A Guide to the

Management of Tailings Facilities

VERSION 3.2

The Mining Association of Canada

A Guide to the

Management of Tailings Facilities

VERSION 3.2

Version date: March 2021

NOTICE TO READERS:

The electronic version of this document has enhanced features to improve the usability of the document:

- hyperlinks to external websites and documents;
- hyperlinks to other sections of the document; and
- pop-up boxes with definitions of key terms that appear when the cursor passes over them.

Please note that the pop-up boxes are not functional in the current (2021) Adobe Reader apps for iPad and iPhone, so they will not appear. Additionally, if the document is previewed as an email attachment using the Apple Mail app, the pop-ups will be visible at all times, blocking portions of the text. If using an Apple mobile device, we recommend opening the document in the Adobe Reader app, or using the Apple-friendly version available at "*http://www.mining.ca/tailings-guide*".

The Mining Association of Canada

CHANGES IN VERSION 3.1

Version 3.1 is an update to the third edition of *A Guide to the Management of Tailings Facilities* (the Tailings Guide), released in November 2017, to reflect the second edition of MAC's ***Developing an Operation, Maintenance, and Surveillance Manual for Tailings and Water Management Facilities*** (the OMS Guide), released at the same time as Version 3.1 of the Tailings Guide.

The most significant change is a re-write of ***Section 5.2*** Emergency Preparedness. This section now provides more detailed guidance for the preparation of emergency response plans and emergency preparedness plans.

Other changes include:

- alignment of terminology and definitions with the second edition of the OMS Guide;
- clarifying the definition of an Accountable Executive Officer;
- affirming that the scope of both Performance Evaluation (***Section 6***) and Management Review for Continual Improvement (***Section 7***) includes the site-specific tailings management system, emergency response plan, emergency preparedness plan, and the OMS manual;
- addition of guidance on post-incident analyses in ***Section 6*** Performance Evaluation;
- addition of text to clarify the difference between the checklist tool described in Section 5.3, and the ***Table of Conformance*** developed by MAC as a tool to assess performance against the Indicators described in the ***TSM® Tailings Management Protocol***; and
- minor editorial corrections.

CHANGES IN VERSION 3.2

Version 3.2 is an update to the third edition of *A Guide to the Management of Tailings Facilities* (the Tailings Guide). Updates were undertaken following the 2020 release of the ***Global Industry Standard on Tailings Management*** (the Standard) to improve alignment between the tailings management component of MAC's ***Towards Sustainable Mining® (TSM®)*** program and the Standard.

The most significant changes are:

- Expanding on aspects to be considered in developing a corporate policy and/or commitment.
- Increasing the level of detail of descriptions of the roles and responsibilities of the Accountable Executive Officer and Responsible Person.
- Expanding on aspects to be addressed in a management review for continual improvement.
- Adding new text and a supporting appendix on information requirements related to:
  - Site characterization
  - Design information
  - Documentation on construction and as-built conditions
  - Closure plan
- Replacing the checklist tool with the ***Table of Conformance*** as a tool for gap analysis.

In addition, text on control of documented information was moved from the OMS Guide to the Tailings Guide, and some text from the OMS Guide on communications was moved to the Tailings Guide to consolidate discussion on this topic.

Foreword

It is with pleasure that I present, on behalf of the Mining Association of Canada (MAC), the third edition of the *Guide to the Management of Tailings Facilities* (the Tailings Guide).

The first edition of MAC's Tailings Guide was released in 1998. At the time, it was one of the industry's first and most comprehensive management guides specific to tailings. Use beyond Canada led to this Guide being made available in Spanish and Portuguese, in addition to French and English.

MAC subsequently launched the *Towards Sustainable Mining® (TSM®)* initiative in 2004, and the Tailings Guide was integrated with the ***TSM Tailings Management Protocol***, which includes performance indicators for tailings management. An updated second edition of the Tailings Guide was released in 2011. The Tailings Guide is also accompanied by MAC's ***Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities*** (the OMS Guide), first released in 2003 and then revised in 2011.

Application of *TSM* is mandatory for MAC members for their operations in Canada. However, the Tailings Guide and the OMS Guide are designed to be stand-alone documents that can be applied by MAC members and non-MAC members alike, anywhere in the world. Exporting our expertise in sustainable and responsible mining practices, including for tailings management, is one important way that MAC and its members are contributing to improving mining performance globally.

Following the 2014 tailings failure at the Mount Polley Mine in British Columbia, MAC launched comprehensive external and internal reviews of the *TSM Tailings Management Protocol*, Tailings Guide, and OMS Guide. The external review was conducted by an Independent Task Force, and MAC's Tailings Working Group led the internal review. The Independent Task Force issued its report containing 29 recommendations in November 2015, which informed the work of the Tailings Working Group.

These reviews confirmed the strength and benefit of the management systems approach in the Tailings Guide, and made recommendations for further improvements. The recommendations of these reviews were highly convergent and complementary, and provided the basis for updating and strengthening the Tailings Guide.

The third edition of the Tailings Guide is another step in the continual improvement process for tailings management, moving towards the goal of minimizing harm: zero catastrophic failures of tailings facilities, and no significant adverse effects on the environment and human health.

We owe a debt of gratitude to the members of the Independent Task Force and MAC's Tailings Working Group who, together, have brought tremendous skill, dedication and enthusiasm to their important work. I trust that MAC members and others will find these improvements a useful contribution to strengthening tailings management in Canada and abroad.

Pierre Gratton

President & CEO

The Mining Association of Canada

Preface

First Edition of the Tailings Guide

The first edition of MAC's *Guide to the Management of Tailings Facilities*, released in 1998, was developed in response to a series of international **tailings**-related incidents that occurred in the 1990s. The purpose of the first edition was threefold:

- to provide information on the safe and environmentally responsible management of **tailings facilities**;
- to help companies develop tailings management systems that include environmental and safety criteria; and
- to improve the consistency of application of sound engineering and management principles to tailings facilities.

The first edition reflected sound management practices already in place at that time. It adopted principles and approaches from sources that included mining company manuals, proceedings of two MAC workshops, the MAC *Environmental Policy and Environmental Management Framework*, the ISO 14000 standards related to environmental management, the Canadian Dam Association's draft *Dam Safety Guidelines* (1997), and international guidelines and standards.

Building on the implementation of the Tailings Guide and lessons learned, MAC introduced a companion document in 2003: *Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities* (the OMS Guide). This guide focuses on the need for a site-specific operation, maintenance and surveillance (OMS) manual as an integral component of an overall tailings management system. Such a document can help companies comply with legal requirements and corporate policy, demonstrate voluntary self-regulation and due diligence, practice continual improvement, and protect employees, the environment and the public.

Introduction of MAC's *Towards Sustainable Mining*® Initiative

In 2004, MAC established the *Towards Sustainable Mining® (TSM®)* initiative. The objective of *TSM* is to enable mining companies to meet society's needs for minerals, metals and energy products in the most socially, economically and environmentally responsible way.

TSM is an award-winning performance system that helps mining companies evaluate and manage their environmental and social responsibilities. It is a set of tools and indicators to drive performance and ensure that key mining **risks** are managed effectively by mining operations. Mining companies that participate in the *TSM* initiative demonstrate their strong commitment to responsible mining. Adhering to the *TSM Guiding Principles*, mining companies exhibit leadership by:

- engaging with communities;
- driving world-leading environmental practices; and
- committing to the safety and health of employees and surrounding communities.

The key strengths of *TSM* are that:

- performance is measured primarily at the facility-level, and results are externally verified and publicly reported;
- implementation of the program is monitored by an external Community of Interest Advisory Panel; and
- the program encourages continual performance improvement.

Tailings management is a core component of *TSM*. Performance indicators for tailings management are described in the *TSM Tailings Management Protocol*. The Protocol refers to, and is supported by, the Tailings Guide and the OMS Guide. The tailings management component of *TSM* provides a strong and consistent message to tailings facility owners, operators and contractors: the key to safe and environmentally responsible management of tailings is the consistent application of sound engineering capability within an effective management system and throughout the full **life cycle** of a facility.

Second Edition of the Tailings Guide

In 2011, the second edition of the Tailings Guide was released. This edition reflected information and experience gained through the course of developing and implementing the tailings management component of *TSM*, and working with tailings management systems around the world.

The second edition provided alignment with *TSM* principles and terminology, as well as with the OMS Guide. The scope of application was broadened slightly compared to the first edition, and the second edition expanded on some concepts described in the first edition, and introduced some new concepts. The second edition retained a strong focus on a management systems approach, and reduced the level of technical detail compared to the first edition.

Third Edition of the Tailings Guide

In August 2014, a tailings dam foundation failure occurred at the Mount Polley Mine in British Columbia. Soon after this incident, the MAC Board of Directors initiated a review of the tailings management component of *TSM*. The key question was whether there were any improvements to the tailings management component of *TSM* that could be made to prevent such an event from happening again.

This review, formally launched in March 2015, consisted of two parts:

- an external review by an Independent Tailings Review Task Force established by the MAC Board of Directors; and
- internal analysis by the MAC Tailings Working Group, which had developed the previous editions of the Tailings Guide as well as the OMS Guide.

The Task Force was broad-based, and its seven members represented a variety of expertise and interests:

- specialists in engineering and geotechnical issues;
- First Nations representatives;
- environmental specialists; and
- individuals with experience in executive management.

The Independent Task Force's review focused primarily on the *TSM Tailings Management Protocol*, but also considered the Tailings Guide and the OMS Guide. The ***Report of the Towards Sustainable Mining Tailings Review Task Force*** was presented to the MAC Board of Directors in November 2015 and included 29 recommendations. Of these recommendations, five related to the Tailings Guide:

- Amend the Tailings Guide to require an independent review of site investigation and selection, design, construction, operation, closure, and post-closure of tailings facilities;
- Evaluate how best to include in the Tailings Guide assessment and selection of both Best Available Technology (BAT) and Best Applicable Practices (BAP) for tailings management;
- Develop and include definitions and/or guidance related to managing a change of Engineer-of-Record and a change of ownership in the change management section;
- Include a risk-based ranking classification system for non-conformances and have corresponding consequences. Guidance on risk assessment methodology should be included; and
- Include more specific technical guidance related to site selection and design, including how to select objectives and set design criteria.

Upon receiving the Task Force's report, the MAC Board of Directors committed to expeditiously identify how to best integrate the recommendations into *TSM* for implementation. The Board Chair stated that "it is imperative that the industry continuously improves how it works to ensure the safe operation of its tailings facilities."

The Tailings Working Group, consisting of MAC members and associate members, and representing a wide range of expertise related to tailings management, developed a suite of recommendations that were highly convergent with and complementary to those of the Task Force.

Once both internal and external reviews were complete, the Tailings Working Group began revising the Tailings Guide, leading to the third edition of the Guide. The *TSM Tailings Management Protocol* was also updated and revised to respond to the Task Force's recommendations.

The third edition of the Tailings Guide retains the second edition's strong emphasis on management systems. However, it has an increased emphasis on technical aspects, especially those critical to the physical and chemical stability of tailings facilities. The third edition also strengthens key concepts that were described in previous editions, and introduces others, including:

Risk-Based Approach: managing tailings facilities in a manner commensurate with the physical and chemical risks they may pose. Managing risk includes:

- regular, rigorous risk assessment;
- application of most appropriate technology to manage risks on a site-specific basis (**BAT**);
- application of industry best practices to manage risk and achieve performance objective (**BAP**); and
- use of rigorous, transparent decision-making tools to select most appropriate site-specific combination of BAT and location for a tailings facility.

Critical Controls: a risk control that is crucial to preventing a high-consequence event or mitigating the consequences of such an event. The absence or failure of a critical control would significantly increase the risk despite the existence of other controls.

Engineer-of-Record: The **Owner**, in assuring that a tailings facility is safe, has the responsibility to identify and retain an EoR, who provides technical direction on behalf of the Owner. The EoR verifies whether the tailings facility (or components thereof) has been:

- Designed in accordance with performance objectives and indicators, applicable guidelines, standards and legal requirements; and
- Constructed, and is performing, throughout the life cycle, in accordance with the design intent, performance objectives and indicators, applicable guidelines, standards and legal requirements.

Independent Review: independent evaluation of all aspects of the planning, design, construction, operation, maintenance of a tailings facility by competent, objective, third-party reviewer on behalf of the Owner.

The third edition also updates the tailings management framework presented in the Tailings Guide as a key tool to help in the implementation of site-specific tailings management systems. Descriptions of the elements of the framework have been strengthened and clarified, and the framework is more aligned with the *ISO 14001 Environmental Management System* standard.

In addition to strengthened technical guidance throughout the body of the Tailings Guide, the third edition provides further guidance in appendices on:

- Risk management framework and approach;
- Integration of BAT and BAP;
- Assessment of alternatives;
- Integration of Independent Review;
- Considerations for managing throughout the life cycle of a tailings facility;
- Technical considerations;
  - Tailings transportation and placement plans;
  - Water management plans; and
  - Closure plans.

The third edition of the Tailings Guide is another step in the continual improvement process for tailings management, moving towards the goal of minimizing harm: zero catastrophic failures of tailings facilities, and no significant adverse effects on the environment or human health. The Tailings Guide; however, is but a roadmap on this journey – to succeed, it is incumbent on MAC members and the mining industry as a whole to achieve effective implementation of the principles embodied in the Tailings Guide.

Table of Contents

1 Introduction

This Tailings Guide provides guidance on best practices for the safe, and environmentally and socially responsible management of tailings facilities. Its purpose is threefold:

- to provide a framework for the management of tailings facilities;
- to help Owners of tailings facilities develop tailings management systems that include environmental and safety criteria; and
- to improve the consistency of application of reasonable and prudent engineering and management principles to tailings facilities.

Reference to a tailings management system does not imply the need for separate documentation specific to a management system for tailings. The tailings management system can be incorporated into broader site management systems. It is up to the Owner to decide how best to organize and integrate relevant information.

Tailings are a byproduct 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 and any associated water must be responsibly managed. Responsible management includes the prevention of impacts to human health and safety, the environment, and infrastructure. Tailings are managed in engineered facilities that are planned, designed, constructed, operated, closed and maintained in the long-term post-closure period (i.e., throughout the facility **life cycle**) in a manner consistent with the need for responsible management. Responsible management is defined by comprehensive assessments of the **risks** associated with a tailings facility, both physical and chemical, that evaluate the potential health, safety, environmental, societal, business, economic and regulatory impacts, and the implementation of appropriate controls to effectively manage those risks.

Tailings facility: The collective engineered structures, components and equipment involved in the management of tailings solids, other mine waste managed with tailings (e.g., waste rock, water treatment residues), and any water managed in tailings facilities, including pore fluid, any pond(s), and surface water and runoff. This may include structures, components and equipment for:

- classification of tailings through water content management (e.g., cyclones, thickeners, filter presses);
- transporting tailings to the tailings facility (e.g., pipelines, flumes, conveyors, trucks);
- containment of tailings and associated water (e.g., dams, dykes, stacks, liner systems, cover systems);
- management of seepage (e.g., underdrains, collection ponds, pumping wells);
- water reclaim systems (e.g., pumping to the ore processing facility);
- management of surface water releases from the tailings facility (e.g., diversions, decant structures, spillways, outlets, flumes, water treatment);
- structures, components and equipment for the surveillance and maintenance of tailings facilities; and
- mechanical and electrical controls, and power supply associated with the above.

Owner is the company, partnership, or individual who has legal possession or is the legal holder of a tailings facility under law in the applicable jurisdiction where the facility is located. For example, the company, partnership or individual that owns the mine or ore processing facility from which tailings and water are generated is the owner of those tailings and can be considered the Owner of the tailings facility.

Each tailings facility is unique, reflecting site-specific environmental and physical characteristics that contribute to shaping the most appropriate approach to performance and risk management for that facility. The mining industry has the technology, experience and resources to locate, plan, design, construct, operate, decommission and close tailings facilities in a safe and environmentally responsible manner, and there remain opportunities to continually review and improve all aspects of tailings management.

The mining industry is accountable and responsible for managing tailings. This responsibility requires the development and implementation of a management system for effective decision making to integrate technical, legal, societal, and business requirements. An essential component of effective tailings management is the implementation of a tailings management system – one that embodies the elements of responsible tailings management. This Tailings Guide details a tailings management framework which provides the basis for Owners to implement a site-specific tailings management system. Elements of this framework are:

- Policy and commitment;
- Planning;
- Implementing the tailings management framework;
- Performance evaluation; and
- Management review for continual improvement.

A management system describes the set of procedures an organization needs to follow in order to meet its objectives. (International Standards Organization)

The intent of this Tailings Guide is to facilitate the development and implementation of facility-specific tailings management systems that address the specific needs of individual Owners and tailings facilities. Development and implementation of the tailings management system takes into account legal requirements and community expectations. The tailings management framework provides a foundation for managing tailings in a safe, and environmentally and socially responsible manner throughout the full life cycle of a tailings facility.

This third edition of the Tailings Guide is the result of a review of the current state of science regarding tailings management, incorporating current international best practice. The review has led to the strengthening of key concepts that were described in the previous editions, and introduces others, including:

Risk-Based Approach: an integral component of a tailings management system, with the goal of managing tailings facilities in a manner commensurate with the presence and magnitude of the physical and chemical risks that they may pose across the entire life cycle, including **closure**, and **post-closure**. Managing and mitigating risk includes:

- identification of potential risks at the **project conception and planning** phase of the life cycle, and rigorous risk assessment early in the life cycle, and updated periodically throughout the life cycle;

- the application of the most appropriate technology to manage risks on a site-specific basis (**Best Available Technology – BAT**);
- the application of industry best practices to manage risk and achieve performance objectives in a technically and economically efficient manner (**Best Available/Applicable Practices – BAP**); and
- the use of rigorous, transparent decision-making tools to select a site-specific combination of BAT and location for a tailings facility.

Critical Controls: a risk control that is crucial to preventing a high-consequence event or mitigating the consequences of such an event. The absence or failure of a critical control would significantly increase the risk despite the existence of other controls.

Engineer-of-Record: The Owner, in assuring that a tailings facility is safe, has the responsibility to identify and retain an EoR, who provides technical direction on behalf of the Owner. The EoR verifies whether the tailings facility (or components thereof) has been:

- designed in accordance with performance objectives and indicators, applicable guidelines, standards and legal requirements; and
- constructed, and is performing, throughout the life cycle, in accordance with the design intent, performance objectives and indicators, applicable guidelines, standards and legal requirements.

Potential **consequences** of unwanted events associated with tailings facilities may include impacts on the environment, human health and safety, infrastructure, financial and legal implications, and reputational impacts. Thus, the scope of potential consequences to be managed is broader than those typically defined in consequence classification systems, such as that of the *Canadian Dam Association's Dam Safety Guidelines (2013 edition).*

Independent Review: systematic evaluation of all technical, management and governance aspects of a tailings facility across the life cycle by competent, objective, third-party reviewer(s). Provides assurance that the tailings facility's management system is effective across the life cycle.

Continual improvement is the process of implementing incremental improvements and standardization to achieve better environmental and management system performance.

Mining companies and their associated projects and operations typically have management systems and frameworks in place. Integrating tailings management into these systems is part of the continual review and improvement of the system. The relevant procedures, activities and controls for managing tailings facilities should be appropriately assigned across personnel, departments, and business units and be scalable, depending on the nature of both the facility and its Owner. Periodic review of the efficiency and effectiveness of management systems will assist in meeting the objectives of responsible planning, design, construction, operation and eventual closure of tailings facilities.

From the initial phases of project conception and planning through to post-closure, a tailings management system should be in place to address and integrate risk management, legal requirements, technical, management, and governance aspects of tailings facilities. The integration of the technical and management components associated with tailings facilities is core to responsible management of tailings facilities and maintaining social acceptance in the mining industry. Owners of tailings facilities may adapt and implement the tailings management framework to meet their site-specific needs. Implementation of a tailings management system using this framework is intended to help Owners integrate environmental and safety considerations in a manner that is consistent with continual improvement in their tailings management and, in doing so, meet societal expectations.

Also important to effective implementation of a site-specific tailings management system is engagement with Communities of Interest (COI). Such engagement is two-way, providing the COI with opportunity to ask questions about tailings management, provide information, and express their concerns. It is also an opportunity for the Owner to respond to proactively provide information, and address concerns and questions as they arise.

The Tailings Guide should be used in concert with MAC's *Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities* (the OMS Guide). Developing and implementing a site-specific OMS manual is essential to implementing a tailings management system. The tailings management system provides an overall framework, but OMS activities need to be developed and implemented to make that framework function on a day-to-day basis.

Implementing the Tailings Guide and the OMS Guide will help Owners of tailings facilities achieve and demonstrate:

- a commitment to develop, implement, review and maintain a tailings policy;
- objective setting for planning and strategic activities related to performance and risk management of tailings facilities;
- continual improvement of a tailings management system;
- that internal controls and procedures are in place, maintained, implemented, and verified for the preparation, proper analysis, consideration and disclosure of technical, scientific, environmental and social information;
- that effective, transparent and appropriate level of authority and competency for decision-making is in place to evaluate, recommend and approve technical, management, environmental, social and economic aspects related to tailings and water management; and
- that verifiable, clearly defined and updated critical controls and procedures are in place to manage risks.

The objective of the Tailings Guide, together with the OMS Guide, is to continually work towards minimizing harm through the application of BAT and BAP in design, engineering, operation, maintenance, and surveillance of tailings facilities, and associated training. This is achieved through the application of risk assessment and management practices, and through the application of "continual improvement" principles. There are complementary guidance documents available and these should be integrated as appropriate provided they embody the principles described in this Tailings Guide.

Minimizing harm encompasses both physical and chemical performance and risks associated with tailings facilities, including:

- zero catastrophic failures of tailings facilities; and
- no significant adverse effects on the environment or human health.

MAC developed the *TSM Tailings Management Protocol* as a tool to measure progress in implementing this Tailings Guide and the OMS Guide. This Protocol contains a series of measurable indicators related to tailings management to complement these two Guides.

In 2016, the *International Council on Mining and Metals* (ICMM) released its *Position statement on preventing catastrophic failure of tailings storage facilities*, which describes a tailings governance framework. This Tailings Guide is aligned with and complementary to the ICMM position statement.

Tailings and water facilities are complex engineered facilities that must be managed appropriately over long periods of time, some in perpetuity. Detailed technical guidance should be sought elsewhere as a complement to this Tailings Guide. Particularly for mines in Canada, implementation of the Tailings Guide is complemented by guidelines published by the *Canadian Dam Association (CDA)*:

- CDA Dam Safety Guidelines 2007 (2013 Edition); and
- Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams (2014).

Other organizations that have produced high-quality, applicable technical guidance, including guidance on risk assessment and management, include, but are not limited to:

- *International Commission on Large Dams* (ICOLD);
- *Australian National Committee on Large Dams* (ANCOLD);
- *International Standards Organization* (ISO);
  - *ISO 9000 – Quality Management*;
  - *ISO 14000 – Environmental Management*; and
  - *ISO 31000 – Risk Management*;
- *International Code for Cyanide Management*;
- *Environment and Climate Change Canada*;
- *Western Australia Department of Mines and Petroleum*;
- *Australian Government Leading Practice Sustainable Development Program for the Mining Industry*;
- South African National Standards SANS 10286 1998;
- US Bureau of Reclamation;
- US Army Corps of Engineers;
- *US Federal Emergency Management Agency*;
- United Nations Environment Programme; and
- *European Union directive* and *Best Available Techniques (BAT) Reference Document for the Management of Waste from Extractive Industries* on mine waste management.

The Tailings Guide does not replace professional expertise or legal requirements. Owners of tailings facilities should obtain qualified professional advice, including legal, to be sure that each facility's specific conditions are understood and addressed.

It is important to note that this Tailings Guide discusses a wide range of information that should be documented as part of the development and implementation of a tailings management system. It is up to the Owner's discretion to decide how best to organize this information.

The Tailings Guide and the OMS Guide are not specific to Canadian conditions, and these Guides can be effectively applied to tailings management anywhere in the world. In addition, while written for tailings and associated water management facilities, many aspects of the Tailings Guide and the OMS Guide are equally applicable to the responsible management of other types of facilities, such as waste rock disposal areas, and heap leach facilities.

2 Tailings Management Framework

2.1 Overview

This chapter presents the key elements of the framework to manage **tailings facilities** in a safe, sustainable, and environmentally responsible manner.

Figure 1 provides an overview of the essential elements of the tailings management framework as applied through all phases of the life cycle of a tailings facility: project conception and planning, design, initial construction, operations and ongoing construction, temporary or permanent closure, post-closure, and reopening of closed tailings facilities. The elements of the tailings management framework are:

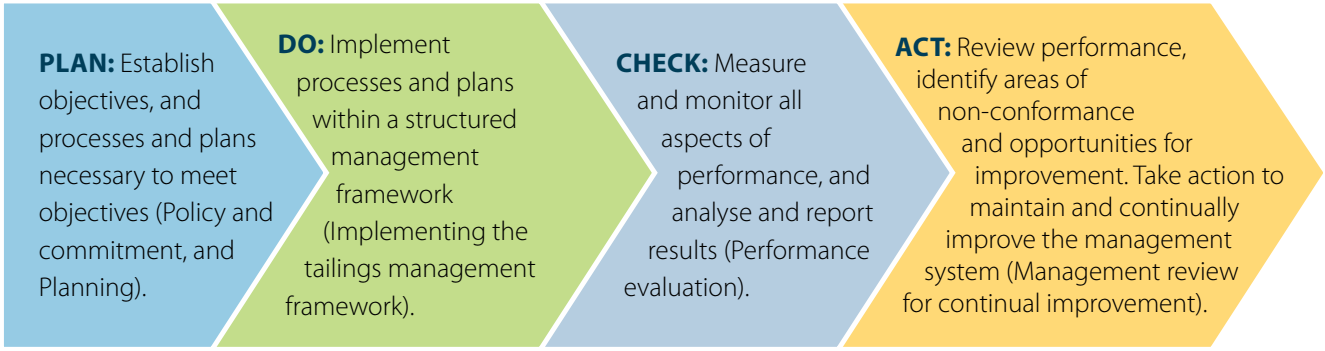
- Policy and commitment (*see Section 3*);
- Planning (*see Section 4*);
- Implementing the tailings management framework (*see Section 5*);
- Performance evaluation (*see Section 6*); and
- Management review for continual improvement (*see Section 7*).

Also integral to the development and implementation of an effective tailings management system is oversight provided through an assurance program. Assurance, which cross-cuts all elements of the **tailings** management framework, is further discussed in *Section 8*.

Environmental Management System (EMS): The part of an overall management system that includes organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the environmental policy and reducing environmental impacts (adapted from ISO 14001)

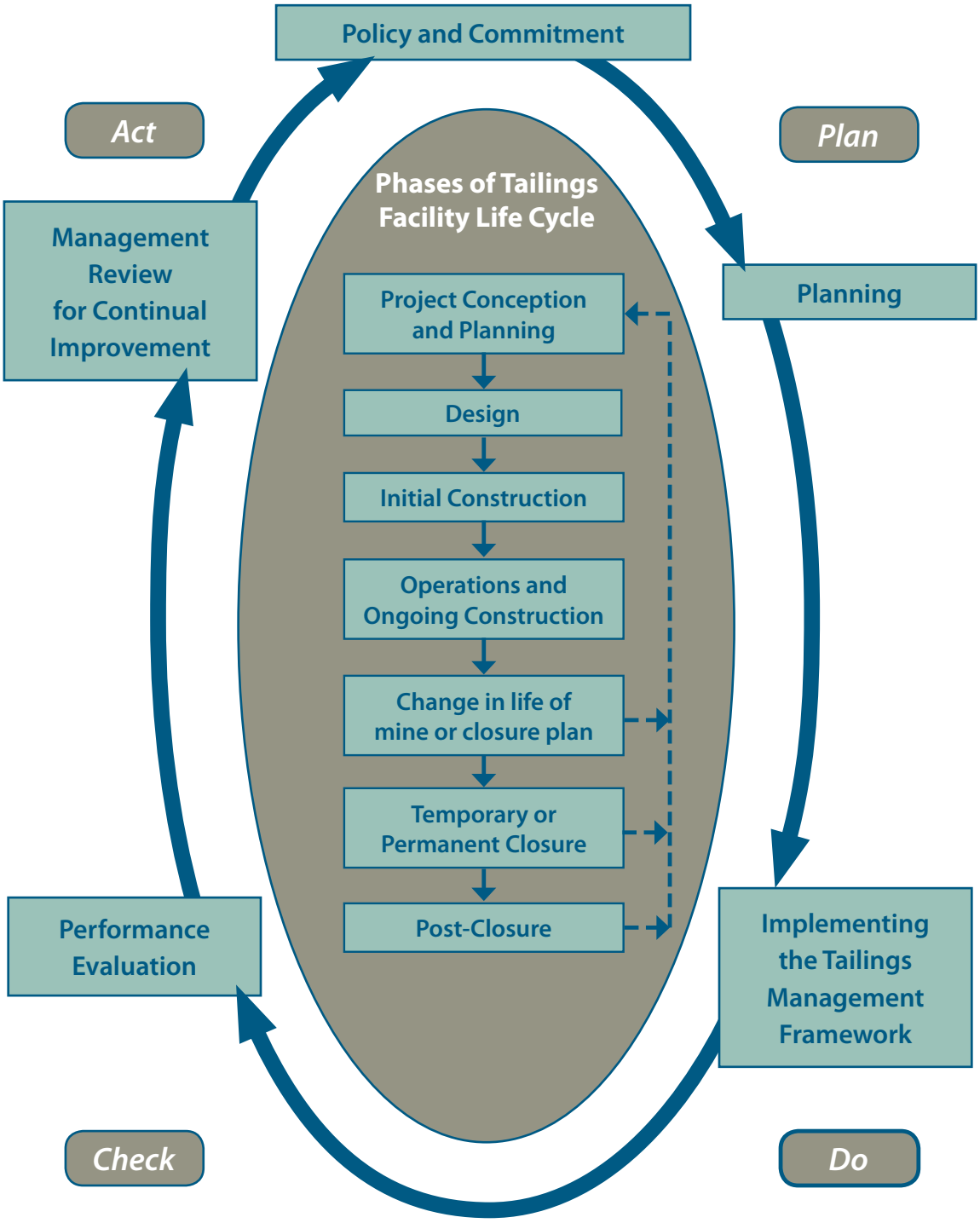
The tailings management framework is based on the *ISO 14001* definition of an environmental management system which includes: an organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining policies.

Consistent with other models for environmental management systems, the tailings management framework follows a cycle of Plan-Do-Check-Act; a management model for control and continual improvement.



The cycle is then repeated, with objectives re-visited and revised as appropriate, and processes and plans adjusted (see Figure 2). This helps to drive continual improvement, leading to improved environmental protection and reduced risk.

Figure 1: Elements of the Tailings Management Framework



Phases of the Life Cycle of a Tailings Facility:

Project Conception and Planning: begins at the outset of planning of a proposed mine, and is integrated with conception and planning for the overall site, including the mine plan and plans for ore processing. The phase includes the use of rigorous decision-making tools to support selection of the location for the tailings facility, and the BAT to be used for tailings management.

Design: begins once the location and BAT for the tailings facility have been selected, and occurs in concert with detailed planning of all aspects of the proposed mine. Detailed engineering designs are prepared for all aspects of the tailings facility and associated infrastructure.

Initial Construction: construction of structures and infrastructure that need to be in place before tailings placement commences. This includes, for example, removal of vegetation and organic soils, and construction of starter dams, tailings pipelines, access roads, and associated water management infrastructure.

Operations and Ongoing Construction: tailings are transported to, and placed in, the tailings facility. Tailings dams may be raised, or new tailings cells added as per the design. The operations and ongoing construction phase of a tailings facility typically coincides with the period of commercial operations of the mine.

Standby Care and Maintenance: the mine has ceased commercial operations and the placement of tailings into the facility is not occurring. The Owner expects to resume commercial operations at some point in the future, so surveillance and monitoring of the tailings facility continue, but the facility and associated infrastructure are not decommissioned and the closure plan is not implemented.

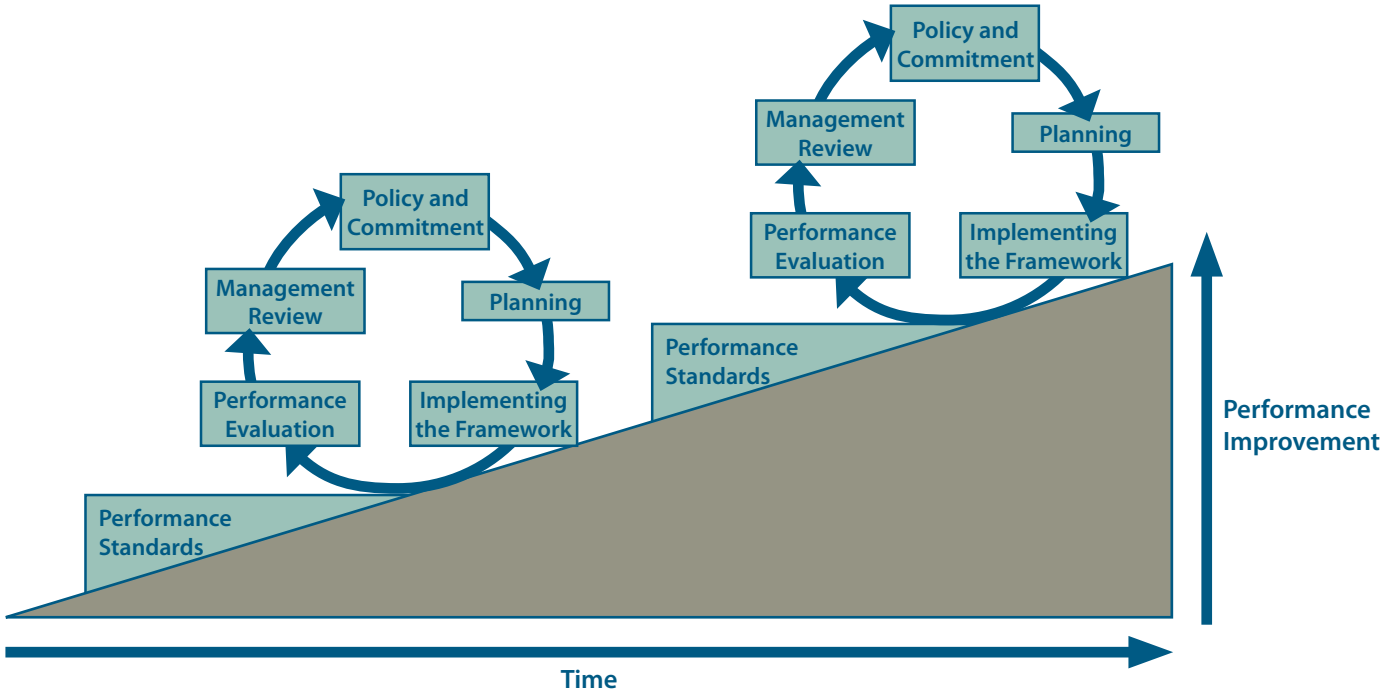
Closure: begins when placement of tailings into the facility ceases permanently. The facility and associated infrastructure are decommissioned, and the closure plan is implemented, including:

- transitioning for operations to permanent closure;
- removal of infrastructure such as pipelines;
- changes to water management or treatment; and
- recontouring or revegetation of tailings and any containment structures or other structural elements.

Post-closure: begins when decommissioning work is complete, the closure plan has been implemented, and the tailings facility has transitioned to long-term maintenance and surveillance. During post-closure, responsibility for a tailings facility could transfer from the Owner to jurisdictional control.

NOTE: particularly with respect to closure and post-closure, there are various legal definitions in different jurisdictions. These definitions are intended strictly as function definitions, characterizing key activities that differentiate these phases.

Figure 2: Continual Improvement through Implementation of the Tailings Management Framework



2.2 Overarching Principles

2.2.1 Risk Assessment and Management

The assessment and management of risk is essential to the effective management of tailings facilities, and is integral across all elements of the tailings management framework, and across the entire life cycle. Potential risks associated with tailings facilities, including the physical and chemical, as well as operational, organizational, financial and management risks, should be identified. Facilities should be conceived, designed, constructed, operated and closed in a manner that effectively manages risks to achieve the objective of minimizing harm.

Risks should be re-assessed throughout the life cycle, and as part of any material changes in the tailings facility, such as a mine life extension or a temporary suspension of operations. As the risk profile of the facility changes, the risk management measures should be updated accordingly.

Risk denotes a potential negative impact, detrimental to operations, the environment, public health or safety that may arise from some present process or future event. The potential severity or consequence of the impact and its probability or likelihood of occurrence are both considered when evaluating risk.

For new and existing facilities, risk assessment should consider potential impacts of climate change, including extreme weather events (extended drought or high precipitation events), and potential impacts on permafrost in areas of high latitude or altitude. Risk management should include measures to ensure tailings facilities are resilient enough that risks continue to be appropriately managed under changing climate conditions, particularly in the long-term, through closure, and post-closure. Climate change adaptation is addressed in detail in MAC's *Guide on Climate Change Adaptation for the Mining Sector*.

Additional guidance on risk assessment and management is provided in *Appendix 1*.

One aspect of risk management is the identification, development, and implementation of critical controls, which are risk controls related to tailings facility management that should be implemented effectively to either prevent a high-consequence event from occurring, or to mitigate the consequences of such an event. The key steps in the identification, development, and implementation of critical controls are to implement a tailings management system, and to identify and evaluate:

- potential high-consequence events and plausible failure modes;
- critical controls for each plausible failure mode;
- performance indicators associated with these controls;
- actions to implement the controls; and
- pre-defined actions to be taken if performance is outside the specified range.

The implementation of appropriate corporate governance, including the implementation of a tailings management system, is a form of critical control. However, most other critical controls are more specific to the risks associated with a given tailings facility. Thus, some critical controls can be implemented and monitored at a corporate level, while others are implemented and monitored at the site-specific level. Critical controls are further discussed in *Section 4.1*.

2.2.2 BAT and BAP for Tailings Management

The identification and implementation of tailings management technology, including the application of site-appropriate BAT, together with the application of BAP, are the cornerstones of achieving performance objectives and managing risk. Selection of BAT requires consideration of a range of potential technologies, to select the most appropriate technology to manage risks on a site-specific basis. There are many factors to consider when choosing BAT for a tailings facility, examples of which include:

- Are the likelihood or consequences of a failure of a tailings facility reduced?
- Is material separation required to manage a potential geochemical concern?
- How much water will be retained in the tailings during their transport and placement?
- Is there potential to place any tailings in mined-out areas?
- Is the post-mining land use best served by a given technology?

BAP are accepted practices across the full spectrum of tailings management to manage risk and achieve the best outcome in a technically sound and economically efficient manner. Elements of BAP can be applied widely, including:

- confirming geochemical and physical design parameters during operations, closure, and post-closure, and adjusting;
- structural monitoring of tailings facilities to detect movement or change;
- implementing a tailings management system;
- monitoring to assess performance against water balance requirements; and
- conducting Independent Review.

Best Available Technology (BAT) is the site-specific combination of technologies and techniques that is economically achievable and that most effectively reduces the physical, geochemical, ecological, social, financial, and reputational risks associated with tailings management to an acceptable level during all phases of the life cycle, and supports an environmentally and economically viable mining operation.

Best Available/Applicable Practice (BAP) encompasses management systems, operational procedures, techniques and methodologies that, through experience and demonstrated application, have proven to reliably manage risk and achieve performance objectives in a technically sound and economically efficient manner. BAP is an operating philosophy that embraces continual improvement and operational excellence, and which is applied consistently throughout the life of a facility, including the post-closure period.

For new facilities, and for facilities undergoing mine life extensions, performance objectives and the management of potential risks are key drivers at the conceptual planning and design phases. The selection of the most appropriate tailings management technology and facility location, using rigorous decision-making tools to assess alternatives, provides the foundation for future risk management and achieving performance objectives. At the design phase, consideration should also be given to BAP that could be applied throughout the life cycle of the facility.

For existing facilities, it may not be technically or financially possible to fundamentally change the technology used for tailings management. However, other aspects of technology associated with tailings management should be re-evaluated based on the results of updated risk assessments and evolving technology that could be applied to further reduce current and future risk. BAP should be re-evaluated throughout the life cycle, with the goal of continual improvement in tailings management. Management measures also need to be re-evaluated throughout the life cycle to ensure that they remain appropriate as the risk profile, or environmental or operating conditions of the tailings facility change.

Additional guidance on the integration of BAT and BAP is provided in *Appendix 2.* Assessment of alternatives for the selection of the tailings facility location and BAT is further discussed in *Appendix 3*.

2.2.3 Independent Review

Regular, systematic Independent Review is recognized as a BAP for responsible tailings facility management.

Independent Review provides **Owners** with independent, objective, expert commentary, advice, and, potentially, recommendations to assist in identifying, understanding, and managing risks associated with tailings facilities. The primary purpose of Independent Review is to provide an opinion to the Owner's **Accountable Executive Officer** (*see Section 4.3.2*) regarding:

- completeness/appropriateness of the risk assessment and understanding;
- effectiveness of tailings governance and the tailings management system;
- whether the tailings facility is being effectively managed based on sound engineering practices;
- whether the risk assessment and the acceptable level of risk should be reviewed and updated;
- whether concepts and design criteria for the facility are consistent with legal requirements, industry guidelines and best practices, and current theory, methodologies and experience; and
- areas for improvement in the management of the tailings facility.

The objectives are to:

- facilitate informed management decisions regarding a tailings facility so that tailings-related risks are managed responsibly and in accordance with an acceptable standard of care; and
- ensure that the Accountable Executive Officer has a third-party opinion regarding the risks and the state of the tailings facility and the implementation of the tailings management system, independent of the teams (employees, consultants, and contractors) responsible for planning, designing, constructing, operating, and maintaining the facility.

As an overarching principle of the tailings management framework, Independent Review is applicable across all elements of the framework. It is also applicable across the entire life cycle of a tailings facility. The input of Independent Review should be sought from the initial conceptual planning and design phases, through to reviewing post-closure performance. However, over the life cycle of a tailings facility, and as the risk profile of a facility changes, the scope and focus of Independent Review should be re-adjusted to ensure it remains relevant and effective.

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. Qualifications and experience of reviewers should be aligned with the tailings facility's complexity and risk profile.

Additional guidance on Independent Review is provided in *Appendix 4.*

2.2.4 Designing and Operating for Closure

Some of the potential impacts and risks posed by mining remain long after mining operations cease. In particular, tailings facilities may pose physical and chemical risks in perpetuity. Thus, tailings facilities may represent a long-term risk and liability that must be responsibly managed for many decades after mining operations cease. Designing and operating for closure is a BAP for mitigating these long-term risks and reducing liability.

A **closed tailings facility** is one that is no longer being used for the deposition of tailings, with the expectation that the facility will not be used for deposition of tailings in the future. The mine or ore processing facility with which the tailings facility is associated may or may not also be closed.

Designing and operating for closure requires a long-term view. Tailings facilities are seldom for temporary storage. While some may eventually be re-mined to recover additional commodities of value, they should be conceived, designed, constructed, operated and closed on the assumption that they will be permanent facilities. 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.[1]

Designing and operating for closure is holistic, and takes all aspects of the mine into account, not just the tailings facility itself. For example, design and operational decisions related to mining and ore processing can impact both the quantity, and physical and chemical characteristics of tailings and associated water, and can have long-term implications for the management of tailings: management of tailings begins upstream in the operation – in the mine planning and in the ore processing plant.

The earlier that tailings hazards and associated unknowns are reduced, the greater the potential for meeting long-term closure objectives. Thus, planning and designing for closure should be initiated at the project conception and planning phase of the life cycle. Figure 3 illustrates the importance of planning for closure, and the application of BAT and BAP throughout the life cycle. For example, selecting the most appropriate combination of technology and the tailings facility location for a given site at the very outset will reduce risks and minimize closure liability.

1. The Australian Government (2016: *Leading Practice Sustainable Development Program for the Mining Industry: Tailings Management*) states that: "Conventional economic analysis can lead to minimising initial capital expenditure and deferring rehabilitation costs. Net present value analysis discounts the current cost of future expenditures on closure, rehabilitation and post-closure management. Therefore, if this short-term economic perspective is taken, without taking into account the longer term social and environmental costs, there is little motivation to invest more substantially at the development phase to avoid or reduce expenditures at the closure phase. There are a number of reasons, however, for applying leading practice at the earliest stage of development and for designing and operating the TSF to achieve optimal closure outcomes."

Figure 3: Risk Management Practice over the Life of the Mine[2]

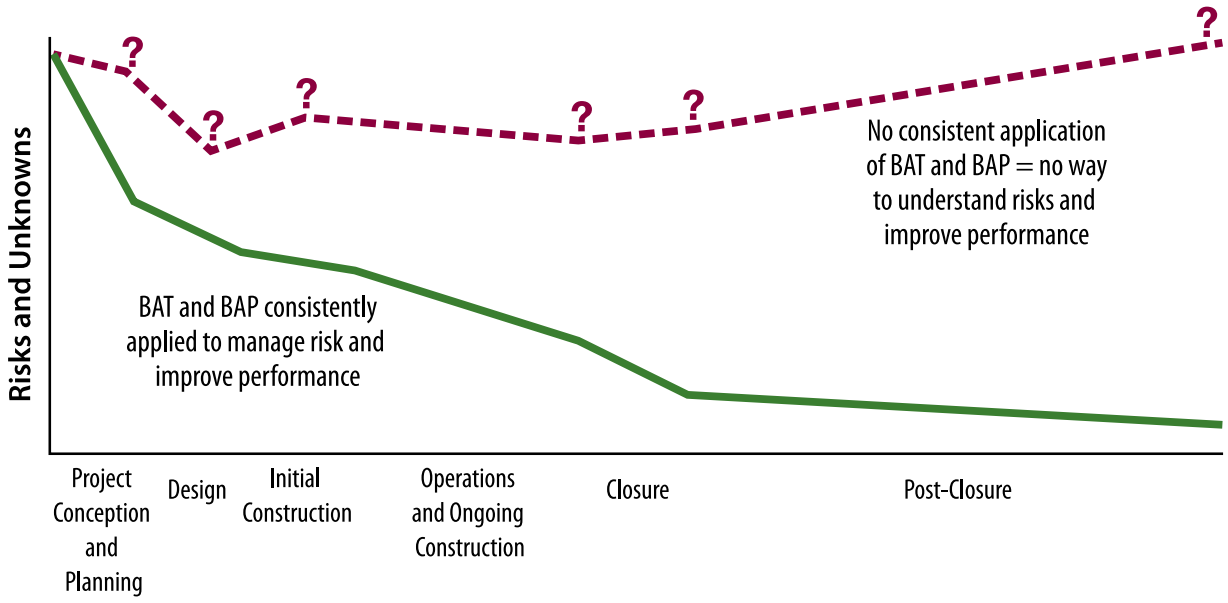


Figure 3 captures the importance of good decisions early in the life cycle of a tailings facility, but does not consider the financial accounting practices used in mine planning, particularly the application of discount rates to longer-term costs. Use of such practices can minimize, from a financial planning perspective, the importance of upfront investment in longer-term management of impacts and risks. At the same time, if every potential project became so risk adverse that financial considerations had no role in management practices, the benefits of mining to society would not be realized. Balance is required and a transparent decision process with input through Independent Review will assist in achieving, demonstrating, and communicating this balance.

After key design decisions are made about the selection of tailings management technology and a location for a tailings management facility, closure plans should continue to evolve and be refined in greater detail, considering changes in the mine plan, legal requirements, the risk profile of the tailings facility, status of progressive reclamation activities, and changes in **COI's** expectations.

Tailings facilities not originally designed with closure objectives in mind, such as facilities that have already been in operation for several decades, may be able to adjust their tailings management practices or adopt newer technologies (e.g., segregation if tailings with high potential for impacting water quality) to reduce risk and better position the tailings facility for closure. Regular review of such opportunities is central to continual improvement.

2. Figure adapted from International Council of Mining and Metals (2008): *Planning for Integrated Mine Closure: Toolkit*

2.3 Managing Throughout the Life Cycle of a Tailings Facility

Mining companies face the challenge of effectively and efficiently managing tailings facilities throughout their life cycle, from project conception and planning, to design[3], through initial construction, operations and ongoing construction, to eventual closure, and post-closure[4] (Figure 1).

Tailings facilities continue to change and evolve over their life, and the life cycle of a tailings facility is rarely a simple linear progression from one phase to the next. For example, while construction is a discrete life cycle phase for most aspects of a mine, construction activities at a typical tailings facility continue throughout the operating life of the mine as dams or other containment structures are raised, or as facilities are enlarged to accommodate increasing volumes of tailings. This is unlike other types of containment structures, such as hydroelectricity dams or water resource management dams, which are typically built to final configuration at the outset. In addition, within the operational phase there can be changes that were not anticipated at the beginning of mine life, such as enlargements of the footprint of tailings facilities, care and maintenance suspensions (and subsequent re-starts), process and technology changes, and so forth, reinforcing the criticality of effective risk management and change management.

The life cycle timescale can extend for many decades to reach the end of the operations and ongoing construction phase, and centuries beyond for closure and post-closure. In some cases, tailings might be re-processed in the future as technology improves and commodity prices increase. Thus, many aspects of tailings management are not predictable at the mine's conception.

Change itself is a key source of risk for tailings facilities, and needs to be effectively managed. Systematic, risk-based management approaches provide a means of navigating these aspects of the mining life cycle.

At each phase in the tailings facility's life cycle, implementation of a tailings management system requires that actions be planned and implemented within the context of policies and commitments, with performance measurement and reporting mechanisms in place.

Typically, responsibility for the management of a tailings facility will come under different roles during different phases of its life cycle. For example, one team may lead the design, another the initial construction, another during the operations and ongoing construction phase, and another team for the closure phase. During post-closure, the facility may transition from active care and management to a more passive mode, but some level of surveillance and maintenance may still be required. Transfer of ownership of the facility may occur, but continuity of some degree of ongoing surveillance and maintenance may be necessary to ensure risks continue to be appropriately managed.

Consequently, having an established management system that ensures that design fundamentals/elements, operating principles and constraints, the risk assessment and risk management processes, and the associated critical controls are consistently carried forward to the subsequent management teams is essential to ensuring that risks are effectively managed and that new, unknown risks are not introduced by losing the original design data and intent.

Additional information on managing through the life cycle of a tailings facility is provided in *Appendix 5*.

---

3. The project conception and planning, and the 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.

4. The closure and post-closure phases correspond to the overall closure phase, as described in the Canadian Dam Association's (CDA) *Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams (2014)*. The closure phase, as defined in this Tailings Guide, corresponds to the transition phase as defined by the CDA. The post-closure phase, as defined in this Tailings Guide, corresponds to the active and passive closure phases as defined by the CDA.

3 Policy and Commitment

Every Owner of a tailings facility should establish a tailings management policy and/or commitments that meet the specific requirements applicable to their portfolio of **tailings facilities**. Each **Owner** should develop their commitments in the manner that best meets their needs and corporate management approach while addressing their commitments to regulators and their **COI**.

Each Owner should demonstrate commitment to:

- protection of public health and safety;
- responsible management of tailings with the objective of minimizing harm;
- allocation of appropriate resources to support tailings management activities;
- implementing a tailings management system through the actions of its employees, contractors, and consultants;
- establishing an organizational culture that promotes learning, communication, and early problem recognition; and
- emergency response and post-incident recovery participation in collaboration with appropriate regulatory authorities and COI.

On a facility-specific basis, the Owner should also make more specific commitments. These additional commitments will likely take the form of the following:

- plan, design, construct and operate tailings facilities in a manner that reduces long-term impacts, **risks** and liability;
- ensure tailings management complies with legal requirements, and conforms with reasonable and prudent engineering practice, set design criteria, company standards/guidelines, and the Owner's tailings management system;
- engage with COI, taking into account their considerations in relation to the design (including location), operation, and management of the tailings facility;
- manage tailings facilities commensurate with the risks they pose through implementation of BAT and BAP, with the objective of minimizing harm, and meeting performance, corporate governance, environmental and social requirements;
- manage all solids and water within designated areas;
- establish an ongoing program of review, including Independent Review, and continual improvement of health, safety and environmental performance through the management of risks associated with each tailings facility; and
- implement the level of accountability, authority and competency for decision making appropriate to the level of risk that the decision entails.

The policy and/or commitments should be:

- reviewed and endorsed by the Board of Directors or **Governance Level** (*see Section 4.3.1*);
- communicated to employees;

- understood to a degree appropriate to their roles and responsibilities by employees and contractors whose activities may affect tailings management either directly or indirectly;
- communicated to COI; and
- implemented with budget allocation.

A tailings management policy does not need to be a stand-alone document, and can be part of an overarching company operation, environmental or sustainable development policy, if that policy contains specific reference to tailings management, and includes the policies and commitments as outlined here.

Some owners may have multiple policies to address different needs.

The key is that all necessary information be documented. It is up to the Owner to decide how best to organize that documentation.

4 Planning

Planning is the first step in the Plan-Do-Check-Act cycle of the tailings management system. It lays the foundation for implementing a tailings management system. It consists of establishing the tailings management system itself, and development of all plans, processes, and systems, including engineering studies, to be integrated into and implemented within the tailings management system.

In subsequent cycles of the Plan-Do-Check-Act cycle of the tailings management system, Management System Planning includes updates, as appropriate, to those plans, processes, and systems as well as any updates to the management system itself. The tailings management system and all associated plans, processes, and systems should be aligned with the **Owner's** policy or commitment (*Section 3*). As such, the tailings management system serves as the primary vehicle to meet that policy or commitment on a site-specific basis.

Owners of existing tailings facilities that are developing a tailings management system for the first time may already have some of these plans, processes, and systems in place. A gap analysis should be conducted that identifies missing plans, processes, and systems and also assesses the current degree of alignment and integration of plans, processes, and systems, and identifies any deficiencies. This should include consideration of the adequacy and potential need for updates to the risk assessment and risk management plan. In conducting this gap analysis, it is important to recognize that a tailings management system is intended to be tailored in a site-specific manner, reflecting the site and tailings facility characteristics, the Owner's policy and commitments, legal requirements, and commitments to **COI**.

As part of Management System Planning an action plan should be developed and implemented to address identified gaps, and existing plans, processes, and systems, including engineering studies, should be revised as appropriate to improve/ensure their alignment and address any deficiencies. Development and implementation of an action plan should be informed by prioritizing the outcomes of the gap analysis and focusing first on:

- Gaps or deficiencies that pose the highest risks.
- Missing or inadequate information that is needed (e.g., site characterization information) to address the gaps or deficiencies identified.

MAC's Table of Conformance may be used to help conduct this gap analysis.

4.1 Risk Management

The identification and mitigation of **risk** are fundamental tenets of good management, and this applies to the management of tailings (*Section 2.2.1*). Risk assessments should be completed as frequently as required to meet the tailings management objectives established for any given facility. The acceptable level of risk should be defined in the context of the facility and for its specific **life** phase, taking into account the likelihood and consequence of catastrophic failure, and perspectives of the Owner, regulators and COI.

Risk assessment and management should take into account:

- physical and chemicals risk of the **tailings facility**;
- environmental hazards such as earthquakes, landslides or avalanches, which could impact the facility; and
- other risks external to the Owner and the facility, including legal and permitting risks (e.g., not obtaining permits in a timely manner, or permits that are not aligned with the design intent of the tailings facility).

A risk management plan should be prepared and documented so that it describes the outcomes of the risk assessment, and mitigation measures to be implemented to:

- eliminate or avoid risk to the extent practicable;
- reduce risk by minimizing the likelihood or potential consequence of an unwanted event or condition that poses a risk; and
- detect, respond to, and minimize the consequences if an unwanted event or condition occurs that poses a risk.

Development of a conceptual risk management plan should begin at the **project conception and planning phase** of the life cycle for new facilities and expansions of existing facilities, and be refined and developed in greater detail during the **design phase**.

For all operations, the risk assessment and the risk management plan should be reviewed and updated regularly as appropriate through the life cycle of the tailings facility. The plan should also be reviewed and updated in the event of changes that were not anticipated at the beginning of mine life, such as mine life extensions, care and maintenance suspensions (and subsequent re-starts), changes in the ore being processed, process and technology changes, etc.

Critical Controls

Risk controls are described in the risk management plan, and are site-specific or governance-level measures put in place to either:

- prevent or reduce the likelihood of the occurrence of an unwanted event; or
- minimize or mitigate the negative consequences if the unwanted event does occur.

Critical controls are site-specific and governance-level risk controls that are crucial to preventing a high-consequence event or mitigating the consequences of such an event. The absence or failure of a critical control would significantly increase the risk despite the existence of other controls. Critical controls may be technical, operational, or governance-based.

Development and implementation of a framework for critical controls management is an important risk management tool that provides a high level of assurance against the occurrence of high-consequence events, as defined by the Owner and its EoR, with input from Independent Review, regulators, and COI.

The designation of critical controls is an Owner and tailings facility-specific exercise. Risk controls are typically designated as critical controls if one or more of the following conditions are met:

- implementation of the control would significantly reduce the likelihood or consequence of an unwanted event or condition that poses unacceptable risk (see also *Appendix 1*);
- conversely, removal or failure of the control would significantly increase the likelihood or consequences of an unwanted event or condition that poses an unacceptable risk, despite the presence of other controls;
- the control would prevent more than one failure mode or would mitigate more than one consequence; or
- other controls are dependent upon the control in question.

Processes for management of critical controls should be implemented, key elements of which are as follows:

- identify potential failure modes and causes using risk assessment techniques (see *Appendix 1*);
- identify risk controls associated with potential failure modes and causes;
- identify those risk controls deemed to be critical on an Owner or facility-specific basis;
- appoint a "risk owner" and "critical control owner" for that risk;
- define the critical controls and their performance criteria, measurable performance indicators, and surveillance requirements;
- identify pre-defined actions to be executed if control is lost;
- verify execution of critical controls by the critical control owner or designate, at a frequency commensurate with the frequency of control execution;
- report deficiencies in critical controls to the Responsible Person(s) and, where appropriate, the Accountable Executive Officer, and identify actions and a schedule to address those deficiencies;
- track implementation of actions to address critical control deficiencies, and report to the Responsible Person(s) and, where appropriate, the Accountable Executive Officer; and
- periodically review and update risk controls and critical controls, based on updated risk assessments, risk management plans, and past performance.

In incorporating concepts such as critical controls into a tailings management system and corresponding OMS activities, it is important that such concepts be effectively implemented. However, there are other closely aligned concepts that use different terminology. For example, some Owners develop and implement Trigger Response Action Plans (TARPs). It is the concept that is essential, and not the terminology used to describe it.

4.2 Performance Objectives

Establish and document performance objectives, indicators, and associated performance measures for the tailings facility based on:

- environmental requirements;
- risk assessment and the level of acceptable impact and risk; and
- risk management plan.

Performance objectives and indicators should be aligned with the Owner's tailings management system and policy and/or commitments, standards/guidelines, legal requirements, commitments to COI, and sound engineering and environmental practices.

Performance objectives and indicators should be developed for the entire life cycle of the tailings facility, including planning for both potential temporary and eventual permanent closure, and 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 continued physical and chemical stability of all components/structures; and
- acceptable post-closure use within a feasible technical and economic framework.

Performance objectives are overall goals, arising from the Owner's policy and commitment, which are quantified where practicable.

Performance indicators are detailed performance requirements that arise from the performance objectives and that need to be set and met in order to achieve those objectives. Performance indicators must be measurable and quantifiable.

(Both definitions adapted from *ISO 14001*)

For new facilities or facilities undergoing expansion, performance objectives should be established early in the conceptual planning and design phases. Assessments of alternatives for facility location and tailings management technology should take these performance objectives into account.

4.3 Accountability and Responsibility

A wide range of employees, contractors, and consultants are typically engaged to implement a tailings management system and apply a duty of care in ensuring that tailings facilities are managed in a responsible manner. Given the number of people involved, and the range of roles related to tailings management, it is important that accountability, responsibility, and authority be clearly defined and in place for all decisions related to tailings management. Decisions should be made by persons who have clear accountability or responsibility, the authority to make those decisions, and who are appropriately qualified and experienced.

It is essential that persons with accountability, responsibility, and authority for tailings management have an understanding—appropriate to their accountability, responsibility, and authority level—of how the tailings facility is planned, designed, constructed, and operated. This includes the risks posed by the facility, the risk management process, critical controls management, and operational constraints.

The circumstances of each Owner and tailings facility vary and, therefore, governance and organizational structure should be appropriately tailored to the needs of each Owner and facility. At a minimum; however, accountabilities, responsibilities, authority, and roles should be clearly defined and documented for:

- Owner's Board of Directors or Governance Level;
- Accountable Executive Officer;
- Responsible Person(s);
- Engineer-of-Record (EoR); and
- Independent Reviewer(s).

The Owner should establish clear lines of communications between these positions.

It is also essential that the Owner understand the roles and mandate of all relevant regulatory agencies, and have a clear understanding of the legal framework within which the tailings facility is planned, designed, constructed, operated, and closed.

4.3.1 Board of Directors or Governance Level

Ultimately, the accountability for decisions related to tailings management rests with the Owner's Board of Directors or Governance Level. This will depend on the size and structure of the Owner company. This includes endorsing the corporate policy or commitment related to tailings management (*Section 3*).

The Owner should determine the respective roles and accountabilities of the Board of Directors or Governance Level and the Accountable Executive Officer.

Governance Level: The company Board of Directors (or a sub-committee of the Board of Directors) is considered the governance level of a company, the level at which the highest-level corporate decisions are made, particularly regarding organizational and financial resources. For companies headquartered outside of the country in which the tailings facility is located that do not have a Board of Directors based in that country, the governance level would be equivalent to the highest-level committee or board that provides oversight and review of tailings management activities within that country.

4.3.2 Accountable Executive Officer

An executive-level person (e.g., CEO, COO, Vice President) designated by the Board of Directors or Governance Level who is accountable for tailings management, and the development and implementation of the systems and associated training needed for responsible tailings management. This accountability cannot be delegated, but the Accountable Executive Officer may delegate responsibilities. This Officer has a direct reporting relationship to the Board, a Board committee, or the Governance level and:

- needs to be aware of key outcomes of tailings facility risk assessments and how these risks are being managed;
- has accountability and responsibility for putting in place an appropriate management structure and is accountable for ensuring development and implementation of site-specific tailings management systems and development of any required plans for emergency preparedness;

- delegates responsibility and authority for tailings management and defines the personnel responsibilities, authority, and reporting relationships to implement the systems needed for responsible tailings management through all phases of the tailings facility life cycle;
- demonstrates to the Board of Directors/Governance Level whether tailings are managed responsibly;
- is accountable for establishing processes to ensure the approval (on the recommendation of the Responsible Person(s) and Engineer of Record, and subject to Independent Review) of:
  - the design and design intent of the tailings facility, including design associated with any material changes; and
  - risk management plan for tailings management;
- is accountable for ensuring that the Responsible Person, EoR, and Independent Reviewers have the appropriate competencies and experience commensurate with risk level and characteristics of the facility; and
- is accountable for ensuring that a process is in place for personnel to be able to report concerns related to tailings management, and for following-up on those concerns.

4.3.3 Responsible Person(s)

As a minimum, the Owner should designate one Responsible Person for each tailings facility. During initial construction, and operations and ongoing construction, there should be a Responsible Person immediately available at all times. The Responsible Person(s) has clearly defined, delegated responsibility for tailings management and appropriate qualifications. The Owner should describe the competencies required. There may also be a designated Responsible Person at the corporate level. The Responsible Person(s) identifies the scope of work and budget requirements (subject to final approval) for all aspects of tailings management, including the EoR, and will delegate specific tasks and responsibilities for aspects of tailings management to qualified personnel.

The Responsible Person(s) should be familiar with the design, construction, operation, and performance of the tailings facility and is integral to the development and implementation of the tailings management system.

The Responsible Person(s) is responsible for the management of the tailings facility, including:

- ensuring that a site-specific organizational structure is in place, with documented roles and responsibilities;
- establishing and maintaining a relationship and ongoing communications with the EoR;
- developing (where one does not currently exist) and implementing a site-specific tailings management system, including ensuring that:
  - the management system and associated plans, processes, systems are developed and implemented, commensurate with the risk profile, characteristics, and life cycle phase of the tailings facility (*Sections 4 and 5*);
  - tailings management performance is evaluated (*Section 6*);
  - management reviews for continual improvement are conducted at the frequency prescribed by the Owner (*Section 7*); and

- recommendations and action plans arising from management reviews are implemented, including reviewing/revising plans, processes, and systems (e.g., risk management plan, OMS manual) (*Section 7*);

- overseeing planning, design, and sequencing of construction, where applicable; and
- ensuring that:
  - risk assessment is conducted and reviewed at an appropriate frequency, and a risk management plan is developed, implemented, and updated accordingly (*Sections 2.2.1 and 4.1*); and
  - an assurance program is developed and implemented, including Independent Review, and that results are documented and considered (*Section 8*).

The Responsible Person(s) should maintain regular communication with the EoR and should also liaise with internal teams with direct and indirect responsibilities related to tailings management such as operations, planning, regulatory affairs, environment, and COI engagement.

4.3.4 Engineer-of-Record

The Owner, in assuring that a tailings facility is safe, has the responsibility to identify and retain an EoR, who provides technical direction on behalf of the Owner. The EoR verifies whether the tailings facility (or components thereof) has been:

- designed in accordance with performance objectives and indicators, applicable guidelines, standards, and legal requirements; and
- constructed, and is performing, throughout the life cycle, in accordance with the design intent, performance objectives and indicators, applicable guidelines, standards and legal requirements.

For tailings facilities that include retention structures/dams, the EoR is responsible for Dam Safety Inspections and associated reports. The EoR should also participate in the facility's risk assessments and be accessible to Independent Reviewers, and, for facilities with retention structures, dam safety reviews. The EoR provides these activities as part of the Owner's broader assurance process, as described in *Section 8*.

The Owner should develop a terms of reference for the EoR that describe the roles and responsibilities of the position, reporting relationships, lines of communications, and required competencies.

The EoR must have experience and knowledge commensurate with the risk management requirements for the facility. The EoR must have the appropriate qualifications, which includes professional certifications relevant to the jurisdiction in which the tailings facility is located (e.g., Professional Engineer registration in the appropriate province or territory in Canada).

4.3.5 Independent Reviewer(s)

The Independent Reviewer(s) provides Owner with independent, objective, expert commentary, advice, and potentially recommendations, to assist in identifying, understanding, and managing risks associated with tailings facilities, as well as the implementation of the Owner's tailings management system. The Independent Reviewer(s) does not have decision-making authority. Accountability and responsibility for decisions rests with the Owner.

Independent Reviewers are third-parties who are not, and have not been directly involved with the design or operation of the particular tailings facility.

4.4 Conformance Management

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

- applicable legal requirements and commitments (including commitments/conditions coming from environmental assessment and permitting) are identified, documented, understood and effectively communicated;
- owner's policies, guidelines, standards, practices are identified, documented, implemented, and reviewed;
- those accountable and responsible for conformance understand the conformance management plan and have the necessary training and competence; and,
- procedures to assess state of conformance have been established, implemented, documented and communicated as required for responsible management of the facility.

In cases of non-conformance, the Owner should:

- report the non-conformance, internally and externally, as appropriate;
- determine the causes of the non-conformance, and identify and implement corrective measures;
- address consequences of the non-conformance, including mitigating environmental impacts;
- review the effectiveness of measures to correct the non-conformance; and
- make necessary changes to the tailings management system to prevent future non-conformance.

The nature of non-conformance events should be documented, together with corrective actions taken, and the results of the corrective actions.

4.5 Managing Change

The Owner should document and implement processes to manage change to maintain the integrity of the tailings facility and the management system, including changes to:

- approved designs and plans, including temporary changes, and expansions to tailings facilities;
- facility ownership;
- persons involved, or roles of, employees, contractors, and consultants with key duties related to tailings management, including the Accountable Executive Officer, Responsible Person(s), EoR, and Independent Reviewer(s);
- conditions that may impact tailings management, including temporary suspension of mining operations;
- the closure plan;
- legal requirements; and
- any other changes that are potentially material to the risks associated with tailings management (i.e., any change that has the potential to change the performance or risk profile of the tailings facility or its component parts).

Processes to manage change should include succession planning for key roles related to tailings management, including the Responsible Person(s), EoR, and Independent Reviewer(s). For roles such as the EoR and Independent Reviewer(s), this could include having documented terms of reference, descriptions of required qualifications, and a documented process for filling roles in the event of change. For the EoR, the succession plan should address the transfer of necessary information to the new EoR, including the procedures and timelines for transfer.

Changes that could impact the risk profile of a tailings facility should be reviewed and potential impacts should be evaluated. Changes should be approved by the relevant persons (e.g., EoR, Responsible Person(s), personnel involved in tailings management and related activities, and the Accountable Executive Officer, as appropriate). In particular, if changes are proposed to the original or current design of the tailings facility (e.g., changes in dam construction specifications), these proposed changes should be carefully documented and risks of the change in the current and future phases of the life cycle should be evaluated. Depending on the nature of the change and the potential impact, Independent Review of the proposed change is recommended (see also *Appendix 4*). Before implementing, the proposed change should be approved at a level commensurate with the potential impact of the change.

If other changes are proposed, such as changes to plans and procedures, the potential impacts of these changes should also be evaluated, and changes should be approved at the appropriate level prior to implementation. Changes should be documented.

4.6 Managing Information

Access to and use of, up-to-date, accurate information, and the retention of relevant information, is critical to responsible tailings management. The Owner should ensure that key information related to the tailings facility is documented, and reviewed and updated as appropriate throughout the life cycle. How this documentation is organized is at the discretion of the Owner.

4.6.1 Information to be Documented

There is a wide range of information that should be documented, as described in detail in *Appendix 6*. Information that should be documented and updated throughout the life cycle includes:

- relevant information about the mine, the tailings facility and its location, local and regional environmental, social, and socio-economic conditions, as well as other factors such as natural hazards and climate conditions (*Appendix 6*);
- information about the design of the tailings facility, including the initial design, updates through the operations and ongoing construction phase, and design for closure (*Appendix 6*);
- documentation of construction and as-built conditions of the tailings facility, including information to demonstrate whether the design intent is being met (*Appendix 6*);
- deviations from the design or operational plans, including assessing the cumulative impacts to risk of changes to the tailings facility, and recommendations to managed risks as appropriate; and
- closure plan (*Appendix 8*).

4.6.2 Control of Documented Information

Information necessary for effective tailings management should be controlled. Owners need to establish and implement a process to ensure that documented information is created, maintained, retained, and archived. There are two aspects to control of documented information:

- access to, and use of, current and accurate documented information; and
- identification and retention of records that are potentially useful to the future management of the tailings facility.

Key documents related to tailings management should be managed as controlled documents, including:

- defining the process for reviewing and updating the documents, including both major and minor updates;
- identifying persons with authority to revise the documents and the scope of their authority (e.g., some may only have the authority to amend certain sections);
- describing mechanisms for approval of revisions; and
- for electronic documents, implementing measures to prevent unintended changes, or to prevent any changes by personnel without the appropriate authority.

In addition, there needs to be defined procedures for:

- providing personnel with access to the documents;
- informing personnel of changes to documents relevant to their roles and responsibilities;
- control of reference information used to develop and update documents;
- restricting access to out-of-date versions and clearly labelling those versions as out-of-date;
- identifying out-of-date materials that need to be retained; and
- archiving or disposing of out-of-date materials, as appropriate.

Archiving of relevant out-of-date materials is important to ensure that valuable records are not lost. Owners should develop and implement a process to identify records that are potentially useful to the future management of the tailings facility. These records should be retained and not destroyed. These records could include records related to planning, design, construction, operation and closure of tailings facilities, including surveillance and monitoring records.

Access to information may be interrupted (e.g., loss of paper copies due to fire, temporary loss of access to electronic copies due to loss of power). The potential loss of access needs to be evaluated, particularly in the case of OMS manuals or ERPs that are accessed electronically. There may be components of these documents that need to be accessible in paper copy in the event that electronic versions are not accessible. Indeed, a loss of power may be linked to certain critical controls (e.g., loss of ability to operate pumps), and having access to these documents during such periods may be necessary for the effective response to the situation.

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

- procedures for backup and recovery of paper and electronic copies;
- plans to prevent unauthorized access, including access to documentation, as well as access to instruments and other technologies that may be connected to mobile networks or wireless internet; and
- retention of paper copies of critical components of the OMS manual and ERP that can be used in the event of a loss of access to electronic documents.

Another consideration for control of documented information is the management of legacy electronic formats. A plan needs to 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 obsolescence of software, electronic file formats, or data storage medium.

4.7 Quality Management

There are two key components to quality management: quality assurance (QA) and quality control (QC). These two components are closely related, but they are different.

To illustrate, a QA plan for the construction of a tailings dam or other containment structure would prescribe the specifications (determined at the design phase) for all aspects of construction, such as the specifications for materials to be used in the construction of the dam. A QC plan would describe procedures to ensure that these specifications are met, and procedures to address cases where specifications are not met. The overall goal is to ensure that the dam is constructed in a manner that is consistent with the design principles, and to eliminate risks associated with sub-standard construction of the dam.

QA and QC plans can be separate, or combined in a quality management plan, but it is important that both components be described and documented.

Quality, quality assurance and quality control are defined in the ISO 9000 Quality Management Standard as follows:

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 fulfill requirements for quality.

Quality control (QC): The operational techniques and activities that are used to fulfill requirements for quality.

QA ensures that you are doing the right things, the right way. QC ensures that your results are what you expected.

Quality management should address a wide range of aspects related to the tailings facility, including:

- initial and ongoing construction, including specifications for materials and construction procedures (e.g., material compaction);
- OMS activities, such as calibration of surveillance instruments; and
- QA and QC related to closure plan implementation.

These aspects of quality management do not all have to be described in a single document. For example, information related to construction should be described in design documentation (*Appendix 6*), and information related to OMS should be described in the OMS manual.

4.8 Operation, Maintenance, and Surveillance Manuals

An operation, maintenance, and surveillance (OMS) manual should be prepared for each tailings facility and should describe requirements for the OMS activities necessary to the effective management of the facility, based on the site-specific design intent, performance objectives, risk management plan, and critical controls. An OMS manual documents and clearly communicates requirements to implement OMS activities to employees, contractors, and consultants involved in tailings management.

The *OMS Guide* provides detailed guidance on the development and implementation of OMS manuals.

OMS activities are necessary to the effective management of risk controls and critical controls. An OMS manual documents these controls and describes pre-defined management actions necessary to retain or regain control.

Surveillance is key to the management of risk controls and critical controls – without surveillance there is no control. An OMS manual describes the performance indicators and criteria for risk controls and critical controls, and the ranges of performance linked to specific pre-defined management actions. An OMS manual also describes the procedures to collect, analyze, and report surveillance results in a manner consistent with the risk controls and critical controls and that supports effective, timely decision-making.

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. It also includes reclamation and related activities.

Maintenance: Includes preventative, predictive and corrective activities carried out to provide continued proper operation of all infrastructure (e.g., civil, mechanical, electrical, instrumentation, etc.), or to adjust infrastructure to ensure operation in conformance with performance objectives.

Surveillance: Includes the inspection and monitoring (i.e., 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.

The link between OMS activities and critical controls management underscores the fact that it is essential that OMS manuals be developed to reflect site-specific conditions and circumstances. An OMS manual cannot be purchased "off-the-shelf". To be effective, it must be tailored to the site.

To be effective, an OMS manual also needs to:

- provide the necessary information to implement OMS activities on a daily basis; and
- be easily accessible to all relevant personnel.

An OMS manual includes or refers to other plans specific to various aspects of tailings management. These plans also need to be developed and documented (see also *Appendix 8*):

- tailings transport and placement plan;
- water management plan; and
- closure plan.

4.9 Resources

For effective and efficient implementation of a tailings management system, including eventual decommissioning and closure, and sustained post-closure management, the Owner should identify, secure and regularly review adequacy of:

- human resources and external contractors and consultants;
- condition, function and suitability of equipment;
- financial resources; and
- schedules of activities that integrate the required resources related to tailings management. Examples of activities to be scheduled include timing of construction, access to construction material, reviews, inspections, and any other item critical to successfully implementing the tailings management system.

Measures should also be in place for financial control, control of documented information, training and competence, and communications, as further described below.

Financial Control

Establish and document a budget for tailings management, considering both short-term and long-term needs for responsible and effective tailings management throughout the life cycle.

Establish and document 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 facility and its life cycle phase, re-evaluate the decommissioning and reclamation provision for each facility commensurate with all applicable legal requirements and commitments.

4.10 Training and Competence

Training

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

Providing appropriate training to those who are involved with the tailings facility, including 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, including their design, construction, and operations, should receive detailed and relevant training that corresponds to their work.

Typical aspects to be covered in training:

- tailings management system;
- tailings facility management plans, permits, approvals, and commitments;
- individual duties, responsibilities, and reporting relationships;
- the importance of conformance to design, operational controls, financial controls, and change management procedures;
- risk assessment;
- risk management and critical controls;
- significance of change, and change management process;
- emergency response plans;
- operation, maintenance and surveillance plans and processes described in the OMS manual; and
- importance of communications and document management.

A training program should be developed and implemented. Records related to training for employees, contractors, and consultants, which was funded by or provided by the Owner, should be maintained.

Training addresses both:

- general aspects, such as the Owner's policy and commitments related to tailings management, and the overall goals of responsible tailings management; and
- specific aspects (e.g., technical, communications, management) related to the roles and responsibilities of individual personnel.

Training may be carried out using in-house resources but there may be a need to involve external parties such as the designer or EoR in development of the training materials. Owners may consider some form of evaluation of personnel on their knowledge of the content of the OMS manual to demonstrate competency. A tracking mechanism needs to be in place (e.g., training needs matrix) to ensure that all relevant personnel receive appropriate training.

4.11 Communications

The Owner should clearly describe lines and expectations for communications, and establish and implement communications processes for personnel with direct and indirect roles related to tailings management, including reporting of significant information (e.g., results of Performance Evaluation) and decisions to senior management, the EoR, regulators, and COI, as appropriate.

Communications processes, associated training, and the overall corporate culture should strive to foster an environment in which personnel are encouraged to report problems/concerns or identify opportunities for improving tailings management. The timely communication of potential problems can be essential to achieving the goal of minimizing harm. Two key mechanisms to establishing such a corporate culture are:

- establishment of a confidential process to receive, investigate and promptly address potential problems/concerns identified by personnel regarding possible violations of legal requirements or related public safety, tailings facility integrity or the environment; and
- development and implementation of mechanisms for whistleblower protection to ensure that there is no retaliation, discrimination against, or otherwise negative consequences to whistleblowers who, in good faith, have reported possible violations of legal requirements or potential problems/concerns related public safety, tailings facility integrity or the environment.

It is important to emphasize that these mechanisms do not need to be specific to tailings management, and in most cases, they are not likely to be. Existing, corporate or site-level processes can be used, or new processes could be developed, provided that it is clear that their scope includes tailings management.

There are limits to what can be achieved through establishment of communications processes. Effective communication is a skill that must be developed, and:

- effective communications need to be addressed as part of training activities;
- breakdowns in communications need to be investigated to learn and improve communications; and
- the effectiveness of communications needs to be assessed regularly, with the aim of identifying deficiencies and opportunities for improvement.

Overarching all challenges around communications is complacency, the sense that "it won't happen to us." Complacency increases risk. A tailings management system, effectively implemented with clear communications, clear roles and responsibilities, and a decision-making framework (see OMS Guide Section 2.3), can help counter the tendency to be complacent by bringing greater rigour to all aspects of tailings management.

Further information on effective communications in relation to tailings management is presented in *Appendix 7*.

5 Implementing the Tailings Management Framework

When fully implemented at a specific site, a tailings management system based on this framework will encourage continual improvement in the safe and environmentally responsible management of **tailings facilities**.

As described in *Section 2*, the tailings management framework has been designed for application through the full **life cycle** of a tailings facility, beginning at any phase. **Owners** of tailings facilities should implement the framework at the earliest practicable opportunity.

Implementing the tailings management framework requires the full implementation of all plans described in *Section 4*. In addition, there are two essential components to implementing the tailings management framework:

- implementing an OMS manual; and
- emergency preparedness.

5.1 Operation, Maintenance, and Surveillance Manual

Implementing a facility-specific OMS manual, developed as described in *Section 4.8* and the *OMS Guide*, is essential to implementing the tailings management framework. A tailings management system provides an overall framework, but an OMS is needed to make that framework function on a day-to-day basis. Developing and implementing an OMS manual is a critical component of meeting performance objectives and managing current and future risks associated with any tailings facility.

An OMS manual is a "living" document that needs to be regularly reviewed and revised as appropriate throughout the **operations and ongoing construction** phase of the tailings facility's life cycle, as well as beyond. An out-of-date OMS manual poses **risks** – it is essential that manuals be up-to-date.

5.2 Emergency Preparedness

There is a wide range of potential emergencies that may occur associated with tailings facilities, including structural failure of a facility, rising water levels within a facility, cracking of a dam, a sudden loss of environmental containment of a facility, or other events linked to the loss of one or more **critical controls**. 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, an earthquake, or extreme conditions such as wildfire, landslide, or avalanche.

It is essential to be prepared to effectively respond to an emergency, should one occur. Being prepared for an emergency includes:

- assessing the range of potential emergency scenarios that could occur, and potential impacts;
- maintaining the necessary capacity (e.g., personnel, equipment, supplies) to respond;
- maintaining a state of readiness to respond, in collaboration with external parties (e.g., local first responders) that would be involved in responding to an emergency;
- developing plans for emergency preparedness; and
- conducting training and exercises/tests of the plans for emergency preparedness.

Owners of tailings facilities should undertake emergency preparedness and response planning for each mine site as a whole. Emergency preparedness for a tailings facility is a component of that broader planning.

There are two components to emergency preparedness: emergency response plans (ERPs) and emergency preparedness plans (EPPs). ERPs and EPPs need to be developed for all tailings facilities, taking into consideration the risk profile, risk management plan, and critical controls for that facility.

In addition to the details provided below, the CDA's *Dam Safety Guidelines (Section 4) (2013 edition)* also provide information on emergency preparedness.

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.

5.2.1 Emergency Response Plans

An ERP describes measures the Owner and, in some cases, external parties will take to prepare for an emergency, and to respond if an emergency occurs. Although some aspects of an ERP may involve external parties, it is intended to be an internal document. Elements of an ERP that would be implemented by external parties should be developed cooperatively and be provided to them. An ERP describes the following. While some of the items below duplicate those listed below for EPPs, it is expected that some of the information provided in the ERP would be more detailed.

- potential emergencies that may occur and the conditions that would trigger implementation of the ERP, including, where applicable, potential effects of inundation (see *Section 5.2.3*);
- resources (people, equipment, materials) required to respond to an emergency, including identifying resources that need to be retained on-site (e.g., equipment, stockpiles of rip-rap or other materials);
- roles and responsibilities of the Owner's employees, contractors, and consultants, and relevant external parties (e.g., local first responders, regulatory agencies) and the overall command structure in the event of an emergency;
- any mutual aid agreements with external parties, such as local first responders, other industrial facilities (e.g., nearby mines), or contractors (e.g., heavy machinery);
- site access, including primary and secondary means to access the mine site and tailings facility, and means of reaching the site of a potential emergency under various conditions (e.g., foot, boat, helicopter, all-terrain vehicle, etc.);
- communications systems, equipment and materials;
- procedures to activate the ERP, including internal and external notification and communications plans for emergency response, including up-to-date contact information (e.g., phone numbers and email addresses) for relevant personnel, both internal and external;
- training requirements and plans for relevant personnel, including external parties such as local first responders;
- procedures or actions to be taken to:
  - prevent an upset or unusual condition from becoming an emergency;
  - mitigate on and off-site environmental and safety impacts associated with emergency situations; and

- mitigate consequences if an emergency occurs, including:
  - evacuation plans; and
  - rescue plans;
- mechanisms to alert potentially affected parties of an imminent or developing emergency situation (e.g., alarms to notify downstream communities in the event of a tailings dam failure);
- linkages with the crisis management and communications plan (see *Section 5.2.4*);
- surveillance requirements;
- procedures and frequencies to test the ERP; and
- procedures for the administration and update of the ERP.

An ERP for a tailings facility in the **closure** or **post-closure** phase of the life cycle will need to be adapted to those phases, when there are fewer personnel and less equipment on-site. ERPs 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 communications infrastructure.

The *OMS Guide* addresses the relationship between OMS activities and ERP. An OMS manual describes OMS activities conducted under normal and upset or unusual conditions, while the ERP functions when there is an emergency. The OMS manual and ERP for a given tailings facility must be aligned, such that there are no functional gaps between normal operations and emergency response, and that procedures are in place to transition from normal conditions to an emergency situation that may arise.

5.2.2 Emergency Preparedness Plans

For emergencies that could result in downstream impacts on the environment, infrastructure, or safety, an EPP is developed for external use with input from **COI**, including local authorities (e.g., first responders, municipal governments), and regulatory authorities. An EPP includes:

- a description of the tailings facility, the potential emergencies that could occur, and the potential effects of those emergencies, including, where applicable, potential effects of inundation (see section 5.2.3);
- roles and responsibilities of the Owner and external parties (e.g., local first responders, regulatory agencies) and the overall command structure in the event of an emergency;
- notification procedures to be followed if an emergency occurs or is imminent, including up-to-date contact information (e.g., phone numbers and email addresses) for relevant personnel;
- mechanisms to alert potentially affected parties of an imminent or developing emergency situation (e.g., alarms to notify downstream communities in the event of a tailings dam failure);
- procedures and frequencies to test the EPP; and
- procedures for the administration and update of the EPP.

Information provided in the EPP may be used by potentially affected COI, including local authorities, to assist in the development of their ERPs. Copies of EPPs need to be provided to potentially affected COI with roles or responsibilities related to emergency response.

5.2.3 Other Considerations for ERPs and EPPs

Risk-Based Approach

The level of detail and aspects addressed in ERPs and EPPs need to be commensurate with the potential consequences if an emergency occurs. For tailings facilities with high-consequence material risks, such as large tailings facilities with impounded water, ERPs and EPPs must be comprehensive and detailed, with active engagement of potentially affected COI. However, for facilities which pose only lower consequence material risks (e.g., stacked facilities with little or no risk of off-site movement of tailings), ERPs and EPPs may be more limited in scope, with a lower level of detail appropriate to the risk profile of that tailings facility. In such cases, COI should still be aware of the potential risks and consequences, but there may be less need for active COI engagement in emergency preparedness.

Integration with Site-Level ERPs and EPPs, and Linkages with other Documents

An ERP and an EPP need to be developed and documented for each tailings facility and integrated with the overall site-level ERP and EPP. Emergencies that may affect a mine site more generally (e.g., wildfire) need to be addressed in the site-level ERP and EPP, while the ERP and EPP for a tailings facility addresses the specific considerations for that facility if such an emergency occurs (e.g., emergency procedures for water management in the event of an extended loss of power).

Depending on the needs of the site and COI, an ERP and EPP can be combined, or they may be separate.

As with other documents related to tailings management, it is up to Owner to decide how best to organize necessary documentation. However, ERPs and EPPs are very important documents. While they may be incorporated into other documents, such as an OMS manual, it may in many cases be best practice to maintain them as separate documents, to ensure that they are:

- readily accessible in the event that an emergency occurs;
- administered and prepared by the appropriate personnel/groups;
- directed towards the appropriate audience; and
- more easily updated, based on the outcomes of reviewing and testing the plans.

Addressing Inundation Risks

For tailings facilities that pose a risk of inundation of downstream areas in the event of a failure, the ERP and the EPP need to take into account inundation mapping. The area that could be inundated needs to be clearly defined, describing the maximum extent of flooding, flood depths, and time to maximum depth. Maps of potentially inundated areas need to be developed and included in the ERP and the EPP, identifying any downstream mine site infrastructure, communities, residences, farms, recreational facilities, roads, railways, bridges, powerlines, other infrastructure, or other features (e.g., wildlife habitat) that could be impacted in the event that an emergency occurs. The scope of an EPP encompasses all COI and local authorities that could be potentially impacted by an inundation event.

Inundation studies identify:

- predicted consequences associated with failure modes for a tailings facility;
- downstream areas that could be directly impacted by the release of tailings solids and water;
- timing and size of overall area of impact following a loss of containment; and
- potential impacts of a failure on: human health and safety, the environment, cultural and archeological resources, and infrastructure.

Inundation studies inform the analysis of potential consequences of a failure, including costs.

In accordance with the *CDA's Dam Safety Guidelines* (Section 2.5) (2013 edition), such analyses should be conducted for two scenarios:

Flood-induced event: Impoundment breach from a natural flood of a magnitude that is greater than what the tailings facility can safely pass.

Sunny-day event: This is a sudden event that occurs during normal operations. It may be caused by various factors, including internal erosion, piping, earthquakes, and operational events or errors leading to overtopping, or similar events.

Additional guidance is also available from the Association of Professional Engineers and Geoscientists of British Columbia, which released *"Flood Mapping in BC - APEGBC Professional Practice Guidelines"*

Review and Testing

Procedures need to be established and implemented for regularly scheduled review and testing of ERPs and EPPs to ensure that the plans are up-to-date and adequate, and that all relevant personnel, including external parties, are familiar with the plans and their roles and responsibilities if an emergency occurs. Review and testing of EPPs need to involve potentially affected COI such as local first responders and relevant government agencies. Portions of ERPs that would require action by external parties if an emergency occurs also need to be tested in this manner. Tests can range from a tabletop exercise to a full-scale simulation of an emergency and can include multiple failures. The results of tests need to be evaluated to identify any deficiencies or opportunities for improving the ERP or EPP, and the plans updated accordingly.

5.2.4 Integration with Crisis Management and Communications Planning

Emergency preparedness needs to be augmented with crisis management and communications planning. A crisis as an event or set of circumstances that could significantly affect an Owner's ability to carry out their business, damage an Owner's reputation and/or threaten the environment, the health and safety and well-being of its employees, neighbouring communities or the public at large. Any tailings-related emergency that constitutes a crisis must be managed as such.

If a crisis occurs, the Owner's first priorities must be to protect the safety and well-being of its employees, impacted communities and environments, and to remediate any negative impacts on nearby communities and the environment. However, there are a number of obstacles that can impede the quick resolution of a crisis.

Effective crisis management and communications, including proactive communication of how the Owner is managing and resolving the situation, can help facilitate the physical response to an emergency and help prevent or lessen impacts on the Owner and COI. Whereas ERPs are intended to guide the initial physical response to the emergency, the crisis management and communications plan is intended to guide communications internally and externally.

Crisis management and communications are addressed in detail in MAC's *Crisis Management and Communications Planning Protocol*, which requires both head offices and facilities to develop crisis management plans, as well as establish crisis communications teams to support the execution of these plans. Facilities must be able to demonstrate, among other requirements, that they have crisis communications programs in place to effectively alert employees and the public of a crisis, its development and resolution. They must also be able to demonstrate that their crisis management plan is regularly tested and updated.

Further information on crisis planning is available, for example:

- MAC's *Crisis Management and Communications Planning Reference Guide*
- United Nations Environment Programme *Awareness and Preparedness for Emergencies at Local Level* (2nd Edition, 2015)

6 Performance Evaluation

Performance evaluation is essential to:

- assess whether performance objectives are being met;
- assess the effectiveness of risk management measures, including **critical controls**;
- inform updates to the **risk** management process for the **tailings facility**; and
- inform the Management Review for Continual Improvement.

Performance evaluation builds upon the results of surveillance conducted in accordance with the requirements contained in the OMS manual by analyzing and interpreting the results to evaluate performance. The evaluation includes results of surveillance and reviews, both internal and independent, to evaluate:

- operating performance against performance objectives and indicators, and critical controls;
- compliance with legal requirements, and conformance with plans and commitments;
- the risk management process, including the need to update the risk assessment;
- the need for changes or updates to the OMS manual or other site-specific **tailings** management system-related documents. This includes evaluating the effectiveness of surveillance activities and the utility of the information being collected, and identifying any gaps in information collection; and
- the need for changes or updates to the ERP and EPP.

Performance evaluation should include the identification of gaps, deficiencies or areas of non-conformance with the tailings management system, including performance objectives and plans to address those objectives. Action plans to make necessary changes or updates should be documented, approved and implemented, and implementation of action plans should be documented and tracked to completion. Deviations from the approved corrective actions should be documented to describe if and why action different from those originally approved were undertaken. The status of action plans should be communicated internally and to **COI**, as appropriate.

Performance evaluation occurs at various timescales, from hourly or daily, to annual or more, depending on the aspect of performance being evaluated. For example, evaluation of conformance for some parameters related to tailings deposition or water management may require daily oversight, while broader, more comprehensive performance evaluation, such as evaluating the need for changes to the OMS manual, may be done on a less frequent basis.

Incidents can and do occur, both at tailings facilities within the **Owners**' portfolio, and at other facilities. It is essential that such incidents be analyzed and learnings from those incidents be identified and applied to improve performance and prevent similar incidents from occurring in the future.

As part of performance evaluation, the Owner should establish a mechanism to conduct post-incident analyses for any incidents related to tailings management that may occur, such as cases of non-conformance, un-anticipated upset conditions, or an emergency. Such analyses are important to learn from what happened to help prevent a similar incident from occurring in the future, and could consider a range of questions such as:

- 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 tailings management system, ERP, EPP, or OMS manual as an outcome of the post-incident analysis?

If an incident occurs, a post-incident analysis should be conducted as soon as possible afterwards, while the memories of all personnel involved remain fresh. Results of the analysis should be documented and reported to the **Responsible Person(s)**, **Accountable Executive Officer**, and Board of Directors or **Governance Level**, as appropriate. Owners are also encouraged to share their analyses and outcomes with the industry more broadly, so that others may learn and improve their tailings management practices.

Results and recommendations arising from performance evaluations should be documented and reported. Frequency of reporting depends on the nature of the performance evaluation and the results.

It is necessary to report the results and recommendations of performance evaluations to the Responsible Person(s), the Accountable Executive Officer and, as appropriate, the Board of Directors or Governance Level, at a frequency and level of detail documented in the Owner's policies and procedures.

Assurance is a critical component of performance evaluation. *Section 8* provides the essential elements of an assurance program.

7 Management Review for Continual Improvement

Management should perform regular reviews to ensure continual improvement, based on Performance Evaluation and Assurance. The management review process should evaluate the:

- status of actions from the previous management review;
- suitability, adequacy, effectiveness, and the need for changes to:
  - the **tailings** management system;
  - the ERP and the EPP; and
  - the OMS manual;
- performance of the **tailings facility**;
- effectiveness of **risk** management;
- adequacy of resources committed to tailings management; and
- integration of tailings management activities with site-wide systems, such as, where applicable, a site-wide environmental and social management system.

The management review process should also identify opportunities for improvement and describe associated action plans.

The frequency of management reviews varies, but is typically annual during the **initial construction**, and **operations and ongoing construction** phases, and the **closure phase**.

The management review for continual improvement is reported to the **Accountable Executive Officer** to ensure that the **Owner** is satisfied that the tailings management system is effective and continues to meet the needs of the facility. The management review for continual improvement goes beyond technical performance to address all aspects of the management of the tailings facility.

The management review process also provides an opportunity for the **Responsible Person(s)**, the **EoR** and other employees and contractors involved in tailings management to: reconfirm alignment between design requirements and OMS activities; discuss realized or anticipated changes and their implications/ management; and identify opportunities for improvement.

The management review should describe current conditions related to the tailings facility, including a summary of construction activities since the last management review and significant changes since the last management review. This should include:

- an assessment of whether the tailings facility is continuing to meet the design intent; and
- a summary of any deviations from the design or expected conditions since the last management review, including an assessment of the cumulative impacts of those deviations.

The management review should identify and evaluate the potential significance of changes since the previous management review that are relevant to the tailings management system, including:

- changes to legal requirements, standards and guidance, industry best practice, and commitments to **COI**;
- changes in mine operating conditions (e.g., 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; and
- relevant new or emerging technologies, practices or knowledge related to tailings management that may potentially be considered in continual improvement.

The management review should also provide a summary of significant issues related to the overall performance of the tailings facility and tailings management system, updated since the previous management review, including:

- compliance with legal requirements, conformance with standards, policies and commitments, and status of corrective actions;
- tailings facility maintenance;
- tailings facility surveillance; and
- inspections, internal or external audits, evaluations of effectiveness, and Independent Review.

The management review outcomes should be documented and reported to the Accountable Executive Officer, including:

- conclusions regarding the performance of the tailings facility, the tailings management system, the ERP and the EPP, and the OMS manual;
- if needed, action plans to:
  - ensure that performance objectives are met;
  - address non-conformance with requirements, standards, policy, or commitments; and
  - implement recommendations for continual improvement.
- any recommendations for modifications to the tailings management system, the ERP, the EPP, or the OMS manual; and
- any recommendations for additional resources for tailings management.

Progress towards implementing action plans should be tracked and reported at least annually to the Accountable Executive Officer.

8 Assurance

Assurance is an oversight process to provide an outside perspective on whether tailings are being managed effectively and responsibly. It is distinct from the Performance Evaluation component of a tailings management system, and cross-cuts all other aspects of tailings management.

Effective assurance is a valuable feedback mechanism to those directly involved in tailings management. Depending on the assurance mechanism used, assurance potentially provides perspectives on current performance, deficiencies, opportunities for improvement, future plans, and other aspects of tailings management. It can also provide a challenge function to those directly involved in tailings management, from a perspective that sees the forest as well as the trees, and depending in the assurance mechanism used, may pose provocative questions such as:

- Why do you do it this way?
- Could there be a better way?
- Have you thought about this?
- Why did you make that assumption?

Outcomes of assurance can be used to help demonstrate the current state of tailings management to the **Owner** (including the **Responsible Person(s)**, **Accountable Executive Officer** and the Board of Directors or **Governance Level**), regulators, and **COI**.

Those providing assurance can be internal to the company (e.g., employees at the corporate level or from other facilities) or external. Assurance providers need to have appropriate qualifications relevant to their assurance activities to ensure that assurance is effective.

Several different mechanisms to be used to provide assurance are described below. These should not be treated as "either/or" options – all should be used, as they serve different purposes.

Audits (both internal and external): The formal, systematic and documented examination of a **tailings facility's** conformance with explicit, agreed, prescribed criteria, often requirements stipulated in law or regulation, or in the Owner's tailings management system. Audits evaluate and report on the degree of conformance with stipulated criteria, based on the systematic collection and documentation of relevant evidence. Audits involve some degree of judgment but are not designed to determine root cause of deficiencies, or to evaluate management system effectiveness.

Internal audits are conducted by employees with appropriate knowledge and competencies who are independent, impartial, and objective with respect to the management of the tailings facility being audited. For example, they could work at other tailings facilities in the Owner's portfolio or that could work at the corporate level.

External audits are conducted by auditors who are external to the company being audited. Auditors maintain an objective viewpoint throughout the audit process to ensure that findings and conclusions are based only on the evidence (Adapted from *ISO 19011*).

Evaluation of Effectiveness: An evaluation of effectiveness goes beyond determining whether a condition has been met and includes an assessment of whether tailings management is achieving the intended results. It considers both the extent to which planned activities have been realized, and the extent to which performance objectives have been achieved.

Criteria to be examined will depend on the scope of the evaluation. Typical sources of information that should be considered when evaluating tailings management system effectiveness include changes in internal or external conditions that could affect the system and achievement of performance objectives.

Performance results and trends that should be evaluated to determine the effectiveness of tailings management include:

- the extent to which performance objectives and indicators are being achieved;
- the extent to which planned activities have been implemented as intended;
- fulfilment of conformance obligations;
- non-conformities and corrective actions;
- surveillance results;
- adequacy of resources to support achievement of performance objectives;
- feedback from practitioners and end users; and
- any additional relevant information or feedback from COI.

Independent Review: one of the overarching principles of the framework, Independent Review is described in *Section 2.2.3* and further discussed in *Appendix 4.*

Glossary

Acceptable risk: The level of risk deemed acceptable to an Owner, considering legal requirements, internal policy, business factors and societal acceptance.

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 Officer: An executive-level person (e.g., CEO, COO, Vice President) designated by the Board of Directors or Governance Level, who is accountable for tailings management, and the development and implementation of the systems needed for responsible tailings management. This accountability cannot be delegated. This Officer has a direct reporting relationship to the Board, a Board committee, or the Governance level and:

- needs to be aware of key outcomes of tailings facility risk assessments and how these risks are being managed;
- has accountability and responsibility for putting in place an appropriate management structure;
- delegates responsibility and authority for tailings management and defines the personnel responsibilities, authority, and reporting relationships to implement the systems needed for responsible tailings management through all phases in the facility life cycle; and
- demonstrates to the Board of Directors/Governance level whether tailings are managed responsibly.

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

Best Available/Applicable Practice (BAP): Management systems, operational procedures, techniques and methodologies that, through experience and demonstrated application, have proven to reliably manage risk and achieve performance objectives in a technically sound and economically efficient manner. BAP is an operating philosophy that embraces continual improvement and operational excellence, and which is applied consistently throughout the life of a facility, including the post-closure period.

Best Available Technology (BAT): The site-specific combination of technologies and techniques that is economically achievable and that most effectively reduces the physical, geochemical, ecological, social, financial, and reputational risks associated with tailings management to an acceptable level during all phases of the life cycle, and supports an environmentally and economically viable mining operation.

Communities of Interest (COI): COI include all individuals and groups who have an interest in, or believe they may be affected by, decisions respecting the management of operations. Facility COI may include, but are not restricted to:

- indigenous peoples;
- community members;
- under-represented groups;
- employees;
- contractors/suppliers;

- neighbours;
- local environmental organizations and other non-governmental organizations (NGO); and
- local governments and institutions.

Other COI may include:

- suppliers;
- customers;
- regional or national environmental organizations and other non-governmental organizations (NGO);
- governments;
- the financial community; and
- shareholders.

Continual improvement: The process of implementing incremental improvements and standardization to achieve better environmental and management system performance.

Critical controls: A risk control that is crucial to preventing a high-consequence event or mitigating the consequences of such an event. The absence or failure of a critical control would significantly increase the risk despite the existence of other controls. Critical controls may be technical, operational, or governance-based. Critical control management is a governance approach to managing high-consequence risks relating to an operation or business.

Documented information: Information of importance that is required to be controlled and maintained by the organization. Documented information can refer to the tailings management system and its processes, documentation, and records.

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.

Engineer-of-Record: The Owner, in assuring that a tailings facility is safe, has the responsibility to identify and retain an EoR, who provides technical direction on behalf of the Owner. The EoR verifies whether the tailings facility (or components thereof) has been:

- designed in accordance with performance objectives and indicators, applicable guidelines, standards and legal requirements; and
- constructed, and is performing, throughout the life cycle, in accordance with the design intent, performance objectives and indicators, applicable guidelines, standards and legal requirements.

For tailings facilities that include retention structures/dams, the EoR is responsible for Dam Safety Inspections and associated reports. The EoR should also participate in the facility's risk assessments and be accessible to Independent Reviewers, and, for facilities with retention structures, dam safety reviews. The EoR provides these activities as part of the Owner's broader assurance process.

Governance Level: The company Board of Directors (or a sub-committee of the Board of Directors) is considered the governance level of a company, the level at which the highest-level corporate decisions are made, particularly regarding organizational and financial resources. For companies headquartered outside of the country in which the tailings facility is located that do not have a Board of Directors based in that country, the governance level would be equivalent to the highest-level committee or board that provides oversight and review of tailings management activities within that country.

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 Owner to:

- facilitate informed management decisions regarding a tailings facility so that tailings-related risks are managed responsibly and in accordance with an acceptable standard of care; and
- ensure that the Accountable Executive Officer has a third-party opinion regarding the risks and the state of the tailings facility and the implementation of the tailings management system, 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, judgment, rule, or regulation of, and the terms of any license or permit issued by, any governmental authority.

Life cycle: The succession of phases in the life of a tailings facility, consisting of: project conception and planning, design, initial construction, operation and ongoing construction, closure, and post-closure. At some sites, the life cycle may also include temporary closure. In the case of tailings facilities, the life cycle, including the closure, and post-closure phases, can extend to decades or centuries, unless the facility is removed at some point in the future if tailings are reprocessed or relocated.

Project Conception and Planning: Begins at the outset of planning of a proposed mine, and is integrated with conception and planning for the overall site, including the mine plan and plans for ore processing. The phase includes the use of rigorous decision-making tools to support selection of the location for the tailings facility, and the BAT to be used for tailings management.

Design: Begins once the location and BAT for the tailings facility have been selected, and occurs in concert with detailed planning of all aspects of the proposed mine. Detailed engineering designs are prepared for all aspects of the tailings facility and associated infrastructure.

Initial Construction: Construction of structures and infrastructure that need to be in place before tailings placement commences. This includes, for example, removal of vegetation and organic soils, and construction of starter dams, tailings pipelines, access roads, and associated water management infrastructure.

Operations and Ongoing Construction: Tailings are transported to and placed in, the tailings facility. Tailings dams may be raised, or new tailings cells added as per the design. The operations and ongoing construction phase of a tailings facility typically coincides with the period of commercial operations of the mine.

Standby Care and Maintenance: The mine has ceased commercial operations and the placement of tailings into the facility is not occurring. The Owner expects to resume commercial operations at some point in the future, so surveillance and monitoring of the tailings facility continue, but the facility and associated infrastructure are not decommissioned and the closure plan is not implemented.

Closure: Begins when placement of tailings into the facility ceases permanently. The facility and associated infrastructure are decommissioned, and the closure plan is implemented, including:

- transitioning for operations to permanent closure;
- removal of infrastructure such as pipelines;
- changes to water management or treatment; and
- recontouring or revegetation of tailings and any containment structures or other structural elements.

Post-closure: Begins when decommissioning work is complete, the closure plan has been implemented, and the tailings facility has transitioned to long-term maintenance and surveillance. During post-closure, responsibility for a tailings facility could transfer from the Owner to jurisdictional control.

Maintenance: Includes preventative, predictive, and corrective activities carried out to provide continued proper operation of all infrastructure (e.g., civil, mechanical, electrical, instrumentation, etc.), or to adjust infrastructure to ensure operation in conformance with performance objectives.

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.

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. The term "operation" applies throughout all phases of the life cycle of a tailings facility and is not limited to the operations and ongoing construction phase of the life cycle when tailings are being actively placed in the facility. As a result, operation also includes reclamation and related activities.

Owner: The company, partnership, or individual who has legal possession or is the legal holder of a tailings facility under law in the applicable jurisdiction where the facility is located. For example, the company, partnership or individual that owns the mine from which the tailings and wastewater are generated is the owner of those tailings and can be considered the Owner of the tailings facility.

In the case of joint ventures or similar projects, they may be more than one company involved in Ownership. In such cases, the Owner would comprise all companies that are represented on the Board of Directors and are involved in decision-making.

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 fulfill requirements for quality.

Quality control (QC): The operational techniques and activities that are used to fulfill requirements for quality.

Responsibility: The duty or obligation of an individual or organization 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 organization with responsibility is accountable to the person that delegated that responsibility to them.

Responsible Person: Identifies the scope of work and budget requirements (subject to final approval) for all aspects of tailings management, including the Engineer-of-Record, and will delegate specific tasks and responsibilities for aspects of tailings management to qualified personnel. The Responsible Person(s) has clearly defined, delegated responsibility for tailings management and appropriate qualifications.

As a minimum, the Owner needs to designate one Responsible Person for each tailings facility. There may also be a designated Responsible Person at the corporate level.

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
- minimize 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.

Surveillance: Includes the inspection and monitoring (i.e., 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 byproduct 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: The collective engineered structures, components and equipment involved in the management of tailings solids, other mine waste managed with tailings (e.g., waste rock, water treatment residues), and any water managed in tailings facilities, including pore fluid, any pond(s), and surface water and runoff. This may include structures, components and equipment for:

- classification of tailings through water content management (e.g., cyclones, thickeners, filter presses);
- transporting tailings to the tailings facility (e.g., pipelines, flumes, conveyors, trucks);
- containment of tailings and associated water (e.g., dams, dykes, stacks, liner systems, cover systems);
- management of seepage (e.g., underdrains, collection ponds, pumping wells);
- water reclaim systems (e.g., pumping to the ore processing facility);
- management of surface water releases from the tailings facility (e.g., diversions, decant structures, spillways, outlets, flumes, water treatment);
- structures, components and equipment for the surveillance and maintenance of tailings facilities; and
- mechanical and electrical controls, and power supply associated with the above.

Appendix 1: Risk Management Framework and Approach

The mining industry operates within a risk management culture aimed at responsible management of risks. A risk management framework should be embedded within each organization's overall strategic and operational policies and practices. In general, risk management entails identification, assessment, and treatment of risks. In the tailings management context, a risk management approach facilitates continual review and improvement of risk management strategies across the life cycle of a tailings facility. It should, therefore, be flexible, iterative and responsive to change. In addition, effective and transparent management of risks requires an appropriate level of competency for decision-making to evaluate, recommend and approve technical, management, environmental, social and economic risks related to tailings management.

Implementation of a risk-based approach requires an Owner of a tailings facility to first define their facility's risk profile, taking into consideration the internal and external operating environment, and quantitative and qualitative factors. Once this context has been established, a risk assessment for the tailings facility can be performed.

As part of this, Owners should consider the "business risk" in the context of a tailings facility breach or other significant unwanted event. Most major mining companies employ comprehensive risk management systems that could be used to characterize potential business impacts such as those to workforce health and safety, lost production, corporate reputation, and market capitalization. In fact, an Owner's business risk may potentially be of more consequence and warrant more stringent design, construction and operating requirements than would otherwise be determined on the basis of other industry standards and/or legal requirements.

There are two basic approaches to risk assessment:

- identify the potential risks and determine the likelihood of a range of potential consequences of those risks; and
- determine credible failure modes and assess what potential conditions (hazards), and their likelihood, could result in those failure modes.

Applying both of these approaches provides for a robust assessment of risks.

Generally, a risk assessment attempts to answer the following fundamental questions:

1) What can happen (unwanted event) and how (failure mode)?
2) If it does happen, what are the consequences?
3) What is the likelihood (probability) that such an unwanted event will happen?
4) Can the risk be practically eliminated?
5) What can be done to reduce the likelihood?
6) What can be done to reduce the consequences?
7) Is the level of risk tolerable or acceptable and does it require further treatment?

Relationship between failure modes and hazards: a single failure mode (e.g., overtopping of a dam) could be triggered by multiple hazards (e.g., landslide, extreme precipitation, etc.); conversely, one hazard (e.g., downstream inundation) could be triggered by more than one failure mode (e.g., overtopping, foundation failure, piping of water through a dam, etc.).

Risk management strategies typically involve developing and implementing risk controls aimed to control or mitigate risks identified during risk assessment. Through application of risk management strategies, organizations take the necessary steps to reduce identified risks within acceptable levels that are As Low As Reasonably Practicable (ALARP). These strategies mitigate and control risks by one or a combination of the following:

- eliminating or avoiding specific risks to minimize overall risk to the extent practicable;
- minimizing the likelihood that the risk will occur by early identification and implementation of appropriate controls; and
- developing contingency and mitigation plans for the potential consequences of the identified risks.

There may be some risks which, even when reduced to ALARP, remain unacceptable and hence require a re-evaluation of alternatives.

As Low As Reasonably Practical (ALARP): The point at which the cost (in time, money and effort) of further risk reduction is significantly disproportionate to the risk reduction achieved.

Additional guidance and information is available in the public domain on the topic of risk and its management with respect to tailings facilities and other similar infrastructure, including documents prepared by the:

- *Canadian Dam Association (CDA)*;
- US Bureau of Reclamation;
- *Australian Leading Practice Sustainable Development Program (LPSDP)*;
- *Australian National Committee on Large Dams (ANCOLD)*; and
- *International Commission on Large Dams (ICOLD)*.

Also, refer to *International Organization for Standardization (ISO)* standards or its country equivalents such as the Australian/New Zealand Standards and the *Canadian Standards Association* for more guidance on risk management and risk assessment concepts and tools. Readers may also refer to a paper entitled *Geotechnical Risk, Regulation, and Public Policy*, written by Dr. Norbert Morgenstern and published in August 2018 in Soils and Rock, volume 41(2).

Application of risk assessment tools:

According to ICOLD Bulletin 139, hazard rating is defined as "the consequential damage from a tailings dam failure (is) generally assessed in terms of its potential effect on the four categories of:

1) Loss of life
2) Environmental damage
3) Cost of physical damage
4) Social impact including public perception"

These four categories could be used as the basis to perform a risk assessment at any phase of the life cycle of a tailings facility. While trying to keep these categories as generic as possible, the above listed four categories could be expanded as follows:

1) Health and safety (including potential injury, health degradation of people, and loss of life);
2) Environmental (including potential environmental damage and/or environmental degradation);
3) Financial (including increased costs to the operation/corporation and/or cost of potential physical damage);
4) Social (including potential cultural degradation and/or public perception);
5) Legal (including non-compliance and insufficient permits);
6) Operational management and control (including inadequate management tools, qualified resources, and/or funding); and
7) Reputation for the Owner, including market capitalization and share loss.

Note: Consequence and risk assessments can be performed with or without the Owner's financial considerations. Either method may be appropriate depending upon context and should be clearly declared.

Risks that are encountered during the different phases of the mine, or during extreme events affecting the tailings facility, can be evaluated against the categories listed above using a failure mode and effects analysis (FMEA) model and a typical likelihood–consequences matrix similar to the one shown in Figure A.1.1. Risks may be identified as extreme, high, moderate or low. As a starting point, all management concepts presented in *Appendix 2* should be assessed following such a risk-based approach and considering all life cycle phases of the tailings facility.

In addition to FMEA, there are several other risk assessment techniques that can assist in the evaluation of the likelihood of occurrence of an undesired event and its consequences to the operation, society, and the environment. Some other commonly-used techniques include preliminary hazard analysis, Monte Carlo simulation, cause and consequence analysis, and decision/event trees analyses. Some of these other techniques can be used in conjunction with a likelihood-consequences matrix. For example, the bow-tie method (see Figure A.1.2) could be used to gain a better understanding of the extent and effectiveness of risk controls, including critical controls, which are in place or could be implemented for the management of high or extreme consequence events, as identified in a likelihood-consequences matrix model. Refer to the Australian Government's *LPSDP document on Risk Management* for further details on the application of bow-tie analysis.

The Independent Reviewer(s) should be provided risk assessments and management plans for the tailings facility in question, and include the results of those assessments and plans in the scope of the IR. Summary results of risk assessments should be reported to the Accountable Executive Officer.

Figure A.1.1. Sample of a typical qualitative risk assessment matrix. The likelihood, consequence and overall risk level descriptors (e.g., possible, major, high risk, etc.) are for illustrative purposes only, and many other descriptors are acceptable provided they are defined, understood, and used consistently.

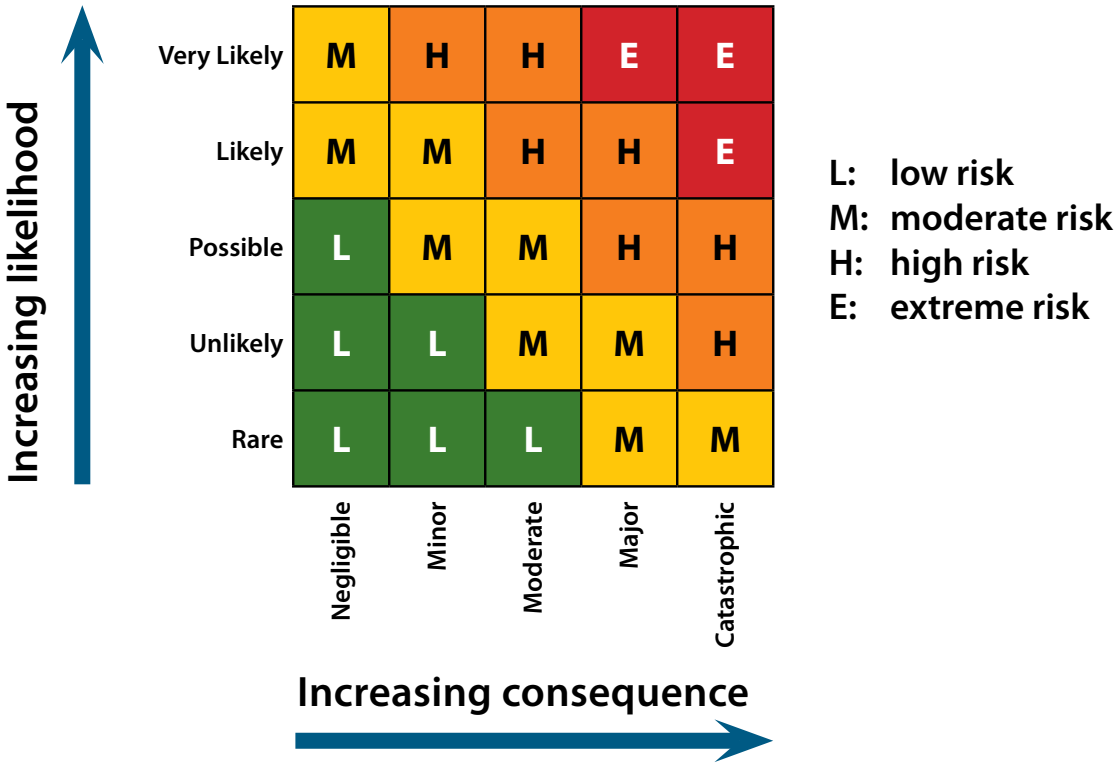
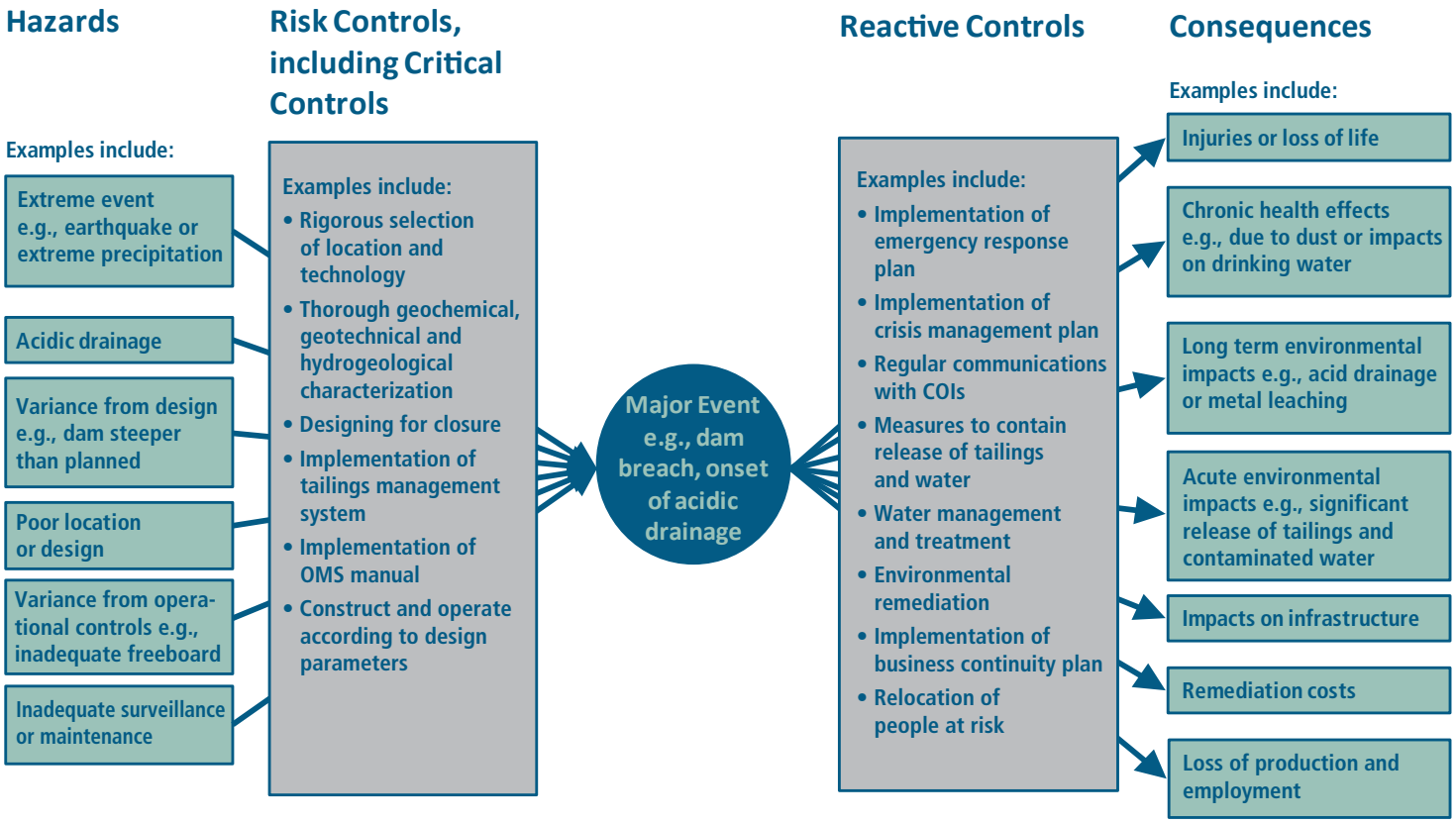


Figure A.1.2: Illustration of a typical bow-tie analysis, providing examples of possible hazards and risk controls to reduce the likelihood or consequence of a major event, and reactive controls and potential consequences if a major event occurs.



Appendix 2: Best Available Technology and Best Available/ Applicable Practice

Best Available Technology, or BAT, is the site-specific combination of technologies and techniques that is economically achievable and that most effectively reduces the physical, geochemical, ecological, social, financial and reputational risks associated with tailings management to an acceptable level during all phases of the life cycle, and supports an environmentally and economically viable mining operation.

Best Available/Applicable Practice, or BAP, encompasses management systems, operational procedures, techniques and methodologies that, through experience and demonstrated application, have proven to reliably manage risk and achieve performance objectives in a technically sound and economically efficient manner. BAP is an operating philosophy that embraces continual improvement and operational excellence, and which is applied consistently throughout the life of a facility, including the post-closure period.

BAT

The incorporation of BAT into tailings management is designed to ensure that the selected tailings technology or methodology effectively achieves performances objectives, manages the identified risks, and is technically and economically feasible. When considering BAT for tailings management, it is important to understand that no single technology or technique, or combination thereof will be the best risk management alternative for every tailings facility. The variability of topography, climate, seismicity, ecosystem, mineralogical and chemical composition of soil and bedrock, project economics, and other site-specific considerations dictates that the BAT should be determined for each tailings facility on an individual basis.

The full spectrum of tailings management alternatives should be assessed for each potential facility location at the project conception and planning phase of the life cycle (see also *Appendix 3*). This rigorous, transparent process for assessing alternatives provides a methodology to identify the optimum combination of tailings management alternatives and facility location, considering the site-specific risk profile and conditions, and taking closure and post-closure risks and liabilities into account. Typically, the criteria to use when selecting BAT are summarized in *Appendix 3.1* and include:

- tailings facility risks;
- closure plan and end land use;
- tailings characteristics (physical and chemical);
- water balance and management;
- COI expectations;
- legal requirements and considerations; and
- project economics.

The goal of applying BAT as part of the tailings management strategy for a site is to determine the tailings management methodology, which will provide a safe, stable facility with an acceptable level of impact and risk for the full life cycle of the facility.

BAT should be reassessed at discrete times throughout the life of the facility when operating data, new technology or other reasons to contemplate a significant change to the facility life cycle plan arise.

BAP

A commitment to using BAP is a commitment to using relevant knowledge and technology to help ensure success. In fact, implementing this Tailings Guide is an example of employing BAP.

For tailings management, BAP encompasses the management systems and operational procedures developed and implemented, in consideration of current engineering and governance practices, so that tailings facilities are designed, constructed, operated, maintained, monitored and closed to achieve performance objectives.

There are several key concepts that help define BAP:

- Tailings management practice is constantly evolving and improving as the collective knowledge base expands. As a result, the management system should include specific processes to ensure that practices stay current, effectively manage facility impacts and risks, and incorporate continual improvement;
- The management practices and processes need to be auditable and verifiable; and
- Successful implementation requires effective, timely communication inside and outside the company.

BAP is used to assess, monitor, verify and continually improve the Owner's management systems and practices. BAP is also used to help ensure that mechanisms are in place to:

- confirm that controls are effective at managing the evolving risks associated with tailings facilities;
- stay current with changes in technology, practice, and industry knowledge, including triggering re-assessments of BAT when warranted; and
- evaluate and incorporate applicable changes into the Owner's tailings management system and operating practices.

Relationship between BAT and BAP

Since technologies and practices evolve over time, it is important to recognize the interplay of BAT and BAP. Selection of BAT does not include the ongoing management, governance, and continual improvement processes throughout the life of the tailings facility – these, however, are components of BAP. Managing a facility with BAP principles may generate the need to reassess BAT if facility performance or available and applicable technology changes, or if some other factor is identified through the continual improvement process that potentially warrants a change to the facility design. The assessment of BAT facilitates a thorough and transparent identification and understanding of the potential impacts, risks, and costs associated with a tailings technology selection and provides a sound framework to manage these risks and costs through BAP.

Appendix 3: Assessment of Alternatives

Overview

A process to assess alternatives for the location of a potential tailings facility, and the site-specific BAT for tailings management, should be implemented at the project conception and planning phase of the life cycle. Selection of BAT and facility location lay the foundation for all subsequent decisions and activities related to the tailings facility, including risk management. Decisions at this phase of the life cycle have profound and often irreversible implications throughout the life cycle.

Alternatives for closure and long-term closure objectives and post-closure land use are essential considerations in the initial selection of location and technology, and may also need to be reassessed at other phases throughout the life cycle. Alternatives may also need to be assessed at other phases throughout the life cycle in the event of a mine-life extension and the need for a new or expanded tailings facility.

Alternatives assessment is typically conducted as a multi-step process:

1) Identify performance objectives, describing how the tailings facility is expected to perform throughout the entire life cycle, including the long-term closure objectives and post-closure land use.
2) Identify possible (i.e., reasonable, conceivable, and realistic) alternatives, avoiding *a priori* judgments about the alternatives.
3) Pre-screen possible alternatives to eliminate from further consideration any that would not meet the performance objectives or otherwise have characteristics that would be "show-stoppers". This step is also referred to as fatal-flaw analysis.
4) Assess remaining alternatives using multiple accounts analysis or a similar decision-making tool.
5) Conduct a sensitivity analysis to test the robustness and validity of the outcomes of the detailed assessment of alternatives against various biases and assumptions. Despite efforts to make the assessment of alternatives as objective as possible, there will be biases and perceived biases in the process. For example, the assessment could be re-done without consideration of project costs, to see the impact of removing consideration of costs on the final outcome.
6) Document the results in a comprehensive technical report.

There are a number of aspects that are important for an effective alternatives assessment:

- The alternatives assessment should consider a wide range of factors, and be conducted by a multi-disciplinary team consistent with the unique conditions for the proposed facility. This team typically includes geotechnical engineers and geologists, fisheries biologists, hydrologists, archaeologists, specialists in community and Indigenous relations, specialists in traditional ecological knowledge, social scientists, and economists.
- Team members should be open minded, both to each other, and to the outcome of the process. Having a pre-conceived notion of the "right" answer can bias results. The team members need to respect the alternatives assessment process.
- Team members should collect and consider a broad range of information, examples of which are provided in *Appendix 3.1*.

- External input is required through the steps described above. Input of COI, including regulators, informs the process, and Independent Reviewers should also be engaged.
- Alternatives should be assessed and documented using a rigorous, transparent decision-making tool, such as multiple accounts analysis, further described below.
- Given the need to select both a location and BAT, the process may require more than one iteration.

Figure A.3.1 illustrates an overall framework for the planning and design of tailings facilities, and the role of alternatives assessment within that framework.

Multiple Accounts Analysis

Multiple accounts analysis (MAA) is a tool that is used to support decision-making, including for tailings management. There are a number of good, structured decision-making tools available to assist the tailings planning and design process. Since the federal regulator in Canada mandates the use of MAA, it is given additional focus here. This approach was described in *A Multiple Accounts Analysis for Tailings Site Selection*.[5] It was expanded upon by Environment and Climate Change Canada in its *Guidelines for the Assessment of Alternatives for Mine Waste Disposal* (2011). This discussion is based on the approach as described in these documents.

MAA and similar tools are effective methods to help make complex decisions, and to help communicate to others how those decisions were made and what factors were considered. These tools are widely applicable to a range of potential decisions. In the context of decisions about tailings management, they are applicable regardless of tailings characteristics, geography, environmental and societal context of a site, and other factors that may influence such decisions.

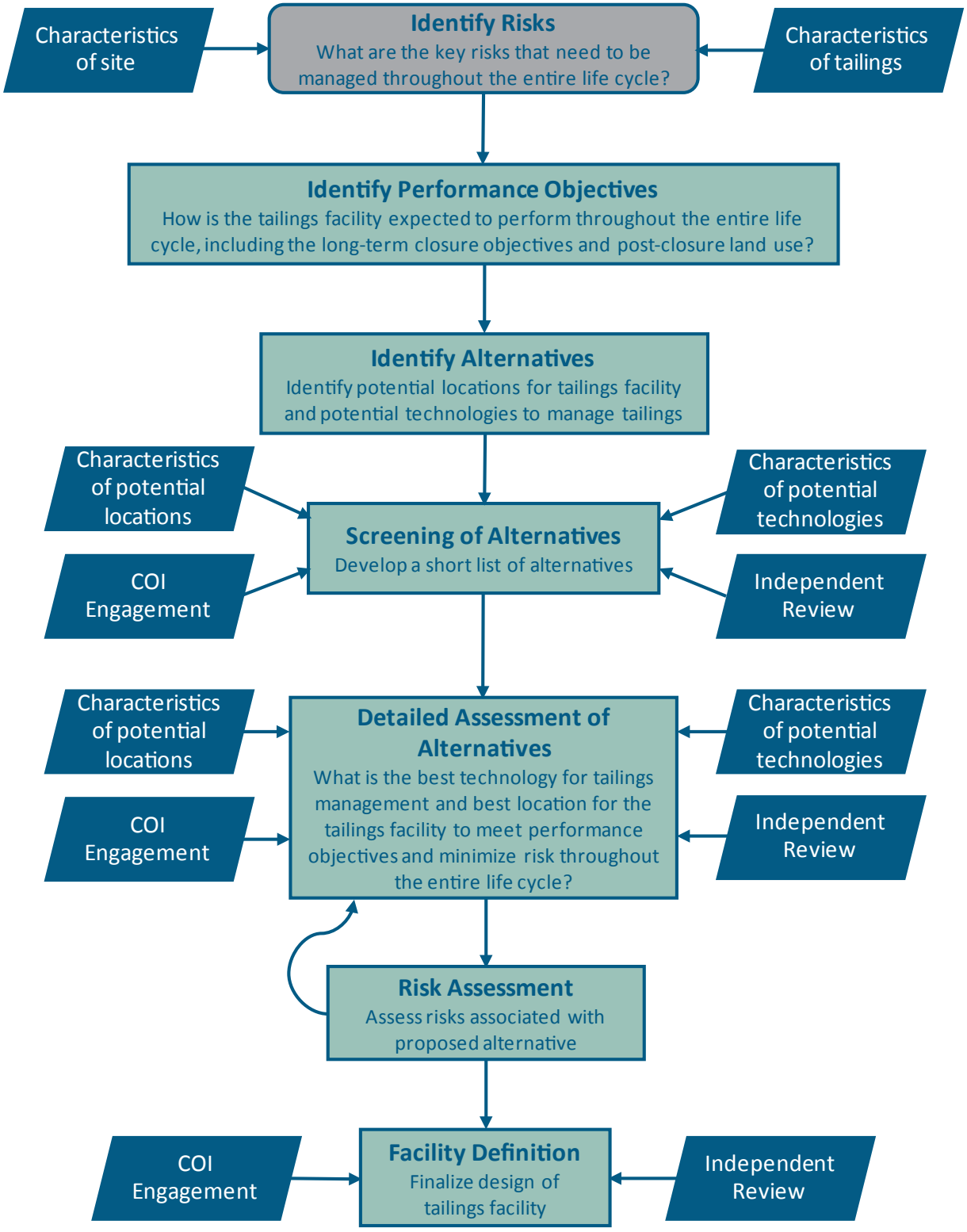
MAA is part of a broader toolbox of methods referred to as multiple criteria decision analysis. The strength of such tools is that they provide a method of integrated assessment of different characteristics of alternatives, for example, for comparing potential impacts on wildlife with capital costs. In effect, these tools provide a rigorous, semi-quantitative means of comparing apples and oranges. The methodology also provides a means to make inherent subjectivity and biases more transparent, and then testable using sensitivity analysis.

MAA is a two-stage process. The first stage consists of the development of a multiple accounts ledger: a list of accounts and various sub-accounts that describe the alternative and its potential impacts. For example, an account for "Environment" could include a wide range of sub-accounts, from impacts on aquatic and terrestrial wildlife, to post-closure land use. Measurable indicators are described for each sub-account. For example, a sub-account describing the surface area of the facility would provide an indicator measured in square kilometres.

The second stage is referred to as a Value-Based Decision Process. It involves "ranking, scaling and weighting the indicator values in the sub-accounts in a systematic, transparent manner such that the value basis for the combination or accumulation of effects is readily apparent" (Robertson and Shaw, 1999).

5. Robertson, A.MacG., Shaw, S.C. (1999): Multiple Account Analysis for Tailings Site Selection. In Sudbury 99 conference proceedings, Mining and the Environment II, vol. 3, pp. 883-891.

Figure A.3.1: Framework for Planning and Design of Tailings Facilities



Appendix 3.1: Typical Information Considered for Assessment of Alternatives and Tailings Facility Design

Examples of the types of information typically considered for assessment of alternatives and designing of a tailings facility are provided below. This information listing is not exhaustive, and is intended to be illustrative rather than prescriptive. Information listed below may not be applicable in all cases, and additional types of information or detail may be needed on a site-specific basis.

1) Basic Characteristics

Characteristics of the Proposed Mine

Ore and host rock:

- Reserves and projected mine life
- Mineralogy
- Chemical composition
- Oxidation processes, including acid-generating potential
- Potential for leaching of metals and other contaminants

Mine plan and mine openings:

- Potential for sequential mine development and use of mined out openings for tailings management
- Potential for use of tailings as backfill during operations

Ore processing parameters related to tailings:

- Process and reagents to be used
- Treatment processes (e.g., cyanide destruction)

Characteristics of Tailings and other Materials

Tailings — characteristics independent of tailings management technology selected:

- Daily/annual throughput
- Total quantity of tailings and other materials to be managed in the tailings facility
- Mineralogy
- Size distribution
- Chemical composition
- Oxidation potential, including acid-generating potential
- Suitability for separating sulphides if potentially acid-generating
- Potential for leaching of metals and other contaminants
- Variability in all of the above

Tailings — characteristics dependent on tailings management technology selected - should be evaluated for each technology alternative assessed:

- Rheology
- Consolidation properties
- Solids content
- Plasticity
- Liquid phase chemistry
- Hydraulic conductivity and anisotropy of fresh and compacted tailings
- Variability in all of the above

Materials to be co-managed with tailings (e.g., waste rock, treatment sludge):

- Daily/annual amount placed and total quantity to be managed in the tailings facility
- Timeframe for placement (could be after the end of operations in the case of treatment sludge)
- Chemical composition
- Oxidation potential, including acid-generating potential
- Potential for leaching of metals and other contaminants
- Stability considerations

Availability and Characteristics of Impoundment Construction Materials (if applicable)

Waste rock and tailings:

- Quantities suitable for construction
- Availability at appropriate time for construction
- Chemical composition
- Oxidation potential, including acid-generating potential
- Potential for leaching of metals and other contaminants
- Physical and engineering properties (e.g., strength, gradation, slaking potential)
- Hydraulic conductivity in the dam structure

Glacial till and other earthfill/rockfill materials:

- Availability and transport distances
- Quantity available
- Environmental impacts of excavating borrow material
- Environmental impacts of quarry development and operation
- Size distribution
- Suitability for low permeability applications
- Chemical composition

- Oxidation potential, including acid-generating potential
- Potential for leaching of metals and other contaminants
- Durability and integrity
- Internal erosion potential
- Freeze/thaw resistance

Air and Water Management

Site climate (seasonal variations, means and extremes):

- Temperature
- Prevailing wind direction and speed, including dust generation potential
- Precipitation, including 1/100-year flood, 1/1000-year flood and Probable Maximum Flood
- Seasonal precipitation patterns, including snowfall, rainy season, etc.
- Evaporation
- Climate change projections (e.g., temperature, precipitation and extreme events)

Overall site water balance — independent of tailings management technology selected:

- Water use in ore processing
- Mine water production
- Evaporation
- Other water flows to be managed on site
- Clean water interceptors and diversions
- Availability of make-up water
- Water discharge to the environment

2) Additional Characteristics – Screening Level Assessment

These characteristics should be considered for each potential alternative included in the initial step of screening alternatives to develop a short list of alternatives for more detailed assessment. The objective at this stage is to identify "fatal flaws" in potential alternatives, to eliminate those alternatives from further consideration.

Basic information about each potential location:

- Distance from ore processing facility – transport of tailings
- Distance from mine – transport of waste rock for construction
- Topography, based on regional and detailed topographic maps, aerial photos or satellite images
- Surface area of potential tailings facility
- Potential locations of dams, and estimated dam heights, if applicable
- Estimated total capacity of potential tailings facility
- Identification of any sensitive downstream areas (e.g., communities) that could be impacted in the event of a failure of the facility

Existing and planned infrastructure:

- Mine-related infrastructure, including roads, buildings, open pits and waste rock facilities
- Non-mine related infrastructure, including roads, utility corridors, proximity to communities or other land owners

Flora and fauna that could preclude a tailings facility at that location:

- Presence of fish-frequented water bodies within the footprint of the possible tailings facility that would have permitting implications
- Presence of endangered or threatened species, migratory species
- Other ecological values (e.g., calving or rutting grounds)

Hazards or other features that could preclude a tailings facility at that location:

- Risk of landslides or avalanche
- Geologic faults or other features
- Geotechnical conditions
- Hydrologic conditions

Social or cultural features that could preclude a tailings facility at that location:

- Significant archeological features, such as burial grounds
- Areas of spiritual significance
- Areas used for traditional harvesting for food, medicinal or spiritual purposes

Closure considerations:

- Ease of closure and related factors that could preclude a tailings facility at that location

Cost:

- Rough but defensible estimate of costs of a tailings facility at each location, across the entire life cycle, from planning and design, through closure and post-closure

3) Additional Characteristics – Detailed Assessment

These characteristics should be considered in a sufficient level of detail to be able to rigorously assess each potential alternative on the short list of alternatives for more detailed assessment. Level of detail is less than that required for detailed engineering design and construction, but should be detailed enough to understand the key factors that influence the selection of the location, and how a tailings facility at that location would be designed, constructed, operated and closed.

Tailings management plan (see also *Appendices 6 and 8*):

- Potential tailings technology (e.g., conventional, cycloned, thickened, paste or filtered)
- Management of acid-generating potential (e.g., wet cover, elevated water table, dry cover, segregation of sulphides)
- Management of neutral pH leaching of metals, metalloids and non-metals
- Surface area of potential facility, locations and heights of any dams or other containment structures

- Capacity of facility as designed
- Design of any dams or other containment structures (e.g., permeable vs. water retaining, centreline or downstream, keyed to bedrock vs. constructed on surficial materials)
- Construction materials for any dams or other containment structures (e.g., glacial till core, waste rock, cycloned tailings, other materials)
- Any materials to be co-managed with tailings, and method of co-management

Closure plan (see also *Appendices 6 and 8*):

- Planned post-closure land-use
- Closure strategy for tailings facility
- Overview of long-term maintenance and monitoring
- Progressive reclamation plan

Basic information about each potential location:

- Detailed topography, based on LIDAR (Light Detection and Ranging) or other sources

Bedrock and hydrogeology:

- Rock units present in footprint of possible tailings facility and adjacent areas
- Presence of faults, aquifers, aquitards or other features that influence the direction and rate of groundwater flow
- Estimated hydraulic conductivity of relevant rock units, based on geological characteristics

Surficial geology and hydrogeology:

- Depth to bedrock in footprint of possible tailings facility
- Stratigraphy of surficial units
- Presence and extent of clay deposits and their potential to cause stability concerns if a tailings facility is constructed on top of the clay
- Presence and extent of other factors that influence stability and foundation conditions, such as organic material, high water table, loose sands, old tailings/filled ground, fractured bedrock, etc.
- Estimated hydraulic conductivity of surficial units, based on geological characteristics
- Presence and extent of high or low permeability units (e.g., sand or clay)

Hydrology within the footprint of the possible tailings facility, and in upstream and downstream areas:

- Watershed delineation and flow patterns
- Size and flow of streams
- Presence of wetland areas
- Runoff
- Return period of floods and potential severity
- Bathymetry of any lakes or ponds

Water management:

- Inflows and outflows to possible tailings facility
- Design parameters for extreme weather events
- Seepage management measures (e.g., control and collection measures)
- Estimated rate of seepage from possible tailings facility
- Estimated quality of seepage groundwater
- Clean water interceptors and diversions

Natural hazards within the footprint of the possible tailings facility, and in adjacent areas that could impact the facility:

- Risk of landslides or debris flows
- Risk of avalanche
- Seismic risk

Terrestrial environment within the footprint of the possible tailings facility, and in adjacent areas that could be impacted by the facility:

- Key animal and plant species present
- Habitat features such as denning areas or natural pastures
- Presence of species of commercial, recreational or Indigenous significance, such as species that are trapped, hunted or gathered for food, sale, medicine or traditional/spiritual use

Aquatic environment within the footprint of the possible tailings facility, and in upstream and downstream areas that could be impacted by the facility:

- Water and sediment quality
- Any upstream or close downstream sources of impacts on water quality or disturbance to the aquatic environment
- Fish species present, including any endangered and threatened species
- Presence of species of commercial, recreational or Indigenous significance

Archeology within the footprint of the possible tailings facility and in immediately adjacent areas:

- Presence of archeological sites of Indigenous or non-Indigenous significance such as burial sites, camp sites, historic sites, etc.

Indigenous considerations associated within the footprint of the possible tailings facility, and in adjacent areas:

- Status of land claims
- Traditional use of the area for hunting or gathering
- Sites of spiritual significance
- Agreements with Indigenous communities

Other considerations:

- Presence of permafrost
- Presence of areas impacted by past mining or other industrial or commercial activity

Socio-economic considerations – may be the same for all alternatives considered, but should be assessed on a location-by-location basis:

- Other current and historical land or water use, including recreation, parks, drinking water sources
- Other commercial uses in the area, such as mining, logging or farming

Cost:

- Estimate of costs of a tailings facility at each location, across the entire life cycle, from planning and design, through closure and post-closure

4) Additional Characteristics – Detailed Design

Bedrock and hydrogeology:

- As above under item (3), but more detailed as appropriate
- Measured hydraulic conductivity of relevant rock units

Surficial geology and hydrogeology[6]

- Detailed information on depth to bedrock in footprint of planned tailings facility
- Detailed stratigraphy of surficial units
- Detailed information on presence and extent of clay deposits and other factors that may influence stability and foundation conditions
- Measured hydraulic conductivity of surficial units
- Relevant physical characteristics of surficial units, particularly in areas of planned dam foundations

Hydrology within the footprint of the planned tailings facility, and in upstream and downstream areas:

- As above under item (3), but more detailed as appropriate

Natural hazards within the footprint of the planned tailings facility, and in adjacent areas that could impact the facility:

- As above under item (3), but more detailed as appropriate
- Description of mitigation measures
- Other characteristics listed under item (3), but more detailed as appropriate

Cost:

- Sufficiently detailed estimate of costs of the selected tailings facility, across the remaining life cycle of the facility.

6. See for example: Association of Professional Engineers and Geoscientists of BC (2016): *Site Characterization for Dam Foundations in BC*

Appendix 4: Independent Review

Introduction

Tailings facilities are complex structures, and all aspects of their management are subject to human error. Tailings governance structures that support effective risk management decisions are critical for maintaining and increasing the resilience of tailings facilities throughout their life. A key aspect of effective Owner governance is regular Independent Review of tailings facilities and their governance, which is recognized as an essential BAP for responsible tailings facility management, and is required in some jurisdictions. In addition, many financial institutions require Independent Review processes to demonstrate responsible risk management. Insurance companies may offer premium reductions if Independent Review is part of a facility's risk management program.

There is no specific method or formula for conducting effective Independent Review. This appendix describes principles and elements that would be common to any effective Independent Review process; however, how these principles and elements are applied for a given facility will be as unique as that facility's characteristics. The following material and examples are intended to provide guidance, and are not intended to be prescriptive.

Owners of tailings facilities employing BAP typically use Independent Review to provide, in a systematic, ongoing manner, an independent, qualified opinion about:

- the risks and the state of the tailings facility;
- whether the tailings facility is being managed based on sound engineering practices; and
- whether concepts and design criteria are consistent with legal requirements, industry standards, and current theory, methodologies and experience.

Independent Review may also provide recommendations to improve tailings facility management, although Independent Review processes do not confer decision-making authority on the reviewers. Accountability and responsibility for decisions whether to implement recommendations rests solely with the Owner.

The objective of Independent Review is to allow those accountable and responsible for tailings facility management to make more informed decisions regarding a tailings facility so that tailings-related risks are managed responsibly and in accordance with acceptable standards of care.

Independent Review is not a substitute for appropriate design, or the role of the EoR, and it is essential that an Owner employ an appropriately qualified and experienced team and/or retains consultants to provide the necessary specialized services throughout the life cycle of the facility. It is important that an Owner designate a person responsible for coordinating Independent Review efforts with designers, operations staff and senior management.

Benefits

Independent Review pools the experience and knowledge of experts in tailings facility design and management to respond to the technical challenges that an Owner is likely to encounter or may be currently facing.

Independent Review is most effective if it begins at the project conception and planning phase of the life cycle, and continues through design, construction, operation, closure, and post-closure. As such, the intent of Independent Review is to identify and address potential deficiencies before they occur and is fundamentally a preventative risk control measure. The preventative focus of Independent Review fosters continual improvement and mitigates complacency.

The Independent Review process requires that the Owner provides comprehensive, high-quality information to Independent Reviewers. Compiling such information helps strengthen documentation of the Owner's institutional memory and can reduce reliance on the memory of individuals involved in tailings management.

Independent Review may be used to support Performance Evaluation and Management Reviews for Continual Improvement.

Spirit of "Independent"

The intention, or spirit, of "independent" is that the reviewer(s) should not be directly involved with the design or operation of the particular tailings facility. Where potential conflict of interest exists, such conflicts should be identified and declared so the Owner understands when 'independence' is theoretically compromised and agrees. For example, it is acceptable to have an Independent Reviewer who is employed by the same company as the EoR for the tailings facility, provided the intent of 'independent' is met. This is further reinforced by maintaining a clear understanding between the Owner and their consultant(s) (e.g., designer, EoR) that an Independent Reviewer may need to abstain from a discussion or withhold an opinion when a conflict of interest may apply. This flexibility allows the Independent Review process to maximize the use of appropriately qualified reviewers; understanding that there may be a limited pool of such qualified individuals available.

Guidance for Independent Review

Guidance provided is for Independent Review intended for internal purposes, to inform the facility Owner. It is not intended to address other types of Independent Review, such as that required by some regulators.

Detail Level of Independent Review

The level and detail of Independent Review should be established clearly and prior to any review proceeding. An example of the level and detail required is consistent with that described for "Review Level" by Robertson and Shaw (2003)[7], as follows:

> *At this level the reviewer generally reviews all key documents and does at least "reasonableness of results" checks on key analyses, design values, and conclusions. Design, construction and operational procedures are reviewed at a level sufficient to develop an independent opinion of the adequacy and efficiency of the designs, construction and operations. The reviewer generally relies on the representations made to the reviewer by key project personnel, provided the results and representations appear reasonable and consistent with what the reviewer would expect. A review report is produced which documents the reviewer's observations as to the adequacy of the design, construction and operations and indicates any recommendations that flow from these.*

7. Robertson, Andy and Shaw, Shannon (2003): *Risk Management for Major Geotechnical Structures on Mines*

Risk-Based Approach

Independent Review is a component of an effective risk management system. As such, the degree of Independent Review involvement over the life cycle of the facility should be risk-based, with particular emphasis on the potential impacts of a significant tailings facility event on the business overall, to worker and community health and safety and to the environment.

While some sites conduct Independent Review on an annual basis, the frequency of Independent Review should be determined on a facility-specific basis, depending on the risk profile and life cycle phase of the facility. In some instances, additional, special one-off type Independent Review sessions may be warranted; for example, where existing facilities are being upgraded to comply with current design criteria and standards or facilities that are in design, commissioning and initial operation. In these conditions, frequency of Independent Review should be determined in consultation with the Independent Review body, Owner and EoR. As a site approaches a "steady state" of operation, frequency of Independent Review may be reduced. The frequency of Independent Review during closure may vary according to risk.

An Independent Review body may comprise a single reviewer or several individuals. The Independent Review body composition and experience level should be commensurate with the tailings facility's complexity and risk profile. Accordingly, an Independent Reviewer could vary from a competent person employed by a separate Owner, to an internationally-recognized subject-matter expert. At high-risk facilities, (where a breach could plausibly result in inundation of residence(s) and loss of life) a panel of three or four subject-matter experts with different but complementary areas of expertise and experience may be required to cover the various disciplines associated with management of the facility (e.g., geotechnology, hydrology, hydrogeology, and geochemistry). In other instances, temporary Independent Review involvement for niche disciplines (e.g., paleo seismology, seismic hazard assessment) outside the expertise of the core Independent Review body may be required. Redundancy of technical disciplines within the Independent Review body should be considered in accordance with a facility's risk profile.

Independent Review Program

The terms of reference for Independent Review should be carefully considered in accordance with the facility risk profile. Recommended terms of reference are provided in Appendix 4.1. Effective Independent Review requires that Owners maintain reliable archives of relevant documents. This becomes particularly important in the event of changes in employees, contractors, or consultants (e.g., EoR) involved in tailings management, or if a significant event or change should occur.

The Independent Review process should involve both site-personnel (e.g., Responsible Person), the EoR, and key consultants to be most effective. The Independent Review process requires a wide range of information, which typically includes:

- facility description, including design and as-built information;
- risk assessment and risk management plans;
- OMS manual, with a summary of key operational, maintenance and surveillance practices and procedures;
- results of Performance Evaluation and Management Review for Continual Improvement;
- for new facilities, assessment of alternatives for selection of tailings facility location and BAT;
- any changes since the last Independent Review (if Independent Review has been done previously);

- other relevant studies and assessments;
- summary of previous recommendations from Independent Review and status of implementation; and
- pertinent information on medium to long-range planning for the facility.

The Independent Review should be documented to describe: the review's scope and process; details of the technical issues evaluated; and, as appropriate, recommendations, including opportunities for improvement.

For Independent Review to best function as an effective risk management tool, the process should be confidential. A lack of confidentiality could undermine the process, because it relies on open discussions of the risks and issues related to a tailings facility, including scenarios about possible future site changes (e.g., information about potential mine life extensions that could influence current or potential shareholders or investors) that cannot legally be disclosed. In this regard, confidentiality is necessary for compliance with securities laws as the Independent Review typically considers future mining plans and "forward-looking information". If required, the Independent Review process and findings can be summarized for disclosure.

In response to any recommendations from Independent Review, an action plan should be developed. Progress of implementing the action plan should be tracked and, as appropriate, shared with the Independent Reviewer(s). The Owner should also identify any recommendations that will not be implemented, and document a rationale.

Suggested Reading

For facilities considering an Independent Review program, a process summary is appended to this document. The following publications are recommended resources to provide further context and examples of Independent Review:

Hoek, E. 2001. Geotechnical Review Boards in Mining. Geotechnical News. March 2001.

Matich, M.A.J. 1986. Design and Review Boards. Alberta Dam Safety Seminar. Edmonton. September 1986.

McKenna, G. 2001. Celebrating 25 Years – Syncrude's Geotechnical Review Board. Geotechnical News. September 1998.

Robertson, A. Shaw, S. 2003. Risk Management for Major Geotechnical Structures on Mines. http://www.infomine.com/library/publications/search.asp?action=16384&search_text=audit+review&search_dt_all=true&Search=Search

Appendix 4.1: Recommended Terms of Reference for Independent Review

Independent Review Mandate: To provide Independent Review of a tailings facility's design, construction, and management to allow the Owner to make more informed decisions regarding the facility so that tailings-related risks are managed responsibly and in accordance with an acceptable standard of care. The Reviewer(s) should comment on matters that:

- affect the physical or chemical integrity of the facility;
- may impact human health and safety, the environment and, potentially affected communities;

- are beyond industry norms of current practice or evolving practice; and
- affect the future conditions of the site.

The Reviewer(s) should also consider the effectiveness of the site's tailings management system.

The Reviewer(s) are managed by an appropriate representative of the Owner. Independent Review findings are made known to the Accountable Executive Officer, either directly or through the Owner's representative. The Reviewer(s) does not have decision-making authority and does not replace the role of the EoR or an experienced independent dam safety reviewer for assessing dam safety. Other than acts of gross negligence, wilful misconduct or fraud, the Reviewer(s) should have no exposure to professional liability and should be indemnified by the Owner to direct and third-party claims.

In circumstances where imminent risk to public health or safety are apparent, the Reviewer(s) is responsible to disclose such risks on an "as soon as possible basis" to the Accountable Executive Officer, and confirms whether those risks are appropriately managed.

Requirements for "independent": The Reviewer(s) must be independent and not be directly involved with the design or operation of the tailings facility. Where there may be some conflict of interest, for part of the review being performed, this conflict should be declared such that the Owner understands when 'independence' is theoretically compromised and agrees or takes other action.

Level of Review: The level and detail intended for Independent Review should be consistent with that described for "Review Level" by Robertson and Shaw (2003).

Appendix 5: Considerations for Managing Throughout the Life Cycle of a Tailings Facility

Considerations for tailings management for all phases of the life cycle are described below. It is important to note that different jurisdictions may have requirements that differ from what is described below, particularly with respect to the closure, and post-closure phases. In such cases, this Tailings Guide should not supersede those legal requirements.

Project Conception and Planning Phase

- For new facilities, or for operating facilities undergoing expansion, this phase is carried out by a multidisciplinary team of specialists such as engineers and geologists, and environmental and social scientists, all with relevant experience in the assessment of appropriate tailings management technologies, site selection, design of the tailings facility components, and construction and operation of tailings facilities. It is preferable to have the EoR engaged in this phase as part of the team. The team reports to the overall project development team assigned by the Owner to develop the mine.
- Designer-of-record should be assigned, which may be the same as the EoR.
- A long-term view is critical (including closure and post-closure), so that short-term financial priorities do not prevail over a more appropriate design that would have lower long-term impacts, complexity, and risks (including the long-term financial risks in the event of a failure).
- During the project conception and planning phase, select site and tailings management technology(ies) (see also Appendices 1, 2 and 3), and develop a conceptual design and closure plan for the tailings facility.

Design Phase

- The design team needs to have competent professional staff experienced in the disciplines required to appropriately design the tailings facility. The team will typically be managed by the project development team assigned by the Owner to develop the mine.
- The facility design needs to consider and address anticipated operating realities to design a robustly operable facility. As such, persons with operational expertise should be involved in the design process.
- During the design phase, develop the detailed facility design, construction methodology, operational controls and procedures, and a more detailed closure plan. Aspects of the tailings facility construction and operation should be planned and designed in compliance with legal requirements and in conformance with the approved plans, appropriate engineering and environmental practices, risk management, commitments to COIs and the Owner's tailings management system.
- Although many critical aspects of design should be completed before initial construction begins, aspects of design continue throughout the life cycle, particularly during the operations and ongoing construction phase.

Initial Construction Phase

- Facility construction up to the commissioning of a facility is usually managed by a mine project development and construction management team.
- Implementation of a quality assurance plan and quality control plan is required to ensure that construction is in accordance with design specifications.
- The EoR provides assurance that design standards are being met.
- Conformance management plan and change management plan should be implemented.

Operations and Ongoing Construction Phase

- Facility operations and continuing construction during the operating phase are usually managed by site operators who are assigned responsibility at the beginning of the commissioning of the mine development.
- This change in the personnel responsible for the tailings facility, from the initial construction phase to ongoing construction during operations, can be problematic from a continuity perspective and, therefore, needs to be appropriately planned for and managed in the tailings management system.
- A facility that was initially designed and constructed in a project environment can be compromised by decisions of the facility operations team during or following commissioning of the facility.
- The facility operations team may not fully appreciate the potential significance and risks of decisions made during the operating phase. Consequently, it is important that the tailings management system plan for and incorporate measures to mitigate such risks.
- The EoR needs to closely support the facility operations team to ensure continuity with the original design requirements, and that an appropriate engineering assessment is carried out if the original design specifications or operating parameters/constraints are to be modified.

Closure and Post-Closure Phases

- A specific project team often takes the lead in preparing for decommissioning and closure. In many cases, this team will manage the decommissioning and closure of the tailings facility.
- At this phase, it is critical that the tailings management system accommodate planning for both the shorter-term, more finite period of decommissioning and closure, as well as addressing the long-term post-closure period, particularly long-term maintenance and surveillance to ensure that tailings landforms remain physically and chemically stable.
- The Owner should provide the financial and physical resources necessary to implement the closure plan and ensure long-term maintenance and monitoring.

Appendix 6: Information to be Documented to Support Responsible Tailings Management

Site Characterization

Site characterization involves the collection and compilation of a wide range of information about a tailings facility and the environment in which it is or may be located. It should be initiated during the Planning phase, and site characterization information should be reviewed and updated throughout the life cycle to help ensure that decisions are based on accurate, up-to-date knowledge of the site. Site characterization information is used to inform:

- Setting performance objectives, indicators, and criteria.
- Risk assessment and the development of the risk management plan, as well as subsequent reviews and updates.
- Assessment of alternatives.
- All aspects of design of the tailings facility, from initial concept to construction-ready design and any subsequent material changes.
- Validation of tailings facility performance against the design and underlying assumptions.
- Development of the closure plan.

Information documented as part of site characterization may include:

- Characteristics of the mine, including production rate, life-of-mine, ore processing methods, locations of the tailings facility relative to the ore processing facility, water rock piles, water management infrastructure, and other relevant infrastructure.
- Physical and chemical characteristics of tailings and other wastes to be managed in tailings facility, and, where applicable, materials to be used in the construction of the tailings facility, including:
  - Moisture content, gradation, mineralogy, geochemistry, shear strength, compressibility, permeability and index tests.
- Characteristics of embankments (where applicable), including type of embankment, method of construction, and consequence classification.
- Physical and chemical characteristics of the tailiings facility foundation and any abutments, including:
  - Test hole logs and locations
  - Results from drill holes, penetration holes, core holes, auger holes, geophysical tests, test pits, etc.
- Potential natural hazards, such as landslides, avalanches and debris torrents, earthquakes, floods, frost heave, permafrost degradation, waves, wind, or ice movement or jamming.
- Characteristics of the potential/proposed/actual tailings facility (e.g., location, topography, surface area, containment structures)

- Bedrock and surficial geology, including:
  - Surficial deposits and bedrock characteristics (moisture content, gradation, mineralogy, geochemistry, shear strength, compressibility, permeability and index tests), stratigraphy, geomorphology, mineral or petroleum resources, background elemental content.
- Local and regional hydrology:
  - Regional creeks, streams, rivers, ponds and lakes, marine conditions, catchment area, downstream areas that may be affected, water flow and volume, and water chemistry/quality.
- Local and regional hydrogeology:
  - Aquifers, aquitards, hydraulic conductivity within the tailings facility and underlying surficial and bedrock materials, direction of groundwater flow, volume of volume, and groundwater chemistry/quality
- Climate characteristics and meteorological conditions:
  - Temperature, wind, precipitation, evaporation, seasonal and extreme events, precipitation and runoff, and air quality
- Projections of future climate conditions, including projected changes in extreme events and projection changes in seasonal and annual "normal" conditions and, where applicable, potential for permafrost degradation.
- Terrestrial environment within the footprint of the tailings facility (for proposed new tailings facilities) and in areas that could be impacted by chronic or catastrophic events, including key species present, presence of any at risk species, and significant habitat features.
- Aquatic environment within the footprint of the tailings facility (for proposed new tailings facilities) and in areas that could be impacted by chronic or catastrophic events, including key fish, amphibian, crustacean, and bird species present, and aquatic environment types.
- Characteristics of any communities that could be impacted by chronic or catastrophic events, including community size, economic activities, etc.
- Status of Indigenous rights and title.
- Traditional use of the area, including sites of spiritual significance, traditional harvesting activities (including species of plants and animals harvested).
- Other commercial activities in the area that could be impacted by chronic or catastrophic events, such as agriculture, forestry, or commercial fishing.
- Recreational activities in the area that could be impacted by chronic or catastrophic events, such as sport fishing, camping, boating, hiking, and tourism
- Archaeological resources
- Existing and planned infrastructure off site that could be impacted by chronic or catastrophic events, such as bridges and other stream crossings, roads or railways.
- Legal requirements

Owners should develop a plan for collecting and compiling site characterization information, ensuring that it is updated throughout the life cycle, and ensuring the relevant information is retained. For existing facilities, Owners should conduct a gap analysis of site characterization information and develop a plan to address gaps, to the extent feasible.

Information about the Design of the Tailings Facility

Detailed aspects of tailings facility design principles and concepts are outside the scope of this Guide. However, documentation of information related to the design of a tailings facility is critical to responsible tailings management.

Design applies to:

- Initial construction of new tailings facilities.
- Planned ongoing construction (e.g., raising embankments to increase tailings facility capacity) throughout the operations and ongoing construction phase.
- Any changes/deviations from the design through initial construction and operations and ongoing construction, including any changes to improve the design and enhance performance or reduce risk.
- Any proposed changes that could impact the risk profile or performance of the tailings facility.
- Design related to components of the closure plan (e.g., design of cover systems).

There are wide range of factors that form the basis for the design of a tailings facility. These should be carefully considered in the design process and should be documented. These factors include:

- Relevant site characterization information including:
  - Physical and chemical characteristics of tailings, construction materials, and the foundation.
  - Hydrology and hydrogeology
  - Climate conditions
  - Mine plan and mine site layout
  - Natural hazards
- Operating requirements, including:
  - Life of mine and production rate
  - Ore processing method
  - Tailings characteristics
  - Water management a water balance
- Other relevant constraints on the design, such as the presence of downstream communities, protected areas, or other factors.

Selection and application of appropriate design criteria are a key step in the design process. This Guide does not provide recommendations for design criteria, but through the planning and design process, it is essential that engineering standards and criteria for tailings embankments and other components be carefully considered.

It is important to emphasize that the application of engineering standards needs to be done on site-specific basis. Each location and tailings facility is unique, and care needs to be taken to ensure that engineering standards and criteria are selected and applied in a manner that is appropriate to the facility. In addition, it is important to select appropriate parameters for analysis and to understand and document both the underlying assumptions and aspects of uncertainty (e.g., knowledge of foundation conditions).

The selection of appropriate, site-specific design criteria should consider:

- Maximum height and slopes of the tailings facility and embankments
- Construction materials and methods
- Seismic hazard
- Potential extreme flood and precipitation events.
- Potential for liquefaction and compaction
- Potential for brittle failure.
- Seepage management and the potential for piping
- Factor of safety for perimeter slopes for operation and closure
- Potential consequences of chronic or catastrophic failure
- Level of acceptable risk
- Legal requirements

Taking into account the design basis and design criteria, the tailings facility, including any embankments and other components, should be designed in a manner that is appropriate to meeting the corporate policy or commitment and site-specific performance objectives, and is informed by site characterization and the risk assessment, including credible failure modes.

Design related information should be documented (sometimes referred to as a design report or design basis report), including:

- Design assumptions and criteria, including operational constraints that provide the basis for the design, construction, operation, and closure of the tailings facility.
- Relevant aspects of site characterization, water balance modelling and water management, design analyses and evaluation of their results.
- Design of all stages of the facility including construction requirements and specifications, and construction drawings.

For existing facilities, Owners should conduct a gap analysis of design-related information and developing a plan to address gaps, to the extent feasible.

Information about Tailings Facility Construction

Tailings facilities are unique in that construction is an ongoing activity that includes:

- Initial construction of new tailings facilities.
- Planned ongoing construction throughout the operations and ongoing construction phase.
- Construction associated with:
  - Implementing any changes that could impacts that risk profile or performance of the facility.
  - Implementing the closure plan.

For all construction activities, construction and as-built conditions should be documented, including:

- Deviations from the design or approvals process followed, and an assessment of the cumulative impacts to risk of changes to the tailings facility design.
- Information to demonstrate whether the design intent is being met, including in the case of any deviations from the design to deviations from expected conditions.
  - This should include documenting any discrepancies between the field conditions and the design assumptions.
- Dates of construction.
- General description of the construction, including a summary of the key elements that were constructed.
- Who was responsible for the construction: Responsible Person, EoR, designer, and construction contractor.
- As-built conditions, including survey drawings of the tailings facility showing the positions and configuration of features including (where applicable):
  - Embankments, including cross-sectional drawings
  - See page management and collection
  - Borrow material sources
  - Conveyance infrastructure for tailings and water management
  - Electrical supply for pumps, surveillance instruments, etc.
  - Access roads
  - Water management infrastructure
  - Surveillance instrumentation including installation details
- Results of field and/or laboratory testing of construction materials and foundation materials (e.g., borrow material, surficial geological units underlying the tailings facility), including documentation of variances between specifications for materials and actual conditions.
- Schedule and sequencing of construction activities completed.
- Procedures and equipment used for construction.
- Quality control and quality assurance data.
- Results of surveillance conducted during construction.
- Photographs, videos, and satellite imagery taken throughout construction.
- Description of any problems or unexpected conditions that arose during construction including natural (ground conditions, weather, etc.) or human-made (changes from approved design, construction methods differing from standard, etc.), and steps take to address these problems, include any mitigation measures implemented or changes made.
- Other relevant documentation.

For existing tailings facilities, Owners should begin documenting current and future construction activities as per the points above. In addition, Owner's should strive to have as detailed an understanding of the current state of as-built conditions of the tailings facility as is feasible. With this goal in mind, Owners should:

- Describe original as-built conditions and construction history to the extent feasible.
- Identify gaps in understanding of the construction and construction history.
- Document the current configuration and state of as-built conditions of the tailings facility.
- Assess the need to conduct studies to better understand the current as-built conditions of the tailings facility. A key consideration in this regard is gaps in understanding that increase uncertainty in:
  - The risk assessment and effectiveness of risk management measures.
  - Design of any future proposed material changes.
  - Closure plan development and implementation.
- If there is a need to better understand current conditions, identify methodologies that may be used to collect information to address gaps (e.g., geotechnical drilling in the facility and/or foundation, ground penetrating radar), and develop a plan to collect this information.
- Use this information to:
  - Update documentation of the current configuration and state of as-built conditions.
  - Inform reviews and updates to the risk assessment and risk management plan.
  - Inform development of potential material changes to enhance performance and reduce risk.

Appendix 7: Factors in Effective Communications, Governance, and the "Human Element" of Tailings Management

Below is a summary of lessons learned about governance and communications that are applicable to tailings management and dam safety, based on *Pearl Harbor: Lessons for the Dam Safety Community*.[1]

1. Personnel delegated the responsibility for a certain activity must have the authority to carry it out. When delegating authority or issuing specific instructions, follow-up to ensure that the delegated authority is being appropriately carried out, or that the instructions have been understood and correctly implemented. Do not assume that all is going according to plan.
2. Communications must be clear and unambiguous. Ensure that the meaning and intent of information communicated is fully understood. Avoid paraphrasing or condensing messages when relaying information, so that the actual meaning or intent is not lost.
3. Keep other personnel adequately informed regarding aspects of tailings management relevant to their responsibility and authority. Communications are two-way, and effective decision-making requires complete information, not a partial presentation of the facts.
4. Do not take anything for granted in communicating with other personnel involved either directly or indirectly in tailings management and either higher or lower in the "chain of command". Do not assume they fully understand the meaning or relevance of information provided. Similarly, do not withhold information from other personnel involved in activities on site. For example, a minor change in tailings characteristics, deemed unimportant by personnel responsible for ore processing because it does not affect recovery rates or reagent use could have significant implications for tailings management.
5. Be open to input from other personnel and those involved in other activities on site. All personnel should be encouraged to raise concerns or suggestions. Observations of personnel lacking in specific training or expertise related to tailings management (e.g., security personnel) should not be ignored or discounted.
6. Corporate personnel should provide all relevant information to the Responsible Person(s) on site and to other site personnel as appropriate. This includes new policies developed at the corporate level, potential legal changes that corporate personnel are aware of, and information on lessons learned from tailings management at other sites or other companies.
7. Never ignore, delay or "water down" an official instruction. If you are unclear, or if you question the validity of the instruction, raise those concerns promptly. But do not unilaterally decide not to carry out the activity as instructed.
8. Personal friendship must not interfere with clear communications on professional matters. Do not assume, because two people are friends, that they clearly communicate in their professional relationship. The reverse may be true, as they may make assumptions about what the other knows, and those around them may assume they are clearly communicating in their professional relationship because they are friends.

9. Effective and timely surveillance is essential to tailings management. The Owner must allocate appropriate resources and ensure that there are competent personnel in place with responsibility for surveillance, and clear lines of communications regarding surveillance program design, implementation, and outputs.
10. Do not interpret surveillance results only through the lens of potential unwanted events or occurrences that were identified in the risk assessment. Consider the possibility that the results are pointing to a risk not previously anticipated.
11. A failure can occur at any time, sometimes without warning. Avoid becoming complacent or deferring actions out of a sense that "all is well". Be alert and ready to respond at all times, even to events with an extremely low probability of occurring, and no matter how good past performance has been. Better to have a false alarm than to ignore the warning signs of an impending loss of control.
12. Be ready to respond to a failure by preparing for any eventuality. Ensure that emergency response plans (ERPs) are developed and tested. ERPs need to be adaptable in case an event occurs that had not been anticipated and planned for.
13. The Owner must have a corporate culture that prioritizes responsible tailings management and avoids competition for resources between business units that could comprise tailings management. Giving secondary importance to tailings management can result in lead to choices with adverse long-term financial or other impacts.
14. The Accountable Executive Officer and Responsible Person(s) need to be familiar with their organization and understand the tailings facilities for which they are responsible, the risks the facilities pose, and the manner in which risk is being managed, including any failures, deficiencies, or opportunities for improvement. They must be informed by annual management reviews, input/results of assurance activities including Independent Review, and be apprised of any material developments in between these activities. If they do not have the competencies and knowledge needed, or if they rely on the assurances of their staff without being themselves fully informed, then they should pass that responsibility and accountability to others with the capacity to be fully engaged. The Accountable Executive Officer and Responsible Person(s) do not need to be involved in all details of tailings management, but they MUST understand the big picture of the facilities and risks for which they are accountable.

Appendix 8: Technical Considerations

The management of tailings facilities involves a wide range of technical disciplines that are applied in a coordinated and timely manner throughout the life cycle of each individual facility. There are numerous sources of technical guidance for Owners, operators, designers, regulators, and others that are readily available. References to some of the available guidance are provided in this Tailing Guide and each of those references will, in turn, point to other relevant materials. As this technical guidance is readily available, this Guide has not been developed to be exhaustive or comprehensive in terms of the technical guidance provided. However, there are three technical aspects essential to any tailings facility that are described in this Appendix, and which form the basis of the technical considerations for this Guide.

Tailings Transportation and Placement Plan

The tailings transportation and placement plan demonstrates both the capacity and flexibility of the tailings facility to meet the demands of the mining plan as it evolves throughout its life cycle, and is crucial to successfully operating the facility from construction to closure. BAP includes having the transportation and placement plan integrated into the OMS manual and executed during the operations and ongoing construction phase. Temporary suspension and closure conditions typically rely on an interim or final tailings surface topography to facilitate the closure strategy and post-closure land use, for example, a water cover, or a "dry" surface with appropriate drainage patterns. Typically updated annually during the operations and ongoing construction phase of the life cycle, the tailings transportation and placement plan is prepared and implemented with eventual closure design and reclamation requirements as an objective.

The tailings transportation and placement plan is predicated upon the tailings management technology used and the site-specific conditions of the tailings facility, and should address:

- 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. Planned moisture content and physical characteristics of the tailings are essential to the transportation and placement plan.
- What types of containment structures, if any, will be constructed, the construction method, materials to be used, and the method of raising those containment structures during the operating phase.
- Methods, if any, to control seepage from the tailings facility, such as the use of liners, water retaining dams, or underdrains.
- 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? If separate, how will these different types of tailings be managed?
- 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 to 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.

- Methods to prevent the release of tailings to 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 snow-pack/melt, extended periods of wet weather, extended periods of water retention, etc?

In developing the tailings transportation and placement plan, a range of information about the physical and chemical characteristics of the tailings should be considered, including those listed in *Appendices 3.1 and 6*. These characteristics should be validated and updated on a periodic basis throughout the life of mine. If characteristics to not meet 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 placement plan should be integrated with the water management plan.

Placement plans typically allow for expansion of the tailings facility over the life of the mine to accommodate increasing amounts of tailings solids. This could include staged lifts to increase the height of containment structures 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.

The tailings transportation and placement plan should be linked to the closure plan such that the tailings facility is in the configuration required for closure. The plan should be reviewed on an annual basis, with any changes to the plan subjected to the site's risk management and change management systems. Any changes should be documented.

Water Management Plan

An appropriate water management plan for any tailings facility will be unique to that facility. However, the following elements are essential to any water management plan.

Hydrology/Hydrogeology: Surface hydrology and hydrogeological data, including the delineation of tailings site catchment area(s) and all potential water sources, both natural and process, are used in the development of a water/contaminant balance and design of tailings facility components. Establish and document design parameters, then monitor actual experience to identify variances, validate projections, and anticipate potential problems.

Design Flood: The appropriate Environmental Design Flood and Inflow Design Flood need to be identified, with reference to current design standards and in consultation with regulatory agencies. Design flood considerations should be consistently applied throughout all phases of the life cycle, taking into account evolving BAP and any changes to legal requirements. Storage requirements, operating freeboard and spillway design are based on the hydrology of the watershed.

Water Balance: Complete a water balance study. Specify requirements for ongoing data collection for the ore processing facility and for tailings facility water balance calibration purposes. Water calculation to estimate fresh water needs and maximum pond storage requirements should be conducted and then updated at a frequency appropriate to the facility-specific conditions. Operational water balance should also be calculated and updated as appropriate.

Surface Water Management Plan: Complete a water management plan detailing appropriate designs and strategies, where required, for: clean water interceptors and diversions; seepage collection; reclaim/pump-back systems; treatment/discharge systems, including all water conveyance systems; and water retention and discharge strategy, including operating parameters. Revise the surface water management plan at a frequency appropriate to facility-specific conditions to consider potential design or operational changes to the facility. Updates to the surface water management plan should take into consideration the life cycle phase, and further requirements and expected conditions through the life cycle, including changes to the surface water management plan for the closure, and post-closure phases, as well as potential care and maintenance.

Contaminant Balance and Release: The contaminant balance provides estimates of contaminant release to surface and groundwater. Develop, where required, a plan to control contaminant release within acceptable levels. Monitor and plan for long-term conformance.

Effluent Criteria: Establish criteria for the quality and quantity of any effluent to be released to the environment, taking into account legal requirements. The intent is to set performance criteria which are below legal requirements, to provide increased assurance of compliance with legal requirements. With respect to effluent quality, this may include criteria for dissolved and suspended solids, metals and metalloids, non-metals, thiosalts, cyanide, ammonia and other nitrogen compounds, and toxicity, and any other parameters that are subject to legal requirements, or of relevance to the Owner. With respect to effluent quantity, this may include criteria for maximum and base flow of effluent, as well as seasonal considerations for effluent release.

Closure Plan

Development of closure plans and performance objectives for closure and post-closure should begin at the project conception and planning phase. A conceptual closure plan, developed with a low level of detail at the project conception and planning phase, should become more detailed and elaborated at the design phase. The conceptual close plan should then be refined, elaborated, verified, and updated periodically during the initial construction and operating phases of the life cycle of the tailings facility, and in preparation for decommissioning, closure, and post-closure. The closure plan and objectives should be considered in the assessment of alternatives to select the tailings facility location and BAT, and should be a key consideration in the design of the facility. The closure plan and objectives should also be aligned with the OMS manual, so that activities during the operating phase are consistent with and support the closure plan and objectives.

A key aspect of closure that needs to be determined as early as possible in the life cycle, and at the project conception and planning phase for new facilities, is the closure strategy for the tailings facility, and the closure technology to be used. The selection of the strategy and closure technology should be driven by the objectives and performance objectives for closure and post-closure, and the planned post-closure land use. The potential physical and chemical impacts and risks of the tailings facility are key considerations. For example, if the tailings are predicted to be susceptible to oxidation or are potentially acid generating, then the facility needs to be designed to prevent or control oxidation to prevent acidic drainage throughout the life cycle. This implies designing and operating the facility, and implementing a closure strategy that will prevent exposure of the tailings to either water or oxygen. Options in such cases include a dry cover, a wet cover, or an elevated water table.

Flexibility is needed in closure planning, in the event that the operating phase is longer or shorter than originally anticipated.

A wide range of information should be considered in the development, updating and, ultimately, implementation of closure plans, including:

- risk assessment and risk management plan;
- design of the facility, including any deviations from the as-designed plans throughout the operations and ongoing construction phase;
- legal requirements, industry standards and guidance, corporate policy and objectives, and COI expectations;
- existing infrastructure, and infrastructure to be retained during closure and post-closure;
- tailings transportation and placement plan;
- water management plan;
- OMS manual;
- physical and chemical characteristics of the tailings;
- topography;
- climate, including long-term climate change projections;
- hydrology;
- hydrogeology of surficial and bedrock units;
- soil conditions and geotechnical considerations;
- potential for revegetation, including access to seeds for native species; and
- availability of materials for reclamation.

Closure plans should address a wide range of topics related to the decommissioning of tailings-related infrastructure, measures to ensure the long-term physical and chemical stability of tailings facilities, and maintenance and surveillance plans for the long-term post-closure period, including:

- Progressive reclamation plan to address reclamation activities to be undertaken during the operations and ongoing construction phase of the life cycle;
- Decommissioning plan to address activities to be undertaken during the closure phase, including:
  - removal of infrastructure (e.g., tailings pipelines);
  - changes to water management, including construction of spillways;
  - changes to water treatment; and
  - recontouring of facilities;
- Reclamation and revegetation plan, including:
  - plan for stockpiling of overburden material for use in reclamation; and
  - revegetation requirements for tailings facility, including species to be used, and collection of plant or seed material;

- Long-term maintenance and surveillance plan, including:
  - assign accountability and responsibility;
  - commit resources (infrastructure, staff, budget) needed to implement the plan;
  - documented requirements for maintenance, including frequency of various activities;
  - detailed surveillance plan, including types of surveillance to be conducted, frequency of surveillance activities, and timeframe for continuance of surveillance (how many years/ decades), and identification of types of surveillance that may be discontinued, with conditions to be met to discontinue;
  - conformance management plan, including action plans in cases of non-compliance or non-conformance with performance objectives, Owner's commitments, and legal requirements;
  - reporting (internal and external); and
  - COI engagement;
- Emergency response plan and emergency preparedness plan for the closure, and post-closure phases; and
- Plan to ensure continuity of control of documented information.

Closure plans require a thorough re-assessment of facility and dam stability under closure and post-closure conditions. All aspects of the facility and dam stability must be reviewed. The actual performance of the dams in service, including deformation, seepage, foundation and sidewalls, should be checked against design projections as well as against projected post-closure conditions. Design loads might be different after decommissioning and closure.

A goal for closure often includes measures to lower the risk profile of a tailings facility and confining dams that will be required to function in perpetuity.

The Mining Association of Canada

www.mining.ca