relationships between different individuals and business units with direct and indirect roles related to tailings management.
- How information related to specific OMS activities should flow.
- Processes and procedures for reporting outcomes of OMS activities.

In describing roles, responsibilities, levels of authority and relationships, an OMS manual development team should focus on functional relationships, rather than organisational relationships. This approach may be useful for overcoming functional and communication silos that may be unintentionally reinforced by organisational structures.

An OMS manual should describe reporting procedures for any surveillance results that are outside the expected range of observations or performance, as these results may be indicative of upset conditions or a potential emergency. Any such results should be communicated in a timely manner so that appropriate decisions can be taken by those with the responsibility and authority to act under the circumstances.

An OMS manual should clearly describe the roles, responsibilities and authority of the RTFE and other employees, the EOR, and the contractors or consultants involved in surveillance. This is particularly important with respect to surveillance linked to critical controls. An OMS manual should describe:

- Who is responsible for surveillance data acquisition and analysis?

- What are the lines of communication for reporting in the event that results are outside the range specified for the critical control performance criteria?
- If critical control performance criteria are exceeded:
  - What actions are the RTFE(s) and other employees expected to take?
  - What actions are contractors or consultants expected to take?

Actions to be taken should be clearly described so that appropriate action can be taken in a timely manner.

2.4.3.2 Operation

Operation refers to the operation of the tailings facility and associated activities, including:

- Transport and deposition of tailings (Section 3.4.4).
- Construction during the Operations and Closure phases (Section 3.5).
- Management of water and seepage during the Operations and Closure phases, and potentially also in the Post-Closure phase (Section 3.2.3).
- Reclamation activities during the Operations and Closure phases (Section 3.7).
- In some cases, operation may also include:
  - Deposition of non-tailings materials in the tailings facility (eg waste rock or lime treatment sludge) during the Operations and Closure phases, and potentially also in the Post-Closure phase.
  - Removal of tailings for reprocessing or other purposes during the Closure or Post-Closure phases.

Thus, operation applies not just to the Operations phase of the lifecycle but also to the Closure phase and in many cases the Post-Closure phase.

This component of an OMS manual should define and describe the plans and procedures for implementing operating controls that enable the tailings facility to be operated in accordance with the design intent, performance objectives, risk management plan and closure plan. Plans and procedures are typically documented in standard operating procedures (SOPs).

The management of every tailings facility should follow a range of SOPs that best reflect the characteristics of that facility and support the performance objectives and risk management plan. A typical approach is to develop a suite of SOPs that serve as the foundation of a well-managed facility. The SOPs described in an OMS manual will be dependent on the lifecycle phase of the tailings facility.

SOPs describe performance indicators and pre-defined actions (eg TARPs) to be taken if associated performance criteria deviate from defined ranges. SOPs include a description of the potential ramifications of not responding to a deviation.

SOPs should be reviewed at an established frequency and updated as appropriate, and any changes in procedures should be documented.

2.4.3.3 Maintenance

The objective of maintenance is to provide preventative and corrective means to achieve performance objectives and manage risk throughout the lifecycle of a tailings facility. Maintenance includes preventative, predictive and corrective activities carried out to provide continued proper operation of all infrastructure related to tailings management, or to adjust infrastructure to ensure operation in conformance with performance objectives.

2.4 OPERATION, MAINTENANCE, & SURVEILLANCE

The maintenance component of an OMS manual identifies and describes:

- All infrastructure (eg embankments, associated water management infrastructure, mechanical systems, electrical systems, instrumentation, etc) within the scope of the OMS manual that has maintenance requirements.
- Preventative, predictive and corrective maintenance activities.

There are three categories of maintenance activities:

Preventative maintenance: Planned, recurring maintenance activities conducted at a fixed or approximate frequency and not typically arising from results of surveillance activities. Examples include:

- Regularly scheduled oil change on a pump, as per manufacturers specifications.
- Calibration and maintenance of surveillance instruments.

Predictive maintenance: Pre-defined maintenance conducted in response to the results of surveillance activities that measure the condition of a specific component against performance criteria. Examples include:

- Replacement of a section of tailings pipeline based on monitoring of the pipe thickness.
- Removal of debris from a spillway based on debris accumulation.
- Removal of trees growing on embankments.

Corrective maintenance: The repair of tailings facility components to prevent further deterioration and ensure their operation in conformance with performance objectives. The need for corrective maintenance is based on surveillance activities, with surveillance results identifying the need and urgency of maintenance. Pre-defined actions based on surveillance results and performance criteria (eg TARPs) may include specific maintenance activities. Examples include:

- Repair of erosion gullies.
- Unplugging of toe drains.
- Replacement of a broken pump or failed section of pipeline.

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For all categories of maintenance activities, an OMS manual should describe (or link to relevant references):

- The nature of the activity and the specific maintenance requirements (eg refer to manufacturers maintenance specifications, SOPs).
- Location of the infrastructure requiring maintenance.
- Qualifications or competencies required to conduct the maintenance (eg must be an electrician, must be certified to work in enclosed spaces).
- Safety hazards and procedures.
- Personnel or groups responsible for carrying out the maintenance.
- Resources required to conduct the maintenance (eg equipment, materials, personnel):
- Communication procedures associated with maintenance activities that potentially affect other activities, eg for maintenance that requires that power be disrupted, what other infrastructure will be affected, when will it be affected, for how long, when will power be restored, and who will need to know this.
- Tracking and documentation requirements, such as:
  - Tracking to ensure activity was completed in a timely manner.
  - Documentation of the condition of the equipment or other observations made by personnel doing the maintenance.
  - Documentation to demonstrate the activity was carried out appropriately.
  - Recommendations from personnel doing the maintenance.
- Reporting requirements:
  - Information to be reported.
  - How information should be reported.
  - To whom information needs to be reported.
  - Reporting timelines.

For preventative maintenance, an OMS manual should also describe the frequency at which the maintenance activity is to be conducted.

For predictive maintenance, an OMS manual should also describe:

- Items described above for preventative maintenance.
- Pre-defined maintenance activities that are conducted based on results of surveillance activities (eg clearing of snow, clearing of debris from spillways).
- Linkages with surveillance activities, including:
  - Associated surveillance parameters.
  - Performance criteria linked to the need to carry out the maintenance.
  - Communication procedures to ensure that results of surveillance activities, and recommendations for maintenance, are documented and reported in a timely manner so that the maintenance activity can be carried out.

For corrective maintenance, an OMS manual should also describe:

- Items described above for preventative and predictive maintenance.
- Credible failure mode based on risk analysis and risk controls.
- For each event, the pre-defined corrective maintenance activities.
- Surveillance activities associated with those events.
- Communication procedures to ensure that:
  - Results of surveillance activities are documented and reported in a timely manner.
  - Necessary resources are mobilised.
  - Corrective maintenance is carried out.
- Procedures to return to normal operation (if applicable).

While predictive and corrective maintenance are linked to surveillance results, these maintenance activities could include maintenance of surveillance instruments if surveillance results indicate that an instrument is no longer functioning or is not functioning reliably.

An OMS manual should identify materials (eg parts, filter material, rip rap) that should be kept in inventory on site to prevent delay in the maintenance of components tied to risk controls. In addition, resources identified in the EPRP should be kept in inventory on site, in the event that an emergency occurs.

2.4.3.4 Surveillance

Surveillance involves the inspection and monitoring (ie collection of qualitative and quantitative observations and data) of activities and infrastructure related to tailings management. Surveillance also includes the timely documentation, analysis and communication of surveillance results, to inform decision-making and verify whether performance objectives (Sections 3.2 and 3.3), the risk management plan (Sections 3.2 and 3.4), and the design intent (Section 3.4.5), are being met. Surveillance results are used to identify trends and behaviours that are indicative of the tailings facility's actual performance.

An OMS manual should describe two types of surveillance activities: site observation and inspections, and instrument monitoring. The different activities are complementary, and are equally important to safe, responsible tailings management.

For surveillance to be effective in risk management and a risk-informed approach, the results should be collated, examined, analysed and reported in a timely and effective manner.

An effective surveillance programme is:

- Conducted by a range of personnel with direct and indirect responsibilities related to tailings management.
- Applied across the lifecycle of a tailings facility, while adapting to the specific surveillance needs of each lifecycle phase and changing site conditions.
- Based on site-specific performance objectives and the risk management plan.
- Used to inform decision-making related to tailings management, based on the clear, timely reporting of surveillance results.

In Detail

Surveillance activities should be aligned with the design intent (Section 3.4.5), performance objectives (Sections 3.2 and 3.3) and the risk management plan (Sections 3.2 and 3.4). A failure to conduct surveillance of the necessary parameters or conducting surveillance at an inadequate frequency could result in a failure to identify instances where action needs to be taken. Similarly, a failure to analyse and report results in a timely manner could result in actions being taken too late, if at all, leading to a loss of control.

Site Observation and Inspections

Site observation and inspections are used to identify and track visible changes in the condition of the tailings facility. Site observation and inspections include the direct observations by personnel on or adjacent to tailings facilities and may also include observations from helicopters, and photos/videos taken from unmanned airborne vehicles (UAVs/drones and satellites) or surveillance cameras.

Site observation and inspections are an integral part of the surveillance programme and may provide the first indication of changing or adverse conditions, particularly where instrument monitoring is scarce or absent, or where adverse conditions develop outside the area of sensitivity of the instruments present.

For site observation an OMS manual should describe:

- Processes and procedures for documenting observations (eg a checklist may be provided to personnel with instructions for written and photographic documentation of observed conditions).
- Processes for reporting any observations that have been documented.

For inspections, an OMS manual should describe the:

- Scope and objective of the inspection.
- Frequency for conducting the inspection (eg could be once or more per shift for some types of inspections, weekly, monthly or quarterly for others).
- Circumstances that would trigger the need for unscheduled inspections.
- Conditions or aspects to be observed as part of the inspection.
- Processes and procedures for documenting and reporting results of inspections.

Instrument Monitoring

Instrument monitoring provides information on parameters or characteristics that cannot be detected through site observation or inspections (eg groundwater movement, water quality), cannot be observed with sufficient precision and accuracy (eg movement or settling of a tailings facility), or need to be monitored at high frequency or continuously (eg bird monitoring to activate deterrent systems).

The objective of instrument monitoring is to collect data to be used to assess the performance of the tailings facility against the performance objectives and indicators, and the risk management plan. Instrument monitoring and site observation and inspections function together as a comprehensive data set to enable the assessment of facility performance and provide a basis for informed decisions. All are essential, and none of these forms of surveillance can be neglected if performance objectives are to be met and risks are to be managed.

For instrument monitoring, an OMS manual should describe:

- Parameters to be included as part of instrument monitoring, including those not directly related to the tailings facility (eg meteorological data, seismic monitoring).
- The frequency of data acquisition for each parameter.
- Instrument(s) to be used for each parameter.
- Who is responsible for data acquisition for each parameter.
- Locations of instruments, or locations where samples are to be collected (eg sampling of pore water quality).
- Methodology and procedures for data acquisition, including those related to quality management (eg instrument calibration).
- Processes and procedures for documenting the results of instrument surveillance, and the interpretation of results.
- Who is responsible for documenting the results.

Analysis of Surveillance Results

For the effective use of surveillance results in tailings management and decision-making, results should be collated, examined, analysed and reported in a timely and effective manner.

For all surveillance activities, an OMS manual should describe:

- The expected range of observations or performance of surveillance parameters, so any results outside that range can be identified and reported.
- Methodology and procedures for data analysis, including comparisons with expected performance and risk controls.
- Who is responsible for data analysis for each parameter.
- Form in which surveillance results and analysis need to be reported (eg written report, graph, table).
- Timeframes for data analysis and reporting.
- Procedures for reporting results if:
  - Observations and performance are within the expected range.
  - Any observations or performance are outside the expected range.
- Who is responsible for reporting.
- To whom the reports are to be provided.

Considerations for the Design of a Surveillance Programme

There is no 'one-size-fits all' approach to surveillance. Each surveillance programme should be designed on a site-specific basis to be able to provide accurate, meaningful information about the performance of the tailings facility.

When designing or reviewing a surveillance programme, the following questions should be considered:

- What do you need to know? Why do you need to know it? What will this information or data tell you?
  - What information do you need to understand the performance of the tailings facility?
  - What is the risk management plan and what are the surveillance requirements stemming from it?
  - What are the performance objectives, criteria and indicators for the risk controls for the tailings facility?
- Who needs to know it, and why?
- What types of information do you need that can be acquired through direct, visual observation of the tailings facility? For this type of information:
  - How often should visual observations or inspections be made to give you the information you need?
  - What should the person(s) observing or inspecting be looking for?
  - Who should they tell if they see something of potential concern?
- What types of information do you need that can only be acquired indirectly, through measurement of associated parameters or analysis of samples?
  - What methodologies can be used to collect the data needed to provide this information?

2.4 OPERATION, MAINTENANCE, AND SURVEILLANCE

- How frequently does this data need to be collected to provide the information you need?
  - Is real-time or continuous monitoring possible? If so, is it appropriate?
- How can surveillance results be verified and calibrated? For example:
  - How can results from remote sensing methods such as satellite observations be verified or 'ground-truthed'?
  - How can results be calibrated to understand what they mean in the context of a specific tailings facility and the performance objectives, design intent and risk management plan? For example, a given degree of movement detected in an embankment structure may be normal and consistent with the design for one tailings facility but may be cause for concern at a different facility.
- How does this data need to be analysed? How frequently does it need to be analysed to provide the information you need?
- What form do the results need to be presented in to allow you to understand what the information is telling you, how it relates to other information, and what it is telling about the performance of the tailings facility?

2.4.4 Implementation of an OMS Manual

An OMS manual is only effective if it is properly and consistently implemented. This requires that the manual be accessible and that all personnel expected to use the manual:

- Are aware of its purpose and importance.
- Know how to access the current version of the OMS manual.
- Understand their roles, responsibilities and level of authority related to tailings management.
- Have the knowledge and competence to fulfil their roles and responsibilities.
- Understand the OMS activities they are engaged in.

The Operator should consider providing training (internal or external) to help ensure that personnel have the necessary knowledge and competence. As part of training, personnel should understand how to recognise problems, upset or unusual conditions, and understand the importance of reporting those to the appropriate person in a prompt manner. Training should emphasise the importance of this and make it clear that personnel are strongly encouraged to do so. Furthermore, it should be made clear that reporting problems, upset, or unusual conditions will not result in negative implications for the personnel reporting (eg disciplinary measures, termination of employment). This is key to the effective early recognition of problems so that timely action can be taken.

The Operator should have a roll-out strategy, including a training component, for a new OMS manual or any significant revisions to the OMS manual.

Beyond training for new versions of the OMS manual, regular refresher activities should be provided (eg annual), and new personnel should receive training specific to their roles in OMS. The Operator may also consider mentoring programmes or other activities to help encourage the retention and advancement of personnel with roles related to tailings management. This will help to ensure a higher level of competency, lower staff turnover and provide a basis for succession planning.

As part of implementation of the OMS manual, and as further described in Section 2.5.4, the Operator should develop systems for the control of information (eg maintenance records) generated by OMS activities, to ensure that all necessary information is appropriately recorded and is stored in a secure, retrievable manner.

2.4.5 Linkages with Emergency Preparedness and Response

It is important to understand the relationship between emergency preparedness and response (Section 2.7) and OMS activities. Typically, OMS activities are conducted under normal, and upset or unusual conditions, while the EPRP functions when there is an emergency. While different Operators may establish the boundary between upset and emergency conditions differently, it is important to define this boundary, and thus define the boundary between the scope of OMS, and the scope of emergency response.

The OMS manual and EPRP for a given tailings facility should be aligned, such that there are no functional gaps between normal operation and emergency response, and that procedures are in place to transition from normal conditions to an emergency situation that may arise.

A mine can have many types of potential emergency situations, although it should be noted that credible failure modes with negligible likelihood may not necessarily need emergency plans. In terms of tailings facilities specifically, for each potential emergency associated with a credible failure mode, an OMS manual should describe:

- The performance, occurrences or observations that would result in an emergency being declared (eg based on risk controls and associated performance criteria) (Section 3.6.4).
- Roles and responsibilities of key personnel in transition from normal or upset conditions to an emergency.
- Actions to be taken to transition from normal or upset conditions to an emergency situation.

2.5 MANAGING INFORMATION

2.5.1 Introduction

The Operator's access to and use of up-to-date, accurate information is critical to enabling safe, responsible tailings management. Preparing and updating documentation on information on all aspects of tailings management is critical to providing a basis for:

- Safe design, construction, operation and closure of tailings facilities.
- Decision-making to ensure safe tailings management.
- Managing change.
- Developing and implementing a closure plan.
- Fully understanding and effectively managing risks.

In addition, it is important to identify and retain key information for future reference, including in the long-term through the Closure and Post-Closure phases.

This includes documentation describing key aspects related to:

- Governance of tailings management.
- Planning, design, construction, operation and OMS activities, and closure of tailings facilities.

This also includes all documents developed by the Operator in response to legal requirements and commitments to communities, including commitments to public disclosure.

First and foremost, this information is critical to the Operator. However, it may also provide the basis for information that is disclosed to regulators, potentially affected communities, other stakeholders and the public (Section 2.2.7).

In describing the information listed in the sections below, it is important to emphasise that it is the concepts and content that are important. It is up to the discretion of the Operator to determine how best to structure and organise this information, including what to call different documents. The sections below are not intended to be a 'table of contents' but rather an identification of the information that Operators should have to enable safe tailings management.

For information and documents identified in Sections 2.5.2 and 2.5.3, Operators should also document, where applicable:

- Resources required (eg budget, human resources, equipment, and material).
- Specific accountabilities and responsibilities.
- Competencies required of personnel with various roles and responsibilities.
- Schedules for implementation and reviews/updates.
- Status of implementation.
- Mechanisms and reporting for documenting outcomes.

2.5.2 Information Related to Governance of Tailings Management

The Operator should appropriately document and maintain information related to all aspects of governance of tailings management and ensure that documentation is up to date. This includes the following elements:

- Accountability and responsibility for key positions (Section 2.2.2), including documentation on:
  - Lines of communication and associated expectations.
  - Succession process and information transfer for succession.
- Corporate policy on tailings management (Section 2.2.3).
- Documentation related to the implementation of the TMS, including (Section 2.3):
  - Mechanisms for implementing the TMS.
  - Outcomes of Identifying Actions to Improve Performance, including action plans developed.
- OMS manual (Section 2.4) and outcomes of OMS activities (eg surveillance results).
- Documentation related to the programme for reviewing tailings safety, including (Section 2.6):
  - Mechanisms for reporting results internally and externally.
  - Outcomes of reviews and the Operator's responses to outcomes (eg actions to implement recommendations).
- EPRP, including results of testing (Section 2.7).

2.5.3 Information Related to the Project Conception, Design, Construction, Operation and Closure of Tailings Facilities

Information related to the project conception, design, construction, operation and closure of tailings facilities should be appropriately documented and maintained to ensure that documentation is up to date.

It is important to note that Operators may not have all of this information for all of their tailings facilities, particularly older facilities that were designed and constructed many decades ago. Such information may not have been produced (eg multi-criteria alternatives analyses were not conducted) or may be inadequate compared to current good practice (eg site characterisation information) or may have been lost or destroyed over time (eg original drawings). In some cases, it will be impossible to fill such gaps (eg an Operator cannot retroactively do an alternatives analysis).

In other cases, Operators may undertake studies to improve information (eg to improve site characterisation). It is important to recognise that gaps, such as a lack of detailed site characterisation, may increase uncertainty about the future performance of a tailings facility.

Types of information that should be documented and maintained include:

- Site characterisation, including plans for updating and improving the site characterisation (Section 3.3.2).
- Risk assessment, including (Section 3.2.4):
  - Outcomes and key conclusions.
  - A summary for senior management (eg Accountable Executive).
  - Schedule for periodic reviews.
  - Factors that would trigger an unscheduled review.
- Multi-criteria alternatives analysis, including a summary for senior management of (Section 3.3.4):
  - Alternatives considered.
  - Factors considered in the decision-making process.
  - Key factors leading to the selection of the preferred alternative.
- Performance objectives, indicators and criteria, including (Section 3.3.3):
  - Schedule for periodic reviews.
  - Factors that would trigger an unscheduled review.
- Risk management plan including (Section 3.2.4):
  - Status of development and implementation.
  - A summary for senior management.
  - A description of risk controls, associated performance criteria and surveillance requirements, and pre-defined actions to be taken if performance is outside expected ranges.
- Information on the design of the tailings facility, including (Section 3.4.5):
  - The design basis and approach.
  - Design of all stages of the facility, including construction drawings.
- Quality management plan (Section 3.5.2).
- Tailings transportation and deposition plan (Section 3.4.4).
- Water management plan (Section 3.2.3).
- Information on the construction of the tailings facility (initial construction and construction activities through the balance of the lifecycle) (Section 3.5).
- Closure plan including:
  - Closure objectives and post-closure land use.
  - Status of development of the closure plan.
  - Community engagement activities related to closure plan development and implementation.
  - Schedule for review and updates to the closure plan.
  - During the Closure phase, the status of implementation of the plan.
  - During the Post-Closure phase:
    - ◊ Status of performance against the closure plan and objective.
    - ◊ Status of achieving the intended post-closure land use.
  - A summary for senior management, appropriate to the lifecycle phase and the status of development/ implementation of the closure plan.

2.5.4 Control of Information

The use of inaccurate, incomplete or out-of-date information can increase uncertainty and pose a risk, as can the loss of records of essential information (eg reports, SOPs, photos, maps, drawings, surveillance results).

Information that is identified by the Operator as necessary to safe tailings management, throughout the lifecycle of the tailings facility, should be controlled.

Control of information includes establishing and implementing a process to ensure necessary information is documented, and that key documents and information are maintained, retained and archived. There are two aspects to the control of information:

- Access to, and use of, up-to-date, accurate information.
- Identification and retention of records that are potentially useful to the future management of the tailings facility.

In Detail

The information described in Sections 2.5.2 and 2.5.3 should be managed within controlled documents, including:

- Providing a procedure for the systematic identification of documents (eg numbering system consistently applied).
- Defining the process for reviewing and updating the document, including both major and minor updates.
- Identifying persons with authority to revise the document, and the scope of their authority (eg some may only have the authority to amend certain sections).
- Describing mechanisms for the approval of revisions to the document.
- For electronic documents, developing and implementing measures to prevent unintended changes, or to prevent any changes by personnel without the appropriate authority.

In addition, there should be defined procedures for:

- Providing relevant personnel with access to the document and any supporting documents (ie distributing paper copies or providing access to electronic versions).
- Informing personnel of changes to the document relevant to their roles and responsibilities.
- Control of reference information used to develop and update the document or referred to in the document.
- Restricting access to out-of-date versions and clearly labelling those versions as out of date.
- Identifying out-of-date materials that should be retained.
- Archiving or disposing of out-of-date materials, as appropriate.

Access to these documents may be interrupted (eg loss of paper copies due to fire, temporary loss of access to electronic copies due to loss of power). The risks associated with the loss of access of documents should be assessed, particularly in the case of documents that are accessed electronically.

There may be certain documents or content that should be accessible as a paper copy in the event that electronic versions are not accessible. For example, a loss of power restricting access to electronic versions may be linked to certain risk controls (eg loss of ability to operate pumps) and having access to a paper copy of the OMS manual (Section 2.4) during such periods may be necessary for the effective response to the situation. Similarly, having access to paper copies of an EPRP may be essential in some potential emergencies.

Specific risks and vulnerabilities associated with the potential loss of access to documents should be identified and contingency plans and information technology security plans should be developed, including:

- Procedures for the backup and recovery of paper and electronic copies.
- Plans to prevent unauthorised access, including access to documentation, as well as access to instruments (eg surveillance instruments) and other technologies that may be connected to mobile networks or wireless internet.
- Retention of paper copies of critical sections of documents that can be used in the event of a loss of access to electronic documents.

Another consideration for the control of documented information is the management of legacy electronic formats. A plan should be developed, with input from information technology and management experts, to address the management of legacy electronic formats to ensure that records potentially useful to tailings management are not lost or made impossible to access in the future as a result of the obsolescence of software, electronic file formats or data storage media.

2.6 PROGRAMME FOR REVIEWING TAILINGS SAFETY

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2.6.1 Introduction

A strong emphasis on the review of safety of tailings facilities is essential to provide oversight of all the factors that influence safety.

A significant challenge in reviewing and assessing the safety of tailings facilities is that they are in a near constant state of change from their initial construction, throughout the Operations phase as the size of the facility increases, and throughout the Closure phase when the closure plan is implemented. Given the complex, dynamic nature of tailings facilities and the mining operations within which they exist, and the nature of the governance structures needed to ensure safe tailings management, the programme for reviewing the safety of tailings facilities should be multi-faceted and comprehensive if it is to be effective. This is imperative given the potential for human error in so many different aspects of tailings management.

Responding to this challenge requires a well-designed review programme with multiple levels of safety assessment. Understanding safety cannot be simplified to a verification of performance against a few key technical parameters or criteria, unless they reveal that a failure is imminent. A review programme providing oversight needs to address a range of questions related to a tailings facility and how it is being managed.

Responding to this range of questions requires a range of competencies in reviewers. In addition, there is no single review mechanism that can answer such a range of questions, nor would it be desirable or effective to rely on a single review mechanism and single team of people to provide oversight of all aspects of tailings management. A review programme consisting of several different mechanisms, implemented in an integrated manner, is needed.

2.6 PROGRAMME FOR REVIEWING TAILINGS SAFETY

In Detail

Questions that may be addressed by a review programme include:

- Are governance structures and systems appropriate and are they being implemented effectively? Do these structures and systems include adequate mechanisms to manage change, and are these mechanisms being implemented effectively (Section 2.3.2.1)?
- Do personnel with accountability, responsibility and authority related to tailings management have the necessary competencies?
- Are lines of communication clear and adequate, and is communication effective?
- Are personnel encouraged to report problems, errors or concerns in a prompt manner, and are they free from potential negative repercussions if they do so?
- Does the Operator have information on the site characteristics necessary to inform decisions throughout the lifecycle (Section 3.3.2)?
- Does the Operator understand the risk to the degree necessary to inform decisions through the lifecycle (Section 3.2.4)?
- Does the Operator recognise and understand uncertainties associated with risk? Has the Operator taken steps to reduce uncertainty (Section 3.2.4)?
- Has the Operator developed performance objectives, indicators and criteria that are consistent with the objectives of safe, responsible tailings management (Section 3.3.3)?
- Has the Operator developed a tailings facility design that is consistent with the objectives of safe, responsible tailings management (Section 3.4)?
- Has the Operator developed a risk management plan that eliminates risk where possible, and describes measures to reduce or mitigate remaining risks (Section 3.2.4.3)? Is the risk management plan being implemented effectively?
- Has the tailings facility been constructed in a manner consistent with the design intent? Have deviations (Section 3.5.3) and as-built conditions (Section 3.5.4) been adequately documented?
- Has the Operator developed OMS activities that are aligned with the performance objectives, risk management plan and design intent (Section 2.4)? Are these OMS activities being implemented effectively?
- Is the tailings facility performing in accordance with the performance objectives, risk management plan and design intent (Section 2.3.4)? Is the tailings facility expected to continue to perform in this manner?
- Has the Operator identified closure objectives and a post-closure land use (Sections 3.3.3 and 3.7)?
- Has the tailings facility been planned, designed, constructed and operated in a manner consistent with the closure objectives and post-closure land use?
- Are there deficiencies in the responses to any of the above questions?
- Are there opportunities for continual improvement?

2.6.2 Designing a Programme for Reviewing Tailings Safety

There are several different review mechanisms that can be implemented to provide a programme for reviewing the safety of tailings facilities, including:

- Independent Review
- Dam safety reviews (DSRs)
- Tailings stewardship reviews
- Reviews of the TMS
- Audits or verifications.

To ensure that the review programme is effective for the tailings facility in question, the Operator should consider the site-specific design of such a programme, including factors such as:

- What are the objectives of the overall review programme and what are the topics or questions to be addressed?
- What is the lifecycle phase of the tailings facility?
- How complex is the tailings facility and what are the risks?
- What will be the relationship between reviewers and the Operator's employees and consultants, including the Accountable Executive, the RTFE and the EOR?
- How frequently is review needed to reflect the state of change of the tailings facility?
- Are there relevant legal requirements or other requirements or commitments that need to be considered in the design of the programme?

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The design of a review programme should describe:

- Review mechanisms to be used.
- Mandate, objectives and scope of each mechanisms.
- Frequency of application of each mechanism.
- Competencies required for reviewers for each mechanism, taking into account the mandate and objectives, and the complexity and risks associated with the tailings facility.
- The degree of independence expected.

The Operator should also consider and describe the relationship between different review mechanisms within the programme, how each mechanism is intended to address the overall objectives of the review programme, and how these mechanisms will be integrated with each other. Different Operators may, for example, define the scope of Independent Review versus a tailings stewardship review differently. There is no 'right' definition of the scope of these mechanisms. However, when designing a review programme the scope of these mechanisms should be made clear to avoid confusion.

The review programme should be designed to be integrated with the TMS to ensure that reviews are fully informed by, and in turn inform, the ongoing Plan-Do-Check-Act cycle of the TMS, including developing and implementing action plans to address deficiencies and opportunities for continual improvement. This is illustrated in **Figure 5**.

A further consideration for an Operator in developing a review programme is balancing the need for the independence of reviewers with the need for familiarity with the tailings facility and how it is managed.

Figure 5: Integration of a programme for tailings safety review into the tailings management system

Regardless of who is involved in conducting a review, it is essential that they undertake the review in an impartial and objective manner. Reviewers must be empowered to bring forward observations, advice and recommendations for safe, responsible tailings management, including constructive criticism of the Operator. Reviewers must be able to conduct the review free of the risk of negative repercussions, particularly in the case of employees who are involved in reviews.

Reviewers would be considered independent if they have not been directly involved with the design or operation of the particular tailings facility. Independence is important because an independent reviewer can bring a fresh, outside perspective. They may recognise deficiencies or opportunities that someone more familiar with the tailings facility may overlook or fail to recognise. Independence also lends credibility.

However, as noted above, tailings facilities and the associated systems to manage them are complex. It can take a long time to fully understand this complexity. The more independent a reviewer is, the less familiar they may be. As a result, there is a potential for their observations or recommendations to be based on an incomplete understanding of the tailings facility and associated systems. On the other hand, this lack of familiarity may lead them to identify concerns not necessarily evident to those more familiar with the facility. There is an important role to play in the review programme both for reviewers with:

- Greater familiarity and a more complete understanding of the tailings facility in question.
- Less familiarity with the tailings facility in question, but a greater degree of independence.

2.6.3 Template for a Programme for Reviewing Tailings Safety

Recognising the importance of designing a review programme on a site-specific basis, this section proposes a template for an effective programme for reviewing tailings safety. This proposed review programme consists of the following elements, implemented in an integrated manner:

- As described in Section 2.3.4, the Performance Evaluation element of the TMS should include the preparation of an annual performance review by the EOR, addressing whether the tailings facility is performing as intended.
  - This report is provided to those involved in tailings safety review for information.
  - The design of the programme should specify which review mechanism is responsible for reviewing this annual report and assessing its conclusions.

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- Independent Review is conducted periodically to review plans and engineering practices throughout the lifecycle.
- Tailings stewardship reviews are conducted periodically to provide detailed reviews of operational practices.
- The TMS and associated governance mechanisms are reviewed periodically.
- Results of Independent Review, tailings stewardship reviews, and reviews of the TMS are considered by the Operator in Identifying Action to Improve Performance (Section 2.3.5), and action plans should be developed and implemented to address deficiencies and opportunities for continual improvement.

A review programme rigorously implemented following this template, with close coordination between the Independent Review and the tailings stewardship review, would provide effective oversight to help ensure safety. Furthermore, it would meet or exceed the level of assurance that is typically provided by the use of dam safety reviews (Section 2.6.5).

2.6.4 Independent Review

Independent Review provides periodic review of the Operator's engineering practices throughout the lifecycle and provides the Operator with objective opinions and advice, and potentially recommendations regarding the risks and the state of tailings management, independent of the personnel responsible for tailings management.

Independent Review is applicable throughout the lifecycle of a tailings facility. The input of Independent Review should be sought from the Project Conception (Section 3.3) and Design (Section 3.4) phases, through to reviewing performance during the Post-Closure phase (Section 3.7). This includes seeking input from Independent Review on the development of the closure plan (Section 3.7.2) and consideration of potential material changes (Section 3.6.3). However, over the lifecycle the scope and focus of Independent Review should be re-adjusted to ensure it remains relevant and effective.

Independent Review typically provides an assessment of the underlying drivers of tailings safety, such as the site characterisation and models (Section 3.3.2), design intent and assumptions, performance against the design intent, and models used to verify design assumptions and to predict future performance. More specific consideration of current performance is also typically included, based on consideration of surveillance data, input from a tailings stewardship review, and site inspection.

Independent Review is conducted by one or more appropriately qualified and experienced individuals. Mechanisms for Independent Review can include a multi-person board, commonly referred to as an Independent Tailings Review Board (ITRB) or an individual reviewer, referred to in the Standard as a Senior Independent Technical Reviewer.

The Independent Reviewers do not have decision-making authority and do not replace the role of the EOR for assessing tailings facility safety.

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In Detail

Independent Review provides input to the Accountable Executive and RTFE on a range of aspects related tailings management, such as:

- Adequacy of site characterisation.
- Design and conduct of the multi-criteria alternatives analysis, and the conclusions of the analysis.
- Completeness/appropriateness of:
  - The Operator's understanding of the risks posed by tailings management and the need to conduct an up-to-date or more thorough risk assessment.
  - The planned or existing risk management plan.
- Design of the tailings facility and the adequacy of associated documentation.
- Whether the design criteria and performance objectives for tailings management are consistent with legal requirements, industry guidelines and best practices, and current theory, methodologies and experience.
- Current or anticipated performance of tailings management including whether:
  - Performance objectives and the design intent are being met.
  - The facility is predicted to continue to perform as intended.
- Effectiveness of plans and processes for tailings management, such as the surveillance programme.
- Development and implementation of the closure plan.
- Opportunities for continual improvement.

To be effective, Independent Review should consider plans for future mine development and associated tailings management. This may include considering information such as the anticipated life-of-mine based on current exploration results, as opposed to the expected life-of-mine based on proven reserves and resources. A difference of several years in life-of-mine may have significant implications for tailings management. However, this may require disclosure to Independent Reviewers of forward-looking information. Public disclosure of information of this nature may be limited by securities law, depending on the relevant jurisdiction. As a result, in such cases, it is important that the meetings and detailed reports of Independent Review be confidential. However, an Operator may prepare a summary that does not reveal forward looking information that may be provided to regulators, investors, communities or other stakeholders.

2.6.5 Dam Safety Reviews

Dam safety reviews (DSRs) are a review mechanism adapted from practices for water dams and are commonly applied to tailings embankments. DSRs are required under legal requirements in some jurisdictions and are required in the Standard.

Ideally, a DSR is a review mechanism that is conducted in a systematic manner by an independent qualified review engineer to assess and evaluate the safety of an embankment or tailings facility against failure modes, in order to make a statement on the safety of the facility, including whether or not it meets the design intent and applicable safety criteria, and whether it poses any unacceptable risks. A DSR may include the consideration of technical, operational and governance aspects. An equivalence to this ideal DSR may exist, such as that described in Section 2.6.3.

DSRs consistent with the above description have certain advantages when conducted in a multi-disciplinary manner, notably:

- Recognition and acceptance by regulators and other stakeholders.
- Potentially, a higher degree of independence compared to other review mechanisms described in this section.

However, particularly given the widespread recognition and acceptance of DSRs, there is a risk of placing too much reliance on and confidence in them. This confidence should be tempered by understanding the limitations of DSRs and, as described in Section 2.6.1, Operators should implement a review programme consisting of several different mechanisms to reduce reliance on any one mechanism.

DSRs also have important limitations, in part based on their origins in practices for water dams:

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- They are often not conducted at an adequate frequency to reflect the dynamic nature of tailings facilities. For example, conducting a DSR every five years may be adequate for a water dam that has been operating for 10–15 years or more after construction is complete. However, in a five-year period a tailings facility may have changed quite considerably.
- Methodologies for DSRs often focus on the embankments. However, the safety of an tailings facility embankment cannot be appropriately assessed in isolation from consideration of the facility as a whole. Thus, a more holistic approach is needed when assessing the safety of tailings facilities.
- The high degree of independence of DSRs, as noted above, can also be a limitation. Persons performing a DSR may lack the familiarity and knowledge needed to fully understand a tailings facility and its management.

It is important that Operators, regulators, and other stakeholders recognise the limitations of DSRs and recognise the importance of considering the outputs of a range of review mechanisms for tailings safety. In addition, Operators should consider measures to address these limitations, such as modifying the DSR methodology to take a more holistic view of the entire tailings facility.

2.6.6 Tailings Stewardship Reviews

There is a review mechanism, sometimes referred to as a tailings stewardship review, that is complementary but different than Independent Review.

- It is more operationally focused than Independent Review:
  - It may go into a greater degree of detail on operational performance, plans and practices (eg OMS activities) related to the safety of the tailings facility and may highlight areas of focus for Independent Review.
  - It would not typically include elements such as reviewing and providing input to the multi-criteria alternatives analysis (Section 3.3.4), the development of the design of the tailings facility (Section 3.4.3), or the development of the closure plan (Section 3.7.2).
- It is conducted by an independent engineer, supported by the EOR, personnel from the site, and potentially personnel from other sites or the Operator's corporate team.

Given the more detailed focus of a tailings stewardship review compared to Independent Review, those conducting tailings stewardship reviews need a greater degree of familiarity with the tailings facility and the Operator's plans and practices. As such, a tailings stewardship review should consider the outcomes of a review of the tailings management system.

The key activities of a tailings stewardship review include:

- Reviewing a detailed summary of information provided by the Operator, including:
  - Current and planned operations.
  - Surveillance results.
  - Status of implementation of recommendations of previous reviews.
- Conducting a detailed inspection of the tailings facility.
- Reviewing operational plans, practices and procedures to assess the effectiveness of implementation in supporting the achievement of the performance objectives and design intent of the tailings facility. The plans, practices and procedures reviewed may include:
  - OMS manual
  - EPRP
  - Tailings transport and deposition plan.
  - Water management plan, including seepage control and collection, as they relate to stability of the tailings facility.

Tailings stewardship reviews may be conducted annually for tailings facilities in the Operations and Closure phases of the lifecycle. They may be conducted less frequently in the Post-Closure phase, depending on the risks posed, the state of reclamation, the performance of the facility and predicted future performance.

The results of the inspection should be documented, including supporting inspection checklists and photographs. A report of the tailings stewardship review is then prepared by the independent engineer, including any recommendations regarding:

- Significant tailings facility safety concerns and/or concerns requiring immediate or time-sensitive actions.
- Tailings facility safety concerns or conditions requiring time-sensitive action by a date recommended in the review.
- Improvements to plans, practices and procedures.

In Detail

A tailings stewardship review considers a wide range of information, such as:

- Current status and future plans regarding the tailings facility.
- History of the tailings facility, including:
  - The design intent and the design basis.
  - The evolution of the facility from the Construction phase onwards.
  - Deviations from the design intent and design basis.
  - Material changes that have been implemented since the last stewardship review.
- Risk assessment.
- Closure plan.
- Status of actions taken on recommendations from previous tailings stewardship reviews.
- Surveillance programme, including parameters, frequency of data collection and instrumentation.
- Results of surveillance and inspections since the last tailings stewardship review.
- Results of Independent Review.
- Status of site characterisation and the site characterisation model.
- Results of modelling of current and future tailings facility performance.
- Status of the OMS manual, EPRP, and related documents.
- Status of training for personnel with direct roles related to tailings management.
- Current and future operational or technical challenges.

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2.6.7 Review of the Tailings Management System

The TMS and associated governance mechanisms should be reviewed periodically to assess whether they are effective and fit for purpose for achieving the objective of safe tailings management.

The scope of a review of the TMS, also referred to as a governance review, should include a review of the completeness and effectiveness of:

- Assignment of accountability and responsibility, including the effectiveness of the Accountable Executive in decision-making related to tailings management (Section 2.2.2).
- Corporate policy of tailings management (Section 2.2.3).
- Implementation of the TMS (Section 2.3).
- Management of information (Section 2.5).
- Functional and organisational structure.
- Lines of communication and effectiveness of communication (Section 2.2.6).
- Relationships with business units with indirect roles related to tailings management.
- Ongoing integrated mine planning (Section 3.2.2).
- Integration with sitewide systems, such as a sitewide ESMS.
- Conformance with legal requirements, corporate policies and practices, and commitments to communities (Section 2.3.2.2).
- Effectiveness of response to any non-conformances, incidents, or complaints.

A review of the TMS should identify deficiencies and opportunities for continual improvement related to the tailing management system and governance mechanisms and make recommendations for actions to be taken to address any deficiencies or opportunities for improvement.

These reviews may be undertaken internally or externally. However, an external perspective may be particularly effective in identifying underlying deficiencies, particularly those related to the overall corporate culture of the Operator.

The results of the review of the TMS should be considered by the Operator in Identifying Actions to Improve Performance (Section 2.3.5). Results help to facilitate informed decisions regarding tailings management so that tailings-related risks are managed safely and responsibly.

2.6.8 Audits

Audits (also referred to as verifications or validations) are formal, systematic, documented examinations of a tailings facility's conformance with explicit, agreed, prescribed criteria, including legal requirements, the Operator's policy and commitments, applicable standards, or performance expectations. Audits evaluate and report on the degree of conformance with stipulated criteria, based on the systematic collection and documentation of relevant evidence. These review mechanisms involve some degree of judgement but are not designed to determine root cause of deficiencies, or to evaluate effectiveness.

Audits can be conducted both internally (eg by employees with appropriate knowledge and competencies who are independent, impartial and objective with respect to the management of the tailings facility being audited) or externally. The frequency would depend on several factors, including the objective and scope of the audit.

2.7 EMERGENCY PREPAREDNESS & RESPONSE

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2.7.1 Introduction

Recognising that the ultimate goal of this Guide is to eliminate fatalities and catastrophic events, it is nonetheless important to be prepared for a potential emergency.

There is a wide range of potential emergencies that may occur associated with tailings facilities, and it is essential for Operators to be prepared to effectively respond if an emergency occurs. Such potential emergency scenarios may include: structural failure of a facility, rising water levels within a facility, unusual and excessive cracking of an embankment, a sudden loss of environmental containment of a facility, or other events. There are also other types of emergencies that may affect a mine site more generally, including a tailings facility, such as a loss of power, or extreme conditions such as an earthquake, wildfire, landslide or avalanche.

Operators should develop and be prepared to implement a site-specific EPRP for credible failure modes that could lead to emergencies. This includes credible failure modes that could lead to catastrophic failures.

Emergency planning related to tailings facilities should be integrated into broader, sitewide emergency planning so that the Operator has a comprehensive EPRP to address the full range of potential emergencies that could occur.

Note that, as described in Section 2.4.5, different Operators may establish the boundary between upset and emergency conditions differently. Operator's should clearly define this boundary, and this defines the scope of potential events to be addressed in the EPRP. The surveillance programme (Section 2.4.3.4) should include surveillance activities capable of identifying the performance, occurrences or observations that would result in an emergency being declared (eg based on risk controls and associated performance criteria) (Section 3.6.4).

The objective of the EPRP is to prevent, mitigate or reduce impacts (eg injury or loss of life) in the event an emergency occurs.

The EPRP should:

- Describe measures the Operator will take to prepare for an emergency and to respond if an emergency occurs. This detailed description is primarily for use by the Operator and should be integrated into the sitewide emergency plan. This description should:
  - Identify potential emergencies that could occur.
    - ◊ Potential emergencies may be categorised based on the nature of the potential emergency or the nature of the response that would be required. This may assist in describing the measures to be taken if an emergency occurs.
  - Describe measures to be taken if an emergency occurs.
  - Identify resources needed to respond to an emergency.
  - Address any necessary coordination with off-site emergency responders, local communities, public sector agencies and other parties that may be involved in emergency response (eg other businesses).
  - Describe mechanisms to implement the plan if an emergency occurs.
- Provide information to off-site emergency responders, communities[2] and public sector agencies to assist in the development of their emergency response measures and collaborate with them in that development.
- Provide information to other parties that may be impacted if an emergency occurs.
- Align with the OMS manual, as discussed in Section 2.4.5.

Operators should engage off-site emergency responders, communities, public sector agencies, and where relevant, other parties that may be involved in emergency response, in the development of relevant components of the EPRP (ie components related to potential emergencies that could have off-site impacts, or for which the Operator may require external support to respond to the emergency). This process should include supporting communities and public sector agencies to develop their own EPRPs. It is up to the Operator, in consultation with off-site emergency responders, communities and public sector agencies, to determine how best to organise information related to emergency preparedness.

The EPRP should be tested throughout all phases of the lifecycle at a frequency established in the plan, or more frequently if triggered by a material change either to the tailings facility or to the social, environmental and local economic context. Testing should involve communities and public sector agencies, including off-site emergency responders, who would be involved in responding to an emergency. Operators should meaningfully engage with employees and contractors to inform the development and testing of the EPRP and co-develop community-focused emergency preparedness measures with project-affected people. The EPRP should be revised, as appropriate, to reflect outcomes and lessons learned from testing.

The EPRP should also be reviewed and updated as appropriate:

- After updates to the risk assessment (Section 3.2.4) if those updates lead to changes in the understanding of credible failure modes or potential consequences of a failure.

2. In the context of emergency preparedness, communities include places where people reside permanently or temporarily, including individual residences and recreational sites such as campgrounds.

- In response to material changes to the tailings facility (Section 3.6.3).
- When the lifecycle transitions to a different phase (eg transition from Operations to Closure phase).
- To reflect relevant changes in:
  - Personnel or organisational structures related to emergency response and referred to in the EPRP.
  - Sources or contact information related to off-site support, such as suppliers of material or equipment that would be used for emergency response.
  - Practices or technology related to emergency response (eg warning systems).
  - Legal requirements.
- Other changes on or off-site relevant to emergency response, such as changes to road access, communication or other infrastructure.

Further Reading:
ICMM and UNEP: *Good practice in emergency preparedness and response*

UNEP: *Awareness and Preparedness for Emergencies at Local Level (APELL)*

2.7.2 Assessing Credible Potential Consequences

The starting point for developing an EPRP is the identification of potential failure modes and determining whether those potential failure modes are credible. Credible failure modes, discussed further in Section 3.4.3, are failure mechanisms that are technically feasible given the materials present in the tailings facility and its foundation, the properties of these materials, the configuration of the tailings facility, drainage conditions and surface water control at the tailings facility, throughout its lifecycle under the static and transient loading conditions the facility may be subject to over that lifecycle. Credible failure modes are identified through the risk assessment process (Section 3.2.4).

Once credible failure modes have been identified, a preliminary analysis should be conducted to identify and assess the scenarios that could develop and the potential consequences of those scenarios, including impacts on human health and safety, the environment and infrastructure. This provides the basis for identifying and describing credible failure scenarios to be addressed in the EPRP.

A credible failure mode and a credible failure scenario are related, but different. A simplified explanation of the difference is as follows:

Credible failure mode = credible mechanism + credible initiating event + credible failure process (each element needs to be credible for the failure mode to be credible).

Credible failure scenario = credible failure mode + credible consequences (each element needs to be credible for the failure scenario to be credible).

For credible failure scenarios that would not have catastrophic consequences, the EPRP may be developed on the basis of this preliminary analysis.

For credible failure scenarios that could have catastrophic consequences, more detailed analysis of potential consequences should be conducted to inform development of the EPRP. The purpose of more detailed analysis is to identify communities, infrastructure, residences, farms, recreational facilities, wildlife habitat and other features that could be impacted in the event that an emergency occurs. This information is needed to help develop emergency response measures.

Such credible failure scenarios fall into two basic categories, based on behaviour of the material if a failure occurs, and thus the methods used to conduct more detailed analysis of potential consequences:

- Credible failure scenarios that would include a flow of materials – water alone or water and solids (ie tailings and other entrained solids such as soil) – into the downstream environment.
- Credible failure scenarios with potentially catastrophic consequences but not related to a flow of materials into the downstream environment (eg a slump of tailings solids with limited water).

Flow failures are the failure mode most often associated with catastrophic consequences when failures occur.

For credible failure scenarios that would include a flow of material, a breach analysis should be conducted to estimate:

- The physical area that would be impacted by a potential failure.
- Flow arrival times at various downstream locations (eg communities, bridges).
- Flow depth and velocities at various downstream locations.
- Duration of flooding.
- Depth of material deposition.

For credible failure scenarios which are not related to a flow of material, the Operator should conduct an appropriate analysis (eg simplified deformation analysis) to estimate in more detail the potential consequences if a failure were to occur.

The decision tree provided in **Figure 6** illustrates this process.

Further Reading:
APEGBC: *Flood Mapping in BC: Professional Practice Guidelines*.

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In Detail

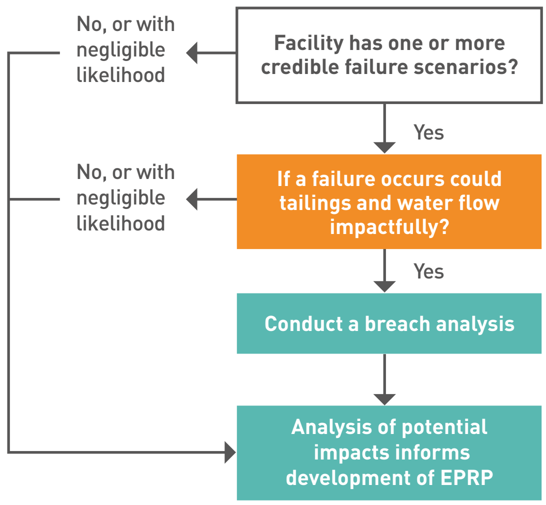
Failure modes may be geotechnical in nature, as described in Section 3.4.3.10. For the purpose of emergency planning, the following types of geotechnical failure modes should be considered:

- Tailings are sufficiently saturated that they are potentially able to flow and could become mobile in the event of a failure (ie credible flow failure scenario).
- Tailings that are sufficiently unsaturated that they could not flow in the event of a failure, but could become mobile (eg credible failure modes could lead to a slump).

However, not all credible failure modes are geotechnical in nature. For example, the EPRP for tailings management may address credible failures associated with tailings transportation such as a break of a tailings pipeline. In addition, sitewide emergencies such as wildfire could also lead to credible failure modes related to tailings under some circumstances. Thus, it is important that Operators consider geotechnical as well as non-geotechnical failure modes when developing EPRPs.

Some credible failure modes may or may not have the potential to be catastrophic, depending on the layers of controls in place. For example, a break in a tailings pipeline could result in minimal spilled volume and associated impact either due to where it is placed relative to the embankment and/or where pressure sensors and auto shut-off valves coupled with visual observations and actions are in place. Alternatively, depending upon where a tailings pipeline is located, a break in that pipeline could result in a catastrophic failure if the pressure sensors and the auto shut-off valves fail and if the facility is remote with infrequent observations.

Figure 6 is focused on decision-making for EPRP development, recognising that risk controls would be developed and implemented, and surveillance measures would be in place to reduce the likelihood of failures (Sections 2.4, 3.2.4.3 and 3.6.4).



Note: The process of evaluating risks and informing/updating the EPRP occurs throughout the life of the facility. For operating facilities, Figure 8 explains the process of reviewing credible failure modes, risk and uncertainty on an ongoing basis.

Figure 6: Decision tree for evaluating potential consequences of credible failure modes to inform development of EPRPs

2.7.3 Description of Measures the Operator Should Take

The EPRP should include a description of the measures the Operator will take to prepare for emergencies, and to respond if an emergency occurs. Although some aspects of this element of the EPRP may involve external parties, it is intended to be an internal document. Elements of an EPRP that would be implemented by external parties should be developed cooperatively and be provided to them.

An EPRP for a tailings facility in the Closure or Post-Closure phases of the lifecycle should be adapted to those phases, when there may be fewer personnel and less equipment on site, and thus fewer resources on hand to be able to respond to an emergency. The EPRP may need to involve local contractors who could provide heavy equipment and operators, as well as measures to ensure that equipment, fuel and personnel can be transported to the site. Contingency plans may be needed for power generation on site and communication infrastructure.

In Detail

An EPRP should describe the following, regarding the measures the Operator will take to prepare for an emergency, and to respond if an emergency occurs:

- Credible failure scenarios that may occur and the conditions that would trigger implementation of the EPRP.
- Potential impacts of credible failure scenarios, and the likelihood of those scenarios.
- Resources (people, equipment, materials) required to respond to an emergency, including identifying resources that need to be retained on site (eg equipment, stockpiles of rip rap or other materials).
- Roles and responsibilities of the Operator's employees, contractors, and consultants, and relevant external parties (eg public sector agencies, off-site emergency responders) and the overall command structure (who is in charge of response and associated reporting relationships) in the event of an emergency.
- Any mutual aid agreements with external parties, such as public sector agencies, other industrial facilities (eg nearby mines) or contractors (eg heavy machinery).
- Description of features and characteristics on and off-site relevant to emergency response, including:
  - Access, including primary and secondary means to access the mine site, tailings facility and potentially impacted areas, and means of reaching the site of a potential emergency under various conditions (eg foot, boat, helicopter, all-terrain vehicle etc.).
  - Communication systems, equipment and materials.
- Procedures to activate the EPRP, including internal and external notification and communication plans for emergency response, including up-to-date contact information (eg phone numbers and email addresses) for relevant personnel, both internal and external.
- Training requirements and plans for relevant personnel, including external parties such as off-site emergency responders.
- Procedures or actions to be taken to:
  - Prevent an upset or unusual condition from becoming an emergency.
  - Mitigate on and off-site safety, environmental, and infrastructure impacts associated with emergency situations.
  - Mitigate consequences if an emergency occurs (eg through the development of evacuation and rescue plans).
- Mechanisms to alert potentially affected parties of an imminent or developing emergency situation (eg alarms to notify downstream communities in the event of a tailings facility failure).
- Measures to provide humanitarian aid, if necessary.
- Surveillance requirements to be described in OMS manual (Section 2.4), to be able to identify the onset of an emergency.
- Procedures and frequencies to test the EPRP.
- Procedures for the administration and update of the EPRP.

2.7.4 Provision of Information to External Parties

For tailings facilities with credible failure scenarios that could lead to off-site impacts, the Operator should provide information to off-site emergency responders, communities and public sector agencies to assist in the development of their emergency response measures and collaborate with them in that development. The information provided is typically similar to but less detailed than the information in the Operator's EPRP. This information should be tailored to the needs of off-site emergency responders, communities and public sector agencies and developed with their input. It typically includes descriptions of:

- The tailings facility, the credible failure scenarios and the potential impacts, including potential impacts if flow of material occurs.
- Roles and responsibilities of the Operator and external parties (eg off-site emergency responders, regulatory agencies) and the overall command structure (who is in charge of response, associated reporting relationships, and relationship between the Operator and other parties) in the event of an emergency.
- Notification procedures to be followed if an emergency occurs or is imminent.
- Mechanisms to alert potentially affected parties of an imminent or developing emergency situation (eg alarms to notify downstream communities in the event of a tailings facility failure).

2.7.5 EPRP Development, Readiness and Response

All relevant personnel, including external parties, should be familiar with the EPRP and their roles and responsibilities if an emergency occurs. They should also know how to access relevant portions of the EPRP, recognising the external parties may not be provided access portions of the EPRP related to any emergencies that would not have off-site impacts, or any portions containing confidential information.

Procedures should be established and implemented for regularly scheduled review and testing of the EPRP to ensure that the plan is up to date and adequate. The results of tests should be evaluated to identify any deficiencies or opportunities for improving the EPRP and the plan should be updated accordingly.

Review and testing of the EPRP should involve communities and public sector agencies, including off-site emergency responders, with roles or responsibilities related to emergency response.

The potential off-site consequences of a failure should be a key consideration in identifying communities and public sector agencies to be engaged in EPRP development and testing, and implementation in the event that an emergency occurs. However, in identifying stakeholders to be engaged, the Operator should consider the engagement of stakeholders beyond those that would be directly impacted by an emergency. In addition, there may be stakeholders who have important response capacity that could assist in responding if an emergency occurs (eg a larger community more distant from the mine site, but with more response capacity than closer communities).

Considering community-focused measures and public sector capacity, an Operator should take all reasonable steps to maintain a shared state of readiness for tailings facility credible flow failure scenarios by securing resources and carrying out annual training and exercises. An Operator should conduct emergency response simulations at a frequency established in the EPRP (at least every three years) for tailings facilities with potential loss of life. Simulations can range from tabletop exercises to field exercises of an emergency and can include the testing of multiple failure scenarios.

In the case of an actual catastrophic tailings facility failure, an operator should provide immediate response to save lives, supply humanitarian aid and minimise environmental harm.

3.1 OVERVIEW

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Sufficiently robust engineering practices, coupled with governance described in Part 2, are essential to safe, responsible tailings management. Elements described in Part 3 of this Guide include:

- Overarching engineering concepts:
  – Integrated mine planning
  – Integrated tailings and water management
  – Managing risk and uncertainty.
- Engineering activities throughout the lifecycle:
  – Project Conception
  – Design
  – Construction
  – Operations
  – Closure and Post-Closure.

While inadequate engineering has been a major factor in many tailings facility failures, rigorous application of this Guide across the lifecycle at all tailings facilities, new and existing, will lead to improved engineering practice and safer tailings facilities. The primary basis for the following content is to establish integrated procedures that prevent catastrophic failures. Governance described in Part 2 of this Guide provides the framework to be sure rigorous implementation of Part 3 occurs.

This Guide encourages integrated procedures that may help to prevent catastrophic failures. This may be realised by implementing full application of the precautionary approach or a performance-based risk-informed approach to tailings facility lifecycle management depending upon the nature of the tailings facility. Comprehensive documentation, such as the Design Basis Report (DBR), Design Report and the Construction Records Report (CRR), irrespective of the design approach, are important to tailings facility lifecycle management. To underscore this point, of the tailings failures reviewed by Morgenstern (2018), inadequate characterisation of foundation conditions, both geological and geotechnical, was a contributing factor in about 40% of the cases.

3.2 OVERARCHING ENGINEERING CONCEPTS

3.2.1 Introduction

Mines and their multiple work areas, facilities, and personnel are complex systems. The mines are only able to function optimally and in a risk-informed manner by integrating the various components and workflows within the mine site.

Through studying lessons learned in case histories, Operators now understand the need to consider all material aspects of the mine site when conducting 'mine planning'. Likewise, Operators increasingly recognise the interdependence of sitewide water management on the integrated understanding and management of tailings facilities.

Once systems and personnel (operators, engineers, managers from relevant disciplines) are integrated, it is possible to ascertain and manage risk and uncertainty, in particular for tailings facilities, more fully. Managing risk and uncertainty is part of the core culture of mining Operators and this Guide expresses how to apply available tools to improve risk-informed decision-making throughout the tailings facility lifecycle.

3.2.2 Integrated Mine Planning Across the Lifecycle

As described in Section 1.2.2, an integrated approach to mine planning is essential to safe tailings management. Integrated mine planning involves the full integration of planning across the lifecycle of all aspects that can impact the project conception, design, construction, operation, and closure of tailings facilities, including:

- Commitments to stakeholders
- Ore extraction
- Ore processing
- Sitewide water management
- Management of other mine wastes such as waste rock
- Mine closure.

An integrated approach to mine planning is particularly important for:

- Integration of water management (Section 3.2.3).
- Development, analysis, and selection of alternatives during the Project Conception phase (Section 3.3.5).
- Design of tailings facilities (Section 3.4).
- Development of the closure plan (Section 3.7.2).

Examples of integration aspects include:

- The life of the mine reserve and resource should be integral in determining tailings capacity requirements.
- Ore processing approaches and anticipated ore variability.
- Tailings technology selection requires consideration of production rate and material properties, climate and water balance, power and closure objectives.
- Consideration of availability and quality of construction materials for components of the tailings facility, such as embankment fill, drainage features and seepage control features.
- Environmental objectives and controls considering local conditions and broader operations and closure.
- Closure considerations such as plans, design, cover materials, progressive reclamation and post-mining land use.
- Planning of mine economics should consider all aspects of tailings management.

Integrated mine planning is also important to optimising decisions during the Operations phase (Section 3.6) and should be considered on the context of potential material changes. As described in Sections 1.2.1 and 2.2.3, integration begins with the corporate policy and the Operator's executives conveying the importance of and coordination of implementing integrated practices.

Change management is integral to integrated mine planning as well, as described in Section 2.3.1.

Figure 7 illustrates the lifecycle phases, the key tailings management outcomes of each phase, and the linkages with integrated mine planning across the lifecycle, including closure plan development and implementation.

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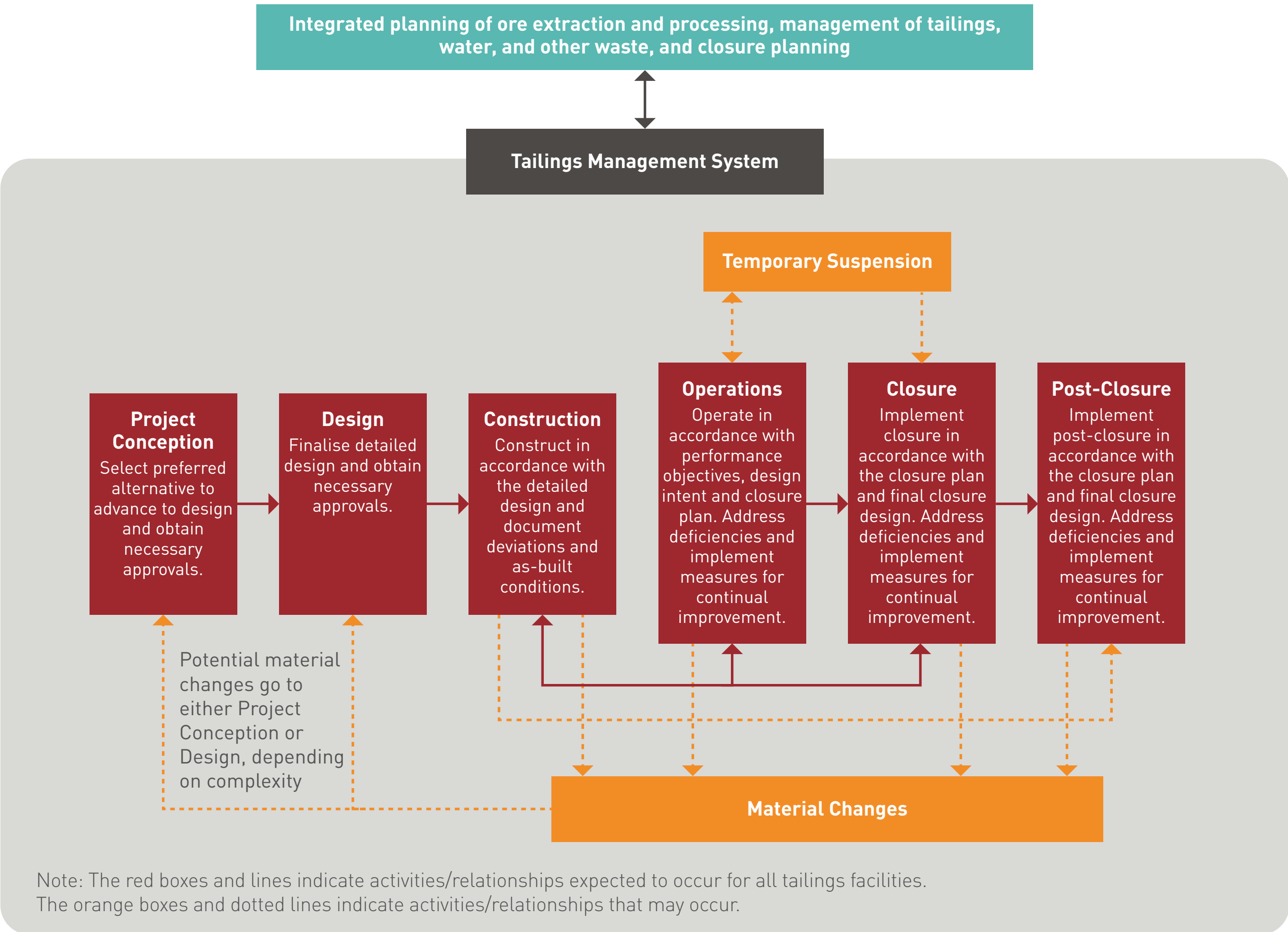

Figure 7: Tailings management lifecycle, key outcomes of each phase of the lifecycle, and the linkages with integrated mine planning across the lifecycle, including closure plan development and implementation

3.2.3 Integration of Tailings and Water Management

Water management is an important aspect in safety and stability considerations for all surface disposal tailings facilities. This is true even for facilities where the tailings have been filtered and are unsaturated, with the tailings stacked and no water storage pond associated with the tailings facility. It is important to evaluate efficient measures to minimise the water in or on the tailings facility as part of the site water management plan. That said, in some cases, storage of water in a tailings facility is integral to the design intent, as an environmental control or to manage seasonal fluctuations at a mine site. Another driver in sitewide water management is to ensure adequate supply of water is always available to the ore processing facility while minimising impacts on water supply for the surrounding area and communities. While these drivers are valid, safety of the facility must always be paramount.

This inextricable linkage between tailings and water management necessitates a good understanding of all water inflows and outflows to a tailings facility, including variations over time and uncertainties in those variations. Many credible failure modes for tailings facilities are rooted in water management and the presence of water exacerbates the consequences of a potential failure even if water is not an initial failure trigger.

There are two concepts fundamental to water management:

- When practicable, keep water that has not come in contact with the mine site from coming into contact with the tailings and other parts of the mine site by diversion of surface water or other means.
- For the water that does enter the site, establish engineering controls to mitigate geotechnical and geochemical risks across the mine site.

3.2 OVERARCHING ENGINEERING CONCEPTS

Management of water needs to be carefully considered throughout the lifecycle of tailings facilities, and an integrated approach to sitewide water management is needed to ensure effective water management (Sections 1.2.2 and 3.2.3). Water management is an integral component of the Project Conception and Design phases. Fresh water demand for ore processing is typically tied to the tailings technology as well as site tailings characteristics. Beyond the tailings facility and the mine site, water management should consider the broader watershed level and potential impacts to the watershed. In this regard, ICMM's Position Statement on Water Stewardship (2017) and A Practical Guide to Consistent Water Reporting apply sitewide, including at tailings facilities.

When developing a water management plan for a tailings facility (within the context of a sitewide water management plan), the plan should clearly define sitewide strategies and objectives for water management, including relevant legal requirements and any additional social and environmental commitments the Operator has made such as protecting against unintentional releases.

Hydrology and hydrogeology data, including the delineation of the mine site and tailings facility catchment area(s) and all potential water sources (process and non-process), should be considered in the development of a water management plan and the design of the tailings facility. Throughout the lifecycle, it is helpful to identify plausible changes and challenges considering operational and natural system variability and uncertainties. For example, depending on site-specific conditions, an active mining operation may lower groundwater levels under a tailings facility, but post-closure, groundwater levels may rise. Similarly, it is helpful to consider regional hydrogeology during the development of facility-specific models. Design parameters should be established and documented, then monitored to identify variances, validate projections and anticipate potential problems.

The appropriate design flood(s) should be identified, with reference to good design practices, input from the EOR and Independent Review, and consistent with legal requirements. Design flood considerations should be consistently applied throughout all phases of the lifecycle. Water storage requirements, operating freeboard of the tailings facility, and spillway design should be based on the hydrology of the watershed and reviewed periodically to assess drying or wetting trends in the climate. Ideally, excess water from storms or run-off volumes would be drawn down from the tailings facility in a relatively short period of time; regardless, post-flood event conditions should be considered in facility stability analyses.

Further, the water management plan should incorporate the assessment of diversions, discharges, and strategies for any water storage inventories. The plan should also address seepage and managing impacts to groundwater (ie ponds, interceptor systems, hydrologic sinks, liners). Other important plan components include reuse pumping systems and treatment systems for recycling or discharge. The plan should begin by defining a conceptual flow schematic, operational rules for given facilities and performance indicators. With the inclusion of the mine plan and associated sitewide water needs (sources, types, reliability), water management should be an ongoing process underpinned by a regularly updated water balance model.

A water balance for the mine site as a whole, and the tailings facility in particular, should consider quantifying inflows and outflows of water to the site and flows within the site. A surveillance programme should be developed and implemented to measure flows and calibrate the water balance. The water balance should consider the need for reused / recycled water and fresh water and maximum pond storage (where applicable) to ensure that the design intent is met. In line with this Guide's overarching theme of integrated mine planning that considers the tailings facility lifecycle, closure considerations should be included in long-term water modelling scenarios and planning.

Forecast scenarios should also include potential future changes in climate conditions, including changes in both mean annual conditions (eg mean annual precipitation) and changes in return period and intensity of extreme events. Operators should use projections to:

- Identify vulnerabilities and assess risks associated with climate change.
- Seek to understand the vulnerability of their site design criteria in the face of a range of incremental risks associated with climate change.
- Ultimately develop a path forward to implement appropriate mitigation measures.

Building on the results of the water balance model, the plan should outline key risks and opportunities for a site (and given tailings facility) with respect to water management, as identified and explained using the water balance model for critical facilities and consideration of regulatory, social and environmental aspects of the broader catchment. Risks should be considered and integrated with broader risk processes and an action plan should be developed and executed. Water modelling and management plans should recognise and evaluate potential implications of uncertainty with the complexities of tailings facilities. Water balance modelling and planning should be a continual improvement process with regular updates to the calibration and validation

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The water management plan should clarify the personnel who are assigned responsibility for water management for specific facilities, description of the facilities and their context within the broader mine plan. The plan should also clarify who has responsibility to manage the water balance model and update it regularly. Most importantly, the water balance and water management plans should be incorporated into overall construction, operation, and closure management planning of the tailings facility and coordinated with broader sitewide planning, such that they guide decision-making and are updated accordingly.

In Detail

Water Balance Modelling
Water balance models are tools for helping make informed water management decisions. In addition to providing a historical accounting of the system flows and an understanding of makeup water needs, they can simulate the future behaviour of a site's water management system (if properly calibrated) and compare options for improving performance. Models should also be forward thinking to assess and adapt to climate change needs. Water balance models are used to:

- Assess the system's past performance.
- Optimise short- to medium-term operational decisions.
- Assess the performance of future water management improvements through evaluation of scenarios.
- Support water reporting requirements on water inflows/ outflows, water use and reuse / recycle, and other water metrics.
- Identify flow monitoring requirements.
- Provide estimates of future flows for closure planning.

An effective approach to water balance modelling is to consider the whole lifecycle of the site, from current conditions through to the Closure and Post-Closure phases. Useful deliverables from a successful water balance model are the model itself, flow diagrams and the associated list of flow components, and a water balance report or user manual that details the assumptions and input parameters used to develop the model. Model development typically starts simply, and complexity is added carefully, if and when required, until the modelling objectives are met.

Key considerations in tailings facility water balance modelling:

- Flow diagram and operational rules including connectivity with surrounding mine and/or downstream environment where appropriate.
- Tailings deposition method, history, plans, and associated modelling inclusive of depositional geometries.
- Tailings deposit density and voids entrainment.
- Infiltration and seepage, and interaction of groundwater with tailings facility.
- Evaporation.
- Metered and unmetered inflows and outflows including contributions from precipitation run-off.
- Uncertainties and sensitivities of physical system such as difficult to measure parameters, error, operational change and trends in climate.

By integrating the water balance with sitewide activities, consideration of sitewide mass balance can be better coordinated, as well. Sitewide mass balance (solids and liquids) is helpful for evaluating impacts to tailings facility operation due to changes in ore body, mining rate, ore processing technology or performance, ore mineralogy, water chemistry and integrated closure plans.

Flow Diagrams
A flow diagram is a visual representation of the water balance model and site water management. Developing flow diagrams is the first step in the development of a water balance model and they provide a conceptual model for model development. Flow diagrams show the water infrastructure, key site features (pits, ponds, dumps, plants, tailings facilities, etc.) and the links, or flow components, between the features and which flows have reliable measurements. Flow diagrams are complemented by descriptions of each flow component. A set of flow diagrams and associated descriptions of flow components may be used to represent the evolution of the site through time.

Attributes of good flow diagrams include:

- The flow diagram elements are superimposed on a site layout drawing/map, or an aerial photo or satellite image is used as the background.

3.2 OVERARCHING ENGINEERING CONCEPTS

- Intuitive symbols are used to represent key features and are positioned where they are physically located on the site layout map.
- Where possible, flow components (the links between the various water features) follow their physical alignment.
- The flow diagram and list of flow components is comprehensive to include all flows (metered and non-metered) that will be modelled and those necessary to meet the objectives of the model.
- The list of flow components contains a clear and concise description for each flow component and the location surveillance instrumentation.
- The flow components naming convention is consistent with the water balance model.

The flow diagrams and the associated list of flow components should be reviewed and updated periodically or following changes to site water management practices. During the water balance review process, input should be gathered from site personnel responsible for managing the water aspects of the site such as mining, ore processing, engineering, environment, tailings and water management.

Attributes of Good Water Balance Models

Water balance model development is site-specific and attributes of a good water balance model include:

- The water balance model includes a clear definition of the tailings facility and its associated storage capacity and other relevant water management facilities within a site's footprint, accounting for inflows, outflows and storage and incorporate the site's mine plan and water management plan.
- The model is easy to understand, review and update including the use of notes and comments within the model.
- There is comprehensive documentation on the input parameters and assumptions as well as the calculations used in the model.
- Model logic is simple and clean with easily identifiable input data. Examples of logic include operational rules/procedures such as hierarchy of water use and variability of recycled versus fresh water during wet and dry periods and after rain events, management pond levels under various conditions, etc.
- Model components naming convention is deliberate and consistent throughout.
- The model is developed to a level of detail necessary to:
  - Meet the specific objectives decided upon by the development stakeholders.
  - Inform and improve a site's current and future water management practices.
  - Provide data to report on water metrics.
  - Assess water performance against pre-defined targets.
- Model complexity and detail is supported by available data and specific purpose to meet the objective.
- The assumptions and uncertainties associated with the model are considered:
  - Calibration is regularly reviewed and validated or adjusted as needed to improve forecasts.
  - Sensitivity analyses and/or probabilistic analyses are conducted to help to improve understanding and confidence in decisions.
- The water balance time step selected is granular enough to represent the variability of flow conditions. Recommended minimum model time steps are:
  - Daily time step for the model runs (recognising that some input parameters could vary hourly, daily, monthly, seasonally or annually).
  - Monthly results reporting.
- The water balance model includes three types of climate scenarios:
  - Historical scenario with historical climate inputs to calibrate and validate the model.
  - Deterministic forecasting scenarios, including average climate conditions, relevant wet/dry climate conditions, and user-defined climate conditions, typically a mixture of wet/dry and average climate conditions.
  - Stochastic forecasting to provide an understanding of climate/hydrologic variability including potential for climate change and the risks to current and planned water management scenarios.
- Results include graphs comparing modelled versus monitored data to allow for model validation at each update.

Further Reading:

ICMM: *A Practical Guide to Consistent Water Reporting*

ICMM: *Adapting to a Changing Climate: Building resilience in the mining and metals industry*

ICMM: *Mining Climate Assessment (MiCA) Tool* (accessible to members at the following *link*)

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3.2.4 Managing Uncertainty and Risk

3.2.4.1 Introduction

Requirement 10.1 of the Standard states, 'Conduct and update risk assessments with a qualified multi-disciplinary team using good practice methodologies at a minimum every three years and more frequently whenever there is a material change either to the tailings facility or to the social, environmental and local economic context. Transmit risk assessments to the ITRB or senior independent technical reviewer for review, and address with urgency all unacceptable tailings facility risks.'

Historically, there have been two approaches in dam safety risk assessment and management; a prescriptive approach and risk-informed decision-making. Risk-informed decision-making builds upon prescriptive approaches which are reliant on prescribed criteria. These criteria are traditionally established through risk-based approaches such as the use of consequence classification during the Design phase.

Risk-informed decision-making is underpinned by risk assessment, which comprises a series of steps: risk identification, risk analysis, and risk evaluation. In turn, risk-informed decision-making improves and informs risk management (risk reduction) activities. Risk management includes implementation of risk reduction measures, surveillance and review, risk communication, and risk recording and reporting. The inter-related nature of these components is shown in **Figure 8**.

Risk management considers all types and severities of risks: this Guide primarily focuses on those risks that have the potential to result in a catastrophic failure. As described below, assessing risk involves consideration of both the potential consequences of an event and the likelihood of that event occurring and an adverse structural response to the event.

There are several tools to support Operators in identifying, analysing and evaluating risk, ranging from simple experience-based ones to more complex quantitative tools. Qualitative or semi-quantitative risk assessment tools using the concept of event trees are typically the most helpful for aiding the understanding of tailings facility risks. Typically, fully quantitative approaches are only appropriate to consider for specific risk drivers. Fully quantitative processes may also inadvertently lead to a false sense of certainty with results.

Risk-informed decision-making steps should be conducted by an experienced team comprising the Operator's staff, the EOR and potentially other multi-disciplinary experts as appropriate. The team should challenge themselves to ensure that the risk process remains unbiased and that it reflects actual credible risks. As such, the risk process and outcomes should be reviewed and updated throughout the lifecycle (regularly and when potential material changes are being considered), and the resulting risk management plan should be updated accordingly. Implementing a TMS, which includes Evaluating Performance and Identifying Actions to Improve Performance (Section 2.3), provides a structured approached to reviewing and updating the risk assessment and the risk management plan.

Figure 8: Framework for a risk-informed approach for tailings management

3.2.4.2 Elements of Risk Assessment

Safety is improved by first understanding a tailings facility's potential failure modes, the likelihood of these hazards occurring, and then using that information to develop and implement measures to mitigate, prevent, and/or reduce risk, where warranted. These safety improvements can be accomplished through effective risk assessment and risk management. The following outlines the components of risk assessment and management. As stated, risk assessment includes the steps of risk identification, risk analysis, and risk evaluation. The EOR should be a key contributor to this assessment and the Independent Reviewer should review the assessment.

Risk Identification

The first step of risk identification is to identify site-specific potential failure modes. A potential failure mode is a cause of failure, chain of events (event tree), or one possible way a system can fail. In the context of tailings management failure modes may include a range of hazards or threats such as:

- Natural hazards (eg earthquake, landslide, extreme weather event).
- Events related to an engineered structure (eg piping of water through a tailings facility embankment).
- Operational events (eg failure of a tailings pipeline).

Once site-specific potential failure modes have been identified they should be characterised, first to determine if they are credible and then to determine the likelihood of occurrence if they are credible. Credible failure modes are defined per the Standard. A potential failure mode may be non-credible if ruled out categorically during initial screening. For example, overtopping by a flood event typically would not be considered a credible failure mode if the facility has a confirmed catchment and storage for multiple maximum credible inflow events, and geotechnical analyses have demonstrated that storing this excess water (even if extended duration is necessary) would not create a stability concern. Further, investigations and analyses may be sufficient to determine from a practical perspective that a failure mode is non-credible. For example, it may be determined that the tailings facility has design features that fully mitigate a potential failure mode and that confidence in the design, as-built condition, and rigorous operating controls render a failure mode as non-credible. This assessment of credibility should be repeated through the life of the facility, particularly if there are material changes. As described in Section 3.4.3 and in the Standard, for closure design, an appropriate design criterion to consider in the analysis of credible failure modes relative to non-credible failure modes may be on the order of 1:10,000 with the provisos outlined in the Standard and this Guide regarding deterministic alternatives. This design criterion should not be confused with likelihood of occurrence of a given failure mode, though.

For each credible failure mode that still exists, the likelihood of the event leading to specific consequences should be estimated, which includes the likelihood of the specific loading condition and the likelihood of an adverse structural response to the event. Event trees help to illuminate the likelihood of an event occurring (along with an adverse structural response).

For example, for a tailings facility embankment to breach and tailings to be discharged, a series of events must typically occur in sequence. Potential scenarios include:

- The design flood occurs but the facility has been constructed and operated as expected and there is no adverse structural response.
- The design flood occurs but there is a defect in the crest height for a measurable distance along the embankment crest due to Operator error in construction sequencing and the flood volume is ponded against the embankment until overtopping occurs at the low section. This overtopping erodes the embankment in an uncontrolled manner, ultimately breaching the tailings facility and allowing flood waters and tailings slurry to leave the facility.

In the first case, the events that occurred did not lead to failure. However, in the second case, the unwanted events compounded, ultimately leading to a failure. Consideration of compounding factors is important, and brainstorming sessions to identify such combinations of events are vital to the efficacy of the risk analysis and assessment process. Some credible failure modes may be catastrophic failure modes (and may involve flow failures) and these are addressed in Section 2.7. Some tailings facilities have credible failure modes, but these may not have potential catastrophic consequences. An Operator's thorough evaluation of each of their tailings facilities can be used to identify the subset of facilities that do have catastrophic credible failure modes. This subset becomes the focus of the Operator for the application of appropriate levels of risk management to prevent any of these modes from manifesting into an actual event.

Risk Analysis

Risk analysis involves the characterisation of what is known and what is uncertain about the present and future performance of an existing or planned tailings facility. During risk analysis, the likelihood of the specific potential failure mode loading condition, the likelihood of an adverse structural response, and the magnitude of the consequences are estimated for each potential failure mode. As discussed in Section 2.7, there are various techniques for determining potential consequences and the appropriate tool should be selected when considering specific failure modes. Risk analysis is often facilitated by someone with significant risk analysis experience, which can help to prevent bias in the process.

The nature of the decisions that the risk analysis will inform determines the level of detail needed and the degree of acceptable uncertainty. Typically, a lower level of detail and a higher degree of uncertainty is appropriate for the Project Conception phase (Section 3.3) or for developing a conceptual closure plan (Section 3.7.2). Potential Problem Analysis is a tool that works well in the Project Conception phase. As the design of a tailings facility or closure plan then advances to final, executable form, more detail and less uncertainty in risk analysis is needed. Potential Failure Mode Analysis or Failure Mode and Effects Analysis (FMEA) or Semi-Quantitative Risk Analysis with Event Tree Analysis are tools that typically work well as design progresses and a facility moves into the Construction and Operations phases. Regardless of the tool selected, it is important follow a consistent approach and to assume that one does not know the answer to the questions that arise unless specific information, data and/or analyses are available to support assumptions.

Uncertainty is the result of imperfect knowledge about the present or future state of a system, event, situation or population under consideration. To manage risk, uncertainty should be acknowledged, assessed and considered. In tailings management, uncertainty may be due to:

- Gaps in knowledge about hazards and potential failure modes (site characterisation, Section 3.3.2). For example:
  - Uncertainty in the results of models used to assess hazards such as hydrogeological models, stability models or climate change models.
  - Lack of complete understanding of foundation conditions, including surficial and bedrock geology.
- Natural variability in any given process or event. The conservative nature of engineering analysis could mute the range of this potential variability.
- An incomplete understanding of the potential consequences of an event. For example, uncertainties in breach analyses (Section 2.7.2).
- The challenging nature of accurately estimating likelihood.
- The effectiveness of risk management measures in reducing likelihood, consequence, or both.
- The changing nature of some risks (hazard creep) for which likelihood or consequence may change over time (site characterisation, Section 3.3.2). This includes changes in climate, downstream conditions (eg new communities or infrastructure) or legal requirements.

Risk estimates will have a degree of uncertainty that should be characterised. This includes acknowledging that there is a degree of subjectivity in estimating risk, reflecting various factors such as the experience and expertise of those involved in developing the estimate, the models used, and the comprehensiveness of available site characterisation information. Uncertainty may be represented by assigning ranges to estimates of both likelihood and consequence.

When uncertainty is high, it is important to consider applying conservative assumptions in the selection of input parameters and the analysis of the likelihood or potential consequences of an event. Steps should also be taken to reduce uncertainty, such as:

- Improving the understanding of the tailings facility and factors influencing it through improved site characterisation (Section 3.3.3).
- Refined modelling of potential consequences (Section 2.7.2).
- Developing a robust tailings facility design with less uncertainty in design criteria (Section 3.4).
- Accurately documenting constructed conditions to reduce uncertainty about the characteristics of the tailings facility and associated embankments (Section 3.5.4).
- Using the results of Evaluating Performance (Section 2.3.4) including surveillance (Section 2.4.3) and the programme for reviewing tailing safety, including Independent Review (Section 2.6) to review and update the risk assessment and validate the design basis of the tailings facility throughout the lifecycle.

As uncertainty is reduced, input parameters and analyses become more realistic as they are based on facts rather than assumptions.

Risk Evaluation

Risk evaluation compares the outcomes of risk analysis for existing conditions to determine if risks are within acceptable limits, whether present risk measures and controls are adequate, and what additional alternative risk reduction measures could be considered.

The process typically considers the following, among other aspects: robustness of design, past and future performance monitoring, site context, and practicality of any remediation considered. Guidelines from regulatory agencies, governing bodies, other industries associated with tailings facility safety, and corporate governance should all be reviewed to determine what risks are within normal operating limits. Understanding environmental, social, cultural, ethical, political, and legal considerations should also be included in risk evaluation.

The team typically considers risk mitigation alternatives at this stage. The outcome of the risk assessment includes recommendations for actions deemed justified by the team.

3.2.4.3 Risk Management

Risk management includes assessing effects due to changes or deviations both in isolation and as a compounding effect. Risk management builds upon the results of risk assessment as well as uncertainty analysis and involves the systematic development and implementation of strategies to eliminate or reduce risks. These strategies include potential actions to reduce the likelihood of occurrence and/or the magnitude of consequences of credible failure modes that were evaluated to have a higher risk.

Typical strategies may include recurring and monitoring activities such as routine and special inspections, instrumentation and its evaluation, structural analyses, site investigations, development and testing of EPRPs,

3.2 OVERARCHING ENGINEERING CONCEPTS

Independent Review and regulatory reviews, and/or implementation of constructed risk reduction measures, projects or improved operational controls.

Risk management should also consider and document estimated risk after a remedial action and/or enhanced operational practices or surveillance have been implemented. Credible failure scenarios that that have elevated levels of risk may require mitigation measures to reduce risk. The level of acceptable risk is defined by each Operator using ALARP or by local regulatory requirements, as applicable.

For those risks that cannot be eliminated or avoided, a key concept in risk-informed decision-making is reducing identified risks (likelihood and/or consequence) to levels that are ALARP. As defined in the Standard, ALARP requires that all reasonable measures be taken with respect to 'tolerable' or acceptable risks to reduce them even further until the cost and other impacts of additional risk reduction are grossly disproportionate to the benefit.

Factors involved in applying ALARP include:

- Application of relevant good practice.
- The level of incremental risk in relation to the established risk guidelines.
- The cost-effectiveness of the risk reduction measures in relation to likelihood and/or consequence.
- Remaining life of the facility and potential alignment with closure planning which may reduce likelihood and/or consequence.
- Societal concerns as revealed by consultation with the community and other stakeholders.
- Other factors such as consideration of standards-based approaches, benchmarking, direct business impacts, constructability, implementation schedule and environmental consequences.

The concept of ALARP is illustrated in **Figure 9**. The 'Resources, effort' line in this graph represents a multiple of potential factors whereby the sharp rise in resources to reduce risks would be grossly disproportionate to the benefit realised. Each Operator will have its own processes to address such factors including use of good practice guidance and jurisdictional requirements on risk evaluations and management.

When a judgement is made that risks are ALARP, this is often determined by comparing the effectiveness of reducing risk further (evaluated by considering the cost to further reduce risk and the amount of risk reduction achieved) and then comparing it to other risk reduction actions implemented by peers in the industry. If the costs to achieve an additional level of risk reduction are grossly disproportional to achieving the same magnitude of risk reduction at other tailings facilities, the current risk may be considered ALARP. This comes with the caveat that operating contexts differ and that this will have a bearing on the determination of ALARP. There are many factors that can contribute to the decision that ALARP has been satisfied and no further action is justified. There may be some instances when ALARP is achieved that an Operator may wish to consider other alternatives at their discretion to further lower risk. This is indicated in Requirement 5.7 whereby Operators identify additional reasonable steps to reduce potential consequences (ie by re-evaluating alternatives for new facilities or considering various engineering solutions for existing facilities).

The Standard states that the Accountable Executive must confirm and document that specific tailings facilities meet ALARP (Requirement 4.7, 5.7). The RTFE should, with input from the EOR and the Operator's site leadership, present the Accountable Executive with risk management measure to achieve ALARP, ideally after seeking advice from Independent Review. It is good practice to provide more than one option for consideration such that risk levels and resource requirements are understood and aligned with the Operator's policy.

The urgency of completing safety actions should be commensurate with risk. Prioritisation of risk reduction measures should be based on prioritisation of safety, while allowing for second-order factors as appropriate.

Risk management plans may be used to describe risk controls to reduced risks identified through risk assessment, as well as actions, persons responsible for completing the actions, and timelines for action completion. Risk controls

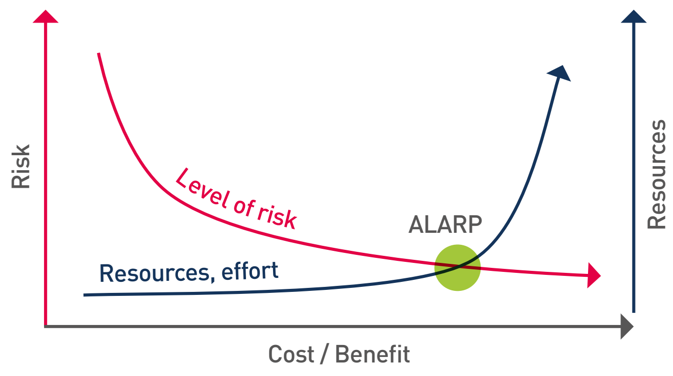

Figure 9: The concept of assessing benefit of mitigation effort to residual risks with ALARP

may include operating rules with ongoing surveillance and validation or discrete implementation of new mitigation measures. Typically, a conceptual risk management plan is developed during the Project Conception phase (Section 3.3) and is refined and developed in greater detail during the Design phase (Section 3.4). A risk register, including the associated prioritised risk controls, should be developed, and it should be reviewed and updated throughout the life of the facility.

The risk processes and outcomes should be reassessed, updated and reviewed regularly as appropriate through the lifecycle of the facility, particularly in the event of material changes.

The key to effective risk management is avoiding complacency. Having a plan does not mean that risks are being properly managed, but it can give the illusion that they are. It is vital that risk management plans be effectively implemented. This includes integrating risk management into the TMS (Section 2.3) and ensuring that risk management plans are integrated into and implemented through OMS activities (Section 2.4) with clear accountability and responsibility (Section 2.2.2), and input from a programme for reviewing tailings safety, including Independent Review (Section 2.6).

Risk communication is an important element of managing risk and includes open, two-way exchange of information and opinion about hazards and risks leading to a better understanding of risk management decisions. It encompasses both internal communication (eg between the EOR, RTFE, Accountable Executive and BoD) and external communication (eg between the Operator and regulatory agencies or communities as appropriate).

3.3 PROJECT CONCEPTION

3.3.1 Introduction

Project Conception consists of the development and analysis of a range of alternatives (eg the location of a new tailings facility, technologies to be applied). The primary output is the final, approved selection of the preferred alternative and associated costing estimates in accordance with corporate requirements.

The Project Conception phase is a process of making some of the most important decisions about tailings management, some of which will be difficult or impossible to reverse once the Design phase has been completed and executed. Thus, Operators should carefully consider the Project Conception phase before the Design phase is initiated.

It is important to emphasise that Project Conception is not relevant only to new tailings facilities. It is a recurring activity through the lifecycle and can also be applied to planning for:

- Potential material changes in design (depending on complexity), such as:
  - Extensions to the life of an existing tailings facility, beyond its initial design capacity.
  - Modification to the design of a tailings facility, such as the strengthening of embankments or reductions in water levels.
- Re-activation of an existing tailings facility for mine re-opening.
- Closure and Post-Closure phases.

Key activities in the Project Conception phase are:

- Risk identification and analysis which begins with Potential Problem Analysis (Section 3.2.4).
- Site characterisation.
- Definition of performance objectives and design criteria.
- Identification of alternatives, development of preliminary designs, and multi-criteria alternatives analysis to select the preferred alternative.

As described in Section 3.2.2, an integrated approach to mine planning is essential to safe tailings management and involves the full integration of planning across the lifecycle of all aspects that can impact tailings management. An integrated approach is particularly invaluable in the Project Conception phase.

In Detail

Operators may consider the following:

- Appoint the EOR and engage the Design Team (ideally from the same firm, but other models can work as well). Ideally, the EOR would follow the project through to the Design, Construction, and Operations phases (recognising that changing the EOR is a significant effort at any phase).
- Appoint Independent Reviewer(s) (or a Senior Technical Reviewer) and determine the initiation of and mechanism for Independent Review moving into the Design phase (Section 2.6.2). The reviewer(s) at this state may follow the project through the next phases of the lifecycle, recognising that changes may be appropriate or necessary if the project needs change from one phase to the next. Independent Review provides input to the Operator on a range of aspects related to Project Conception, such as:
  - Design of site characterisation, to help ensure that the right information is collected and to help eliminate gaps and reduce uncertainty.
  - Conduct of the risk analysis, including the uncertainty assessment.
  - Design and conduct of the multi-criteria alternatives analysis.
- Independent Reviewer(s) can be a sounding board to test ideas: their experience with other projects may be invaluable to the Operator.
- Initiate risk analysis and evaluation (Section 3.2.4). Risk analysis is used in the Project Conception phase to inform development of preliminary designs and the multi-criteria alternatives analysis. Potential Problem Analysis, including identification of hazards and potential failure modes, is particularly important during the Project Conception phase.
- Uncertainty Analysis to assess and recognise uncertainty in the risk analysis. This analysis will inform the multi-criteria alternatives analysis as well as further site characterisation work aimed at reducing uncertainty. This uncertainty analysis includes broad topics, such as climate change and foundation conditions.
- Undertake preliminary site characterisation studies and develop preliminary site characterisation models (Section 3.3.2).

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- Consider the operating strategy including the Operator's forecast of ability to implement controls, especially administrative controls (often found in a project's future OMS), and a clear definition of the inherent risk posed by each option.
- Identify alternatives and develop a preliminary design for each alternative consistent with the guidance in Section 3.3.4, including a preliminary selection of design criteria (Section 3.4.3) and the development of a preliminary design, which will be refined moving into the Design phase (Section 3.4). This stage would consider the options for siting and technology management technology (alternative processing, dewatering, blending and/or comingling, transport, storage, construction materials).
- Evaluate alternatives to select the preferred alternative to advance to the Design phase (Section 3.4).
- Develop and submit documentation to support the approval of the preferred alternative, both internally by the senior management/Accountable Executive and, if applicable, by government authorities.

During this phase, an Operator may wish to initiate community engagement (Section 2.2.5). Input from community engagement is helpful in identifying community values to be considered in the Project Conception phase and gathering information about community knowledge and understanding of the area. This input helps to inform the multi-criteria alternatives analysis.

Figure 10 highlights the key activities of the Project Conception phase of the lifecycle.

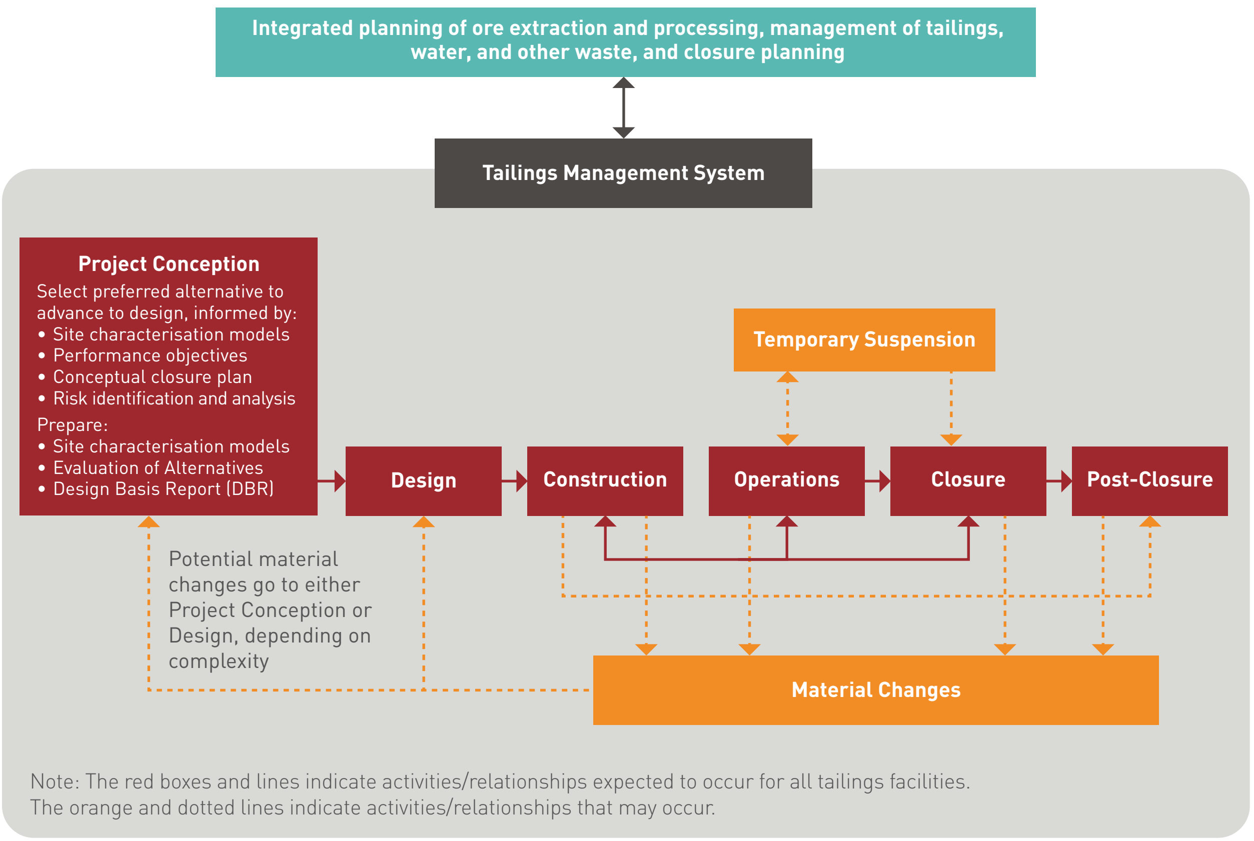

Figure 10: Key activities of the Project Conception phase of the lifecycle

3.3.2 Site Characterisation

Site characterisation is an iterative process that is initiated during the Project Conception phase and continues throughout the lifecycle of the tailings facility. It involves the collection and compilation of a wide range of information about a site and the adjacent environment, and the development of a site characterisation model. Site characterisation typically begins as a desktop assessment and field reconnaissance. It is refined with field investigations as alternatives are narrowed and the project proceeds to the Design phase. (Section 3.4). Site characterisation is critical to the long-term stability of the tailings facility and it requires substantial field investigations and analyses.

The information collected as part of the site characterisation studies is used to inform integrated mine planning (Section 3.2.2), the Project Conception and Design phases (Section 3.4), and closure plan development (Section 3.7.2). The site characterisation also serves as an input for:

- Conducting and updating the risk assessment (Section 3.2.4).
- Developing and updating the risk management plan (Section 3.2.4).
- Identifying alternatives and developing preliminary designs for alternatives and evaluating alternatives and developing the detailed design (Section 3.3.4).
- Developing and updating the DBR (Section 3.4.5) and helping to validate the design intent.

- Development of the closure plan (Section 3.7.2).
- Informing the knowledge base for the site, which focuses on the holistic consideration for social and economic factors as well as environmental and infrastructure factors (Section 1.3.1).

The information collected through site characterisation informs a range of models that are aggregated to create an overall site characterisation model such as:

- Climate including predictions of potential changes
- Geology
- Hydrogeology and hydrology
- Tailings characteristics (geotechnical and geochemical)
- Foundation characteristics
- Seismic conditions.

During the Project Conception phase, at least preliminary site characterisation is conducted for each alternative developed and evaluated. For preliminary screening of alternatives, this may focus on a few specific parameters with a higher degree of uncertainty. As alternatives are eliminated through pre-screening and remaining alternatives are designed in more detail and are then evaluated more rigorously, site characterisation information and models for those alternatives should be refined to increase detail and reduce uncertainty.

Once the preferred alternative is selected and the Operator proceeds to more detailed studies, and ultimately the executable design for construction, the level of detail should increase further, and models should be refined to further reduce uncertainty.

The collection of site characterisation information should continue throughout the lifecycle. The site characterisation model should be refined and updated based on updated site characterisation information, constructed conditions (Section 3.5.4) and surveillance results (Section 2.4).

Site characterisation information and the level of detail required changes and expands through the project lifecycle.

Site characterisation should also address the information requirements identified through community engagement and Independent Review, as well as the collection of information related to relevant legal requirements.

In Detail

Site characterisation involves the collection and consideration of potential future changes with a wide range of information such as:

- Characteristics of the proposed mine.
- Characteristics and anticipated behaviour (geotechnical and geochemical) of the tailings. It is especially critical for tailings facilities having embankments or other structural elements constructed of tailings.
- Characteristics of other materials intended to be used in construction.
- Availability and characteristics of impoundment construction materials.
- Basic information about potential alternatives.
- Existing and planned infrastructure.
- Features that could preclude a tailings facility at that location (eg flora and fauna, hazards, social or cultural features).
- Closure considerations and closure plan.
- Site topography and other geographical information.
- Bedrock and surficial geology, and hydrogeology.
- Site geotechnical characterisation.
- Seismicity.
- Hydrology.
- Natural hazards (eg landslides, avalanches, tsunami impact zones, etc).
- Terrestrial environment, aquatic environment, archaeology, socio-economic factors, indigenous and other considerations within the footprint of the planned tailings facility, and in upstream and downstream areas.
- Climate trend considerations.
- Air and water management related studies.

3.3.3 Performance Objectives

Setting performance objectives underpins safe tailings management. Performance objectives should be aligned with and translate the corporate policy on tailings management into specific performance expectations for a tailings facility throughout its lifecycle, including the Closure and Post-Closure phases (Section 3.7).

Performance objectives and associated performance indicators and performance criteria should address:

- Protection of employee and public health and safety.
- Design objectives and criteria, including geotechnical, geochemical, operational, community and environmental performance objectives that the tailings facility is expected to achieve.
- Mitigation of negative environmental impacts by ensuring the continued physical and chemical stability of the tailings facility.
- Acceptable post-closure use within a feasible technical and economic framework.

Setting performance objectives begins during the Project Conception phase. Although performance objectives set at this phase may be high level, they are crucial to providing a basis for the multi-criteria alternatives analysis.

Performance objectives should then be refined and developed in more detail, particularly during the Design phase (Section 3.4) (eg more specific performance objectives for water management or geotechnical aspects of design and operation). Going into the Construction and Operations phases, performance objectives should be quantifiable for a given tailings facility.

The tailings facility should be constructed, operated, and closed in accordance with the performance objectives, while recognising that those objectives should be reviewed and updated, as appropriate, during these lifecycle phases.

3.3.4 Multi-Criteria Alternatives Analysis

Multi-criteria alternatives analysis (also known as evaluation of alternatives or options assessment) is a rigorous, multi-step process to inform decisions. In a tailings management context, this process should be used to inform decisions during the Project Conception phase. Per the Standard, the primary goal of evaluating alternatives for an overall development project is to: (i) select an alternative that minimises risks to people and the environment throughout the tailings facility lifecycle; and (ii) minimise the volume of tailings and water placed in external tailings facilities.

3.3 PROJECT CONCEPTION

From an Operator's perspective the evaluation of alternatives for a tailings facility, including a multi-criteria analysis such as multiple accounts analysis (MAA), provides a structured approach to assessing and weighing various 'musts' and 'wants.' As such, an effective evaluation is an invaluable tool during Project Conception. It provides a means of integrating a wide range of relevant information into the decision-making process, and provides a basis for documenting outcomes that can then be used to demonstrate the basis for decisions to:

- Senior management
- Regulatory agencies
- Investors and insurance providers
- Potentially affected communities.

The process allows for the consideration of environmental, technical, socio-economic and project economics factors in a transparent manner and allows the testing of the outcomes under different assumptions.

The evaluation of alternatives can be used to inform a range of decisions such as the selection of the preferred options for:

- Locations to be used for new tailings facilities.
- Tailings management technology.
- Increasing the capacity of existing tailings facilities.
- A material change in tailings facility design.
- Re-activation of an existing tailings facility.
- Closure design.

To be effective, it is essential that the evaluation of alternatives:

- Be conducted by a multi-disciplinary team, in order to be able to interpret and assess the full range of information considered in the process.
- Be informed by the work on site characterisation and the knowledge base for the site, which focuses on the holistic consideration of social and economic factors as well as environmental and infrastructure factors (Section 3.3.2).
- Have technical input from Independent Review during the design of the evaluation of alternatives and through the steps in the process.
- Be appropriately scaled and scoped to the planning decision to be made.
- Have input from potentially affected communities as appropriate (eg new tailings facilities, closure planning).
- Consider the performance objectives and risk analysis and integrate those into decision criteria in the evaluation of alternatives.
- Consider all aspects of the project, direct or indirect, that may contribute to the evaluation of each alternative (eg design of the mine and ore processing to the extent that they would impact tailings production, water management and treatment).
- Consider and integrate a wide range of information about the characteristics of each alternative being evaluated, and relevant to the planning decision to be made, such as:
  - Technical considerations (eg geotechnical, geochemical, mine operations).
  - Environmental considerations (eg potential impacts on terrestrial and aquatic ecosystems).
  - Socio-economic consideration (eg potential impacts on communities and other economic, recreational, spiritual or subsistence activities).
  - Project economics (eg short- and long-term capital and operating costs).
- Consider the uncertainty of assumptions and design parameters and their potential implications of outcomes of the analysis process. An example of managing these uncertainties includes use of sensitivity analysis.
- Consider each alternative across the relevant phases of the lifecycle of the tailings facility (eg for new tailings facilities, consider the lifecycle implications of each alternative from the Construction phase through to the Closure and Post-Closure phases).

One of the strengths of the methodology is that it provides a mechanism to be transparent about biases and assumptions, and to test outcomes against those biases and assumptions in a robust and rigorous manner. No decision is entirely objective and there is always an element of subjectively. Rather than trying to remove that subjectivity, the methodology recognises it and allows that subjectivity to be tested.

In Detail

Decisions made based on the evaluation of alternatives require an understanding of the potential positive and negative impacts of each alternative evaluated across a range of aspects encompassing technical, environmental and socio-economic considerations, and project economics. Evaluating and balancing these potential positive and negative impacts is important in making the optimum decision, but it is challenging to evaluate such disparate aspects. An evaluation of alternatives methodology, including MAA, provides a tool to do this, while allowing inputs to and outcomes of the decision-making process to be communicated internally and externally in a transparent manner.

Evaluation of alternatives should be conducted as a multi-step process:

1. Identify the objective and scope – the decision that is to be informed by the evaluation of alternatives process and factors that will be considered.
2. Develop a plan for conducting the evaluation of alternatives, including who will be involved.
3. Identify possible alternatives.
4. Pre-screen possible alternatives to eliminate from further consideration any that would have characteristics that would be 'show-stoppers'.
5. Characterise remaining alternatives.
6. Assess remaining alternatives using MAA or a similar decision-making tool. MAA can be broken down into two sub-steps:
   a. Describe all factors that will be considered in the analysis by establishing accounts (eg environmental, technical, and socio-economic considerations), sub-accounts within each account, and indicators for each sub-account.
   b. Conduct a value-based decision process to assess the combined benefits and impacts (advantages and disadvantages) for each of the alternatives assessed.
7. Conduct a sensitivity analysis to test the robustness and validity of the outcomes of the MAA against various biases and assumptions.

MAA provides a method of integrated assessment of different characteristics of alternatives (eg for comparing potential impacts on wildlife with capital costs). In effect, these tools provide a rigorous, semi-quantitative means of comparing apples and oranges.

3.4 DESIGN

3.4.1 Introduction

The design process is iterative, starting during the Project Conception phase when conceptual designs are developed for alternatives to be evaluated (Section 3.3.4). Those conceptual designs are further refined to preliminary designs for the detailed analysis leading to the selection of the preferred alternative. During the Design phase, the preliminary design for the preferred alternative is developed to the stage of a detailed design for approval, and ultimately to an executable design for construction.

The objective for this design process throughout the lifecycle of the tailings facility should be to limit credible failure modes, either to having no credible failure modes or, where credible modes cannot be eliminated, ensuring that potentially catastrophic credible failure modes are managed using the ALARP approach through the phase(s) of the facility's lifecycle where they are present (Section 3.2.4).

The main activities for the Design phase are:

- Appointing an EOR for the Design phase if the EOR from the Project Conception phase is not retained. This EOR will likely have a longer-term responsibility.
- Establishing the Design Team , including engineering consultants (typically from the same firm as the EOR, recognising that other models may exist) including the Operator's representatives who engage in the design process (typically includes the RTFE and other experienced operational experts).

- Defining the roles and responsibilities of the EOR and Design Team and their relationship through the design process.
- Engaging Independent Reviewers in the design process.
- Developing a formal change management system.
- Refining site characterisation information and the site characterisation model to a degree where residual uncertainties are acceptable.
- Refining the risk assessment to reduce uncertainties and addressing residual uncertainties in the design and risk management plan.
- Developing the tailings facility design:
  - Develop the design initially using the precautionary-based approach.
  - Enhance the design based on adoption of the performance-based approach or define why this is not necessary.
- Establishing quality management specifications including requirements for consideration and documentation of deviations and documentation of constructed conditions.
- Documenting the design criteria and intent in the Design Basis Report (DBR).
- Developing the tailings transportation and deposition plan.
- Complete design verification.

The steps are similar, although they may be simplified when the Design phase is being applied to other decisions such as closure design or design for material changes.

The outcome of the Design phase is an executable engineering design with detailed specifications, including quality management, to be used for the subsequent Construction, Operations and Closure phases, as well as any other documents required for final approval and initiation of construction. The design should be reviewed and updated as performance and site data become available and in response to material changes to the tailings facility or its performance.

In parallel, a full assessment of the potential social, environmental and local economic impacts of the tailings facility and of any credible failure modes throughout its lifecycle should be undertaken, to inform the design process. Where impact assessments predict material acute or chronic impacts, the Operator should develop, document and implement impact mitigation and management plans using the mitigation hierarchy. The conduct of social, environmental and local economic impact assessments is not addressed in this Guide.

Figure 11 illustrates the key activities of the Design phase of the lifecycle.

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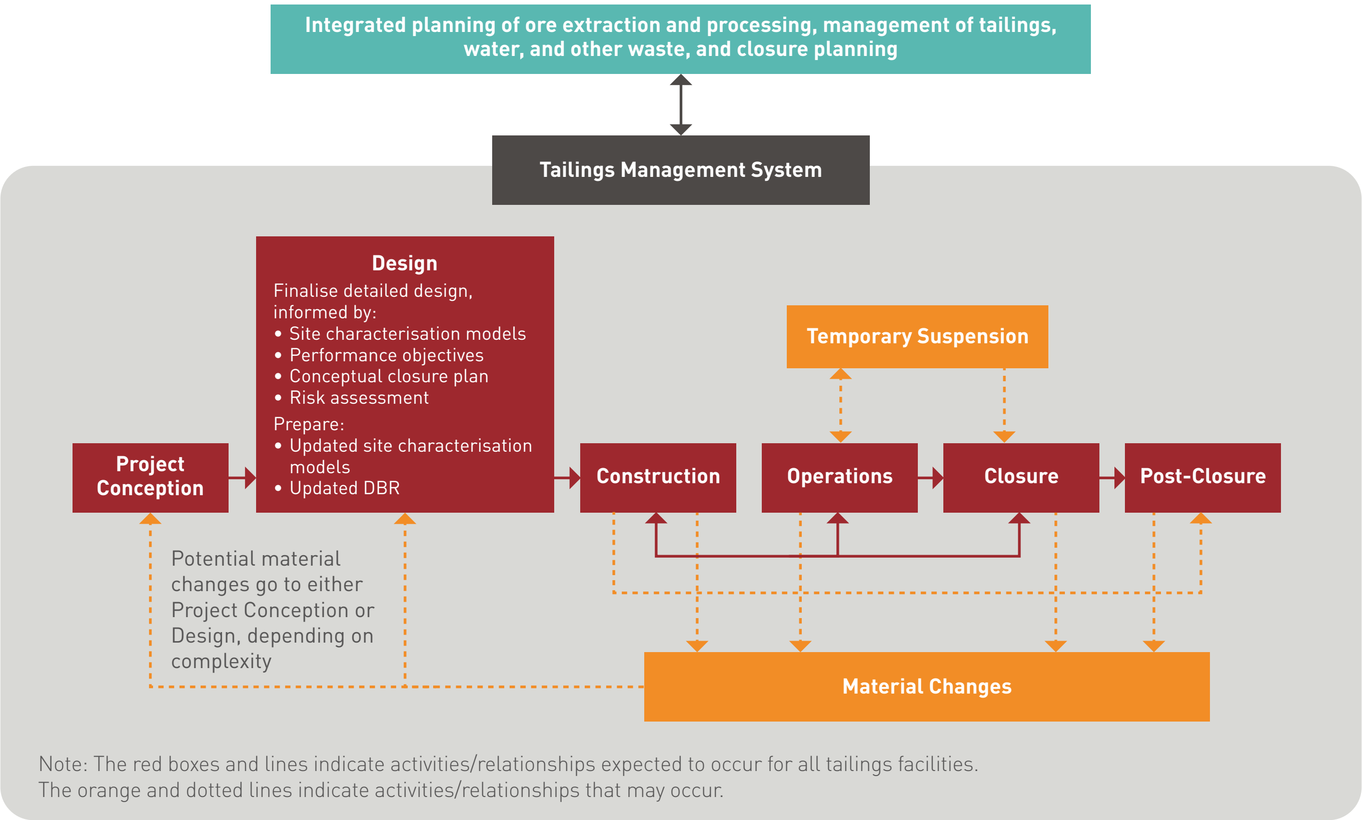

Figure 11: Key activities of the Design phase of the lifecycle

3.4.2 Managing Uncertainty and Assessing Risk in Design

Risk assessment during the Design phase continues the work done during the Project Conception phase but is focused on supporting the design process.

The objectives are to:

- Reduce the uncertainty associated with key design elements and design the tailings facility to reduce or eliminate specific risks, to the extent feasible.
- Develop a risk management plan to limit the impact of residual risks.
- Develop a surveillance plan to sufficiently inform implementation of the risk management plan.

In Detail

Reduce Uncertainty and Refine Risk Estimates
Reducing uncertainty may often be facilitated by additional site characterisation and more relevant modelling that targets key design elements.

Risk estimates should be refined, based on a better understanding of both the likelihood and potential consequences of various unwanted events. This guidance recommends semi-quantitative risk assessment supported by event tree analyses where such detail is appropriate, supported by the ALARP principle.

A risk management plan should be developed in detail as part of the Design phase, with components of the risk management plan incorporated into the design of the tailings facility, where applicable (eg seepage control features).

To support the implementation of the risk management plan, a surveillance plan should be developed and integrated into the OMS manual (Section 2.4). OMS requirements should be considered in the final design, particularly for any instrumentation that would need to be installed during the Construction phase, and for any surveillance activities that would need to be initiated during Construction.

3.4.3 Tailings Facility Design

3.4.3.1 Overview

Failure of a tailings facility is unacceptable, particularly any failure that leads to fatalities or otherwise catastrophic outcomes. Thus, designing, constructing, operating and closing facilities to reduce or eliminate credible failure modes is of paramount importance.

Conventional tailings facility design philosophy over the past decades can generally be grouped into the approaches depicted on Figure 12, all of which are best implemented when risk-informed. The more layers that are applied, the better risk informed the approach becomes.

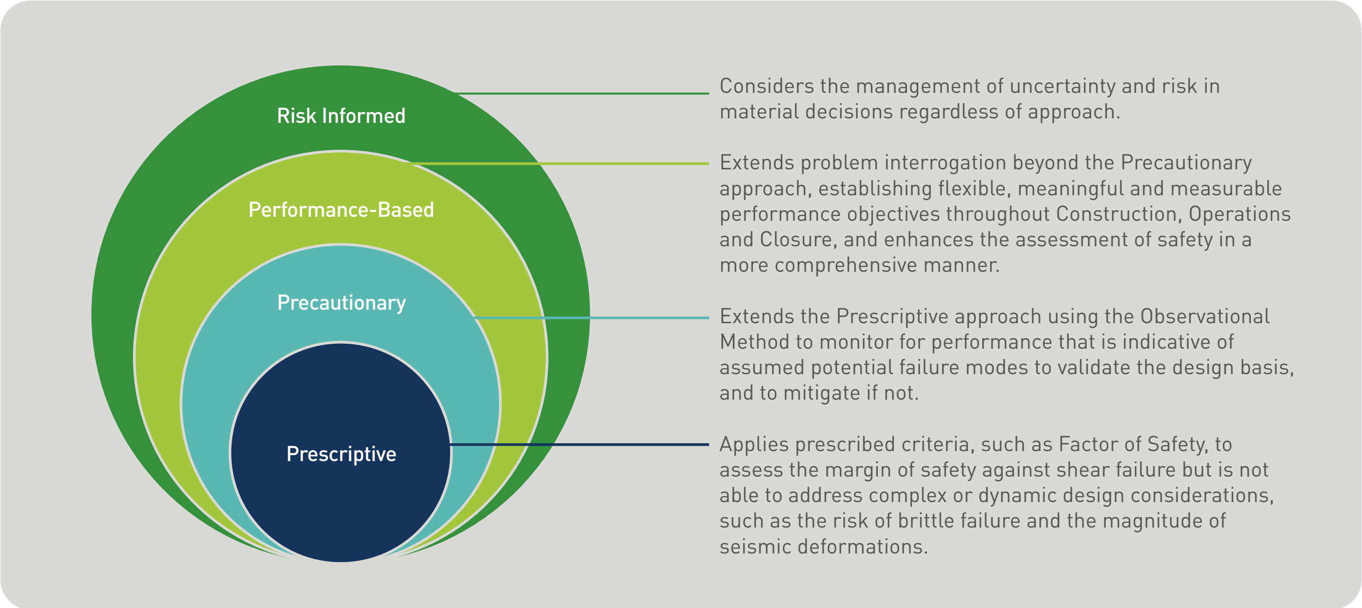

Figure 12: Management of uncertainty in design approaches

The following sub-sections explain each approach: prescriptive, precautionary and performance-based, with risk-informed decision-making as an overarching theme.

3.4.3.2 Prescriptive Approach to Tailings Facility Design

The prescriptive approach to designing tailings facilities came to prominence in the 1970s as an adaptation from design practices for water dams. In its basic form, the approach often uses a prescribed Factor of Safety (FoS) as a criterion that is perceived by some to denote whether or not a tailings facility is safe. Due to the seemingly straightforward application of FoS, it has broad appeal.

3.4.3.3 Limitations of Prescriptive Approach

A FoS is often misinterpreted as a sole measure of safety. It is based on the premise that a higher FoS reduces the likelihood of failure. However, a FoS is not a measurable value; it is an outcome based on inputs which are derived by the designer based on site data, laboratory testing and modelling. Natural variations in site and laboratory data give rise to uncertainty around the calculated FoS. However, FoS values are rarely reported with uncertainty limits. Further, a given value of FoS has an entirely different meaning if an identical value exists for both a site with a brittle credible failure mode and one with only non-brittle credible failure modes.

An over-reliance on FoS can lead to complacency – a sense that if the design FoS is met then the facility is safe. Complacency can also lead to an inadequate standard of care regarding other factors that may be just as important, if not more so, to the safety of a given tailings facility, such as using engineering analysis methodology that may not be applicable to a specific situation, just because the method is convenient or familiar, or a lack of urgency to act in response to specific problematic observations in the field.

As noted, the concept of FoS was originally developed for water dams and has been adapted to tailings facilities. One significant difference between water dams and tailings facilities is that water dams are typically built to final height at the outset, whereas tailings facility embankments are typically constructed in stages, with a starter embankment before deposition of tailings commences, and raises to increase capacity through the Operations phase of the lifecycle. There may be further modifications during the Closure phase. As a result, the approach commonly used for water dams to apply a lower FoS for construction than in operations is not transferable to tailings facilities since construction is often ongoing together with tailings facility operation. Despite this, the approach is still used too frequently for tailings facilities.

A further limitation of the FoS is that formulating a valid FoS for a given tailings facility is dependent upon the selection of appropriate parameters and access to reliable data (eg extensive field and laboratory studies as part of site characterisation (Section 3.3.3)). It is also dependent upon the competency and experience of those involved. If the FoS has been erroneously calculated to be above a prescribed value, but the actual FoS is really below that value, then the tailings facility may be less safe than assumed by the Operator. Additionally, since the FoS is calculated for an embankment as a whole, it may not adequately account for zones of local resistance and/or weakness within an embankment, thus potentially overlooking or not recognising the significance of the 'weakest link' in an embankment. Solutions to addressing these limitations are outlined in the following sub-sections.

3.4.3.4 Precautionary Approach to Tailings Facility Design

Despite the limitations regarding FoS, many tailings facilities have been safely constructed and operated by combining a prescriptive approach with the oObservational method, which is referred to in this Guide as the 'precautionary approach'. Performance that is indicative of a potential failure mode is identified and monitored in order to validate whether the design basis remains sound and if not, to initiate mitigation measures. The amount by which variances from expected performance can be tolerated is often then supported by additional design calculations and judgement. During the Construction, Operations, and Closure phases, performance behaviour surveillance is conducted in accordance with the design criteria and expected ranges such that appropriate corrective action can be taken when exceedances are encountered. The precautionary approach also requires a contingency design to be implementable when and if observations require that mitigation is necessary.

Currently, the use of the precautionary approach is widespread across the mining industry, and in many cases the continued use of this approach is appropriate and effective in ensuring safe tailings management. The precautionary approach is applicable and effective in many circumstances because:

- There are existing tailings facilities that have been safely designed, constructed and operated using this approach. If properly understood and calibrated with relevant experience, the precautionary approach can continue to be used for such facilities.
- The application of the precautionary approach can be validated by precedence and by confirmation that neither the foundation materials nor the foundations themselves or other structural components of the tailings facility are susceptible to strain weakening failure under the design criteria or other elements of non-homogeneous straining.
- It provides an initial Design phase as a first step to a performance-based design which in turn leads to improved safety and reliability of performance.

3.4 DESIGN

An illustration of the precautionary approach for design, construction, operation, and closure is presented in Figure 13. As illustrated, this approach relies on defining the acceptance criteria for the facility, which is often the minimum acceptable FoS, either prescribed by regulation or defined by the EOR or Design Team (recognising that separate FoS values may be adopted for the Construction, Operations, and Closure phases). During the life of the tailings facility observations are made via surveillance to assess whether the facility is meeting the intent of the design, and hence consistent with the required FoS.

It should be noted that most of the recent high-profile failures of tailings facilities had an acceptable FoS within the context of the precautionary approach, although there were challenges with its application and understanding. The precautionary approach is not appropriate when brittle failure modes are present, especially if they are not recognised and eliminated. Appropriate material characterisation with appropriate representation of pore pressure conditions and external loading conditions, along with appropriate surveillance for all credible failure modes is necessary with the precautionary approach.

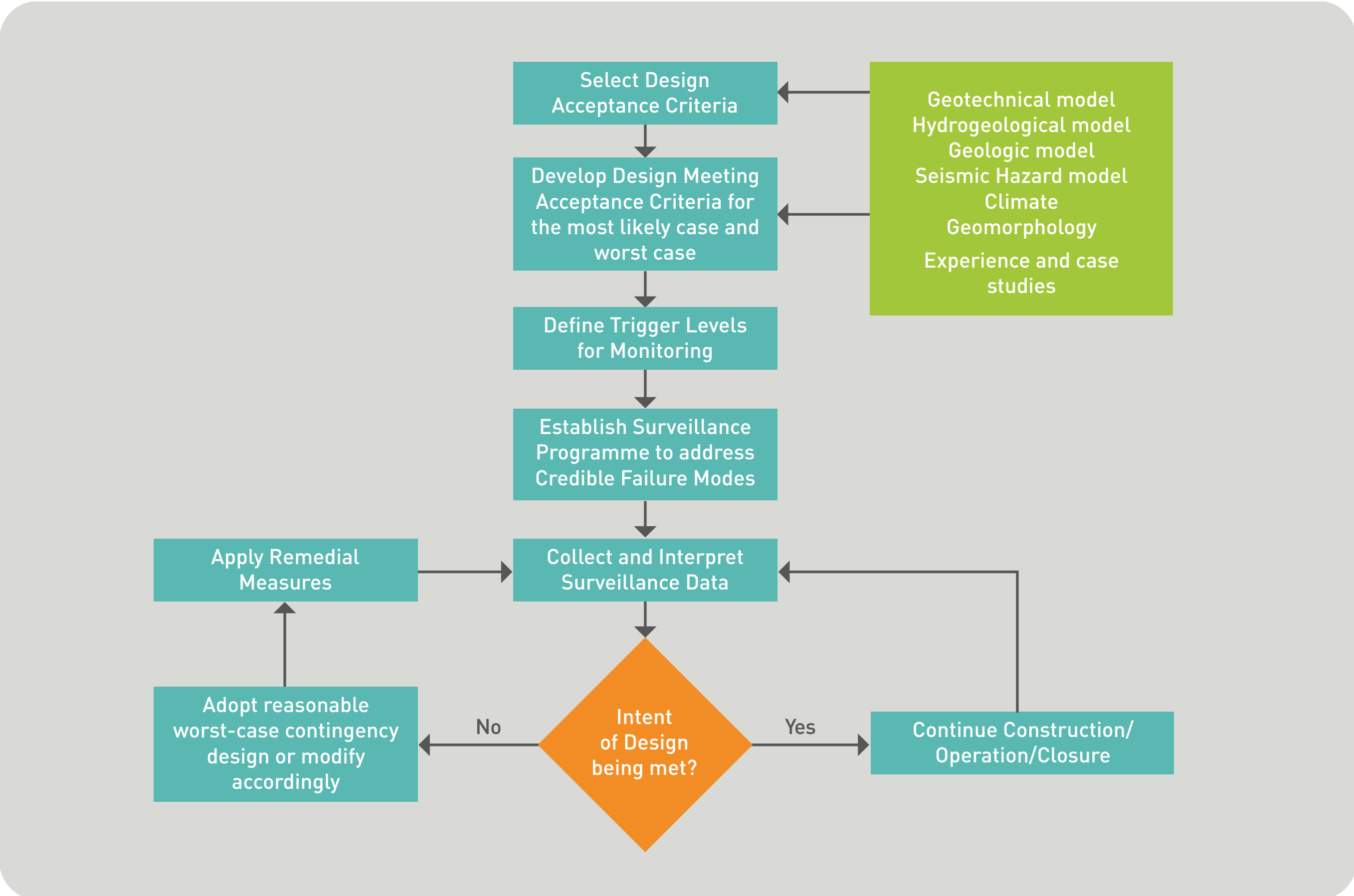

Figure 13: Precautionary-Based Approach to Design, Construction, Operations and Closure

A key point of the precautionary approach is that the tailings facility response (via surveillance) is always reactive, based on what has been observed.

For the application of the precautionary approach to design for static failure modes, this Guide recommends that:

- Design FoS are not prescribed but should be determined by the EOR and the Design Team and should be endorsed by Independent Review.
- The sensitivities of safe design to material characterisation and site characterisation should be recognised by the EOR and the Design Team and their evaluations should be endorsed by Independent Review. Significant consideration should be given to selecting appropriately conservative material strength parameters for deterministic analysis of the FoS.
- The reliance on and limitations of the observational method should be recognised (see below).

Regarding the application of precautionary-based design in practice for dynamic (seismic) failure modes, appropriate methods for assessing both potential seismic deformations and post-earthquake stability should be selected by the EOR and the Design Team and reviewed by the Independent Reviewer(s). There may also be occasions when using a FoS approach or simplified deformation analysis can be a preliminary screening tool, but screening should not replace the need for more rigorous seismic deformation analyses in highly seismic areas or with designs that contain fragile elements (eg a low permeability core prone to cracking, drains prone to clogging). The design criteria to be adopted for these cases are:

- There should be no loss of containment.
- There should be no secondary failure modes (eg cracking, shear of filters, disruption of drains) that can lead to collapse.

Experience indicates that a specified post-earthquake FoS can be useful to ensure that runaway displacements are precluded early in the design process.

Finally, as noted above, for the precautionary approach, the tailings facility design should be developed in terms of two cases: i) the recommended design case; and ii) the reasonable worst case. This distinction has the following strengths:

- The recommended design case provides guidance on how to interpret variability in material properties based on detailed field and laboratory characterisation as well as providing a first step towards the adoption of performance-based design.
- The reasonable worst case considers what might occur in a worst-case scenario and how it might be mitigated. It is not intended to be an operational target but facilitates the proactive consideration of potential challenges leading to potential design modification. The provision of a constructible contingency design is an integral part of the reasonably worst-case design.

3.4.3.5 Limitations of the Precautionary Approach

The precautionary approach has important limitations, related to shortcomings inherent in the application of the observational method:

- It is a reactive method. Once an observation is made that appears to be contrary to the intent of the design, remedial actions may be required. Determining the appropriate remedial measures may be complicated by a lack of data, poor interpretation of the surveillance data, and/or a lack of understanding of the origin or cause of the observation. In some cases, the lack of understanding could lead to the adoption of an incorrect remedial measure. For more complex tailings facilities, there is an increased risk of reaching an incorrect conclusion regarding the performance of the facility if the surveillance programme is not designed or interpreted appropriately.
- It is not readily applicable in cases where the failure mechanism is predominantly brittle, which might occur in tailings prone to liquefaction or in cases of strain weakening foundations. Such mechanisms typically evolve more rapidly than could be observed or responded to with contingency measures, or where other constraints preclude the timely and effective application of such measures. Brittle failure mechanisms have been involved in many of the historical catastrophic failures of tailings facilities.
- It is only effective for variances in performance that were foreseen, and for which remedial measures/actions have been identified in advance. If a variance occurs that was not foreseen and monitored, the method will not detect the variance and often remediation cannot be applied.
- Implementation of remedial measures/actions requires that the initiation mechanism be well-understood among the Operator's team working on the tailings facility (ie operators, managers, RTFE, EOR).
- If contingency measures are not planned at the outset the value of the observational method is seriously impaired. For example, if an initiation mechanism is observed that could be addressed by constructing a downstream buttress on the embankment, but the construction of an embankment as a contingency measure was not foreseen, then construction may not be possible due to a lack of adequate space to construct the buttress and/or a lack of construction materials.
- For more complex tailings facilities, there is an increased risk of reaching an incorrect conclusion regarding the performance of the facility if the surveillance programme is not designed or interpreted appropriately.

3.4.3.6 Performance-Based Approach to Tailings Facility Design

For some tailings facilities, including those with credible brittle failure modes, the precautionary approach has important limitations that can render it inappropriate. In these cases, the application of a performance-based approach to tailings facility design, operation and closure serves to reduce risk and improve safe tailings management, consistent with the ultimate goal of eliminating catastrophic events and fatalities. The performance-based approach moves toward adopting a proactive procedure for managing tailings facility performance data. This is accomplished by defining performance objectives using sequential forecasts of the tailings facility behaviour through all phases of the lifecycle and verifying that the performance is behaving as intended throughout the lifecycle.

3.4 DESIGN

The performance-based approach is made possible by some of the major developments in tailings management that have occurred, notably the expansion of surveillance capacity, including remote data gathering and automated processing, together with numerical simulation tools to forecast tailings facility performance and behaviour in a timely manner. The communication technology with sometimes remote facilities and increased computational speeds enable real- or close-to-real-time ability to evaluate actual performance relative to predictive tools and to continually improve those predictive tools to better inform future behaviour.

This performance focuses on all observable, relevant parameters and characteristics such as deformations, piezometric pressures, seepage flows and cracking. The validation of performance in this comprehensive manner provides increased confidence that the facility is behaving as intended and that safety is being ensured.

As an example, a performance objective of limiting the amount of strain/deformation within the foundation or a layer within the foundation may be adopted in order to prevent the material from reaching residual strength by realising its brittle behaviour potential. Monitoring the strain within this layer relative is a key performance indicator; results are used to calibrate and forecast strain (performance criteria) through modelling.

An illustration of the application of the performance-based approach in design, construction, operation, and closure is presented in **Figure 14**.

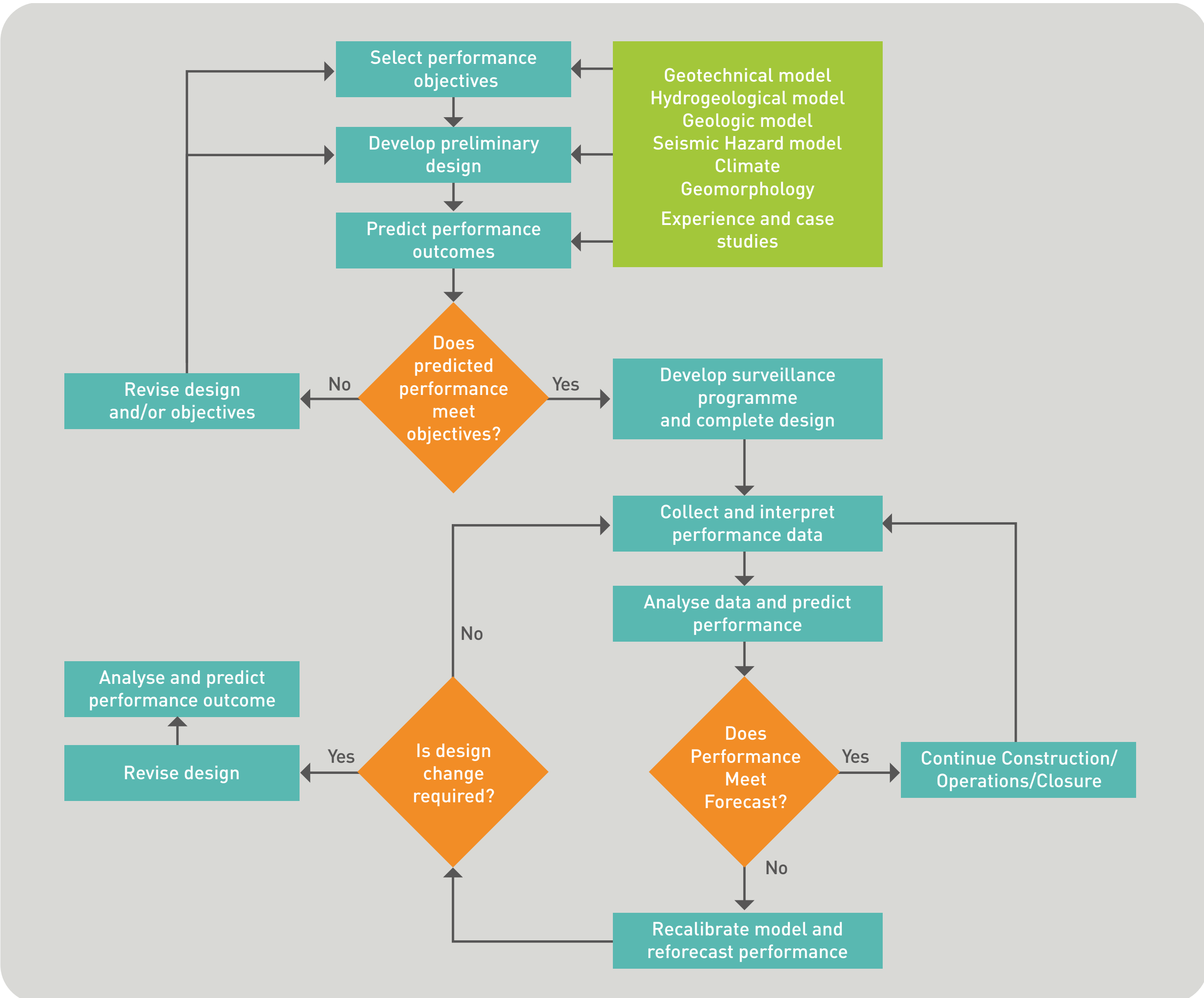

Figure 14: Performance-Based Approach to Design, Construction, Operations and Closure

The following are key to this approach:

During the design process:

- Use site characterisation data (geotechnical, geologic, hydrogeologic, seismic, climate) to establish performance objectives for the tailings facility. These objectives should focus on the critical elements that would affect safe construction, operation, and closure.
- Forecast behaviour as part of the design process to inform the evolution and finalisation of the design to meet the performance objectives. Forecasting tools are selected dependant on the complexity of the challenges and the questions that need to be answered. The tools may be relatively simple analytical models but, where appropriate, forecasting may utilise advanced numerical techniques such as finite element or finite difference models. These tools are often initially constructed using case study inputs and the somewhat limited site characterisation data that are available during the Design phase. The ability to calibrate many of these models during the Design phase is limited.

During the Construction, Operations, Closure, and Post-Closure phases:

- Assess current behaviour.
- Calibrate and re-forecast the performance of the facility, comparing against the performance objectives. If the re-forecast does not meet the performance objectives, changes to the design and/or performance objectives may be required, as indicated by the EOR.
- Inform the need for potential changes to the design to improve facility safety and test proposed changes to the design by predicting future behaviour if the proposed changes are implemented.

The advantages of applying the performance-based approach include:

- It provides a reliable and proactive basis for interpreting all of the significant aspects and observations of tailings facility performance related to evaluating safety.
- Design assumptions are continually challenged and subject to validation in a comprehensive manner.
- The staged simulation of behaviour and incremental forward projection strengthens the confirmation of safety.
- Its adoption (including use of specific/specialised monitoring instruments for collecting data for updating analyses) overcomes some of the limitations associated with the definition of FoS to shear failure modes as often defined in practice. (The FoS may not adequately highlight zones of local resistance and/or weakness.)
- The improved simulation and calibration with time also provides a more authoritative record that the overall response of the facility based on constructed conditions is in accordance with the design intent.

- Seismic resistant design relies on the approach to assess potential deformations.
- The onset of localisation of deformations and progressive failure can be determined.
- Experience indicates that regulators benefit from more observable performance objectives to meet their needs and this is facilitated by the performance-based approach.

The performance-based approach can be applied to all tailings facilities, but based upon the analysis of past failures, it can be particularly valuable to achieve robust design and maintain integrity to prevent the failure of tailings facilities that:

- Are spatially complex and variable, including having issues of strain compatibility and interaction of material within the facility and foundation zones.
- Exhibit the potential for strain weakening (brittle).
- Are susceptible to liquefaction leading to potential flow failure.
- Include a need to assess deformations resulting from earthquakes.
- Are potentially unstable due to high pore pressure due to loading from the tailings facility.

The EOR is responsible for recommending detailed design criteria and for utilising a Design Team with adequate relevant experience compatible with the complexity of the assignment. In addition, the EOR and the Operator must always recognise legal requirements applicable to the design process and the selection of design criteria.

The EOR and the Design Team are expected to formulate the procedures and the material property characterisation required to initiate the design process. Relative to a precautionary approach, the required instrumentation is expanded in order to maximise the validation of performance to the degree considered to be of value. The EOR is responsible for determining whether the facility's embankment and foundation are adequately robust to meet the performance objectives.

This Guide recommends the adoption of performance-based design utilising the forecast of deformation, pore pressures and seepage for all phases of the lifecycle of a tailings facility where conditions such as those outlined apply.

Furthermore, the adoption of the principles of risk-informed decision-making enhances the capacity to convey safety assessments to multiple stakeholders.

3.4.3.7 Limitations of the Performance-Based Approach

The performance-based approach is a natural extension of the observational method that is established good practice within the precautionary approach. It extends to the evaluation of total performance of the tailings facility throughout its lifecycle from construction to closure. By validating total performance of the tailings facility, the evaluation of safety is enhanced. Total performance includes deformations, pore pressures, and other aspects such as drain performance and cracking (if tolerable). The capacity to undertake performance-based design requires the knowledge of current advances in deformation and pore pressure modelling as well as advances in surveillance technology and methodology needed to be able to apply the performance-based approach to validate performance. This relies on the EOR and Design Team having the necessary competency to undertake design on this basis, and to determine adequate deformation and resistance limits to ensure safety. Broad application of the performance-based approach will therefore require a focused building of capacity in the industry and sharing of case history examples, of which a number already exist.

Further, the Operator's tailings engineers, operators and management team need to understand what is required to use this approach. Because design assumptions are continually challenged and subject to validation, the successful application hinges on an Operator's adaptability, planning and ability to embrace new technology (software and hardware).

3.4.3.8 Risk-Informed Decision-making in Design

Regardless of the design approach, designs should be informed by an appropriate assessment of the risks and uncertainties associated with the proposed or existing tailings facilities. An overview of a range of risk management tools available to inform design was presented in Section 3.2.

A design appropriately informed by risk applies the evaluation of uncertainty in material properties, external loadings, analytical models and interpretations. It also requires an appropriately informed level of independent review; to do otherwise is in itself a risk to the design. A risk-informed design takes the input from the risk assessment at any level of sophistication, as sophistication should be commensurate with the design stage of the facility (Section 3.2), and uses that information in setting performance criteria and analytical methodology, and the bounds of sensitivity applied to both.

The ALARP concept is fully compatible with the principles of risk-informed design. As discussed in Section 3.2, while there are descriptions of the ALARP process in the public domain, the application of ALARP can be quite robust. ALARP can be implemented using a range of semi-quantitative, qualitative or experiential methods, depending on the project conditions (eg geographic location, social considerations/constraints, environment considerations, etc) and complexity. Regardless of the method(s) used to implement ALARP, the process itself is a powerful tool to document the decisions and approaches that were adopted to reduce risk during the lifecycle of the tailings facility.

3.4.3.9 External Loading Criteria for Design

Recognising that Operators can follow the Standard directly, as an alternative, this Guide proposes beginning the design process for new tailings facilities by assuming the need for extreme loading design criteria because, while not the only factor involved, robust design with conservative criteria is supportive of preventing catastrophic failures. Selecting conservative criteria is consistent with the safety culture of the mining industry and the ultimate goal of preventing catastrophic failures. By beginning with extreme loading criteria, consequence classification of a credible failure is not necessary for the purposes of establishing design criteria.

Although this Guide enters the design process assuming extreme criteria, it provides the flexibility that the EOR may recommend alternative criteria if appropriate, based on site-specific considerations, a risk assessment that justifies a different approach as appropriately protective against catastrophic risk, and endorsement by Independent Review. ALARP applies to existing facilities as well.

The extreme loading design criteria proposed by the Guide are:

Design flood: A maximum design flood (MDF) with a return period of 1 in 10,000 years should be considered for new facilities and for the screening of facilities already under construction (in operation) or already closed. In the latter cases, a reduction in the MDF can be considered based on a recommendation from the EOR, endorsement by Independent Review and approval by the Operator. This should be supported by a risk evaluation using the ALARP principle.

This Guidance also recognises that more extreme floods (probable maximum flood (PMF)) may be recommended by the EOR or they may be required under legal requirements in some jurisdictions. In such cases, the judgement of the EOR and/or legal requirements take precedence. Recent developments in estimating extreme floods increases the confidence in estimates of PMF and should be recognised.

Design earthquake: A maximum design earthquake (MDE) with a return period from a probabilistic seismic hazard analysis (PSHA) of 1 in 10,000 years should be considered for new facilities and for the screening of facilities already under construction (in operation) or already closed.

Alternatively, where appropriate for the seismological setting, a deterministic maximum credible earthquake (MCE) may be adopted as MDE for new facilities and for the screening of facilities already under construction or already closed. In either case, the selection of probabilistic or deterministic methodologies and their associated loadings and a reduction in the MDE from those outlined above can be accepted based on a recommendation from the EOR, endorsement by Independent Review and approval by the Operator.

There are nuances between this Guide and the Standard, with the common objective of selecting external loading criteria to support the safe design of a given tailings facility. While the Guide provides a design process that does not require the use of a prescriptive consequence classification process, the Standard enters the design process for new facilities by formally determining the consequence of failure classification of a tailings facility by assessing downstream conditions and consideration of credible failure modes as described in Requirement 4.1.

Further, the Standard provides a consequence classification (Annex 2, Table 1) as well as external loading criteria (Annex 2, Tables 2 and 3) applicable for the safe design of new tailings facilities while recognising that other guidelines and/or legal requirements may be applied. The external loading criteria for the Operations and Closure phases vary based on the consequence classification. The external loading criteria for the Post-Closure phase are associated with extreme consequence for tailings facilities Closure phases. During the Operations phase, the design may be based on extreme loading criteria or the current consequence classification criteria. If the current criteria are used, the Operator must maintain the ability to upgrade to extreme external loading criteria throughout the facility lifecycle and check at least every five years whether there is a material change that requires upgrade of the facility. If so, upgrade must be completed within three years. Regardless, the design for closure should ultimately use appropriate design criteria, such as those included in Annex 3 of the Standard or should justify using lower criteria through use of the ALARP principle for existing facilities per Requirement 4.7.

The Guide recognises that consequences will need to be considered in the risk assessment process and EPRP if catastrophic credible failures are present, even if using extreme loadings for the design process.

3.4.3.10 Failure Modes

Beyond establishing external loading criteria, many other factors are critical to preventing catastrophic failures. The next piece of design is assessing potential failure modes and the development of a design that minimises or eliminates credible failure modes and thus sets a tailings facility up for success in the prevention of catastrophic outcomes from credible failure modes.

As described in Section 2.7.2 and 3.7.4 and consistent with the goal of eliminating fatalities and catastrophic failures, ideally each tailings facility would have limited or no credible catastrophic failure modes. However, some facilities do have credible failure modes that can lead to catastrophic outcomes and these should be addressed by appropriate design measures.

Every historic catastrophic failure has resulted from one or more of the following failure modes:

- Overtopping (ie loss of containment through a breach).
- Seepage and erosion (eg piping, decant structure failure and any other failure related to water movement).
- Instability both due to excessive deformations within the embankment and/or its abutments/foundations.

The following sections highlight some special considerations associated with each potential failure mode.

In Detail

Overtopping
Tailings facilities are not typically designed to accommodate overtopping. Exceptions can exist when the embankment(s) is composed of sufficiently coarse rockfill or other erosion-resistant material and is designed to act as a flow-through embankment. In general, safety with respect to overtopping is ensured by the provision of adequate freeboard that can include a sufficiently sized and operating spillway. This design consideration is incorporated in the water balance (Section 3.2.3) around the tailings facility as an element that reflects the construction schedule of the facility.

The construction plan should incorporate the consideration of the ore processing facility's tailings production plan as well as the tailings transport and deposition plan, water management requirements, tailings deposit density, associated contingencies, and adequate freeboard to safely manage the extreme design flood event. Maintaining freeboard requirements is a critical performance objective of any tailings facility where overtopping is a credible failure mode. Violating this requirement has been known to aggravate consequences even if initial overtopping was not the cause of a failure.

Some design considerations related to freeboard requirements are:

- The implications of wind-generated waves and reservoir setup.
- The storage of the MDF event, or a portion thereof, that results in temporary wetting and restoration of the beach.
- Use of good practices for estimating the design flood, considering climate trends and the potential for a series of events to occur consecutively (wet season or year, as is appropriate for local conditions).
- Where present, the malfunction of spillways that may be relied upon to manage the extreme design flood event.
- Long-term settlement of tailings and embankments.
- Earthquake-related settlement of tailings and embankments.
- The potential for cracking due to desiccation in the upper portion of the beach.
- The operational beach length that would be a performance requirement under normal operating conditions.
- Restriction on the migration of the reclaim pond(s) within the tailings facility.
- Recognition of competing water utilisation objectives such as management of geochemical risks or fugitive dust.
- Ice formation that may interrupt/impact the water reclaim system.
- Presence of upstream hazards or structures that could fail and cause a cascading failure of the tailings facility.

Seepage and Internal Erosion
Design and construction to control seepage and prevent internal erosion that may result in the failure of a tailings facility falls into two classes of problems:

- Physical aspects of seepage control.
- Chemical aspects of seepage control.

Piping is a form of internal erosion in a tailings facility, embankment, or foundation resulting from seepage that causes progressive erosion and formation of a cavity or 'pipe' which may progress. Piping failures typically occur rapidly and Fell *et al.* (2003) noted that in the majority of cases there were less than 6–12 hours between the first observation of a concentrated leak and a breach of the tailings facility. While piping may occur during the Construction and Operations phases, given the usual composition of tailings, the occurrence of catastrophic failure from this mode is not common. However, it is noted that decant towers and/or other engineered conduits (pipelines) in tailings facilities may fail structurally and may also lead to piping. The rate of filling of a tailings facility of any significant size is generally low enough to allow time to intervene and modify the design if piping due to filter incompatibility is observed (finer material is able to migrate into coarser material). Nevertheless, the significance of controlling seepage in tailings facilities and the prevention of piping is a paramount consideration in tailings facility engineering and the principles follow those in use for water dam design.

The physics governing seepage through both saturated and unsaturated materials are well established. With the determination of the controlling hydraulic conductivity properties at a given tailings facility, for both the foundation and tailings embankment section(s), the calculation of seepage discharges and associated piezometric distributions are readily computed. The critical hydraulic gradient at which upward directed flow reduces the effective stress to zero is also determined by the porosity and density of the local porous material. However, it is well established that the gradient at which particles begin to move is less than the critical gradient at which effective stress is zero, but there is no clear limit regarding the rate of particle migration at these reduced hydraulic gradients. A variety of tests have been developed to aid in determining this limit. This is made more complex by the occurrence of suffusion which is the selected transportation and washing out of fines from a coarse material. The uniformity of the tailings and/or foundation materials under consideration affect the hydraulic gradient at which suffusion becomes significant and the issue of internal stability needs to be considered. Critical hydraulic gradients are very sensitive to the degree of internal stability of a granular material.

Simple prescriptive design measures are not well-suited to accommodate the variations of materials that commonly occur in tailings facility embankments. The EOR should be responsible for:

- Establishing the parameters required for the evaluation of seepage-induced flows in both the tailings facility and the foundation. Unsaturated flow needs to be considered where appropriate.
- Establishing critical hydraulic gradients to control internal erosion.
- Establishing the capacity/demand ratio (FoS for drains) for all drainage elements.
- Providing capacity for seepage modelling in both two- and three-dimensions, where appropriate.
- Providing specifications for all drainage control measures.
- Design of the surveillance programme for seepage.

Some design considerations associated with seepage and internal erosion of tailings facilities include the following:

- The capacity/demand ratio should be large enough to accommodate the uncertainties associated with estimating seepage flows.
- Care should be taken to avoid utilising materials in seepage control elements that can degrade with time.
- Design of control elements such as filters should consider the ease of construction and related quality control to enhance reliable performance. Design should also should recognise tailings facility deformations including those anticipated by design earthquake ground motions and should be robust enough to continue functioning following such events.
- If the closure plan includes a functional water body on the surface of the tailings facility and if there would be active seepage as a result, consideration should be given to reducing the allowable hydraulic gradient in the tailings facility.
- In addition to piezometric and discharge monitoring, considerations should be given to methods that can be invoked to locate zones of excessive seepage if they are threatening safe performance. Techniques based on self-potential measurements (passive electrical geophysical method) and differential temperature measurements have proved successful in practice.

The development of powerful and effective numerical modelling software to forecast piezometric distributions and seepage discharges is an integral component of performance-based design. While accurate prediction of both piezometric distributions and seepage discharges of tailings facilities is challenging and often not reliable, predictions can be improved by means of history-matching of model behaviour to historic data and incremental forward projections conducted in a systematic manner. The net result is an increased confidence in safe operation and the development of an insightful tool for final closure design.

Chemical aspects of seepage are typically thought of in relation to the water quality of the process-affected water and the composition of the groundwater (which may be influenced by the construction and operation of the tailings facility). These considerations are important throughout the facility lifecycle to ensure Design and Operations are in compliance with the permit / regulatory requirements for the facility. Seepage considerations should also include potential geochemical changes to materials in the tailings facility and the foundation to assess whether such changes could affect the physical stability of the tailings facility. For example:

- Consideration of whether geochemical changes could affect the strength of tailings (if used as a structural element in the facility), other embankment materials and/or foundation materials.
- Whether precipitates or other geochemical changes could reduce the permeability of structural elements such as drainage features or embankment fill.

- Whether seepage water could increase or decrease permeability in the foundation due to geochemical reactions.

Tailings Embankment Stability

The stability of the tailings embankments and abutments may be impacted by:

- The presence of brittle materials, either within the embankment, abutment, or foundation of the embankment, that could lead to the rapid loss of shear strength.
- The development of static liquefaction due to rapid construction loading or the development of undrained loading conditions in brittle materials at the onset of yield.
- The development of dynamic liquefaction due to seismicity or blasting.
- Excessive differential settlement of soft zones.

Many of these issues can be identified during site characterisation (Section 3.3.2), however others, such as construction loading, will need to be addressed as part of the construction documentation and the quality management process.

The driving forces of the tailings facility behind an embankment and, in turn, on the foundations for the embankment, need to be sufficiently met by the resisting forces of the embankment at all phases of the facility's lifecycle. The driving forces can and will vary due to construction activities, external loads (ie seismic events) and the size and shape of the facility as it evolves. The nature of the foundation materials and the embankment materials need to work in tandem to create a stable mass. As above, brittle materials in either the embankment or the foundation require special consideration inclusive of design and construction based upon either lower bound strengths (eg assume the brittleness is triggered) or sufficient robustness to prevent the sudden loss of strength from ever occurring.

Many tailings facilities have embankments constructed using tailings. This is a widespread, safe and logical approach as it does not involve the use of other natural materials and minimises disturbance outside the tailings facility footprint. However, tailings material varies in mechanical behaviour and it is essential that the gradation, fabric (including grain angularity) and bulk density be determined.

Where tailings are used as a construction material or are present in the embankment foundation, likely pore pressure conditions should be modelled during the Design phase and during construction they should be appropriately measured and interpreted. A proper combination of pore pressures and bulk density is required to correctly estimate in-situ stresses and, hence, in-situ state. There can be considerable non-conservatism involved in using incorrect values.

Tailings facility embankments are commonly classified according to their geometry (ie upstream, centreline, downstream). There are variations of this classification, but it is adequate for the purposes of this Guide. Experience indicates that failures have occurred at a small percentage of each type of tailing facility embankment geometry, but that instances of catastrophic failure have been relatively more common at upstream-type embankments, for example due to static or dynamic liquefaction conditions. While failures have occurred with upstream construction, there have also been numerous successes.

Setting aside failure associated with foundation conditions, this Guide considers that upstream construction embankments can be safely constructed, operated and closed provided they are supported at the downstream embankment zone by a dilative and/or unsaturated buttress that can be monitored and that provides adequate resistance if the upstream contents liquefy. This resistance does not preclude deformations associated with seismic loading provided there is no loss of containment and that no secondary failure modes develop. Examples of physical features that are often helpful in achieving upstream embankment stability include:

- Having a relatively low rate of increases in embankment height.
- Using relatively coarse tailings with low clay content for the construction of the embankment.
- Having a well-drained foundation
- Being located in an area with a relatively arid climate
- Being located in an area with relatively low seismicity
- Having a relatively small ponded water on tailings facility surface.
- Compaction of the downstream embankment zone

- Having relatively flat embankment side slopes.

In addition, upstream facilities require rigorous TMS implementation.

Recent experience has highlighted the challenges associated with selecting the appropriate FoS to prevent failure in a variety of facility configurations. Instead of specifying fixed values, this Guide favours the selection of site-specific design criteria based on the evaluation of site complexity by means of the EOR (in accordance with applicable legal requirements) and notes that the following particularly complex circumstances should be recognised:

- Accumulated experience with a particular soil or rock mass.
- Variable construction and operating conditions that may affect in-place properties and stability of the tailings facility and embankments.
- Response of unconsolidated materials in the foundation and variations in response under different confining stresses and stress levels.
- Time-dependent, deformation-dependent and stress path-dependent processes that may affect the critical material processes such as the operational pore pressures and shear strengths.
- Potential for brittle failure.
- Susceptibility to static and dynamic liquefaction that may include strain weakening.

3.4.4 Tailings Transportation and Deposition Plan

The tailings transportation and deposition plan is initially developed during the Project Conception phase and refined during the Design phase. It should be integrated with the design approach for the tailings facility and the overall plan for ore extraction and processing. It should describe how tailings will be transported to and deposited in the tailings facility, and how the capacity of the tailings facility will be increased over the life of the mine. It is crucial to successfully operating the facility from construction to closure.

The tailings transportation and deposition plan should be integrated into the OMS manual (Section 2.4) and implemented and regularly reviewed and updated during the Operations phase of the lifecycle (Section 3.6).

The plan should be developed, implemented and updated in a manner that is aligned with the closure concept and closure plan (Section 3.7.2), to ensure that the final tailings surface topography at the end of the Operations phase facilitates the implementation of the closure plan and post-closure land use.

Proposed changes to the tailings transportation and deposition plan should be carefully considered taking into account:

- Potential operational impacts.
- Potential impacts on risks.
- Potential impacts on the implementation of the closure plan.

In developing the tailings transportation and deposition plan, a range of site characterisation (Section 3.3.2) information should be considered. These characteristics should be validated and updated on a periodic basis throughout the lifecycle. If some characteristics do not meet the design specifications or intent, then the potential impacts and risks of these deviations should be assessed, and appropriate actions taken to address them.

Depending on how water will be managed, and whether water will be stored in the tailings facility, the tailings transportation and deposition plan should be integrated with the water management plan.

Deposition plans typically allow for the expansion of the tailings facility over the life-of-mine to accommodate increasing amounts of tailings solids. This could include staged lifts to increase the height of embankments to accommodate additional tailings, or planned lateral expansions into new cells of the tailings facility. Depending on the water content of the tailings, and the relationship between tailings management and water management, such expansions may also increase the capacity to store water and increase the retention time of water within the tailings facility.

In Detail

The tailings transportation and deposition plan is integral to the selection of the tailings management technology and the site-specific conditions of the tailings facility. Examples of aspects to consider include:

- Whether the tailings will be managed as slurry, or whether they will be dewatered to some degree and managed as thickened, paste or filtered tailings. The planned moisture content and the physical characteristics of the tailings are essential to the plan.
- What types of embankments, if any, will be constructed? What will the construction method be? What materials are to be used? What will be the method of raising those embankments during the Operations phase?
- Overall sitewide mass balance considerations for operation and closure and integration of deposition planning with the water balance and management plans.
- Consideration of the potential range of tailings index properties, moisture content, rheology, swelling clays, etc, as relevant for project-specific conditions.
- Material placement/approaches planned.
- Methods, if any, to control seepage from the tailings facility, such as the use of liners, water retaining embankments or underdrains. This should also consider the potential implications of the inclusion of liner materials on the geotechnical stability of a facility.
- Whether there will be a single type of tailings, or whether there will be different types. For example: Will there be separate 'clean' tailings and potentially acid-generating tailings, which would be managed differently? Will tailings be split based on particle size distribution or other physical factors? If separated, how will these different types of tailings be managed?
- Consideration of whether alternative deposition approaches might be feasible approaching the end of the Operations phase to achieve closure objectives.
- Whether any other materials, such as waste rock or treatment sludge, will be managed with the tailings. For example: Will potentially acid-generating waste rock be managed with the tailings to prevent or control acidic drainage? What quantities of these materials will be placed in the tailings facility, compared with the quantity of tailings?
- How will the tailings be transported from the ore processing facility to the tailings facility? Options include a pipeline in the cases of slurry, thickened or paste tailings, and truck or conveyor belt in the case of filtered tailings.
- In colder climates, whether ice lenses could form in deposit and how to manage them.
- Methods to prevent the release of tailings into the environment during transportation to the tailings facility.
- How will the tailings and any other materials be placed or deposited within the tailings facility?
- How much water will be retained in the tailings facility? What measures are in place to deal with excess water, such as due to high intensity precipitation, extreme snowpack/melt, extended periods of wet weather, extended periods of water retention, etc?

3.4.5 Documentation of Design

The Standard refers to a Design Basis Report (DBR) and a Design Report. Some Operators may wish to combine all this information into a single report, others will prefer to spread it out over a few reports. Regardless of format, it is important to document the design basis as well as issued for construction drawings, specifications, and construction quality management planning as key elements of the Design phase. This Guide refers to the important components to be considered in developing documentation and refers to documents where information might be housed, for ease of writing this text; however, it is not intended to be prescriptive.

The DBR is a foundational document that records the design basis and the outcomes from the design process. It also incorporates updates throughout the lifecycle of a tailings facility. The site characterisation studies (Section 3.3.2) inform the DBR. The models and information described in the DBR underpin the decisions that the EOR (with the support of the Design Team) makes in setting design criteria for the facility. Development of the DBR should begin during the Project Conception phase (Section 3.3) to include the alternatives evaluated (Section 3.3.4), and should be refined during the design of the selected alternative to provide the basis for construction, operation, and closure of the tailings facility. The DBR should be further updated throughout the lifecycle of the facility, with each phase informing subsequent phases.

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The DBR should include the following:

- Design criteria considering site-specific conditions that underpin tailings facility designs through field investigation, laboratory work and modelling and analyses. Where assumptions are made early in the lifecycle, this should also be clearly defined until data is available to confirm criteria.
- Performance objectives which will be met by TARPs (eg seepage stability, allowable deformation) and the tailings facility design components.
- Summary of supporting information used to demonstrate that the tailings facility, as designed, will meet the design criteria and performance objectives.

Facets of a DBR typically include site conditions, geotechnical properties of and criteria used for foundation and tailings material, starter facility and embankment characteristics, tailings transport (distribution) and deposition system, reclaim water system, water management, environmental components, supporting infrastructure, and a description of battery limits (boundary for area of responsibility).

The DBR should be updated throughout the design process to include increasing detail and complexity reflective of the design decisions and site-specific data that are collected as progress is made on the project design studies. Early design stages often include assumptions or estimates for certain parameters until site-specific data become available as the design of the tailings facility advances. It is important to note the status of information in the DBR (assumed or estimated from similar projects versus site specific) with the goal of ultimately transitioning to ensure that the DBR is reflective of site-specific investigations and studies.

The DBR should describe the risk controls and associated performance criteria (Section 3.6.4) that are used in the design and implementation of the surveillance programme (Section 2.4.3.4). The EOR should review and update the DBR throughout the lifecycle of the facility to ensure the DBR reflects the current status of the tailings facility and future plans. A DBR should contain enough detail to provide a basis for comparison of:

- Constructed conditions (clarifying any deviations from the original design).
- Any changes to the original design intent.
- Actual performance against performance objectives, indicators, and criteria described in the DBR.
- Updates to the closure plan.
- Any extensions to the capacity of the tailings facility beyond the original design intent.

It is important to keep the DBR-related information up to date and integrated. For example, it is valuable to incorporate data and analyses from periodic material characterisation programmes with previous design/material characterisation data to validate interpretation and to document any in-situ changes. Likewise, if there are known changes to construction material/methods (eg to seismic loading models, input data, etc) these should be incorporated with DBR information. Similarly, designs may change due to the permitting process and approvals. Important changes should be managed and integrated into the documentation.

Independent Review is critical for the DBR due to its foundational nature in tailings management. The DBR should also address the information requirements identified through community engagement and Independent Review, as well as provide information related to the relevant legal requirements and risk management plan.

The DBR or other documents further include detailed construction drawings and construction specifications. These are used together with the construction quality management plan for the basis for execution of the design.

3.4 DESIGN

In Detail

A typical DBR includes the following sections with reference to the relevant technical references and reports:

- Tailing facility general information
- Mine production plan
- Battery limits
- Topographic survey methodology, datum/coordinate system
- Climate and meteorology
- Geology (including structural geology and presence of faults) and hydrogeology
- Geological and hydrogeological characterisation
- Site geotechnical characterisation – including foundation and borrow materials
- Seismicity and seismic design requirements
- Surface water management
- Geochemical considerations
- Tailings characteristics and rheology
- Water balance
- Embankment characteristics
- Slope stability
- Discharge and seepage controls
- Breach analysis and inundation studies (if appropriate based on risk assessment)
- Tailings distribution and reclaim water system
- Tailings deposition
- Earthworks and constructability
- Structural design criteria
- Design criteria for electrical infrastructure (eg pumps, surveillance instruments, etc.)
- Closure design criteria
- Costing basis and drawing standards.

Beyond integrating the underpinning models, the DBR defines whether the tailings facility approach will use precautionary design or performance-based design and provides important design criteria such as FoS and allowable deformations, potential for strain weakening, etc. It describes the scope and level of detail of information and analyses used to make decisions, along with applicable legal requirements and guidelines, demonstrating the validity of those decisions.

3.5 CONSTRUCTION

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3.5.1 Introduction

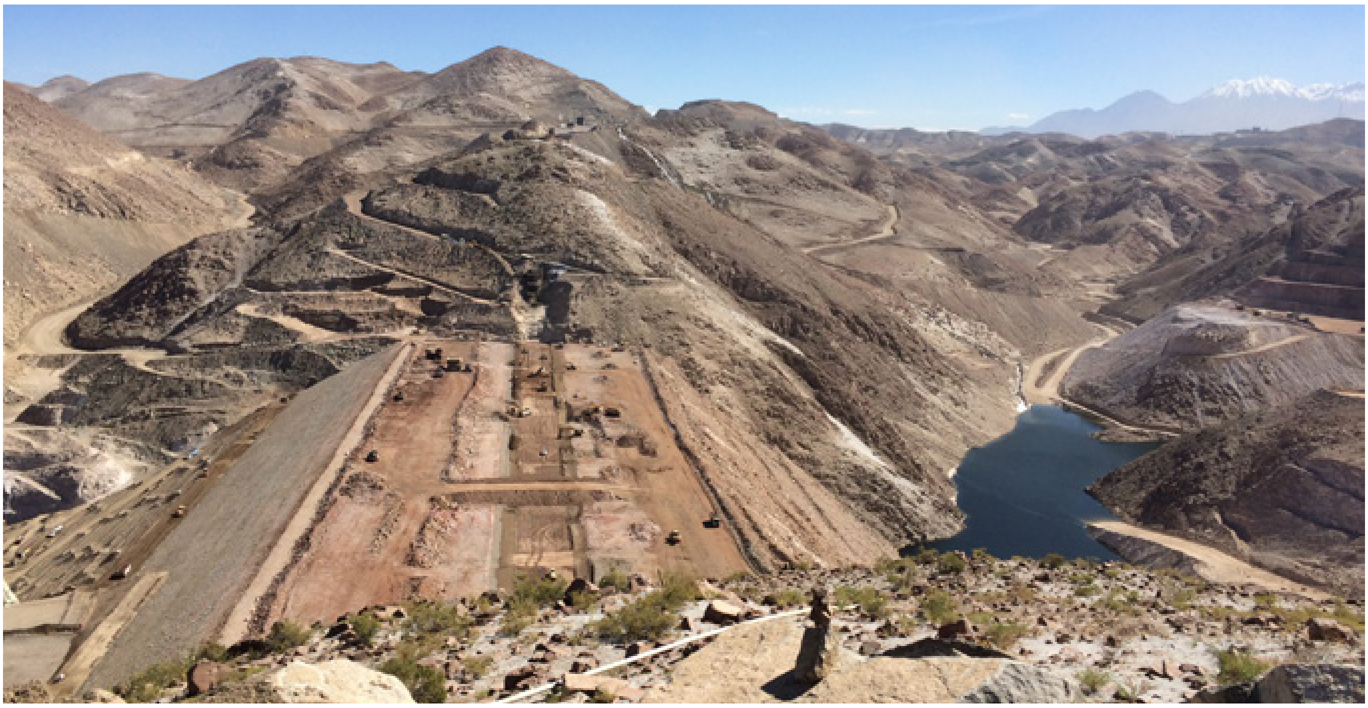
Construction is a recurring lifecycle activity that progresses the Design phase outputs of a construction design including drawings, technical specifications and quality management into a commissioned facility that is received by the Operator for ongoing operations. The initial stage of a tailings facility is commonly constructed by a contractor with subsequent stages either continuing to be contractor built or alternatively built by the Operator's site team. Sometimes at existing mine sites, the Operator's team may have the capacity to perform some of the initial stage construction of a new tailings facility. Regardless of who performs the construction, a strong quality assurance (QA) and quality control (QC) programme is important.

Construction implementation should incorporate the consideration of the ore processing facility's tailings production plan, as well as the tailings transport and deposition plan, water management requirements, associated contingencies, and adequate freeboard to safely manage the design flood event.

The main activities for the Construction phase are:

- If the EOR from the Design phase is not retained, appointing an EOR for the Construction phase through a change management process. This EOR is likely to have a longer-term responsibility.
- Developing a construction management plan.
- Developing a project execution plan.
- Establishing the construction team, including defining the roles and responsibilities of the EOR and the construction team and their relationship through the design process.
- Execution of the QA/QC programme based on the plans developed during the Design phase.
- Developing and maintaining a construction risk register to track risks to project schedule and cost. The construction risk register is one piece of the broader risk assessment and risk management process for the tailings facility which should also be considered through the Construction phase, particularly when considering changes to the design (Section 3.2.4).
- Initiating the tender process and procurement with clarity around required qualifications and experience in establishing potential bidders and the assessment of bids.
- Developing a construction health, safety and environmental plan.
- Advancing construction activities.
- Commissioning the constructed facility.
- Developing accurate documentation including the Deviance Accountability Report (DAR) and the Construction Records Report (CRR).

The outcome of the initial Construction phase is a commissioned facility constructed in accordance with the design intent, detailed specifications, quality management programme for subsequent use in the Operations and Closure phases, as well as any other documents required for final approval and initiation of the Operations phase.



3.5 CONSTRUCTION

Subsequent Construction phase activities use similar elements to progress the tailings facility through its lifecycle, as required per the Design, Operations, and Closure phases and/or if mitigation is required.

Figure 15 illustrates the key activities of the Construction phase of the lifecycle.

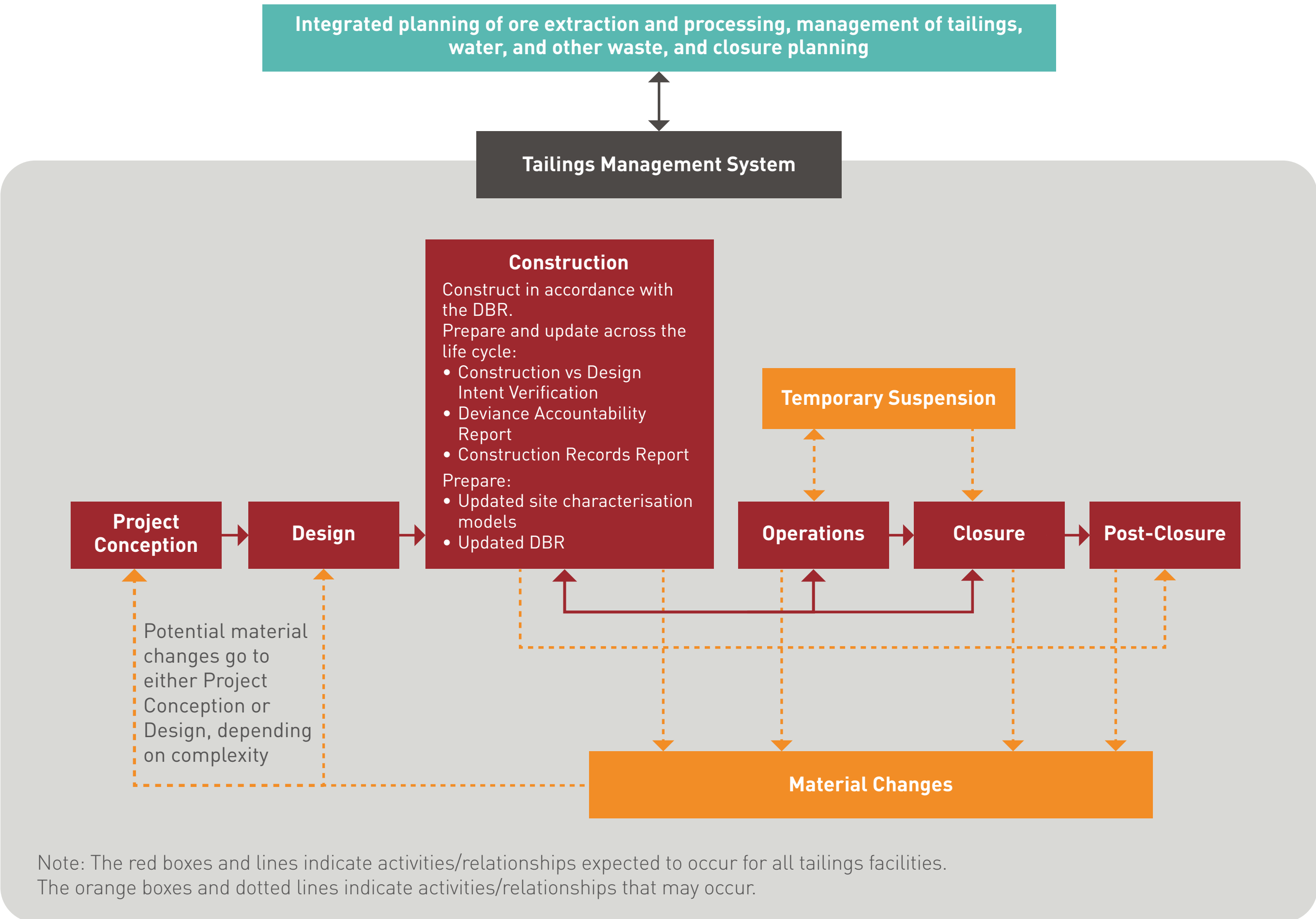


Figure 15: Key activities of the Construction phase of the lifecycle

3.5.2 Construction Management Plan

The execution of the engineering design requires a well-developed management framework to ensure its successful implementation. The management framework encompasses the development of a construction management plan to establish uniform policies and procedures that ensure facility construction is conducted safely in accordance with the construction drawings, technical specifications and the QA/QC programme. The construction management plan is an overarching plan and is intended to be flexible in its application, and revised and improved as warranted. It is not intended to be a step-by-step procedure for each activity. Typically, it is a document that outlines general activities, procedures, requirements and schedules for successful completion.

The construction management plan typically includes several elements that may be packaged in a variety of formats at the preference of the Operator. The planning process and clarity of outcomes is the important aspect of the following, not the specific nomenclature or how the outcomes are packaged:

Project execution plan:

- Describes how the construction is to be undertaken. It provides specific requirements for the activities, schedules (including key milestone dates), and organisational framework.

Construction execution plan:

- Details how and when the construction activities are to be undertaken.

Risk management plan:

- Details results of facility risk assessment activities conducted during the Design phase. This information should be referenced carefully when design changes are proposed. Risk ownership and continuity from the Design phase across Construction and into the Operations phase is critical in managing change during this transition period.
- Facility risk assessments are updated to reflect constructed conditions and any additional information relevant to risk (eg hazards) collected during construction (new information, new developments, changes required in design due to geomorphology, water management, climatic changes, or unforeseen major events or topographic conditions).
- Project-level risk (risks to schedule and cost) may also be captured in a construction risk register.

Quality management plan:

- Describes both the QA and QC requirements determined by the EOR for construction, where:
- QA is the implementation of a system to ensure design and construction activities will deliver the project requirements in accordance with the design intent.
- QC is the inspection of the construction works and material verification, via testing, to ensure compliance with the requirements of the drawings and technical specifications.

Water management plan:

- Details how water will be managed during construction, outlines start-up water requirements, and references overall objectives for safe water management for the completed tailings facility and is tied to the sitewide and tailings facility-specific water balance model and plan (Section 3.2.3).

3.5.3 Deviations from Design

It is not uncommon for situations to arise during construction that necessitate a deviation from the design or construction specifications. Such deviations do not create any facility safety concerns provided they are assessed, reviewed and documented as part of the overall construction management process. These deviations can range from very minor to material changes requiring a design modification. Deviations are a normal part of the construction process, as actual conditions (eg foundation conditions or characteristics of construction materials) will never be exactly the same as those anticipated based on the information available during the Project Conception and Design phases. Deviations may also occur due to permitting requirements.

Proposed deviations should be carefully considered. Haphazard or undocumented deviations should be avoided. A clear process should be established in advance of commencing construction for the consideration and potential approval of deviations, including delegating responsibility and authority for such decisions. This process should be aligned with tailings management governance and involve the entire breadth of the team responsible for safe management of tailings (Accountable Executive, RTFE, EOR, Design Team and Independent Review).

The potential impacts of the proposed deviations on the design intent, expected performance, and risk profile of the tailings facility should be assessed and understood before any deviation is approved.

It is important to be aware of the potential cumulative effects of multiple minor deviations which may not be of consequence on their own. In assessing proposed deviations, previous deviations should be considered and the potential for a cumulative effect should be evaluated.

Construction QA processes may identify non-conformances with design specifications from time to time. If not immediately resolved, a non-conformance report should be issued and tracked until it is resolved. The intent is to eliminate these, and this is the typical outcome. However, some non-conformances may be disputed and unreasonable to resolve due to costs and/or schedule implications. Under these few circumstances, the non-conformances can be considered deviations from the design.

A CDIV process should be conducted by the Operator with support from the EOR to ensure:

- The design intent, as per the DBR, has been implemented and is still being met if the site conditions encountered during construction varied from the design assumptions.
- Any discrepancies between the field conditions encountered during construction and the design assumptions are clearly identified and reviewed, such that the design can be reviewed and adjusted as required to account for the actual field conditions. This information is critical for the design of subsequent facility stages.

The results of the CDIV should be included in a CRR for new tailings facilities or other relevant documents such as an annual report for operating tailings facilities.

3.5.4 Documentation of Constructed Conditions

Accurate documentation of as-constructed conditions is critical. Such documentation provides the information needed to:

- Continue construction of the tailings facility during the Operations phase.

3.5 CONSTRUCTION

- Inform any future consideration of changes in the design of the tailings facility.
- Understand and remedy problems that may arise in the future.

Constructed conditions should be documented in a CRR signed by the EOR and RTFE per Requirement 6.3 of the Standard. Through the CDIV and Independent Review, this includes verification of whether the constructed conditions meet the design intent and specifications.

The CRR should also summarise the results of the CDIV to ensure that all changes to the design or any aspect of construction are documented, together with any non-conformances and their resolution.

Any unresolved deviations identified in the CRR can be carried into the DAR process. The DAR process can be used throughout the lifecycle of the tailings facility, identifying and reviewing potential implications of changes to the facility and evaluating their acceptability. The DAR is discussed further in Section 3.6.3.

The CRR should document the initial construction of a new tailings facility and should be updated to reflect other construction activities when they occur throughout the lifecycle, including:

- Ongoing construction through the Operations phase to increase the capacity of the tailings facility.
- Construction for any material changes.
- Design modifications and implementation of the closure plan.

Construction records, including QA/QC documentation, construction surveys and as-built drawings, and commissioning documentation should be retained to provide the documentation that the construction was in accordance with the construction drawings and technical specifications. These may be consolidated in the CRR. These records are important for the ongoing management of the tailings facility and provide a critical database for ongoing construction and geotechnical assessments. If construction is conducted in multiple stages, it is helpful to consolidate the CRR and drawings as a complete reference of the cumulative facility construction or develop another equivalent approach to integrating information.

To facilitate ease of access and the analysis of constructed conditions this information may include detailed geo-location data and be compiled in a comprehensive GIS-based retrievable system. This may not be possible for existing sites with incomplete construction records.

3.6 OPERATIONS

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3.6.1 Introduction

The Operations phase is the period in the lifecycle when tailings are transported to, and placed in, the tailings facility. It may also include the temporary suspension of mine operations (Section 3.6.5).

The full range of concepts, principles and practices for tailings management are deployed during the Operations phase to ensure safe, responsible tailings management.

- Tailings are managed in accordance with overall governance for tailings management, with accountability and responsibility appropriately assigned (Section 2.2).
- TMS is implemented (Section 2.3).
  - Evaluating Performance is ongoing.
  - Identifying Actions to Improve Performance includes the reporting of performance to the Accountable Executive.
  - Action plans are developed and implemented to address deficiencies or opportunities for continual improvement.
- Risk management plan is implemented and is reviewed and updated regularly (Sections 3.2.4 and 3.4).
- OMS activities are implemented to operationalise the TMS and risk management plan (Section 2.4).
- Tailings transportation and deposition plan is implemented, reviewed and updated regularly (Section 3.4.4).
- Risk assessment is updated periodically (Section 3.2.4).
- Construction activities continue to increase the capacity of a tailings facility and the volume of stored tailings as mining and ore processing operations proceed (Section 3.5). Constructed conditions are accurately documented, including deviations from the design intent and design basis. Deviations are assessed through the change management system (Section 2.3.2.1).
- A programme for reviewing tailings safety is implemented (Section 2.6).
- Community engagement continues (Section 2.2.5).
- TMS and OMS manual are reviewed and updated as appropriate (Sections 2.3 and 2.4).
- EPRP is tested and updated as appropriate (Section 2.7).
- Development of the closure plan continues (Section 3.7.2).
- Site characterisation information is updated and improved through sample and data collection, testing and analyses to identify any changes that could affect the design or operation of the tailings facility. This information is used to confirm site characterisation models (eg tailings material characterisation) and the DBR is updated accordingly (Section 3.3.2).
- All updates and operational changes are assessed through the change management system (Section 2.3.2.1).

During the Operations phase, the Operator should plan for the possible temporary suspension of mine operations. The Operator may also implement progressive reclamation, depending on the nature of the closure plan.

3.6 OPERATIONS

Figure 16 illustrates the key activities of the Operations phase of the lifecycle.

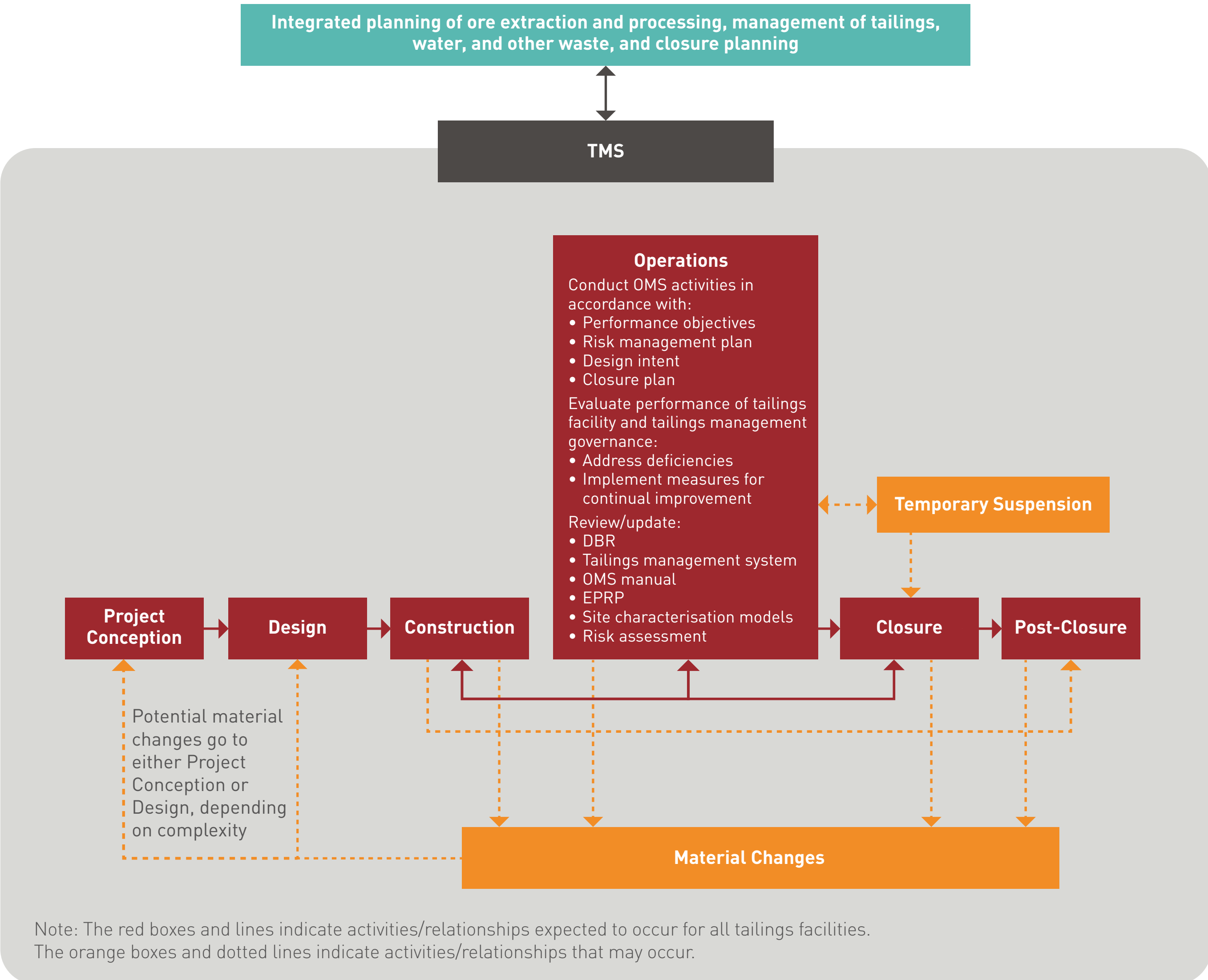

Figure 16: Key activities of the Operations phase of the lifecycle

3.6.2 Applying to Existing Tailings Facilities

This Guide is intended to support the management of both new and existing tailings facilities. However, determining how to apply the Guide to an existing facility can be challenging and a site-specific approach should be taken.

The first step should be to conduct a gap analysis against the elements related to governance of tailings management (Part 2) and the implementation of good engineering practices described in Part 3. Depending on the Operator, conducting a gap analysis may require external expertise and input. This analysis should include inspection and identification of any immediate concerns followed by a more detailed analysis that includes review of the:

- Application of the TMS (Section 2.3) and its integration in sitewide integrated mine planning (Sections 1.2.1 and 3.2.2).
- Risk assessment (Section 3.2).
- Documentation related to tailings facility engineering and management, if available, even if under different name/format:
  - Site characterisation information and models (Section 3.3.2).
  - Design information including the design, the design intent and design basis (Design Report and DBR, Section 3.4.5).
  - Information on the construction of the tailings facility, including as-built conditions (CRR, Section 3.5.4), and

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deviations from the design (DAR, Section 3.5.3).
  – OMS activities (OMS manual, Section 2.4).
  – Closure plan (Section 3.7.2).
- Current and historical performance of the tailings facility, including conformance with the design intent, corporate policy on tailings management, legal requirements and commitments to communities (Section 2.3.4).
- EPRP and results of any tests conducted (Section 2.7).
- Reports from a programme for reviewing tailings safety (eg Independent Review) (Section 2.6).

Once a gap analysis has been completed, the Operator should prioritise gaps that present the highest potential facility safety risks and develop action plans to address those gaps (eg operational improvements to address identified potential instability, additional site investigation or data collection to develop or refine site characterisation models to validate understanding of stability performance, updated or more comprehensive risk assessment). Prioritisation of gaps and the development of action plans should be done with input from the EOR and Independent Review.

A key consideration in prioritising gaps and the development of action plans is appropriately scaling application of the guidance to the tailings facility in question. Considerations in scaling application of the guidance will typically include:

- Availability of meaningful information about the history of the tailings facility.
- Uncertainties associated with credibility of potential failure modes.

- Complexity and size of the tailings facility.
- Risks and the potential consequences of failure.
- Lifecycle phase.
- Closure plan.

In addition, the Operator should consider the continued suitability of application of the precautionary approach, versus adoption of a performance-based approach (Section 3.4.3).

The Operator should develop a schedule for sequencing and implementing action plans, develop a budget, and obtain budget approval. Action plans should then be implemented in accordance with the schedule, cognizant of the importance of effectively managing change through this process (Section 2.3.2.1).

In Detail

Questions to consider in this gap analysis include:

Questions related to governance of tailings management

- Does the Operator have a corporate policy on tailings management? Does this policy include a goal of eliminating fatalities and catastrophic failures (Section 2.2.3)?
- Have accountability and responsibility been assigned for roles described in Section 2.2.2 and are persons in these roles appropriately competent as per Section 2.2.4? Are there clear lines of communication between key roles?
- Has a TMS been developed and implemented (Section 2.3)? Are processes in place to manage change (Section 2.3.2.1)?
- Has an OMS manual been developed and implemented? Is it up to date, accessible, understood and utilised by relevant personnel (Section 2.4)?
- Is the Operator effectively managing information related to tailings management (Section 2.5)?
- Does the Operator have a programme in place to review tailings safety, including Independent Review (Section 2.6)?
- Does the Operator have an EPRP? Is the plan tested and updated appropriately (Section 2.7)? Are communities and public sector agencies engaged (Section 2.2.5)?

Questions related to engineering practice

- Is site characterisation information (including tailings material characterisation) adequate and is this information up to date (Section 3.3.2)?
- Are facility performance objectives, indicators and criteria identified and described, including quantification (Section 3.3.3)?
- Does the Operator have an up-to-date risk assessment (Section 3.2.4)? Does the Operator understand the uncertainties associated with the risk assessment? Has the Operator identified credible failure modes and assessed the potential consequences of failure?
- Does the Operator have an up-to-date risk management plan and is it being implemented (Section 3.2)? Does the risk management plan reduce risk according to ALARP? Are additional mitigations needed?
- Does the Operator have documentation on the design, the design intent, and the design basis for the tailings facility (eg a Design Report and DBR)? Is this documentation adequate and updated as appropriate (Section 3.4.5)?
- Has an integrated tailings and water management plan been developed and is it based on up-to-date data and operating rules (Section 3.2.3)?
- Does the Operator have a plan for construction management, including quality management (Section 3.5.2)? Is construction being done in accordance with this plan?
- Does the Operator have an accurate, up-to-date record of the constructed tailings facility, including and accurate understanding of:
  - Current conditions (Section 3.5.4)?
  - Deviations from the design intent and design basis, including the rationale for such decisions and assessment for implications to facility performance (Section 3.5.3)?
- Does the Operator have and use an up-to-date closure plan towards which progress is being made?

3.6.3 Potential Material Changes

As described in Section 2.3.2.1, managing change is essential to safe tailings management. Potential material changes, in particular, should be carefully considered.

A material change is a change to the design or operation of a tailings facility, proposed or made after the design for the initial construction has been finalised and initial construction has commenced. A material change would be a change important enough to merit attention, such as a change that has the potential to influence the risk or performance of a tailings facility. The criteria for what would constitute a material change should be defined by the Operator, with input from the EOR and Independent Review.

Examples of potential material changes include changes to:

- The tailings facility design, design intent, or design basis as documented in the design report and DBR (Section 3.4.5).
- Operating plans or procedures (eg tailings transportation and deposition plan (Section 3.4.4)).
- Business case and overall mine plan, such as a mine life extension.
- Other changes such as:
  - Behaviour or characteristics of tailings associated with the ore or ore processing.
  - Behaviour or characteristics of construction materials for embankments.
  - Site water management and water balance (eg increase in volume of water from underground mine workings as mine development progresses).
  - Climate conditions.
  - Upstream or downstream infrastructure or conditions.

This may also include changes to address deficiencies in performance or changes to improve performance (eg adoption of improved engineering practices).

It is important to be aware of the potential cumulative effects of multiple changes or deviations which may not, on their own, be material. In considering non-material changes, previous changes or deviations should be considered and the potential for a cumulative effect should be evaluated.

Potential material changes should be carefully considered by the Operator and EOR, taking into account both short- and long-term implications, before making any decision on implementation, to determine:

- Whether or not to proceed with the change, if applicable.
- How best to proceed with the change.

On a case-by-case basis, the Operator and EOR should engage personnel with the appropriate competencies and qualifications in the evaluation, planning and design of potential material changes. In some cases, a multi-disciplinary approach may be appropriate and may involve personnel outside the RTFE's immediate organisation. For example, a proposed change in ore processing that would result in different tailings characteristics may require ore processing and tailings management teams to collaborate, consistent with the integrated mine planning approach (Sections 1.2.2 and 3.2.2).

Depending on the complexity of the potential material change, it may be appropriate to evaluate the potential change using the steps outlined for the Project Conception phase (eg risk analysis and multi-criteria alternatives analysis) (Section 3.3). In other cases, a less rigorous decision analysis approach may be appropriate, and the proposed material change can proceed to the Design phase (Section 3.4).

Input should be obtained from the EOR on potential material changes. Some Operators may wish to seek input from Independent Review as well.

As part of the planning to implement a material change, the Operator should consider not only the need to update relevant aspects of the design, but also other plans and processes. For example, implementing the material change may necessitate changes to the OMS manual.

The decision to implement the proposed material change should be made at a level in the organisation commensurate with the significance of the change (eg RTFE, Accountable Executive or BoD, as appropriate).

The process of considering potential material changes, and of implementing approved material changes should be properly documented. The DAR (Section 3.5.4) is intended to contain a record of all the deviations from the design across the lifecycle, including both material and non-material changes. The records contained in the DAR also provide a basis for assessing the potential cumulative effects of proposed changes or deviations. If any material changes are proposed that are outside the scope of the DAR, these should also be properly documented.

3.6.4 Decision-Making

3.6.4.1 Introduction

Making risk-informed decisions is essential to safe tailings management through the Operations phase and the subsequent Closure and Post-Closure phases. This applies equally to new tailings facilities planned, designed and constructed following the guidance in Sections 3.2, 3.3, 3.4 and 3.5, and to facilities that are many decades old that were constructed to very different standards.

No matter how a tailings facility was originally designed, constructed and operated, a rigorous approach to decision-making, conducted within an effective governance structure, can help to ensure that tailings are safely managed. Elements of a risk-informed approach to decision-making are described in Section 3.2.4.

Decisions to be made during these lifecycle phases can be categorised as:

- Immediate or short-term operational decisions, such as responding to unusual or upset conditions (eg a decision to implement predictive maintenance (Section 2.4.3.3) or a decision to increase surveillance frequency (Section 2.4.3.4)).

- Medium- or longer-term decisions, such as:
  - Responding to deficiencies in performance or opportunities to continual improvement (eg responding to recommendations from Independent Review) (Section 2.6).
  - Material changes to improve performance (eg construction of a buttress).
  - Adjusting the design or operating practices in response to an updated validation of the design basis or updated predictions of the future performance of the tailing facility.

Decision-making for medium- and longer-term decisions would typically be addressed through the process to manage change (Section 2.3.2.1) as these would be considered material changes (Section 3.6.3). These types of decisions are also addressed in Section 3.4.3 in the context of the discussion of the precautionary-based approach and application of the observational method (Sections 3.4.3.4 and 3.4.3.5), and the discussion of the performance-based approach (Section 3.4.3.6).

The balance of this section is focused on decision-making for immediate and short-term operational decisions.

Good information is essential to all decisions. The effective implementation of risk-informed decision-making is predicated upon the effective surveillance of tailings facility performance. A properly designed and implemented surveillance programme, aligned with the performance objectives and risk management plan, is essential to making good decisions (Section 2.4.3.4).

3.6.4.2 Developing a Framework for Decision-making

To facilitate making immediate and short-term decisions in a risk-informed manner, Operators should develop a framework for decision-making. A TMS provides a governance framework for decision-making and surveillance plays an essential role in providing information. However, without a rigorous approach to decision-making for tailings management, informed by surveillance results, there is an increased risk that decisions:

- Are based on incomplete or inaccurate information.
- Are ad hoc and short-sighted in nature.
- Fail to recognise and account for embedded ignorance, increasing the potential for human error.
- Fail to support the objective of the safe management of tailings.
- Fail to account for interactions between seemingly unrelated decisions.
- Defer or transfer risks to the Closure phase without fully considering the potential implications.

A rigorous approach to decisions provides a structured, consistent mechanism for decision-making, helping to ensure that decisions are taken by persons with the appropriate authority and competencies, and are based on relevant information.

A decision-making framework is based on the intersection between credible failure modes, performance indicators and criteria, and the risk management plan. A decision-making framework should identify:

- Credible failure modes potentially subject to immediate or short-term decisions (ie implementation of mitigation).
- Performance indicators and criteria able to measure and assess performance relevant to those credible failure modes.
- Surveillance measures aligned with the performance criteria.
- Pre-defined risk management measures (risk controls) to be taken if the performance criteria associated with the credible failure modes are not met.

Once the framework is established, surveillance measures are then implemented, results are measured against the performance criteria, and if those criteria are not met, then the pre-defined risk controls are implemented.

Risk controls may include a subset of controls referred to as critical controls, which are risk management measures to mitigate credible failure modes that could lead to a catastrophic failure (Sections 2.7 and 3.2.4). Risk controls may include operating rules with ongoing surveillance and validation or discrete implementation of new mitigation measures.

Clear, effective, timely communication is essential to decision-making (Section 2.2.6), particularly in the case of any variances from the expected ranges of performance. Communication procedures and lines of communication associated with decision-making should be documented and communicated to relevant personnel. Similarly, the pre-defined risk controls should be documented, and personnel who may be responsible for the implementation of those risk controls should be informed and trained appropriately so that they are able to act if necessary.

The advantage of this approach, including pre-defining the risk controls to be implemented, is that it facilitates prompt action if the performance is outside the specified range, since the Operator, with input from the EOR, has already identified the action to be taken. It also empowers junior

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staff with the authority to act in the event that the RTFE and EOR cannot be contacted in a timely manner.

Other business units that could be affected by or involved in the implementation pre-defined risk controls should be engaged in developing the decision-making framework and understand the actions to be taken. For example, if exceeding the minimum freeboard behind an embankment means that risk controls need to be taken to reduce or stop the flow of tailings into the tailings facility, then those responsible for ore processing / generating tailings material need to be aware of this and need to be part of the process.

3.6.4.3 Trigger Action Response Plans

When defining the performance criteria and the risk controls to be implemented if those criteria are not met, there are two basic approaches. For a given performance indicator associated with a credible failure mode the Operator may:

- Define a single threshold for the performance criteria and define the risk control(s) to be implemented if that threshold is exceeded.
- Define a series of thresholds corresponding to increasing concern or risk. For each threshold level, define the risk controls to be implemented. The risk management response is escalated as the concern (magnitude of variance of performance) increases. The number of levels of thresholds is dependent upon the performance indicator and the associated risk controls.

The most appropriate approach to take depends on the nature of the credible failure mode and associated performance indicators. Where the second approach is feasible, it will provide the Operator with greater flexibility and capability to manage risk.

This second approach is sometimes referred to as a trigger action response plan (TARP), although other terms are also used to describe this concept. TARPs may be used to define escalating risk management actions under upset or unusual conditions and may also define the transition to emergency situations. It is up to the Operator to determine what is considered upset versus emergency conditions, and the role of TARPs in the management of upset conditions.

In Detail

An example of a four risk-level framework for a TARP is:

- **Green – Acceptable Situation**. Normal operating conditions. Performance is in line with performance criteria.
- **Yellow – Minor Risk Situation**. The EOR and RTFE should be notified. There may be a pre-defined risk control to be implemented, or the pre-defined action may be to increase the frequency of surveillance and analysis. Additional surveillance activities may be undertaken. Surveillance results and corresponding actions are documented and reported.
- **Orange – Moderate-Risk Situation**. In addition to the EOR and RTFE, the Accountable Executive is notified. Depending on the credible failure mode and associated level of concern, regulators, local emergency responders and communities should be notified if further escalation could lead to an emergency. Pre-defined risk controls are implemented. Surveillance activities are intensified to monitor the performance indicator in question, related performance criteria, and the effectiveness of the risk control implemented. Expert advice may be sought as appropriate. Results of follow-up surveillance activities are documented and reported. The accumulation or combination of moderate-risk situations could lead to a high-risk situation and threshold values may need to be assessed accordingly.
- **Red – High Risk Situation**. Depending on the credible failure mode and how the thresholds are defined, reaching this level means there is an imminent loss of control or that a loss of control has occurred. Depending on the potential consequences, this may trigger very significant pre-defined risk controls (eg ceasing ore processing operations, emergency release of water through the spillway) or it may trigger the implementation of the EPRP. It is important to note that the accumulation or combination of moderate-risk situations could lead to a high-risk situation and threshold values may need to be assessed accordingly.

3.6.5 Temporary Suspension of Mine Operations

During a temporary suspension of operations, ore extraction and processing have been suspended and the placement of tailings into the facility is not occurring. A suspension may be short-term (eg temporary suspension due to wildfires, labour disruption) or of a longer, indeterminant duration (eg due to low commodity prices).

The specific timing, duration and circumstances related to a temporary suspension are not usually known in advance. However, a temporary suspension is a significant change and, like all changes, must be appropriately managed to reduce the risks associated with tailings management.

The Operator should consider developing a contingency plan for different credible scenarios for a temporary suspension, including identifying the resources (eg personnel, power supply, equipment) needed for the continued safe management of the tailings facility for the duration of a temporary suspension and coordination with the regulatory authority as appropriate. Such plans should also address OMS activities specific to temporary suspension (eg suppressing dust from areas of the tailings facility that are normally wet) and the re-start of mine operations. Contingency plans should also address the potential implications of a longer temporary suspension, such as changes in water management and implications for water levels in the tailings facility or changes to seepage volume and chemistry.

During temporary suspension, OMS activities continue and the closure plan is not implemented. However, in some cases temporary suspension may lead to closure of the mine and implementation of the closure plan.

3.6.6 Progressive Reclamation

Progressive reclamation is the reclamation or remediation of certain portions of a mine site during the Operations phase, in advance of the Closure phase and implementation of the closure plan (Section 3.7).

Progressive reclamation may not be possible at some tailings facilities. Where progressive reclamation is possible, it may be temporary, or intended to be a component of the closure plan. However, where non-temporary progressive reclamation can be undertaken, it should be planned and undertaken:

- In accordance with the operating plans (eg tailings transportation and deposition plan) and the closure plan (Section 3.7.2).
- In a manner consistent with the performance objectives and risk management plan (Sections 3.2, 3.3 and 3.4).
- In a manner consistent with ongoing OMS activities (Section 2.4).

As progressive reclamation proceeds, the risk assessment should be reviewed accordingly, and the risk management plan updated as appropriate. OMS activities should also be reviewed and revised as appropriate. The closure plan should be updated to reflect the state of progressive reclamation.

3.7 CLOSURE & POST-CLOSURE

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3.7.1 Introduction

Planning for closure and operating a tailings facility in a manner consistent with the closure objectives are activities that crosscut the entire lifecycle. Thus, while Closure and Post-Closure can be regarded as distinct phases of the lifecycle, planning and design for these phases begin at the outset of the Project Conception phase and continues throughout the lifecycle. Closure planning for an existing tailings facility that is not yet closed does not exclude it from this process; rather, it accelerates the need to apply the scope of work described in this section to ensure a successful outcome.

The guidance presented here is focused on the theme of preventing catastrophic tailings facility failures from the beginning of the tailings facility's lifecycle through to the Closure and Post-Closure phases. For many tailings facilities, a post-closure objective can include having the facility become a landform. Landforms, as used in this guidance, are not prescriptive, but meet the objective of being long-term stable earth structures which are capable of being closed with surveillance and limited management or maintenance requirements. To be considered a landform, the facility cannot develop a credible catastrophic failure scenario. Irrespective for the closure configuration selected, it is good practice to reference not only this section, but also the *ICMM Integrated Mine Closure: Good Practice Guide* (2019) and any site-specific regulatory criteria to ensure long-term sustainability is achieved.

Considerations when following this guidance will include the recognition of application in variable environments, under different (and sometimes changing) legal requirements, and sometimes changing stakeholder objectives and success criteria. The ability to adapt to these considerations is key to a successful outcome. Also key is to look for opportunities to execute progressive reclamation (when/where possible) to test closure concepts, ensure regulatory acceptance and integrate stakeholder engagement into the process.

3.7.2 Development of the Closure Plan

For new tailings facilities or major expansions, the development of closure plans and performance objectives for closure and post-closure should begin during the Project Conception phase (Section 3.3). Tailings facilities should be planned and designed, from the outset, with closure and post-closure in mind. Realising that many Operators are dealing with existing facilities and legacy facilities, the guidance provided here expresses the importance and urgency around the acceleration of a timeline for the guidance that follows to arrive at the goal of a final closure plan that will achieve a stable landform status.

A conceptual and final closure plan requires a vision, principles and objectives. It should become more detailed and elaborated during the Design phase (Section 3.4). The closure plan should then be refined, elaborated, verified and updated periodically during the Operations phase of the lifecycle, and in preparation for transition to the Closure phase. The closure plan and objectives should be considered in the multi-criteria alternatives analysis conducted during the Project Conception phase of the tailings facility and should be a key consideration in the facility design and location, and in the technology decisions of the facility. The OMS manual (Section 2.4) should be aligned with the closure plan and objectives so that activities during the Operations phase (Section 3.6) are consistent with and support the closure plan and objectives.

For existing tailings facilities that do not have closure plans, the development of closure plans should begin as soon as possible. If the facility was not planned and designed from the outset with closure in mind, then options for closure vision, principles, and objectives may be more limited, but it is none the less imperative that the Operator begins the process of planning for closure. The development of the closure plan may lead to changes in current practices or the adoption of newer technologies to reduce risk and better position the tailings facility for closure. Regular review of such opportunities is central to continual improvement for any tailings facility.

Designing and operating for closure requires a long-term view. Tailings facilities should be planned, designed, constructed, operated and closed on the assumption that they will be permanent landforms. Tailings facilities, designed for closure, are true future engineered landforms, intended to remain physically and chemically stable for the long-term. It is important to ensure that short-term financial or operational priorities do not prevail over better design and operational practices that would have lower long-term impacts, complexity or risks.

The development of the closure plan should be informed by a range of available references materials and tools including *ICMM Integrated Mine Closure: Good Practice Guide* (2019). In addition, it is important to have an established DBR. Through the DBR development process, the Design Team should identify information gaps to fill prior to finalising the closure detailed design. Closure plans typically evolve and should be viewed as living documents throughout the mining lifecycle.

3.7.3 Execution of Closure Plan

The execution of the closure plan can be a period of rapid change. It is vital to have established performance objectives and success criteria in order to establish metrics and achieve designated goals during the Closure phase when the plan is executed. It is important that the Operator continues to be diligent through this phase, and does not become complacent about tailings safety because tailings are no longer being produced and deposited in the tailings facility. In particular:

- Overall governance structures should remain in place, with accountability and responsibility appropriately assigned.
- Change management should remain robust as transitions occur in processes and personnel from the Operations phase to the Closure and Post-Closure phases.
- TMS continues to be implemented to the extent appliable and this is revised to reflect post-closure activities.
- Risk assessment should be updated for closure, and the risk management plan updated accordingly.
- OMS manual should be updated for closure and implemented to meet the requirements for the Closure and Post-Closure phases.
- Construction activities are carried out as per the closure plan, with adherence to design specifications and quality management requirements.
- Independent Review continues with a focus both on implementation of the closure plan and preparations for the Post-Closure phase.
- Community engagement continues.
- EPRP is updated to reflect closure conditions, including a potential change in the role of the Operator and third parties in responding to an emergency as the Operator's on-site resources change.

Figure 17 illustrates the key activities of the Closure phase of the lifecycle

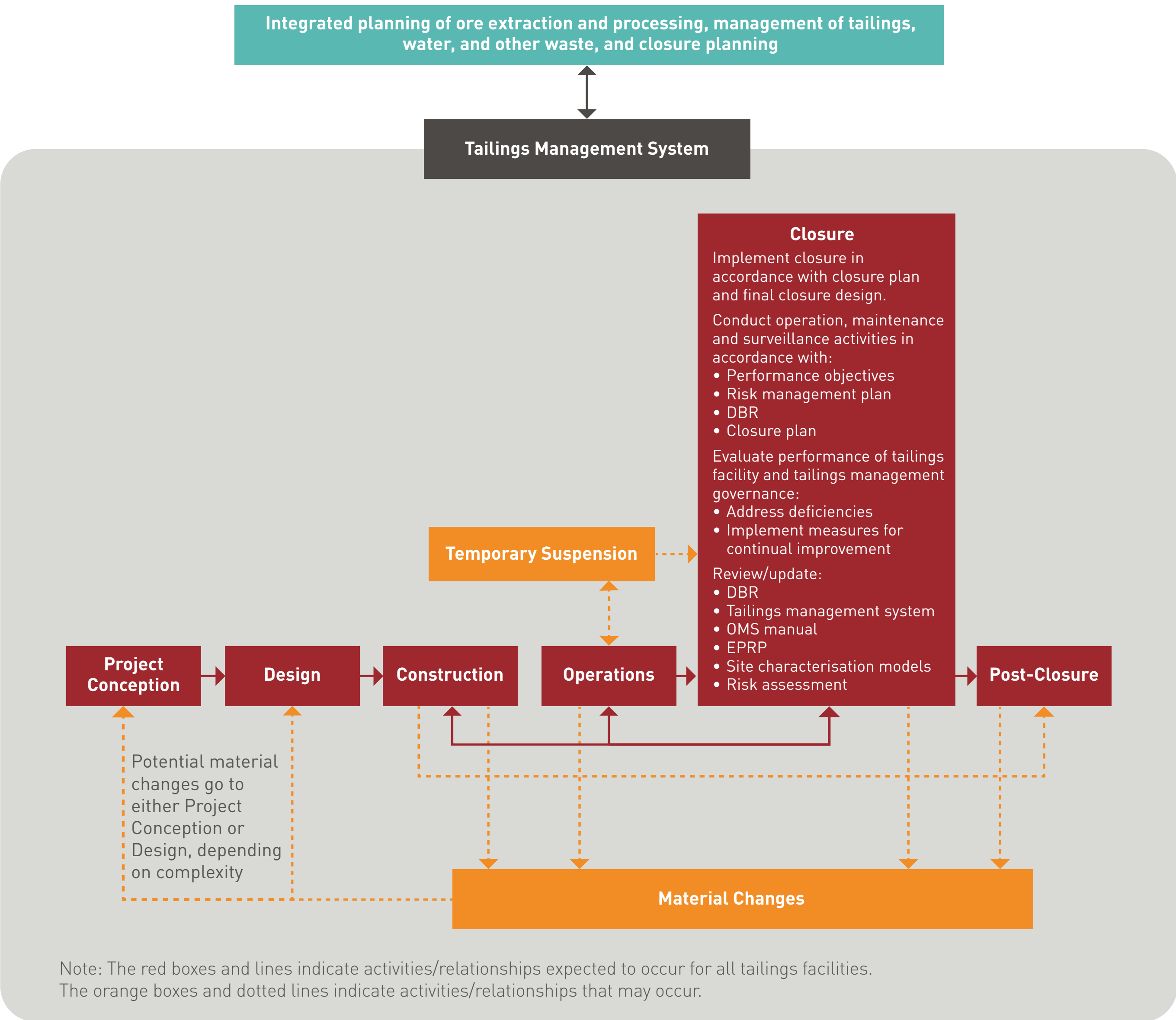

Figure 17: Key activities of the Closure phase of the lifecycle

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3.7.4 Post-Closure

In contrast to the Closure phase, the Post-Closure phase begins when the changes from the Closure phase have been fully implemented, and the facility enters a period of long-term maintenance and surveillance. Complacency remains a significant risk, however, since the consequences of a tailings facility failure may be the same as if the facility were still in the Operations or Closure phase. It is important that all stakeholders are engaged in and understand the Post-Closure phase objectives and success criteria. A tailings facility in the Post-Closure phase may require the same level of care as it did in earlier phases of the lifecycle. This can be a challenge, since the Operator will have few if any personnel on site at all times, and depending on the location there may be more limited access to a power supply, communication infrastructure, etc.

For the Post-Closure phase, the Operator should:

- Ensure a form of governance structure remains, with accountability and responsibility appropriately assigned (this may include a hand-over process of the Operator itself).
- Continue to implement the TMS, although the frequency of Identifying Actions to Improve Performance and reporting to the Accountable Executive may be decreased.
- Maintain the tailings facility site characterisation and knowledge base.
- Periodically update the risk assessment, particularly if there are changes in the facility performance or external changes that could impact the risk (eg increased population in the potential area of inundation).
- Update the risk management plan as appropriate.
- Update the OMS manual and review periodically through the Post-Closure phase and update as appropriate. There may be a greater role for community engagement in surveillance in the Post-Closure phase.
- Continue to conduct Independent Review, although the frequency can be reduced.
- Continue community engagement, although the frequency may be reduced once established success criteria have been achieved.

3.7 CLOSURE & POST-CLOSURE

Performance/success monitoring is needed to determine whether specific pre-set criteria are being met. The EPRP should be updated, in particular to reflect that the Operator may have a limited capacity for immediate response to an emergency, and emergency response may be much more reliant on third parties. The EPRP should also reflect changes in other resources available to respond to an emergency, such as a lack of heavy equipment, power supply, fuel or communication infrastructure. Continued testing of the EPRP is imperative.

Figure 18 illustrates the key activities of the Post-Closure phase of the lifecycle.

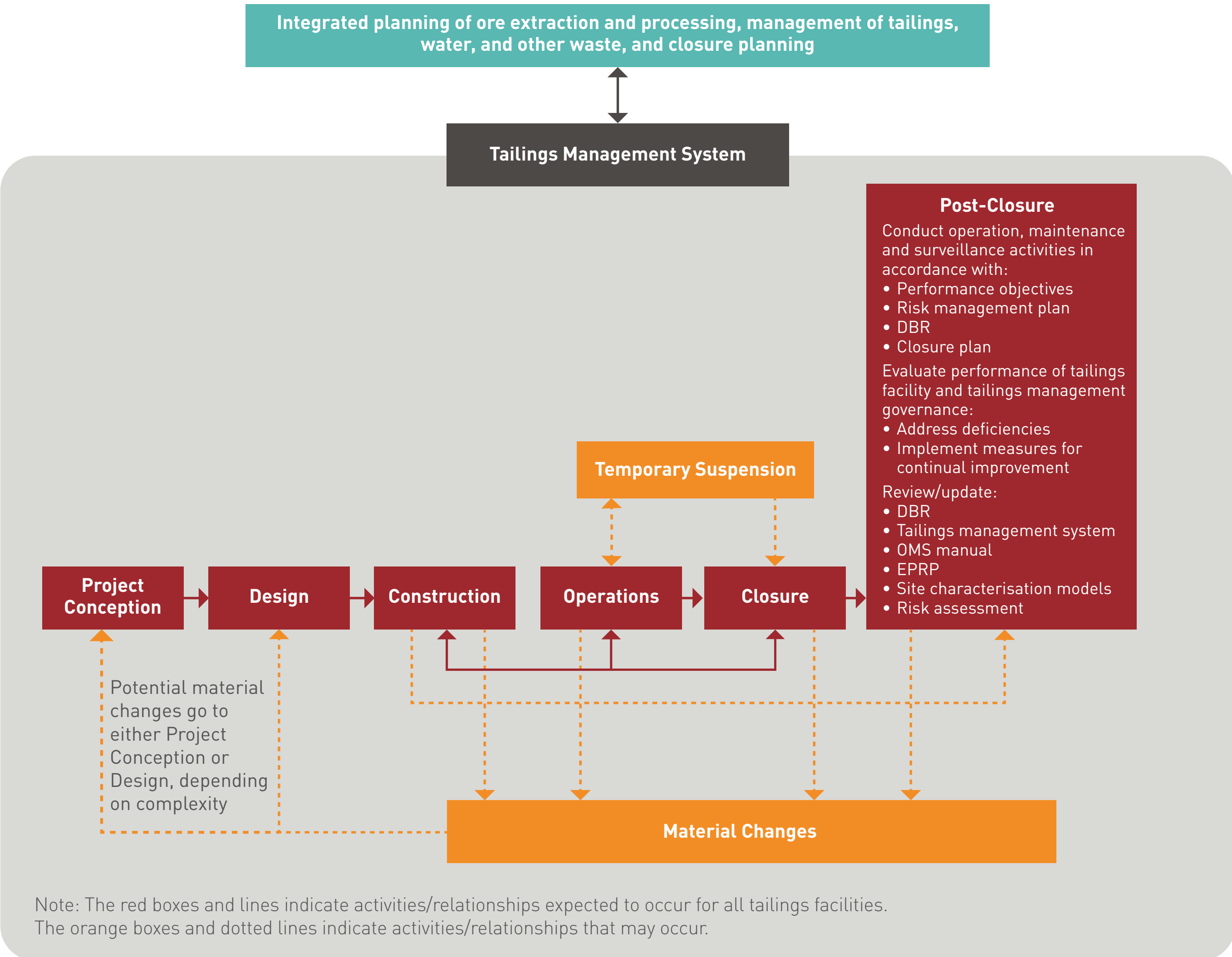

Figure 18: Key activities of the Post-Closure phase of the lifecycle

GLOSSARY

Accountability: The answerability of an individual for their own performance and that of any personnel they direct, and for the completion of specified deliverables or tasks in accordance with defined expectations. An accountable person may delegate responsibility for completion of the deliverable or task, but not the accountability.

Accountable Executive: One or more executive(s) who is/are directly answerable to the CEO on matters related to this Standard, communicates with the Board of Directors, and who is accountable for the safety of tailings facilities and for minimising the social and environmental consequences of a potential tailings facility failure. The Accountable Executive(s) may delegate responsibilities but not accountability. [based on the definition provided in the Standard]

As low as reasonably practicable (ALARP): ALARP requires that all reasonable measures be taken with respect to 'tolerable' or acceptable risks to reduce them even further until the cost and other impacts of additional risk reduction are grossly disproportionate to the benefit. [based on the definition provided in the Standard]

Authority: The power to make decisions, assign responsibilities, or delegate some or all authority, as appropriate. The ability to act on behalf of the Operator.

Board of Directors (BoD): The ultimate governing body of the Operator typically elected by the shareholders of the Operator. The BoD is the entity with the final decision-making authority for the Operator and holds the authority to, among other things, set the Operator's policies, objectives and overall direction as well as oversee the firm's executives. As the term is used here, it encompasses any individual or entity with control over the Operator, including, for example, the owner or owners. Where the State serves as the Operator, the BoD shall be understood to mean the government official with ultimate responsibility for the final decisions of the Operator. [based on the definition provided in the Standard]

Breach analysis: A study that assumes a failure of the tailings facility and estimates its impact. Breach analyses should be based on credible failure modes where loss of containment is possible. The results should determine the physical area impacted by a potential failure, flow arrival times, depth and velocities, duration of flooding, and depth of material deposition. The breach analysis is based on scenarios which are not connected to probability of occurrence. It is primarily used to inform emergency preparedness and response planning and for determining the potential consequences of failure. [based on the definition provided in the Standard]

Catastrophic failure: A tailings facility failure that results in material disruption to social, environmental and local economic systems. Such failures are a function of the interaction between hazard exposure, vulnerability, and the capacity of people and systems to respond. Catastrophic events typically involve numerous adverse impacts, at different scales and over different timeframes, including loss of life, damage to physical infrastructure or natural assets, and disruption to lives, livelihoods and social order. Operators may be affected by damage to assets, disruption to operations, financial loss or negative impact to reputation. Catastrophic failures exceed the capacity of affected people to cope using their own resources, triggering the need for outside assistance in emergency response, restoration and recovery efforts. [based on the definition provided in the Standard]

Community: A social group possessing shared beliefs and values, stable membership and the expectation of continued interaction. It may be defined geographically, by political or resource boundaries, or socially as a community of individuals with common interests.

Construction versus Design Intent Verification (CDIV): Intended to ensure the design intent is implemented and still being met if the site conditions vary from the design assumptions. The CDIV identifies any discrepancies between the field conditions and the design assumptions, such that the design can be adjusted to account for the actual field conditions. [based on the definition provided in the Standard]

Construction Records Report (CRR): Describes all aspects of the 'as-built' product, including all geometrical information, materials, laboratory and field test results, construction activities, schedule, equipment and procedures, quality control and quality assurance data, results of Construction versus Design Intent Verification (CDIV), changes to design or any aspect of construction, non-conformances and their resolution, construction photographs, construction shift reports, and any other relevant information. Instruments and their installation details, calibration records and readings must be included in the CRR. Roles, responsibilities and personnel, including Independent Review, should be documented. Detailed construction record drawings are fundamental. [based on the definition provided in the Standard]

Continual improvement: The process of implementing incremental improvements and standardisation to achieve better environmental and management system performance.

Credible failure mode/scenario: Refers to technically feasible failure mechanisms given the materials present in the structure and its foundation, the properties of these materials, the configuration of the structure, drainage conditions and surface water control at the tailings facility, throughout its lifecycle. Credible failure modes can and do typically vary during the lifecycle of the facility as the conditions vary. A tailings facility that is appropriately designed and operated considers all of these credible failure modes and includes sufficient resilience against each. Different failure modes will result in different failure scenarios. Some tailings facilities will have no credible failure modes. Further, even more tailings facilities will have no credible catastrophic failure modes. The term 'credible failure mode' is not associated with a probability of this event occurring and having credible failure modes is not a reflection of facility safety. The process of assessing credibility or non-credibility of failure modes for a given tailing facility should consider, among other factors such as construction and operations, whether the facility is designed to extreme external loads. [based on the definition provided in the Standard]

Critical controls: A control that is critical to preventing a potential undesirable event or mitigating the consequences of such an event. The absence or failure of a critical control would disproportionately increase the risk despite the existence of the other controls. [based on the definition provided in the Standard]

Dam Safety Review (DSR): A convention from the water dam industry to describe periodic and systematic process carried out by an independent qualified review engineer to assess and evaluate the safety of a dam or system of dams against failure modes, in order to make a statement on the safety of the facility. A safe tailings facility is one that performs its intended function under both normal and unusual conditions; does not impose an unacceptable risk to people, property or environment; and meets applicable safety criteria. An alternative approach that involves regular review of the entire facility though use of a programme for reviewing tailings safety as outlined in this Guide. [based on the definition provided in the Standard]

Design Basis Report (DBR): Provides the basis for the design, operation, construction, monitoring and risk management of a tailings facility. [based on the definition provided in the Standard]

Deviance Accountability Report (DAR): Provides an assessment of the cumulative impact of changes to the tailings facility on the risk level of the achieved product and defines the potential requirement for updates to the design, Design Basis Report (DBR), and operation, maintenance, and surveillance (OMS) activities. [based on the definition provided in the Standard]

Embankment: A term used to denote engineered structures designed and built to retain tailings solids and, where applicable, water. Constructed of tailings and/or other materials, embankments may include dams, dikes or other structures.

Emergency: A situation that poses an impending or immediate risk to health, life, property, and/or the environment, and which requires urgent intervention to prevent or limit the expected adverse outcomes.

Emergency Preparedness and Response Plan (EPRP): A site-specific plan developed to identify hazards, assess capacity, and prepare for an emergency based on tailings facility credible failure scenarios, and to respond if it occurs. This may be part of operation-wide emergency response planning and includes the identification of response capacity and any necessary coordination with off-site emergency responders, local communities and public sector agencies. The development of the EPRP includes a community-focused planning process to support the co-development and implementation of emergency response measures by those vulnerable to a tailings facility failure. [based on the definition provided in the Standard]

Engineer of Record (EOR): The qualified engineering firm responsible for confirming that the tailings facility is designed, constructed and decommissioned with appropriate concern for integrity of the facility, and that it aligns with and meets applicable regulations, statutes, guidelines, codes and standards. The EOR may delegate responsibility but not accountability. In some highly regulated jurisdictions, notably Japan, the role of EoR is undertaken by the responsible regulatory authorities. [based on the definition provided in the Standard]

Independent Review: Independent, objective, expert commentary, advice, and, potentially, recommendations to assist in identifying, understanding and managing risks associated with tailings facilities. This information is provided to the Operator to:

- Facilitate informed management decisions regarding tailings management so that tailings-related risks are managed responsibly and in accordance with an acceptable standard of care.
- Ensure that the Accountable Executive has a third-party opinion regarding the risks and the state of the tailings facility and the implementation of the TMS, independent of the teams (employees, consultants and contractors) responsible for planning, designing, constructing, operating and maintaining the facility.

Legal requirement: Any law, statute, ordinance, decree, requirement, order, judgement, rule or regulation of, and the terms of any license or permit issued by, any governmental authority.

Lifecycle: The series of activities or phases in the life of a tailings facility, consisting of: Project Conception, Design, Construction, Operations, Closure and Post-Closure. At some sites, the lifecycle may also include temporary suspension of mine operations. Some phases, such as Operations, Closure and Post-Closure, typically only occur once in the lifecycle of a tailings facility, while other activities, such as Project Conception, Design and Construction, may be recurring at different periods through the life of a tailings facility.

Project Conception: A recurring lifecycle activity that is the first step in the planning and design for:

- Construction and Operations phases of new tailings facilities.
- Closure and Post-Closure phases of tailings facilities.
- Any material changes to the design or operation of tailings facilities.
- Re-commissioning of an existing tailings facility for a mine re-opening.

Project Conception consists of the analysis of a range of alternatives (eg location of a new tailings facility, technologies to be applied).

Design: A recurring lifecycle activity that builds upon the decisions made in the Project Conception phase. Once a preferred alternative has been selected, all aspects of that alternative are designed in detail, based on the design intent and defined performance objectives.

Construction: A recurring lifecycle activity that includes:

- Initial construction prior to the start-up of a new tailings facility (eg starter embankment, tailings lines).
- Ongoing construction through the operating life of the mine to increase the capacity of the tailings facility (eg facility raises).

Construction may also include:

- Construction for any material changes (eg increase capacity beyond original design intent, buttress to strengthen a tailings facility).
- Construction during the Closure phase (eg installation of covers).

Operations: The period in the lifecycle when tailings are transported to, and deposited in, the tailings facility, inclusive of any periods of inactivity prior to the commencement of implementation of the closure plan. Construction may be ongoing or periodic throughout the Operations phase. In addition, progressive reclamation in preparation for closure and consistent with the closure plan may occur during the Operations phase. In some cases, after the end of the active deposition of tailings, tailings may be removed from the tailings facility for reprocessing or other uses. Such activity would also be considered Operations.

Temporary suspension of mine operations: A period of time when mine operations have been suspended and tailings are not being deposited into the facility. The suspension may be short-term (eg temporary suspension due to wildfires, labour disruption) or of a longer, indeterminant duration (eg due to low commodity prices).

During temporary suspension, maintenance and surveillance continue and some operation activities (eg active water management) may also continue. The closure plan is not implemented. However, temporary suspension may lead to closure in some cases.

Closure: This lifecycle phase begins when deposition of tailings into the tailings facility ceases permanently and the closure plan is implemented, including:

- Transitioning from the Operations phase to the Closure phase and the Post-Closure phase.
- Removal of infrastructure such as pipelines.
- Changes to water management or treatment.
- Construction of covers, recontouring or revegetation of tailings and any embankments or other structural elements.
- Other reclamation and decommissioning activities

Post-Closure: This lifecycle phase begins when the closure plan has been implemented and the tailings facility has transitioned to long-term maintenance and surveillance. The Post-Closure phase should recognise all the aspects of safety and environmental compliance related to long-term stability and legal requirements.

During the Closure or Post-Closure phases, tailings facilities could return to the Operations phase. In addition, tailings could be removed for reprocessing to recover additional commodities of value, or to be used for other purposes (eg construction material).

In some jurisdictions, during the Post-Closure phase, responsibility for a tailings facility may transfer from the Operator to jurisdictional control.

Maintenance: Includes preventative, predictive and corrective activities carried out to provide continued proper operation of all infrastructure (eg civil, mechanical, electrical, instrumentation, etc), or to adjust infrastructure to ensure operation in conformance with performance objectives.

Material change: A change to the design or operation of a tailings facility, proposed or made after the design for initial construction has been finalised and initial construction has commenced. A material change would be a change important enough to merit attention, such as a change that has the potential to influence the risk or performance of a tailings facility. The criteria for what would constitute a material change should be defined by the Operator, with input from the EOR and Independent Review.

Management system: Processes and procedures that collectively provide a systematic framework for ensuring that tasks are performed correctly, consistently and effectively to achieve a specified outcome and to drive continual improvement in performance. A systems approach to management requires an assessment of what needs to be done, planning to achieve the objective, implementation of the plan, and review of performance in meeting the set objective. A management system also considers necessary personnel, resources and documentation requirements. Other definitions associated with management systems are:

Policy: The expression of management's commitment to a particular issue area that presents the stance of the company to interested external parties.

Practice: Documented approaches to carrying out a task.

Procedure: A documented description of how a task is to be carried out.

Observational method: A continuous, managed, integrated, process of design, construction control, monitoring and review that enables previously defined modifications to be incorporated during or after construction as appropriate. All of these aspects must be demonstrably robust. The key element of the observational method is the proactive assessment at the design stage of every possible unfavourable situation that might be disclosed by the monitoring programme and the development of an action plan or mitigative measure to reduce risk in case the unfavourable situation is observed. This element forms the basis of a performance-based risk management approach. The objective is to achieve greater overall safety. See Peck, R.B. (1969), 'Advantages and Limitations of the observational method in Applied Soil Mechanics', Geotechnique 19(2), pp.171–187. [based on the definition provided in the Standard]

Operation: Includes activities related to the transport, placement and permanent storage of tailings and, where applicable, process water, effluents and residues, and the recycling of process water, inclusive of any periods of inactivity prior to commencement of implementation of the closure plan. The term 'operation' applies throughout all phases of the lifecycle of a tailings facility and is not limited to the Operations phase of the lifecycle when tailings are being actively placed in the facility. As a result, operation also includes reclamation and related activities.

Operator: An entity that singly, or jointly with other entities, exercises ultimate control of a tailings facility. This may include a corporation, partnership, owner, affiliate, subsidiary, joint venture or other entity, including any State agency, that controls a tailings facility. [based on the definition provided in the Standard]

Performance: There are three key terms related to performance, defined as follows:

Performance objectives are overall goals, arising from the Operator's policy and commitment, which are quantified where practicable. They may be defined at various levels of detail such as this tailings facility will not experience a catastrophic failure versus deformation of the embankment will be minimised.

Performance indicators are detailed performance requirements that arise from the performance objectives and that need to be established and met in order to achieve those objectives. Performance indicators must be measurable and quantifiable.

Performance criteria are established based on expected or predicted performance and are used to evaluate performance indicators and define limits of performance outside which risk management action needs to be taken.

Personnel: Includes employees, contractors and consultants (eg designer, Engineer-of-Record) and includes those with direct responsibilities for tailings management as well as those with indirect responsibilities whose roles may be related in some manner to tailings management (eg heavy equipment operators working on or adjacent to tailings facilities).

Quality: The degree to which a set of inherent characteristics fulfils requirement.

Quality assurance (QA): All those planned and systematic activities implemented to provide adequate confidence that the entity will fulfil requirements for quality.

Quality control (QC): The operational techniques and activities that are used to fulfil requirements for quality.

Responsibility: The duty or obligation of an individual or organisation to perform an assigned duty or task in accordance with defined expectations, and which has a consequence if expectations are not met. An individual or organisation with responsibility is accountable to the person that delegated that responsibility to them.

Responsible Tailings Facility Engineer (RTFE): An engineer appointed by the Operator to be responsible for the tailings facility. The RTFE must be available at all times during the Construction, Operations and Closure phases of the lifecycle. The RTFE has clearly defined, delegated responsibility for management of the tailings facility and has appropriate qualifications and experience compatible with the level of complexity of the tailings facility. The RTFE is responsible for the scope of work and budget requirements for the tailings facility, including risk management. The RTFE may delegate specific tasks and responsibilities for aspects of tailings management to qualified personnel but not accountability. [based on the definition provided in the Standard]

Risk: A potential negative impact, detrimental to operations, a facility, the environment, public health, or safety, that may arise from some present process or future event. When evaluating risk, both the potential severity and consequence of the impact and its probability of occurrence are considered.

Risk controls: Measures put in place to either:

- Prevent or reduce the likelihood of the occurrence of an unwanted event; or
- Minimise or mitigate the negative consequences if the unwanted event does occur.

Risks need to be managed via controls, and risk controls should have designated owners and defined accountabilities. Some risk controls are designated as critical controls.

Stakeholders: Persons or groups who are directly or indirectly affected by a project, as well as those who may have interests in a project and/or the ability to influence its outcome, positively or negatively. Stakeholders may include workers, trade unions, project-affected people or communities and their formal and informal representatives, national or local government authorities, politicians, religious leaders, civil society organisations and groups with special interests, the academic community, or other businesses. Different stakeholders will often have divergent views, both within and across stakeholder groupings. [based on the definition provided in the Standard]

Surveillance: Includes the inspection and monitoring (ie collection of qualitative and quantitative observations and data) of activities and infrastructure related to tailings management. Surveillance also includes the timely documentation, analysis and communication of surveillance results, to inform decision-making and verify whether performance objectives and risk management objectives, including critical controls, are being met.

Tailings: A by-product of mining, consisting of the processed rock or soil left over from the separation of the commodities of value from the rock or soil within which they occur.

Tailings facility: A facility that is designed and managed to contain the tailings produced by a mine. A tailings facility includes the collective engineered structures, components and equipment involved in the management of tailings solids, other mine waste managed with tailings (eg waste rock, water treatment residues), and any water managed in tailings facilities, including pore fluid, any pond(s), and surface water and run-off.

Tailings management system (TMS): The site-specific TMS comprises the key components for management and design of the tailings facility and is often referred to as the 'framework' that manages these components. The TMS sits at the core of the Standard and is focused on the safe operation and management of the tailings facility throughout its lifecycle (see above). The TMS follows the well-established Plan-Do-Check-Act cycle. Each Operator develops a TMS that best suits their organisation and tailings facilities. A TMS includes elements such as: establishing policies, planning, designing and establishing performance objectives, managing change, identifying and securing adequate resources (experienced and/or qualified personnel, equipment, scheduling, data, documentation and financial resources), conducting performance evaluations and risk assessments, establishing and implementing controls for risk management, auditing and reviewing for continual improvement, implementing a management system with clear accountabilities and responsibilities, preparing and implementing operation, maintenance and surveillance (OMS) activities and the emergency preparedness and response plan (EPRP). The TMS, and its various elements, must interact with other systems, such as the environmental and social management system (ESMS), the operation-wide management system, and the regulatory system. This systems interaction is fundamental to the effective implementation of the Standard. [based on the definition provided in the Standard]

Technical: In this Guide, the term 'technical' refers to the physical science and engineering aspects of tailings management.

Trigger Action Response Plan (TARP): A TARP is a tool to manage risk controls, including critical controls. TARPs provide pre-defined trigger levels for performance criteria that are based on the risk controls and critical controls of the tailings facility. The trigger levels are developed based on the performance objectives and risk management plan for the tailings facility. TARPs describe actions to be taken if trigger levels are exceeded (performance is outside the normal range), to prevent a loss of control. A range of actions is pre-defined, based on the magnitude of the exceedance of the trigger level. [based on the definition provided in the Standard]

LIST OF ACRONYMS

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ALAR: As low as reasonably practicable

BoD: Board of Directors

CRR: Construction Records Report

CDIV: Construction versus Design Intent Verification

CEO: Chief Executive Officer

DAR: Deviance Accountability Report

DBR: Design Basis Report

DSR: Dam Safety Review

EOR: Engineer of Record

EPRP: Emergency Preparedness and Response Plan

ESMS: Environmental and Social Management System

FoS: Factor of Safety

ICMM: International Council on Mining and Metals

ITRB: Independent Tailings Review Board

ISO: International Organization for Standardization

MAA: Multiple Accounts Analysis

MAC: Mining Association of Canada

MCE: Maximum Credible Earthquake

MDE: Maximum Design Earthquake

MDF: Maximum Design Flood

OMS: Operation, maintenance and surveillance

PMF: Probably Maximum Flood

PSHA: Probabilistic Seismic Hazard Analysis

QA: Quality assurance

QC: Quality control

RTFE: Responsible Tailings Facility Engineer

SOP : Standard operating procedure

TARP: Trigger Action Response Plan

TMS: Tailings Management System

ICMM is an international organisation dedicated to a safe, fair, and sustainable mining and metals industry. Bringing together 28 companies – and over 35 regional, national, and commodities associations – we support mining with principles to sustainably manage the natural resources of our planet, and enhance the wellbeing of local communities.

ICMM
International Council on Mining & Metals

35/38 Portman Sq.
London W1H 6LR
United Kingdom
+44 (0) 20 7467 5070
info@icmm.com
www.icmm.com

Follow us:
@ICMM_com

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