FORTUNA SILVER MINES INC.

DESIGN STANDARDS FOR TAILINGS AND FILTERED STORAGE FACILITIES, HEAP LEACH FACILITIES AND WASTE ROCK STORAGE FACILITIES

1. INTRODUCTION

The purpose of this document is to establish the minimum requirements for design standards and criteria for Tailings Storage Facilities (TSF), Filtered Tailings Storage Facilities (FTSF), Heap Leach Facilities (HLF) and Waste Rock Storage Facilities (WRSF). The objective of the criteria is to ensure that the designs of the facilities are robust and minimize risk.

The criteria presented herein considers standards of the industry, best management practices, and recognized industry publications. The recommended minimum geotechnical, hydrological and environmental design criteria are described in the following sections. The criteria presented should be considered minimum design criteria. Local regulations and site specific requirements will need to be reviewed during the design, and the more stringent criteria, between the criteria listed in this document and local regulations, should dictate during the development of the design.

This document is applicable in all Fortuna Silver Mines operation sites.

2. GENERAL DESIGN CRITERIA

The following sections describe minimum design criteria that are applicable to the TSF, HLF and WRSF design.

2.1. Baseline Conditions

Baseline conditions should be determined prior to the design of the Tailing Storage Facilities (TSF) and Heap Leach Facilities (HLF) in order to define the climate (including average monthly temperatures, precipitation and evaporation), surface water hydrology, groundwater hydrology and water quality, seismicity, geology, geochemistry, soils, flora and fauna. Climate data should be monitored throughout the life of the mine using a site meteorological station. At a minimum, maximum, minimum and average temperatures, wind speed, precipitation and evaporation should be collected on a daily basis by the site meteorological station.

2.2. Road Design

Table 2-1: Design Criteria for Roads

Description	Value
Road Width	2.5 times the largest vehicle traveling on the road
Safety Berm Height	Axle height of the largest vehicle traveling on the road
Maximum Road Grade	Light Vehicles – 15% Haul Roads – 8 to 10%

2.3. Stormwater Diversion Channel Design

Stormwater runoff generated outside of the TSF and HLF shall be diverted away from the facility unless the facility has been designed for incorporation of the runoff.

Table 2-2: Design Criteria for Stormwater Diversion Channels

Description	Value
Storm event for depth sizing and erosion control[1] (areas upstream of integral mine infrastructure)	100-year, 24-hour
Storm event for depth sizing and erosion control (areas upstream of non-integral mine infrastructure)	25-year, 24-hour
Minimum Freeboard	300mm (1 foot)
Storm event for depth sizing during closure	500-year, 24-hour

Note:

1. The Nevada Administrative Code NAC 445.433 (c) defines the 100-year, 24-hour storm as the minimum design criteria that all process components must be designed to withstand.

2.4. Geochemical Considerations

The construction materials, ore and tailings should be geochemically characterized using a recognized Acid Base Accounting (ABA) methodology. The results of the geochemical characterization testing should be utilized in the design of the TSF and HLF.

Typical geochemical testing methods are provided in Appendix A.

2.5. Cyanide

Where cyanide solutions are present, facilities should meet the requirements of the International Cyanide Management Code.

2.6. Engineer of Record

An Engineer of Record (EOR) should be identified for all facilities. In accordance with the Canadian Dam Association (CDA) "Application of Dam Safety Guidelines to Mining Dams," (CDA, 2014) the EOR should be a qualified and competent engineer who is responsible for the design and performance of the facility. At a minimum, the EOR should have a collegiate level engineering degree, a professional registration and at least ten years of experience with TSFs.

The responsibilities of the EOR are summarized below:

- Ensure that the TSF is designed, constructed, operated and decommissioned with appropriate concern health and safety and the environment. To that effect, the EOR should oversee the design, construction and operation of the facility.
- Complete annual inspections and submit inspection report.
- Provide monitoring frequencies to ensure the facility is functioning as designed for inclusion in the OMS. The EOR should also review monitoring data from instrumentation.
- Participate in risk assessments and Dam Safety Review.
- In the event that the EOR changes, the previous EOR should assist in implementing a succession plan to ensure that the new EOR is equipped with the appropriate information to take on the responsibility of the EOR.

A Responsible Person (RP) that is qualified and located at the mine property should also be identified and assigned to the TSF. The responsibilities of the RP should include:

- Developing and implementing tailings and water management plans for the TSF
- Coordinating the design, construction and management of the TSF on site with the EOR
- Implementing the plans outlined in the OMS manual.
- Delegating specific tasks and responsibilities for aspects of tailings management to qualified personnel.

The responsibilities and qualifications of the EOR and RP should be clearly identified in the Operation, Maintenance and Surveillance (OMS) manual.

Although we are not aware of any published standards for HLFs, an EOR and RP should be identified and regular inspections should be conducted.

3. TAILINGS STORAGE FACILITIES

The CDA guidelines and Nevada Administrative Code (NAC) for mining facilities were used to develop the TSF design criteria detailed in the following subsections.

3.1. Dam Classification

The TSF should be given a dam classification based on the consequences of a dam failure. The consequences should be evaluated based on the following categories (at a minimum):

- The population at risk;
- Potential loss of human life;
- Environmental and cultural losses;
- Infrastructure and economic losses.

An inundation study is necessary to support the assessment of the consequences of a potential dam failure. The inundation study should evaluate a dam break during “sunny day” and “flood-induced” conditions. The “sunny day” failure occurs during normal operations, while the “flood-induced” failure is the result of a significant storm event.

Table 3-1 summarizes how the severity of the above mentioned categories influences the dam classification. The selected dam classification can then be utilized in selecting additional design criteria for the TSF, including the annual exceedance probability for water storage requirements and seismic criteria.

Table 3-1: Dam Classification (CDA, 2014)

Source: Table 2-1 of CDA 2013

Dam class	Population at risk [note 1]	Incremental losses		
		Loss of life [note 2]	Environmental and cultural values	Infrastructure and economics
Low	None	0	Minimal short-term loss No long-term loss	Low economic losses; area contains limited infrastructure or services
Significant	Temporary only	Unspecified	No significant loss or deterioration of fish or wildlife habitat Loss of marginal habitat only Restoration or compensation in kind highly possible	Losses to recreational facilities, seasonal workplaces, and infrequently used transportation routes
High	Permanent	10 or fewer	Significant loss or deterioration of *important* fish or wildlife habitat Restoration or compensation in kind highly possible	High economic losses affecting infrastructure, public transportation, and commercial facilities
Very high	Permanent	100 or fewer	Significant loss or deterioration of *critical* fish or wildlife habitat Restoration or compensation in kind possible but impractical	Very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities for dangerous substances)
Extreme	Permanent	More than 100	Major loss of *critical* fish or wildlife habitat Restoration or compensation in kind impossible	Extreme losses affecting critical infrastructure or services (e.g., hospital, major industrial complex, major storage facilities for dangerous substances)

Note 1. Definitions for population at risk:

None—There is no identifiable population at risk, so there is no possibility of loss of life other than through unforeseeable misadventure.

Temporary—People are only temporarily in the dam-breach inundation zone (e.g., seasonal cottage use, passing through on transportation routes, participating in recreational activities).

Permanent—The population at risk is ordinarily located in the dam-breach inundation zone (e.g., as permanent residents); three consequence classes (high, very high, extreme) are proposed to allow for more detailed estimates of potential loss of life (to assist in decision-making if the appropriate analysis is carried out).

Note 2. Implications for loss of life:

Unspecified—The appropriate level of safety required at a dam where people are temporarily at risk depends on the number of people, the exposure time, the nature of their activity, and other conditions. A higher class could be appropriate, depending on the requirements. However, the design flood requirement, for example, might not be higher if the temporary population is not likely to be present during the flood season.

3.2. Water Storage Requirements

In accordance with the CDA guidelines (CDA, 2014), the water storage volumes in the TSF should account for the following:

- Minimum operating pond elevation required to operate the reclaim system
- Normal operating pond volume required for recycle to the mill or other processes
- The Environmental Design Flood (EDF), which is the storm event that can be managed in the TSF without activating a spillway. The EDF shall be determined based on the site conditions, but should not be less than the volume generated from the 100-year, 24-hour storm event.
- The Inflow Design Flood (IDF) volume resulting from the most severe inflow flood. The storage requirements for the IDF are based on the dam classification, and are summarized in Table 3-2. If not included in the design storage volumes for the pool, a spillway shall be constructed to convey the IDF.
- Minimum freeboard of 3-feet (1 meter) measured from the high water level to the crest of the TSF. For larger supernatant ponds, wave run-up should also be considered.

Table 3-2: Target Levels for Flood Hazards, Standards-Based Assessments, for Construction, Operation, and Transition Phases (CDA, 2014)

Dam Classification	Annual Exceedance Probability – Floods (note 1)
Low	1/100
Significant	Between 1/100 and 1/1,000 (note 2)
High	1/3 Between 1/1,000 and PMF (note 3)
Very High	2/3 Between 1/1,000 and PMF (note 3)
Extreme	PMF (note 3)

Notes:

Acronyms: PMF, Probable Maximum Flood; AEP, annual exceedance probability

1. Simple extrapolation of flood statistics beyond 10^{-3} AEP is not acceptable.
2. Selected on basis of incremental flood analysis, exposure, and consequence of failure.
3. PMF has no associated AEP.

3.3. Seismic Criteria

The annual exceedance probability for earthquakes shall be selected based on the CDA dam classification. The annual exceedance probability for each dam classification is summarized in Table 3-3. These values should be considered minimum requirements. Dam performance and expected deformation should be evaluated for the 1:10,000-year event or the Maximum Credible Earthquake (MCE), whichever is greater.

Table 3-3: Target Levels for Earthquake Hazards, Standards-Based Assessments, for Construction, Operation, and Transition Phases (CDA, 2014)

Dam Classification	Annual Exceedance Probability – Earthquakes (note 1)
Low	1/100 AEP
Significant	Between 1/100 and 1/1,000
High	1/2,475 (note 2)
Very High	1/2 Between 1/2,475 (note 2) and 1/10,000 or MCE (note 3)
Extreme	1/10,000 or MCE (note 3)

Notes:

Acronyms: MCE, Maximum Credible Earthquake; AEP, annual exceedance probability

1. Mean values of the estimated range in AEP levels for earthquakes should be used. The earthquake(s) with the AEP as defined above is(are) then input as the contributory earthquake(s) to develop the Earthquake Design Ground Motion (EDGM) parameters as described in Section 6.5 of the *Dam Safety Guidelines* (CDA 2013).
2. This level has been selected for consistency with seismic design levels given in the National Building Code of Canada.
3. MCE has no associated AEP.

3.3.1. Geotechnical Considerations

Typical factors of safety (FOS) for slope stability are summarized in Tables 3-4 and 3-5. These should be considered minimum values, and the design engineer should account for site specific conditions such as consequence of failure, loading conditions and strength parameters when establishing FOS for the TSF.

Table 3-4: Target Factors of Safety for Slope Stability in Construction, Operation, and transition Phases – Static Assessment (CDA, 2014)

Loading Condition	Minimum Factor of Safety	Slope
During or at end of construction	>1.3 depending on risk assessment during construction	Typically downstream
Long term (steady state seepage, normal reservoir level)	1.5	Downstream
Full or partial rapid drawdown	1.2 to 1.3	Upstream slope where applicable

Table 3-5: Target Factors of Safety for Slope Stability in Construction, Operation, and transition Phases – Seismic Assessment (CDA, 2014)

Loading Condition	Minimum Factor of Safety
Pseudo-static	1.0
Post-earthquake	1.2

Other important considerations that should be accounted for during the design phase include liquefaction, post-earthquake strength characteristics of the tailings, permanent deformation and containment.

3.4. Containment Requirements

Containment requirements are typically specific to the jurisdiction or location (per Regulations) and are many times dictated by Corporate Policy and/or internal standards. In light of the current political, social, environmental and economic climate, a loss of containment is typically not an acceptable Corporate risk. Containment considerations are fundamental design criteria that should be determined based on an assessment of the relevant risks.

The minimum recommended level of containment is 300mm "(twelve inches) of recompacted native, imported, or amended soils which have an in place recompacted coefficient of permeability of no more than $1x10^{-6}$ cm/s", or equivalent (NAC 445A.437).

Many recent TSF designs include a geomembrane instead of a low permeability soil layer.

3.5. Leak Detection System

A leak detection system may be required by local regulations due to shallow ground water (less than 30.5 meters (100 feet) below ground surface) in the area. The leak detection system should be placed beneath the primary containment in the main drainages of the facility, and should outlet to a sump for monitoring.

3.6. Underdrain Criteria

When feasible, an underdrainage collection system should be included above the TSF containment system to reduce the phreatic surface in tailings. The underdrain system will allow for faster dewatering of the tailings, leading to tailings consolidation that will result in a more efficient facility. This will also reduce the head on the geomembrane, which in turn reduces the propensity for seepage through the embankment. The water collected in the underdrain system can be reused in the process.

3.7. **Filter Criteria**

Particle size distribution testing should be completed on the construction materials and tailings to determine if a filter material, geotextile or combination of the two is required to prevent the migration of tailings through the embankment or underdrain system.

3.8. **Instrumentation**

At a minimum the following instrumentation are recommended for a TSF:

- Piezometers shall be installed in the TSF embankment to measure the phreatic surface in the embankment. This information shall be monitored by site and reported to the EOR for review to ensure that the phreatic levels does not exceed the trigger levels developed by EOR.
- Movement of the embankments (vertical and horizontal) shall be monitored using conventional survey methods or with remote sensing methods such as InSAR or equivalent.

Other instrumentation considerations include the following:

- Inclinometers and piezometers may be required in the TSF foundation if the foundation is susceptible to movement as determined by the EOR.
- Piezometers may be required in the tailings or within drainage systems at the base of the tailing to monitor how the drainage system is functioning.

The required instrumentation and frequency of monitoring should be detailed in the OMS manual for the facility.

3.9. **Operations**

An OMS Manual and Emergency Action Plan (EAP) should be prepared for use during operations. The Mining Association of Canada’s “A Guide to the Management of Tailings Facilities Third Edition” and “Developing an Operation, Maintenance, and Surveillance Manual for Tailings and Water Management Facilities” provide guidance for management of a TSF and development of an OMS manual, respectively. An example table of contents for an OMS manual is shown below:

Figure 4-1: OMS Example Table of Contents

4. Filtered Tailings Facilities

The criteria for a filtered tailings storage facility (FTSF) should generally be the same as the criteria defined for conventional TSFs. Special considerations that should be included for a FTSF are summarized below:

- A rock armor berm should be provided on the exterior slopes of the filtered tailings stack to protect the tailings from wind and water erosion.
- A specification for the moisture content and compaction of the tailings should be defined. This will be dependent on site specific materials.
- In the event that the filter presses are not operating, a contingency area in the facility or in close proximity to the facility should be considered for placement of out of specification tailings.

5. Heap Leach Facilities

5.1. Seismic Criteria

The annual exceedance probability for earthquakes is summarized in Table 5-1. These values should be considered minimum requirements.

Table 5-1: Target Levels for Earthquake Hazards

Description	Annual Exceedance Probability - Earthquakes
Operational Condition	1/475
Closure Condition	1/2,475

5.2. Geotechnical Considerations

Typical Factors of Safety (FOS) for slope stability are summarized in Table 5-2.

Table 5-2: Target Factors of Safety for Slope Stability

Description	Minimum FOS
Static	1.3
Pseudostatic	1.0 [1]

Notes:

1. Permanent deformation modeling should be completed for cases where the pseudostatic factor of safety is less than 1.0.

5.3. Containment Requirements

Containment requirements for HLFs are typically dictated by Regulation, by Corporate policies and/or internal standards. In accordance with NAC 445A.434, the minimum recommended containment requirements include a composite lining systems that consist of 300mm (12-inches) of low permeability soil overlain by a geomembrane. The low permeability soil should have a maximum recompacted in place coefficient of permeability of $1x10^{-6}$ cm/s. and shall be compacted in lifts which are no more than 150mm (6 inches) thick. The geomembrane shall have a coefficient of permeability of $1x10^{-11}$ cm/s.

The pool area for a valley leach is typically double-lined and leak detected. This can be a potential operational issue if and when leakage is measured.

To ensure that containment is maintained within the HLF, a berm should be designed around the perimeter of the HLF that is a minimum 1m above the ore. The channel formed between the berm and the slope of the ore should be capable of conveying runoff from the 100-year, 24-hour storm event. In addition to the perimeter berm, the basin slopes of the geomembrane should be a minimum of 2-percent away from the perimeter berm in order to ensure that pregnant solution drains toward the solution collection system and does not pond near the perimeter of the HLF.

Additional design considerations should also be made at locations where haul ramps and access ramps cross onto the HLF. At these locations, a culvert should be designed to convey stormwater runoff from upstream of the ramp. The culvert should be able to convey the 100-year, 24-hour storm event in order to prevent ponding upstream of the haul ramp from potentially overflowing the perimeter berm. The 100-year, 24-hour storm event is based on the requirements in NAC 445A.433 (c).

5.4. Drainage Criteria

Drainage systems are typically installed above the composite liner, and consist of a pipe network installed in a drainage aggregate. The drainage systems are intended to protect the lining system, promote drainage of leach solution and minimize fluid head on the lining system. Table 5-3 presents typical design criteria that will result in a drainage system that functions properly.

Table 5-3: Drainage System Design Criteria

Description	Value
Drainage Aggregate Properties	Competent material with little to no fines. Material must not break down due to the loads resulting from the ultimate heap height.
Drainage Aggregate Permeability	Two order of magnitude (or more) greater than the permeability of the ore when experiencing loads equivalent to that of the maximum ore height.
Drainage Aggregate Minimum Thickness	450 mm (18 inches)[1]
Pipe Spacing	Spaced at an interval which limits the head on the geomembrane to the drainage aggregate thickness.
Pipe Sizing	When sizing the collection piping, the calculation should consider that the pipe is flowing 50% full in order to account for pipe deformation.
Liner Integrity Testing	Liner integrity testing should be completed to demonstrate that the selected drainage aggregate will not damage the geomembrane when experiencing loads equivalent to that of the maximum ore height.

Notes:

1. Low ground pressure equipment must be used to place the drainage aggregate.

5.5. Instrumentation

In general, instrumentation is not required in a heap leach pad unless the facility is designed with an embankment, such a valley fill with in-heap solution storage. If instrumentation is installed, the frequency of monitoring should be detailed in the OMS manual for the facility. For this scenario, the following instrumentation is recommended:

- Piezometers shall be installed in the buttressing embankment to measure the phreatic surface in the embankment. This information shall be monitored by site and the EOR to ensure that the phreatic levels does not exceed the trigger levels developed by EOR.
- For valley fill leach pad piezometers should be installed in the pool area to monitor solution level in the heap.
- Movement of the embankment (vertical and horizontal) shall be monitored using conventional survey methods or with remote sensing methods such as InSAR or equivalent.

Other instrumentation considerations include the following:

- Inclinometers and piezometers may be required in the HLF foundation if the foundation is susceptible to movement as determined by the EOR.
- Piezometers may be useful within drainage systems at the base of the HLF to confirm that the drainage system is functioning as designed.

5.6. Loading Considerations

Loading of the HLF should consider the final reclamation slopes of the heap. Ore should be loaded from the downstream edge of the facility towards the upstream edge, and it should be placed perpendicular (uphill) to the slope at the base of the heap. Loading in this manner will decrease the likelihood of damage to the drainage system and liner during ore placement.

6. Waste Rock Storage Facilities

6.1. Seismic Criteria

The seismic criteria for a HLF should be used in the evaluation of WRSFs.

6.2. Geotechnical Considerations

The geotechnical criteria for a HLF should be used in the evaluation of WRSFs.

6.3. Containment Requirements

Prior to determining the containment requirements for the WRSF, the waste should be characterized as non-potentially acid generating (PAG) or PAG material.

6.3.1. Non-Potentially Acid Generating Waste Rock

Containment for non- PAG waste is not required. However, diversion channels, sediment control features, and sediment basins should be installed around the perimeter of the WRSF to control sediment laden water. The sediment basins should be designed to trap sediment and slowly release water into native drainages.

6.3.2. Potentially Acid Generating Waste Rock

PAG waste will require some level of containment. If the majority of the waste is PAG, the minimum recommended level of containment is 300mm (twelve inches) of recompacted native, imported, or amended soils which have an in place recompacted coefficient of permeability of no more than 1x10-6 cm/s. In this case, the WRSF should also have geomembrane lined perimeter channels that report to a lined pond.

If only a portion of the waste is expected to be PAG, the PAG material should be encapsulated by a 10m zone of non-PAG material. In the event that material with neutralizing potential is available, it may be used to reduce the potential for acid generation.

The work associated with PAG waste should be reviewed by qualified geochemists.

6.4. Loading Considerations

The benching and lift height of the WRSF should account for the proposed overall slope of the WRSF during reclamation in order to minimize the volume of regrading required during reclamation.

7. Ponds

Process and underdrain ponds that are intended to contain process solution during normal operations shall be lined with a synthetic liner.

7.1. Process Ponds

Process ponds are typically double-lined with an intermediate leak detection and collection system (NAC 445A.435). Design criteria for process pond storage are site specific and are somewhat dependent on the reliability of site infrastructure. In most cases, permanent, dedicated diesel powered generators are installed to provide backup power in the event of a power loss or other upset event. Power loss duration is a site specific design criteria and are dependent on many factors, but should not be shorter than the time it would take to get power restored to energize pumps and/or repair or replace pumping capabilities, which is typically specified as 24 hours. Gensets should be checked regularly for operational readiness and functionality. A sufficient dedicated supply of diesel fuel should be available to keep the gensets running for the duration of the upset.

7.2. Storm/Event Ponds

On-site runoff (contact water) from the design storm event should be accommodated in the single lined Storm/Event pond (NAC 445A.435). Design storms and the methodology used to compute runoff should be reasonably conservative to allow for seasonal fluctuations from prolonged cold winter weather and/or seasonal precipitation (wet season, cyclonic conditions, etc.). Industry standard practices typically require that the Storm/Event Pond is drained within 20 days of the storm event.

8. Water Balance

A site-wide water balance should be developed in order to manage facilities during operation. The water balance should include the TSF and HLF. Methods used to evaluate the water balance range from simplified spreadsheet tools to more advanced models, such as GoldSim, etc.

It is important to recognize the amount of leach solution that is in transit within the mature heap. Water balance issues can easily develop when a new HLF phase is brought online and the inventory in the mature heap is not accounted for, leaching practices are not adjusted to account for this inventory, and pond inventories are not realistically assessed.

9. References

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Summary of Laboratory Methods

Test	Method Reference	Description
Static and Basic Composition Tests		
Acid Base Accounting (ABA)	Modified Sobek	Acid potential (AP) is calculated using results from LECO furnace analysis of total sulfur and other sulfur forms after hydrochloric acid and nitric acid extraction. Neutralization potential (NP) measured by Sobek titration; NP:AP ratio; and net neutralization potential (NNP) calculated as NP-AP.
	Paste pH: ASA Mono #9 Part 2, Method 10-2.3.1	Saturated paste pH measurement by electrode.
	Net Acid Generation (NAG) EGI (2002) Metals: EPA 200.7/ 200.8 (ICP/ICP-MS Analysis) Hg: EPA 7471B Anions: EPA 300.0 Alkalinity: SM2320B	Samples are oxidized with hydrogen perioxide to promote oxidation of sulfides and generation of acid. Acid is neutralized by chemically available carbonate. Results are reported as net acidity in kilograms of sulfuric acid per tonne of sample (kg H2SO4/t). NAG solution is analyzed for a target analyte list of dissolved metals and anions.
Whole Rock Elemental Analysis	Borate Fusion / XRF - or - EPA SW846 3050B (Extraction) EPA 200.7 / 200.8 (ICP/ICP-MS Analysis)	Elemental analysis will be completed using x-ray diffraction, or constituents will be extracted from 1 gram samples of rock pulp using strong acid digestion and elemental Analysis would be done using ICP-AES and ICP-MS (USEPA 1996).
Dynamic and Microscopic Tests		
Decant Analysis	Laboratory SOP for collecting decant Metals: EPA 200.7/ 200.8 (ICP/ICP-MS Analysis) Hg: EPA 7471B Anions: EPA 300.0 Alkalinity: SM2320B Acidity: EPA 305.1 TDS: SM 2540C TSS: EPA 160.2	A pulp sample is mixed for 1 hour at 200 RPM using a Rushton turbine disc impeller, then allowed to settle for two hours. Decantation is completed by syphon from a location immediately above the solid/liquid interface. Decant is analyzed for a target analyte list of constituents.
Shake Flask Extraction (SFE)	ASTM D3987 EPA 200.7 / 200.8 (ICP/ICP-MS Analysis) Hg: EPA 7471B Anions: EPA 300.0 Alkalinity: SM2320B	SFE evaluates the potential for samples to release metals and other constituents under ambient conditions. 250 g of pulp sample is continuously mixed with 500 or more grams of water. Constituents are measured in the supernatent.
Mineralogy	Rietveld XRD	Neutron and x-ray diffraction of powder samples results in a pattern characterised by reflections (peaks in intensity) at certain positions. The height, width and position of these reflections is used to determine the mineral structure.

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Preface

The Canadian Dam Association publication *Dam Safety Guidelines* (CDA, 2013) outlines principles that are applicable to dams of all types. These include "mining dams" which are retaining structures at mine sites or metallurgical plant sites that retain solids or liquids that may or may not be contaminated.

This Bulletin was prepared by the CDA Mining Dams Committee, which has members representing a broad range of the mining community in Canada. The focus has been on the Canadian context, but the principles are generally applicable to dams in any jurisdiction. Regulatory requirements vary considerably and must be met in all cases. Other expectations and requirements may also apply, including corporate policies and guidelines, industry standards, and legislation at provincial and federal levels.

This Bulletin is not intended to duplicate or replace the extensive guidance that has been prepared by other organizations. For example:

- The Mining Association of Canada (MAC) has published a number of guides for the mining industry, particularly in relation to management of mining facilities.
- The International Commission on Large Dams (ICOLD) has issued guidance on overall tailings systems, sustainable design and closure principles, and long term monitoring.

In making dam safety assessments and decisions, the responsible engineer or decision-maker must assess and interpret guidance and information from all available sources and determine the appropriate requirements for a specific situation.

While every reasonable effort has been made to ensure the validity and accuracy of the information in this Bulletin, the Canadian Dam Association and its membership disclaim any legal responsibility for use of *Dam Safety Guidelines* and this Technical Bulletin.

1.0 Introduction

This *Technical Bulletin* ("Bulletin") is intended to complement the *Dam Safety Guidelines* published by the Canadian Dam Association (CDA, 2013) by providing additional explanation of how the concepts described in the *Dam Safety Guidelines* (CDA, 2013) apply to mining dams. The Bulletin identifies some specific issues that should be considered during the design and safety evaluation of mining dams.

Regulation of dam safety in Canada is primarily a provincial or territorial responsibility. This Bulletin has been prepared in the context of the Canadian regulatory framework where the regulator is involved at key milestones in the development of mining dams and the closure of these dams. It is recognized that elements of this Bulletin may be relevant in other jurisdictions when applied in conjunction with the local dam safety guidelines and regulators.

A number of documents provide guidance on the design of mining dams (in particular tailings dams) and the reader is referred to the list of References included in this Bulletin for information. A key reference document is the ICOLD Bulletin 139, "Improving Tailings Dam Safety: Critical Aspects of Management, Design, Operation, and Closure," issued in 2011. ICOLD Bulletin 139 provides information on the overall tailings system, including tailings deposition, design, water management, environmental management, operation, closure, risk management, emergency preparedness, and the role of the regulators. In 2013, ICOLD issued Bulletin 153, "Sustainable Design and Post Closure Performance of Tailings Dams," which builds on the previous bulletin with a focus on sustainable design and closure principles and long term monitoring.

This Bulletin is intended for a technical audience familiar with mining operations and issues related to managing mine waste, including: contact water, process water, leach solutions, treatment solids, tailings, acid rock drainage/metal leaching (ARD/ML), leachates, etc. The focus is on the dam safety aspects for dams typically associated with mining of metals (e.g. nickel, iron, copper, lead, zinc, gold), non-metals (e.g. phosphate, potash, gypsum), structural materials (aggregate and limestone) and fuels (uranium, coal, oil sands).

This Bulletin is organized as follows:

- Section 2 describes mining dams in general and the associated objectives of mining dams. It focuses on earth embankment dams and does not address concrete dams explicitly, but many of the concepts can be applied to concrete dams as well. Section 2 also describes the life phases of mining dams, an important concept used throughout this Bulletin.
- Section 3 describes how the *Dam Safety Guidelines* (CDA, 2013) can be applied to mining dams during operation and preparation for closure.
- Section 4 addresses closure, which is a significant issue for mining dams. It addresses criteria and minimum practices for dam safety during closure.
- Section 5 provides guidance on items that should be considered when designing for wet covers.
- Section 6 presents long term issues such as ownership, liability, and custodial transfer of mining dams back to the Crown.

2.0 Mining Dams – Description and Phases

2.1 Definition and Functions of Mining Dams

In this Bulletin, the term "mining dams" refers to retaining structures that exist at mine sites or metallurgical plant sites that are designed to retain solids (that may or may not be contaminated[1]) and/or contaminated liquids. Examples of mining dams include:

- Tailings dams (including perimeter dams for thickened tailings disposal)
- Contaminated runoff collection and diversion dams
- Dams that contain reservoirs as part of a collection and treatment system
- Polishing pond dams
- Seepage collection dams
- Sludge storage dams

Mining dams are built during the development and operation of mines. Many mining dams can remain as part of the landscape, becoming permanent features that have to perform as designed for many years after closure of the mine.

Tailings dams are the most significant type of mining dams as they usually contain large quantities of fluids and solids that are generated from the processing of ore. These fluids and solids can cause environmental damage if released and, in the majority of cases, this applies for hundreds of years after the cessation of operations, and possibly in perpetuity.

Tailings dams are usually earthen dams that are constructed of:

- Naturally occurring materials including blasted or crushed rockfill, and/or borrow fill material
- Tailings either without additional processing or after cycloning
- Geosynthetic materials

A tailings dam may or may not have a water pond impounded directly against the dam.

In some cases, the tailings contained by a mining dam are not contaminated and do not present a risk to the environment in terms of surface and groundwater chemistry, but the solids must be contained.

In this Bulletin, the terms "pond" and "impoundment" are used interchangeably, referring to the ponded water or deposited tailings upstream of the dam (or upstream of the structural portion of an upstream constructed tailings dam).

In the *Dam Safety Guidelines* (CDA, 2013), a dam is defined as a barrier constructed for the retention of water, water containing any other substance, fluid waste, or tailings. Although there is guidance provided with respect to the minimum size of a structure that could be considered a dam

[1] "Contaminated" means that the solids or fluids have concentrations of chemicals of concern that have the potential to adversely affect the environment or human health.

(minimum of 2.5 m in height), the definition of a dam includes dams less than 2.5 m high if the consequence of failure is likely to be unacceptable to the public, such as dams retaining contaminated substances. Hence, in the context of mining dams, there is no minimum size if they contain contaminated substances (fluids and/or solids) where the consequences of failure could be unacceptable to the public.

Mining dams are designed, constructed, and operated to meet a number of objectives of their owners that include:

- Ensuring safe storage of tailings or other mine wastes that are produced during operation and closure, both fluids and solids, in many cases for the long term.
- Protecting the environment from degradation due to the release of water from the containment ponds during their operation and after closure.
- Supporting the water management requirements of the site including recycle water, diversion of fresh water, and managing mine effluent to meet discharge requirements.

Many mining dams are built in stages over the life of the mine, rather than built in a single stage prior to commissioning.

In some cases, a mine site may not have a concentrator[2] that produces tailings but still generates contaminated water that requires containment and management on site.

In some cases, the term "dam" has been used by mine operators to refer to an entire tailings storage facility. For the purpose of this Bulletin, the dam is considered to be the perimeter containment structure(s) around the tailings facility. Within a tailings facility, there can also be internal structures that should be treated as dams if they provide containment of solids and/or fluids. The terms "dyke" or "dike" are used by some mining operators. In this Bulletin, these are all treated as dams.

Mining dams can be located within mined out pits to isolate a portion of the pit for the storage of the contaminated water and solids. In this instance, a failure of the in-pit dam may not have significant environmental consequences, but there could be substantial operational issues and threats to life (mine operators). In some cases, such as when depositing tailings in an open pit, the natural ground areas (overburden and bedrock) on the sides of the pit are used for containment. Or, when an open pit is excavated, a separating natural berm can be left in place to isolate the pit from a nearby lake or pond. These cases need to be assessed to determine if the structure should be treated as a dam and if so, then the guidance provided in this Bulletin and the *Dam Safety Guidelines* would apply.

In many cases after mine operations cease, there is no pond or there is limited pond on the surface of the facility such that the facility appears as a tailings "stack." If a breach of the perimeter containment, regardless of the triggering mechanism, can trigger liquefaction or flow of the contents of the stack that can extend beyond the perimeter containment, then the perimeter containment must be considered as a dam, even though there is no visible water on the surface of

[2] In this Bulletin, the term "concentrator" is used to represent the facility that produces the tailings but could also be referred to as a processing facility, mill, or upgrader.

the stack (i.e. no pond). In some cases, there can be water temporarily ponded on the surface from precipitation. This is consistent with the definition of a dam as described above.

If the contents are not liquefiable and cannot flow, then the perimeter containment does not need to be considered as a dam but rather an embankment slope, and the facility can be treated as a waste disposal area similar to an overburden disposal area. The consequences of failure would need to be evaluated for such a slope and appropriate slope design practice would apply. Often, design guidance exists for dumps and overburden disposal areas and would be applicable in this instance.

In this Bulletin, the term "conventional dam" is used to describe dams that control or manage fresh water, such as for (i) the generation of hydroelectric power, (ii) flood control, and (iii) fresh water storage. Fresh water containment and diversion dams can exist on a mine site and they are still considered to be conventional dams. Often, these dams are intentionally breached shortly after the mining operation ends. However, in some cases these dams are required to divert water to support a wet cover over tailings (with or without free visible water at the surface), to maintain separation of water that has been affected by mining from non-contact water, or for fish habitat compensation or preservation during the closure phase. If such dams are required for the long term, consideration of design criteria for mining dams in the closure phase may be appropriate (see Section 4).

2.2 Phases in the Life of a Mining Dam

2.2.1 Definitions

This section defines and describes the phases in the life of a mining dam as shown in Figure 2-1, discussed in the following sub-sections, and listed as follows:

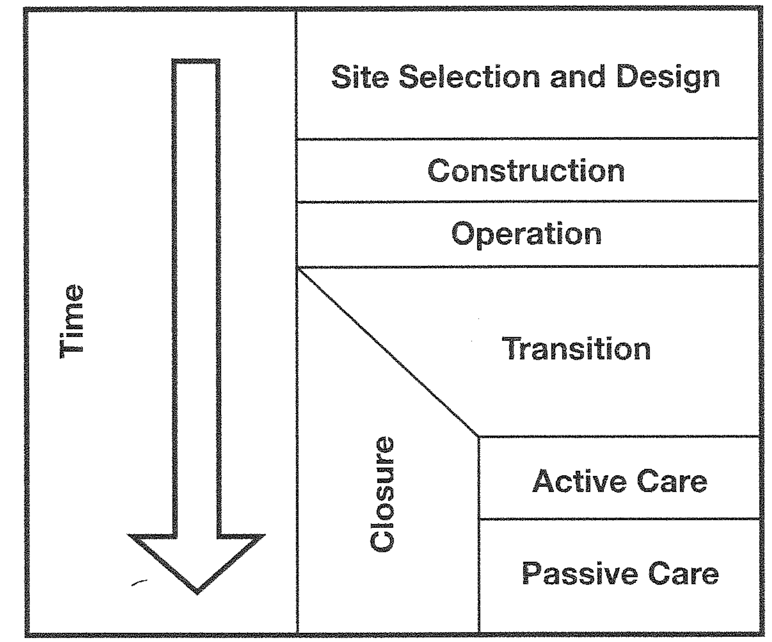
- Site Selection and Design
- Construction
- Operation
- Transition
- Closure – Active Care
- Closure - Passive Care

The term "life cycle" is often used to describe the life of a facility, but that term is most suitable for structures that are constructed and then removed. For many mining dams that cannot be removed, the term "cycle" is not applicable. For this reason, the term "phase" has been adopted for this Bulletin.

On a single mine site, there may be several mining dams, each at a different phase of the life as described in the following sub-sections. Each dam is to be considered independently.

Appendix A provides a comparison of the life phases described in this Bulletin with guidance from the Mining Association of Canada (MAC) and the International Commission on Large Dams (ICOLD). The concept of Transition Phase, as described below, is not explicitly addressed in the MAC and ICOLD documents.

Figure 2-1. Phases in the Life of a Mining Dam



2.2.2 Site Selection and Design

The Site Selection and Design phase includes all of the preparatory work that is undertaken prior to constructing the mining dam. Improper siting of a mining dam has resulted in dam safety problems as the mine development proceeds and the siting needs careful consideration. During this phase, design criteria will be established that recognize the planned operational life of the dam and also the anticipated closure requirements. The closure requirements for a mine site can have a significant bearing on the site selection and design of a mining dam.

Other items that merit consideration in siting a mining dam are as follows:

- Foundation conditions with respect to geotechnical characteristics and seepage containment
- Potential for future expansion of the mining operation and possible modifications that may be required to the mining dam
- Water management requirements and size of water management facilities (i.e. ponds)
- Proximity to environmental receivers.

2.2.3 Construction

Some mining dams may be completely constructed before a mine or mill commences operations. More often, a mining dam is initiated with a starter dam at the start of the operation and then periodically modified or raised during the Operation Phase.

A mining dam can also be modified after operation as part of mine closure (typically within the Transition Phase described below).

2.2.4 Operation

During the Operation Phase, the dam may continue to be modified. Changes in tailings composition or regulatory requirements may necessitate amendments of the original design criteria. The dam may also be raised or a new dam added to provide for additional storage capacity.

The Operation Phase can last for decades. It should be noted that the duration of the Operation Phase is often different than the life that may have been contemplated during site selection and initial design, since mine life can be affected by the availability of resources and economic, technical, social and environmental factors that may evolve over time. Regardless of the mine life, the dam should be designed to anticipate the potential for temporary production suspension and the potential for that temporary condition to become permanent. During a temporary or indefinite suspension of mining activities, the dam owner should monitor the dam and maintain it, but no modifications are made to the structure. In this condition, measures are not implemented to prepare the dam for closure. The dam would be operated and maintained in anticipation of restarting production.

In cases where the mining dam is constructed over the life of the mine, the design, construction, and operation phases are closely integrated and can be difficult to separate.

Measures can be undertaken by the mine owner during operation to progressively reclaim and decommission the site and prepare for closure.

2.2.5 Closure

As described above, many mining dams will need to remain in service well after the mining operation has ended. ICOLD (2011) defines closure as follows:

> "The shutting down and decommissioning of a mine and tailings dam when production has ceased including the transition of the mining area and dam into long-term stable structures. Normally, closure includes decommissioning, remediation (reclamation or rehabilitation) and after care at the site and the tailings dam."

ICOLD (2013) defines closure as follows:

> "The planned cessation of tailings disposal into the tailings dam and the modification/ engineering of the tailings dam with the objective of achieving long term physical, chemical, ecological, and social stability and a sustainable, environmentally appropriate after use."

Of interest, the ICOLD definitions infer that modifications to the dam are taken as mandatory for closure. Often, the dam can be "designed for closure" such that modifications at closure are not required. For tailings dams, closure of the tailings facility begins when the tailings storage ends. The same can be said for dams that store water treatment sludges.

For other mining dams on a site, such as water treatment dams and diversion dams, the closure might not begin until the mine operation has ended and the rest of the mine is being decommissioned. Hence, for this Bulletin, there are two aspects with respect to closure. There is closure of the mine or processing facility after they are no longer required. This involves decommissioning structures and reducing the work force on site. However, for a tailings or sludge storage dam, closure can begin when the tailings or sludge storage facility has reached capacity. This can happen while the mine or processing facilities are still operating at the site, well before the mine or processing facility "closes." For many mining dams, they have to provide their intended function for a very long time including closure. Hence, this Bulletin provides the following definition for closure of a mining dam:

> Closure is the process of establishing a configuration for the dam with the objective of achieving long term physical, chemical, ecological, and social stability and a sustainable, environmentally appropriate after use. This configuration can be achieved during or after mine operations.

As noted above, on a mine site there may be several dams at different phases of their life, with some dams considered to be in closure while the mine is still operating. This would be considered part of progressive reclamation, but from the perspective of regulators, closure of a mining dam might not officially begin until the mine or processing facility is shut down (i.e. the site is closing).

It is important to note that the closure of a mining dam has to be done in the context of the closure of the impoundment contents contained by the dam. The two are interdependent as the closure of the impoundment contents can have a direct bearing on the closure requirements of the dam.

In this bulletin, the terms "reclamation" and "rehabilitation" both refer to upgrades or modifications of the mining dams to meet the design objectives for closure.

The term "decommissioning" is often used when referring to closure of mining dams. In this Bulletin, the term "decommissioning" is used when referring to removal or breach of a dam so that it no longer retains tailings or water that may pose safety or environmental concerns. Partial breaching of a dam is considered rehabilitation not decommissioning. The portion of the dam that remains in place holding tailings back will still need to function as a tailings retaining dam (if the tailings can flow). In general, water retaining dams can be decommissioned by breaching. Decommissioning of a tailings retaining dams will typically require complete removal of the dam and relocation of tailings it retains. However, the consequences of failure would be significantly reduced through the partial breaching.

In addition, the closure designs have to consider aboriginal and social issues associated with the future land use of the areas affected by the mining dams.

As noted in Figure 2-1, there are three main phases in closure of a mining dam: Transition, Closure - Active Care, and Closure – Passive Care.

2.2.6 Transition

The first phase of closure is Transition. This phase typically commences when the mining dam has reached its capacity and ceases to be operated or when the mine or processing operation is terminated permanently. Activities are undertaken during this period to prepare the mining dam for the Closure – Active Care or the Closure - Passive Care Phases.

During the Transition Phase, the mining dam may be decommissioned through breaching or removal. From an environmental perspective, dams that contain non-contaminated solids are easier to breach than dams that contain contaminated solids. When there is no practical option to decommission the dam, the dam must be designed and maintained as a long term and possibly permanent structure.

Where there are multiple storage facilities, it is not uncommon that tailings or sludge storage dams are progressively rehabilitated once they are filled and deposition commences in a newly developed area. In this case, such dams that are progressively rehabilitated would be in the Transition Phase during that rehabilitation period.

The Transition Phase can be undertaken at the same time as other decommissioning activities at the mine site (e.g. demolition, sealing of mine openings, etc.)

The Transition Phase can typically involve one or a combination of the following activities related to a mining dam:

- Breaching the mining dam, as noted above. Portions of the mining dam may remain, but the consequences of failure of these portions would be substantially reduced or eliminated.
- Modifying the dam, spillway, and discharge structures to accommodate a water cover and water treatment system. In some cases, the water cover is established within an upper layer of soil or gravel such that the water is not visible, but the closure concept for the impoundment requires an elevated water table to prevent acid generating and metal leaching. This is effectively the same concept as establishing a water cover, also referred to as a wet cover. The dam could be modified by re-grading or contouring to improve stability, the surface drainage systems could be modified to manage flood events while recognizing other long term factors (vegetation and beavers), the upstream and downstream slopes could be protected by placing erosion protection materials, site access could be controlled, and other measures may be undertaken to reduce the need for long term maintenance and surveillance. As noted above, the dam can initially be designed for closure such that these modifications would be minor. Note that Section 5 provides a discussion on considerations when designing for covers.
- Modifying the dams, spillways, and discharge structures to remove a pond and not allow a pond to remain on surface while also safely passing floods. This may also be done in conjunction with the installation of a reclamation cover on the facility, such as vegetating the tailings beaches. The items noted in the previous bullet related to regrading the dam, placing erosion protection materials, etc., would be applicable to this activity as well.

If it can be demonstrated that the material contained by the mining dam (i.e. in the impoundment) is not liquefiable and will not flow if the containment structure is breached, then the containment structure is no longer considered a dam. (See Section 2.1 for the discussion related to a stack.) Measures may be implemented during the Transition Phase to achieve this condition (i.e. to reduce liquefaction potential of the tailings). Factors that need to be considered in this assessment are discussed in Section 3.5.

The end of the Transition Phase occurs when the activities noted above are completed for entering the Closure – Active Care Phase. The mining dam may or may not have achieved a steady state condition with respect to pore water pressures, deformations, erosion, etc. While the physical modifications can be completed in a relatively short time frame (e.g., several years), the confirmation of performance can take longer and this would extend into the Closure – Active Care Phase.

Typically, a closure plan for a mine will detail the measures that are to be implemented for closure including the required modifications to the dams. At the end of the Transition Phase, these measures will have typically been completed and the dams are considered "closed." The Transition Phase can last from one year to decades. On some mine sites, a tailings facility and dam may end operation well before the end of the mine life and will be considered to either be in the Operation Phase or the Transition Phase until closure measures are implemented at the site that address this particular facility.

2.2.7 Closure – Active Care

This phase involves active care of a mining dam, including monitoring, inspection, water management, operation of a water treatment system, etc. after the Transition Phase is completed.

For the case where the mining dam has been designed to accommodate a water treatment system, this phase would involve ongoing operation, maintenance and surveillance, and possibly management of the water levels. This phase is often referred to as "care and maintenance."

In many cases, these activities could last for decades or centuries. In some cases, a treatment system may be established to address a short term concern with respect to water quality and the treatment system may be needed for less than a decade. The treatment system can be decommissioned and the dams could move into the Closure – Passive Care Phase at that time.

For the case where the pond has been removed from upstream of the dam and the mining dam still has to be treated as a dam because the contents upstream of the dam can flow upon failure of the dam, the following activities would typically be involved in this phase:

- Surveillance and maintenance of the mining dam (i.e. inspections, maintenance of erosion protection, vegetation management, inspection of the cover system, etc.)
- Monitoring to verify the performance that was expected during the design.

In some cases, these activities may last for less than a decade and then the dams can move into the Closure – Passive Care Phase. The mine owner will typically have staff monitoring the site on a regular basis during the Closure - Active Care Phase.

During the Closure – Active Care Phase, the performance of the dams should achieve a steady state condition. This could include the following:

- Pore pressures have reduced and stabilized as a result of removing a pond.
- Pore pressure adjustments after modifying a dam have stabilized.
- Erosion gullies are not forming that do not self-heal; the dam erosion measures are effective.
- Deformations are either non-existent or are at a steady state and do not present a concern with respect to the stability of the dam.

When this steady state condition has been achieved, the dam could be considered for Closure – Passive Care. Due to the time needed to reach a steady state condition, it is unlikely that a mining dam will be able to move directly from the Transition Phase to the Closure – Passive Care Phase. However, the length of the Closure – Active Phase could be quite short in some cases (i.e. a few years). In other cases, the Closure – Active Care Phase could last decades or longer.

A key requirement of the Closure – Active Care Phase is that the mining company normally has resources on site that are able to respond to problems and possible emergencies that may develop. This is an important consideration when addressing the design criteria as noted in Section 4. Where there is no active effluent treatment or water management requirement, the mining dam could be monitored and maintained during the Closure – Active Care Phase using off site personnel who inspect the dam on a regular basis. As noted in Section 4, the surveillance program during the Closure - Active Care Phase should be clearly described in the Operation, Maintenance and Surveillance (OMS) Manual, including emergency response.

ICOLD (2013) defined Active Care as the period when intervention and monitoring is required to achieve a final sustainable form. In this Bulletin, this period has been divided into the Transition and Closure - Active Care Phases where the majority of the intervention, if required, is in the Transition Phase and the Closure – Active Care Phase is operating (such as a water management and treatment system), maintaining, and monitoring.

2.2.8 Closure - Passive Care

In this phase, there is no active operation of the mining dam and no changes to the mining dam are expected to occur. The dam is considered to be in a steady state condition and sufficient experience has been gained with the structure and sufficient monitoring has taken place to demonstrate that no further intervention is required by the owner. There is no requirement for water treatment or intervention by operating personnel to manage water levels in the pond upstream of the dam. The system is in a passive state that does not require operating personnel on site or regular surveillance. A spillway has been established to passively release water from the system to the

environment. Potentially erodible exterior slopes have been covered or otherwise treated (i.e. vegetation or rock fill).

This phase is an important goal for a mining company - to have the structure in a stable form with low maintenance. Inspections by dam safety engineers and dam safety reviews will continue with maintenance undertaken as required. Remote monitoring systems might be employed. Special inspections may be required after extreme events.

The monitoring plan discussed in Section 4 would describe the Owner's plans for monitoring the dam during this phase and the plans would be subject to the regulator's review and approval before implementing. This phase can last for hundreds of years or longer and is the longest phase in the life of a mining dam that is not decommissioned.

It is important to note that Closure – Passive Care Phase is not the same as "abandonment" or "walk away." Many dams are abandoned without the appropriate measures implemented to prepare the dam for Closure – Passive Care Phase. Such dams often pose an unacceptable risk because they were not prepared for closure properly. As discussed in Section 4, a dam in Closure – Passive Care Phase still requires some level of inspection, dam safety reviews, and emergency response. This should be spelled out in an OMS Manual for this phase.

If a dam is modified beyond routine maintenance (e.g. a toe berm is constructed as compared to repairing erosion gullies), then the dam would be considered to return to the Transition Phase and no longer be in the Closure - Passive Care Phase. A period of time would have to pass again (Closure – Active Care Phase) to demonstrate that the dam could return to the Closure - Passive Care Phase.

When a mining dam is on a lease from the provincial or federal government and is in the Closure – Passive Care Phase, then it may be eligible for transfer back to the Crown – referred to as Custodial Transfer. This is discussed further in Section 5.

2.3 Possible Resumption of Operations

In some cases, even though a mining dam and associated facility are in either the Closure – Active Care or Closure – Passive Care Phase, the owner may wish to reactivate a dam. I f this occurs, then the mining dam would revert back to the Construction or Operation phases and the life phases would start over.

2.4 Landforms

ICOLD (2013) has identified the condition whereby a structure may not be considered a dam if "in the opinion of the authorities, [the dam] is considered to be physically, chemically, ecologically, and socially stable and no longer poses a risk to life or the environment." One approach to achieving this is to create the dam as a permanently stable landform where the risk of release of solids and contaminated water is negligible. This is consistent with the discussion above, where the facility contained by the mining dam can be modified such that it no longer meets the definition of a mining dam in Section 2.1 and is consistent with the objective of moving towards Closure – Passive Care.

In Canada, an initiative is underway in the oil sands industry, where tailings dams could be designed and constructed to become landforms and no longer be considered dams. This condition is achieved through shallow side slopes, wide spillways, changing the contents of the pond, etc. Such structures might not require regulatory oversight. This approach could also be considered for dams beyond the oil sands industry. General guidance for mining dams for what would constitute a "landform" as opposed to a dam is not available at the time of this Bulletin. The risk informed approach to support the creation of a landform would be consistent with Section 6 of the CDA (2013). This approach could take a dam to a "walk away" condition.

The interaction between the dam owner and regulator to achieve this condition is specific to the different jurisdictions in Canada. In Alberta, the oil sands initiative noted above is being developed with input from the regulators, to provide guidance.

Most mining dams are not expected to be classified as landforms; hence, that "phase" of the mining dam life was not included in Figure 2-1.

2.5 Environmental Considerations

This Bulletin focuses on structural failure modes (sliding, overtopping, internal erosion, etc.) as these are the items of focus in *Dam Safety Guidelines* (CDA 2013). Environmental factors can affect the structural stability of a dam, for example when precipitate formation clogs drains or damages filters.

There are other failure modes associated with mining dams that are non-structural in nature and are related to environmental protection. These include:

- Unplanned release of contaminated water via an emergency overflow spillway.
- Release of excessive contaminated seepage down gradient of the dam.
- Contamination of groundwater.
- Excessive seepage causing the loss of water cover required over a tailings deposit to inhibit sulphide oxidation[3].
- Excessive erosion by wind resulting in dust releases (in the case of mining dams constructed of tailings).

The first item above is addressed through the concept of the Environmental Design Flood discussed in Section 3.5. The second, third, and fourth bullets relate to seepage through the dam and foundation. Seepage control as it relates to protecting a dam from internal erosion is an important structural consideration and is discussed below. But, the situation where the seepage presents an environmental risk is not addressed in this Bulletin. The last bullet is an important design consideration, but it does not affect the structural safety of the dam.

[3] Loss of water cover can also be due to high evaporation, but that is not related to the design of the dam.

ICOLD (1996) and Szymanski (1999) further discuss the distinction between structural and non-structural failure modes. The "Environmental Code of Practice for Metal Mines"(Environment Canada 2009) provides a series of recommended environmental practices pertinent to mining dams throughout the life of a mining dam. The focus of that code of practice is on metal mines, including uranium. The document can be used to assist with the development of objectives and criteria for the design of mining dams with respect to environmental protection requirements.

3.0 Construction, Operation and Transition Phases

3.1 Dam Safety Management

3.1.1 General

As previously noted, mining dams can exist for a very long time. Conventional dams are often decommissioned (removed), modified to become free overflow weirs, or rehabilitated to extend their service lives, but typically these dams may be designed for a service life of 50 to 100 years. The service life of a closed mining dam, however, can be over 1,000 years. Hence, to assist with considering the risk exposure for a mining dam and developing criteria for the design of a mining dam, the concepts of design life and design interval are discussed herein.

Design life is the period for which a component is expected to function at its designated capacity without major repairs. In the context of a mining dam, design life is the expected service life of a structure, at the end of which either the structure is removed or it undergoes significant rehabilitation to upgrade and bring the dam to current design guidelines. If a mining dam is breached or removed from service, then that would end the design life of the dam. However, most mining dams are not expected to be breached and are required for the long term.

Because the design life can be indefinite, the concept of the design interval is considered in this Bulletin. This concept is described in detail by Szymanski (1999) where the design interval is defined as "the period under which the conditions can be considered known or predicted and the design can be based."

For example, the Operation Phase of a mining dam typically lasts 20 to 50 years. The conditions during the Operation Phase can be reasonably predicted, there are staff on site conducting surveillance, and emergency response is possible. Hence, the design interval for the Operation Phase would typically be 20 to 50 years. The *Dam Safety Guidelines* (CDA, 2013) work well for this length of design interval.

In some cases, the Construction Phase for mining dams can be similar to conventional dams, although for many mining dams the Construction Phase and Operation Phase occur at the same time, with the tailings dams raised over the life of the mining operation. Thus, *Dam Safety Guidelines* (CDA, 2013) apply to the Construction Phase of mining dams.

As noted above, the Transition Phase can last from one year to decades. Like the Operation Phase, the conditions can be reasonably predicted, surveillance is conducted, and emergency response is possible. Hence, the *Dam Safety Guidelines* (CDA, 2013) apply to the Transition Phase as well.

The remainder of this section discusses how the *Dam Safety Guidelines* (CDA, 2013) can be applied for the Construction, Operation, and Transition phases. Section 4 discusses how the guidelines can be applied for the Closure - Active and Closure - Passive Care Phases.

The guidance in this section would also apply to those dams that are in a state of inactivity or temporary suspension, where the mining operation has been suspended and the potential remains to resume operation at some point in the future. This assumes that the mining company is conducting surveillance and emergency response is possible. If this is not the case, then other measures need to be considered.

Section 2 of *Dam Safety Guidelines* (CDA, 2013) describes the overall process for managing dam safety, including the elements of a management system, supporting processes and dam classification. The section is applicable to mining dams with appropriate recognition and consideration of the different phases in the life of the dam. Some of the aspects that are often a challenge with mining dams because of their long life are as follows:

- CDA 2013 defines the owner of a dam as the person or legal entity, including a company, organization, government department, public utility, or corporation that is responsible for the safety of the dam. For mining dams, the ownership can sometimes be confounded because the person or legal entity that owns the dam is not well defined and there may not be a government license to operate the dam. The owner of the mining dam must be clearly identified.
- Records management becomes a challenge with the extended life of the dam. Pertinent records and documents must be available and protected well into the future.

3.1.2 Engineer of Record

Section 2.3 of the *Dam Safety Guidelines* (CDA, 2013) states that "the owner's policy should clearly demonstrate the organization's commitment to safety management throughout the dam's life cycle." This includes "delegation and authority for all dam safety activities. Further, "the owner's staff and any consultants and contractors who carry out dam safety activities on behalf of the owner should be made aware of the decision making process and who is accountable for that." In support of these requirements, this Bulletin considers the Engineer of Record (EOR) as an important aspect of risk management for mining dams. The EOR should be a qualified and competent engineer who is responsible for the design and performance of a mining dam. For a single mining dam, there can often be several engineers and engineering firms involved in the design, construction, and performance assessment of the dam over its life and it may not be clear who the EOR is for the dam. This can present a challenge for the owner when managing the risks associated with the dam.

The EOR should be clearly identified by the owner with the concurrence of the EOR. Typically, the EOR would be involved in the construction of the dam as well. Where the construction is directed by the owner and continuous construction inspection is not provided, the EOR is not responsible for the quality during construction, but is responsible for ascertaining that changes made to the design during construction continue to meet the applicable design standards, criteria, and guidelines. The EOR may be declared after the construction is completed and, in this circumstance, the EOR and owner need to work together to make sure that the EOR is equipped with the appropriate information to be able to take on this responsibility.

During the Construction, Operation and Transition Phases, the EOR could change over time and it is important that the EOR, with associated responsibilities, be clearly identified. If there is to be a handover of the dam as a result of a transfer of ownership, then the EOR must remain clearly defined. Also, the EOR can change due to changes in employment status (such as a transfer or retirement) and the owner should ensure that a replacement EOR is clearly named.

Records management related to the dams should be an integral part of a transfer to a new EOR, or transfer of ownership.

The concept of an engineering consulting firm as the EOR needs further consideration and is beyond the scope of this document at this time.

3.1.3 Consequences of Failure

The consequences of failure of a mining dam that contains liquefiable solids and solids that can be transported with water can be greater than the consequences for the same dam containing only water. Although tailings and liquefiable solids may travel a shorter distance than water, the material can act as a viscous fluid with a high specific gravity that can cause more damage than water alone. The damage can be both physical and environmental. Removal of released solids and clean-up could be impractical in many cases, for example in densely forested areas or water bodies.

Dam break and inundation studies are necessary to support assessment of the consequences of potential failure of mining dams, as for conventional dams. However, there are a number of challenges associated with dam breaks for tailings dams because the science of predicting tailings dam breaches and flows is relatively new. The current techniques for predicting tailings flow slide inundation are limited and the lethality of tailings dam failures can be quite different than for conventional dam breach flooding. The limitations in accurately modeling the effects of a tailings flow slide need to be considered when assessing the consequences of failure.

Section 2.5.2 of *Dam Safety Guidelines* (CDA, 2013) calls for conducting dam break studies for a "sunny day" and a "flood-induced" failure. The "sunny day" failure is one that occurs during normal operations. Because of the contaminated fluids and solids that are contained by the mining dams, the incremental environmental consequences are often worse for a sunny day failure than a flood induced failure.

Since many mining dams are remote from population centres, the potential for loss of life is often not as prevalent as it is for conventional dams. There could be occasions where there are people in the area downstream of the dam temporarily due to seasonal cottages, roads and highways, rail corridors, and recreational activities. Mining dams can also have the special case where the failure could threaten employees of the mine working downstream of the mining dam, such as in an open pit mine. In this instance the training of the mine staff can be considered with respect to evacuation procedures and the potential for reducing the potential for loss of life.

Environmental losses are often the most significant aspect of a mining dam failure. Specific studies may be required to predict the degree of environmental loss. This could include damage to the downstream environment, but in some cases, mining dams have supported ponds and wetlands that have become suitable fish and terrestrial habitat and this habitat can be lost through a failure.

The economic losses to a mining company can be substantial and may be much larger than the direct financial burden associated with a failure. Failures of mining dams can result in lost production, have a negative impact on the market capitalization of a company, and limit the ability of the company to engage in other mining projects.

Mining dam failures can result in loss of site infrastructure such as roads, pump stations, power lines, and pipelines.

All of the potential consequences of failure need to be considered and the severity of these consequences predicted to aid in developing a risk profile for the dam.

Table 2-1 in the *Dam Safety Guidelines* (CDA, 2013) presents a classification scheme that can be used to provide guidance on the standard of care expected of dam owners and designers. It considers a segment of the consequences discussed above: population at risk, loss of life, environmental and cultural values, and infrastructure and economics. For ease of reference, Table 2-1 is reproduced here (labeled Table 3-1 in this document).

The population at risk and potential loss of life are determined using standard approaches. However, little guidance is provided in CDA (2013) for assessment of "Environmental and cultural values." Since the environmental and cultural conditions associated with each mining dam can vary, specialist knowledge must be applied in the fields of ecosystems, land, water quality, fisheries, and cultural values. The classification criteria and terminology such as "significant loss" and "critical habitat" should be defined and agreed upon early in the design or safety review process, with input from specialists and the regulatory authorities. Because of the difficulty in predicting the environmental and ecosystem effects from accidental releases, it is often necessary to be on the conservative side when applying dam classifications.

The *Dam Safety Guidelines* (CDA, 2013) consider only the economic losses to third parties beyond the limits of the mining lease on which the mining dam is situated. In many cases, the failure of a mining dam can have no effect on a third party, if the failure and runout is wholly contained on the mine property. As noted above, the financial consequences to a mine owner can be much larger than the financial effects on third parties.

Hence, it is important to note that the classification scheme in Table 3-1 is one consideration for the owner in terms of establishing the risk profile for the mining dam. The owner must also consider the other consequences, as described above that the dam presents to their operation when establishing the risk profile and although this may not change the classification, the risk profile could have a bearing on the surveillance activities and design criteria.

Table 3-1. Dam Classification

Source: Table 2-1 of CDA 2013

Dam class	Population at risk [note 1]	Incremental losses		
		Loss of life [note 2]	Environmental and cultural values	Infrastructure and economics
Low	None	0	Minimal short-term loss No long-term loss	Low economic losses; area contains limited infrastructure or services
Significant	Temporary only	Unspecified	No significant loss or deterioration of fish or wildlife habitat Loss of marginal habitat only Restoration or compensation in kind highly possible	Losses to recreational facilities, seasonal workplaces, and infrequently used transportation routes
High	Permanent	10 or fewer	Significant loss or deterioration of *important* fish or wildlife habitat Restoration or compensation in kind highly possible	High economic losses affecting infrastructure, public transportation, and commercial facilities
Very high	Permanent	100 or fewer	Significant loss or deterioration of *critical* fish or wildlife habitat Restoration or compensation in kind possible but impractical	Very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities for dangerous substances)
Extreme	Permanent	More than 100	Major loss of *critical* fish or wildlife habitat Restoration or compensation in kind impossible	Extreme losses affecting critical infrastructure or services (e.g., hospital, major industrial complex, major storage facilities for dangerous substances)

Note 1. Definitions for population at risk:

None—There is no identifiable population at risk, so there is no possibility of loss of life other than through unforeseeable misadventure.

Temporary—People are only temporarily in the dam-breach inundation zone (e.g., seasonal cottage use, passing through on transportation routes, participating in recreational activities).

Permanent—The population at risk is ordinarily located in the dam-breach inundation zone (e.g., as permanent residents); three consequence classes (high, very high, extreme) are proposed to allow for more detailed estimates of potential loss of life (to assist in decision-making if the appropriate analysis is carried out).

Note 2. Implications for loss of life:

Unspecified—The appropriate level of safety required at a dam where people are temporarily at risk depends on the number of people, the exposure time, the nature of their activity, and other conditions. A higher class could be appropriate, depending on the requirements. However, the design flood requirement, for example, might not be higher if the temporary population is not likely to be present during the flood season.

The consequences of dam failure (and associated risks) and the classification can change if the dam is being raised, if there are substantial changes to the downstream environment including development, or if there are other regulatory drivers.

Internal dams (dams that are contained within a larger facility and are not on the perimeter of the facility) can also be classified. If the consequences of failure of an internal dam can trigger the failure of a perimeter dam or vice versa (cascading failure scenario), the cascading failure scenario needs to be considered when setting the classification.

3.2 Operations, Maintenance, and Surveillance

Section 3 of *Dam Safety Guidelines* (CDA, 2013) provides guidance on the key elements related to operations, maintenance, and surveillance (OMS) including the development of an OMS Manual. The Mining Association of Canada has developed recommendations for developing OMS Manuals (MAC 2004).

Operation and maintenance procedures and the appropriate levels of monitoring that are necessary, can change during different phases of the dam or as the dam evolves during a particular phase. Because of these changes, the OMS Manual must be considered a "living" document and it should be revised or updated as required. In some cases, a review of the OMS manual should be done as part of the dam safety inspections and as part of the Dam Safety Reviews.

Section 3.6.2 of *Dam Safety Guidelines* (CDA, 2013) includes suggested frequencies for visual inspections that include routine inspections done by the owner (weekly or monthly frequency), engineering inspections done by a qualified professional engineer (annual or semi-annual), and special inspections after unusual or extreme events. For dams in the Low consequence category, the inspection frequency can be extended to once every two years, depending on the overall risk that the dam poses. For dams in the Significant classification, the frequency could be from annually to every other two years, depending on the risk. For dams in the High to Extreme consequence category, the inspections should be semi-annually to annually depending on the risk.

3.3 Emergency Preparedness and Response

Section 4 of *Dam Safety Guidelines* (CDA, 2013) outlines key elements of emergency preparedness and response plans, which also apply to mining dams. More extensive guidance on Crisis Management and Business Recovery has been published by the Mining Association of Canada (MAC 2013).

Release of water that has been affected by mining operations can cause more damage than release of a similar amount of fresh water. In some cases, the water supply downstream can be adversely affected. These factors have to be considered in the emergency planning and development of measures to minimize the impacts resulting from a dam failure. A risk assessment of various scenarios is useful to guide the development of appropriate response and mitigative measures.

The following planning considerations are provided as examples that apply specifically to mining dams:

- In addition to general access to the site (e.g. primary and secondary routes) to repair or contain damage, it may be necessary to access a specific area or segment of the dam. If access is not readily available for a potential failure scenario, then a decision should be made by the owner as to whether such access should be developed ahead of time or a plan developed to ensure that such access could be established in a timely manner.
- Regulatory approvals (requirements and procedures) may be required before implementing certain mitigative measures such as construction of a berm in natural water courses to contain tailings or other solids.
- There may be a need to provide an alternate water supply for the potentially impacted downstream population.

3.4 Dam Safety Reviews

Dam Safety Reviews should be undertaken for mining dams in the Operation and Transition Phases, consistent with Section 5 of the *Dam Safety Guidelines* (CDA 2013). It is noted that the CDA is currently developing additional guidance on Dam Safety Reviews.

The suggested frequency of Reviews ranges from 5 to 10 years, depending on the consequences of failure and changes in the dam or surroundings; any regulatory requirements would always need to be met as a minimum, but more frequent Reviews may be warranted for some mining dams depending on their risks. Low consequence dams may not need Dam Safety Reviews, but the consequences of failure should be reviewed periodically for confirmation. Dam Safety Reviews should also be undertaken when there is a substantive change in the operation of a mining dam, if significant changes occur downstream, or if applicable regulations change.

On many mine sites, there may be several dams with different dam classifications that could have varying frequencies for Dam Safety Reviews. Because of the dynamic nature of mining developments, the Review could be undertaken for all of the structures on the site in accordance with the most stringent frequency derived from the dam classifications.

Dam Safety Guidelines (CDA, 2013) state that it is the "owner's responsibility to ensure that the findings of the review engineer will not be influenced by his or her prior participation in the design, construction, operation, maintenance or inspection of the dam under review," and also that "it is advisable that the same review engineer not carry out two consecutive safety reviews of the same dam."

While recognizing this principle of independent reviews, there may be cases when there is an advantage to having the EOR significantly involved in a Dam Safety Review. Mining dams can often evolve over time with a long and complex design, construction and operational history. There can be frequent changes among the mining company personnel who are responsible for the safety of the dams and the EOR provides continuity between personnel. In addition, ownership changes can result in changes to staff responsible for dam safety.

Typically, a dam safety specialist who has not been involved in the previous designs will be engaged as the "review engineer" but the EOR should be consulted and input obtained during the Dam Safety Review.

In special cases, the EOR may lead the Dam Safety Review and be considered the "review engineer," with additional external reviewers who participate in an advisory capacity. This approach can satisfy the need for the review findings to be independent of conflict of interest. However, this approach should be limited in application. An example of an appropriate case might be where an owner has never done a Dam Safety Review of a dam and the EOR is the person most familiar with the location and content of key information. In this instance, it may be most effective for the EOR to lead the Review and present the findings to external reviewers. Thus, in the initial Dam Safety Review, the documentation would be gathered and compiled in a form such that subsequent Reviews can be done effectively by a third party.

3.5 Analysis and Assessment

3.5.1 Risk-Informed and Traditional Standards-Based Approaches

Section 6 of *Dam Safety Guidelines* (CDA, 2013) outlines approaches to dam safety analysis and assessment to support decision-making related to dam safety. A risk-informed approach is encouraged because it includes traditional deterministic standards-based analysis among many considerations. Also, as noted above, the consequence classification does not address all of the potential risks presented by a dam. The risk-informed approach is continuing to develop and a standards-based approach may be appropriate for certain elements of dam design and assessment.

CDA 2013 presents a number of considerations for hydrotechnical, seismic, geotechnical, structural (for concrete dams), and mechanical and electrical analysis and assessment. The discussion below addresses hydrotechnical, seismic and geotechnical aspects that apply to mining dams in the Construction, Operation and Transition Phases.

The design of a mining dam must meet the requirements of the project as it is defined at the time of the design. Often, a mine will expand and result in an increase in the mining dam size. The design should take into consideration the possibility of such an increase in size. Also, the design must consider the possibility that there could be a premature suspension of mining activities, due to economic or environmental reasons, where there may not be an opportunity for operator intervention and the usual controls (such as operating water management structures) may not occur.

As noted above, it is important that the design of dams consider the ultimate end point that is expected to be achieved for the dam (including plans for maintenance and inspection and the configuration of the ultimate facility). An assessment should then be done as to whether the dam should be constructed for the Closure – Active and/or Closure - Passive Care Phases prior to cessation of the operation, or if it is more advantageous to modify the dam during the Transition Phase in preparation for the Closure - Active Care and/or Closure - Passive Care Phases.

For tailings facilities, the risk assessment approach should be used when assessing the tailings technologies and closure strategies that are considered for the facility.

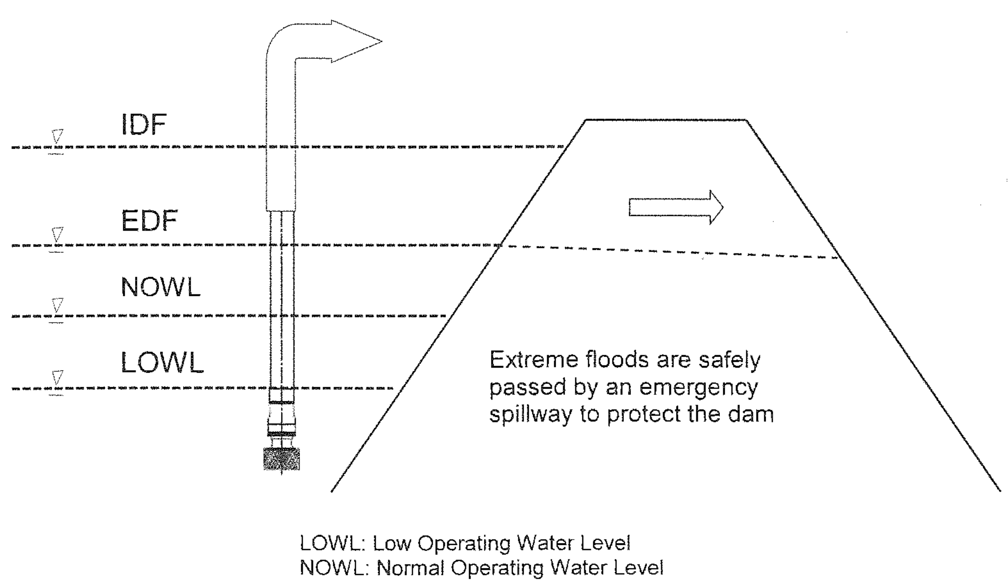
3.5.2 Hydrotechnical

Management of water contained by mining dams has a number of major functions:

(a) Temporary storage of seasonal flows and sufficient water to allow settling of fines
(b) Temporary storage of the Environmental Design Flood (EDF, discussed below)
(c) Storage and/or safe passage of the Inflow Design Flood (IDF) runoff to ensure the integrity of the containment dams.

Figure 3-1 shows a section through a generic mining dam and how the storage and conveyance of runoff is often managed (i.e., a pump system or flow decant to control the water level and an emergency spillway to prevent overtopping of the dam).

Figure 3-1. Typical Appurtenances Required for EDF Storage and IDF Conveyance



The IDF is either stored or conveyed from the pond via a spillway or equivalent overflow structure. Water may be released from the pond via a low flow structure or reclaim pumping system. Even for those dams where the IDF can be temporarily stored, the installation of an emergency spillway should be considered as a precautionary measure.

Runoff that is impounded is typically recycled or treated and released over time following a storm event to draw down the reservoir from a level at or below the Environmental Design Flood High Water Level (EDF level) to the Normal Operating Water Level (NOWL). In many cases, discharge from a pond can be subject to seasonal and environmental constraints, resulting in periods when water is meant to accumulate in the impoundment and these inflows must be managed between the LOWL and

NOWL. The design of the dam must be based on an appropriately detailed water balance, which will change over the life cycle (see Section 2.2).

Factors That Can Affect Water Levels During Operations

Many factors can affect operational pond levels in addition to the factors of EDF and IDF (discussed below). These include: the minimum pond volume required to clarify supernatant that is reclaimed for milling; the need for a reserve volume to guard against a mill water supply interruption during the winter or dry periods; the minimum pond depth required to operate reclaim facilities; the minimum pond size to effectively control beach length when tailings dam fill is hydraulically placed; and the pond size necessary to control beach length to control dusting.

The central element of a good water management plan is a water balance. This is an important tool in the design of a mining dam. Some of the items that a water balance needs to consider with respect to dam safety are the following:

- The quality of input data particularly related to pre-mining conditions. In many mining areas, there is not good quality climate or hydrologic data.
- In addition to the use of "average" conditions, it is necessary to account for extreme wet/drought periods of extended duration.
- The dam raising schedule.
- Consequences of inadequate water treatment capacity possibly due to mechanical problems or scaling in pipelines.
- Extent of submergence of beaches for upstream constructed tailings dams and the consequent seepage.
- Effect of blockage of spillways or discharge facilities.
- If an impermeable liner is used in the pond, then there may be a lower limit for the water level to prevent ice damage to the liner and/or dessication of the liner (such as a clay liner or geosynthetic clay liner).

Environmental Design Flood (EDF)

The Environmental Design Flood (EDF) is the most severe flood that is to be managed without release of untreated water to the environment. An EDF is necessary in situations where contaminated water must be retained either with no discharge to the environment or with controlled discharge through a treatment system prior to discharge to the environment. Retention of water during the EDF requires storage capacity above the NOWL.

The selection of return period and duration of the EDF must take into account factors such as the water quality that is being stored and could be released, regulatory requirements, frequency of overflow events, the rate and duration of overflows, the environmental sensitivity of the receiving environment, downstream flow in the receiver, downstream mixing characteristics, and public perception on the matter. The selection of an appropriate EDF is therefore site specific and should be derived through:

1) Consultation with regulatory agencies.
2) Consideration of environmental effects associated with the frequency, magnitude and duration of an infrequent release.
3) Consideration of dilution that may be available from flood flows in the receiving water.
4) Consideration of the time needed to draw down the EDF volume from the storage area.
5) Consideration of the costs associated with varying degrees of environmental control.

Typical EDF return periods range from 1 in 50 years to 1 in 200 years, but more stringent criteria may be required depending on the site conditions. The appropriate EDF duration is site specific and typically ranges from weeks to months depending on the assimilative capacity of the receiving stream and the capacity of the water treatment system to process the stored volume.

Inflow Design Flood (IDF)

As noted in *Dam Safety Guidelines* (CDA 2013), the IDF is the most severe inflow flood (peak, volume, shape, duration, timing) for which a dam and its associated facilities are designed. Table 3-2 below presents suggestions on target levels for the inflow design flood as excerpted from CDA (2013). These are considered applicable for the Construction, Operation, and Transition Phases.

As noted in Section 3.1, the dam classification and the associated target levels shown in Table 3-2 should be considered when developing the design criteria. In addition, the mining dam owner will want to factor in other risks and may choose to adopt more stringent design criteria than suggested by the classification alone.

Table 3-2. Target Levels for Flood Hazards, Standards-Based Assessments, for Construction, Operation, and Transition Phases

(For Initial Consideration and Consultation Between Owner and Regulator)

Dam Classification	Annual Exceedance Probability – Floods (note 1)
Low	1/100
Significant	Between 1/100 and 1/1,000 (note 2)
High	1/3 Between 1/1,000 and PMF (note 3)
Very High	2/3 Between 1/1,000 and PMF (note 3)
Extreme	PMF (note 3)

Notes:

Acronyms: PMF, Probable Maximum Flood; AEP, annual exceedance probability

1. Simple extrapolation of flood statistics beyond 10^{-3} AEP is not acceptable.
2. Selected on basis of incremental flood analysis, exposure, and consequences of failure.
3. PMF has no associated AEP.

Freeboard

Freeboard guidelines as outlined in the *Dam Safety Guidelines* (CDA, 2013) apply to most mining dams. However, the following should be considered for mining dams:

- The suggested minimum freeboards in the *Dam Safety Guidelines* (CDA, 2013) were developed to account for the typical nature of a pond on a river system where the high water level generated during a flood event may not occur at the same time as a high wind event that occurred during the storm that resulted in the flood. For mining dams that contain ponds, there can be a condition where the high water level does occur at a similar time as the storm event and high wind event and this condition should be examined when developing the return period for the design wind for the minimum freeboard calculation.
- The fetch of the pond contained by a mining dam can often be less than a conventional dam and the water depth can be shallow as a result of tailings or sludge deposition.
- As discussed below in Section 3.5.4.2, the freeboard guidelines can be superseded by minimum beach length guidelines for upstream and centerline tailings dams, if these other guidelines are more conservative.

3.5.3 Seismic Criteria

Table 6-1 of the *Dam Safety Guidelines* (CDA, 2013) provides suggestions on the target levels for earthquakes. As discussed above with respect to the IDF, these target levels may generally be applied for the Construction, Operation, and Transition Phases of a mining dam. Table 3-3 below shows these target levels.

Similar to the discussion for the IDF and the owner's risks, the owner may adopt criteria more stringent than these target levels suggested by the classification alone or those required by the regulator.

The current state of practice with respect to seismic effects on dams comes largely from the conventional dam industry where deformations of the crest could result in potential for overtopping. For many mining dams, the crest deformations could be much larger and not result in a release of contents. Hence, criteria should be established for suitable deformations of a mining dam and the appropriate analyses undertaken to demonstrate the effect of an earthquake on the dam and determine if the deformation criteria is met.

With respect to tailings stacks that do not have water ponded at the crest, but contain potentially liquefiable sediment, the liquefaction potential should be reviewed as part of each Dam Safety Review to determine if there have been changes in the seismic criteria or the conditions of the dam that may affect the liquefaction potential (i.e. lowering of the phreatic surface).

Table 3-3. Target Levels for Earthquake Hazards, Standards-Based Assessments, for Construction, Operation, and Transition Phases
(For Initial Consideration and Consultation Between Owner and Regulator)

Dam Classification	Annual Exceedance Probability – Earthquakes (note 1)
Low	1/100 AEP
Significant	Between 1/100 and 1/1,000
High	1/2,475 (note 2)
Very High	1/2 Between 1/2,475 (note 2) and 1/10,000 or MCE (note 3)
Extreme	1/10,000 or MCE (note 3)

Notes:

Acronyms: MCE, Maximum Credible Earthquake; AEP, annual exceedance probability

1. Mean values of the estimated range in AEP levels for earthquakes should be used. The earthquake(s) with the AEP as defined above is(are) then input as the contributory earthquake(s) to develop the Earthquake Design Ground Motion (EDGM) parameters as described in Section 6.5 of the *Dam Safety Guidelines* (CDA 2013).
2. This level has been selected for consistency with seismic design levels given in the National Building Code of Canada.
3. MCE has no associated AEP.

3.5.4 Geotechnical

3.5.4.1 Criteria

Tables 3-4 and 3-5 show the target levels related to slope stability. These are based on the values provided in Tables 6-2 and 6-3 of *Dam Safety Guidelines* (CDA 2013). However, the *Dam Safety Guidelines* call for a factor of safety of 1.3 for the condition: "End of Construction Before Reservoir Filling." For tailings dams that are constructed over time and the reservoir is filled and operated as the dams are constructed, this factor of safety may not apply. On the other hand, a factor of safety of 1.5 was intended for the loading condition where the seepage was at steady state and the reservoir was at the NOWL. Steady state seepage may not be achieved in a tailings dam until near the completion of the dam raises and, if the pond geometry is adjusted after the dam reaches its final elevation, the seepage pattern may change again and reduce from when the dam was being raised.

Hence, the designer needs to consider the consequences of failure, the loading conditions, and the strength parameters when establishing factors of safety that are appropriate for the mining dam in question. A factor of safety of 1.3 may be acceptable during construction of a dam where the consequences could be minor and measures are taken during construction to manage the risk such as detailed inspection, instrumentation, etc. But, the factor of safety of 1.3 should not simply be adopted because it is "End of construction."

Therefore, when setting the design criteria for the dam, these target levels can be considered, but the risks associated with instability of the dam also need to be considered.

Table 3-4. Target Factors of Safety for Slope Stability in Construction, Operation, and Transition Phases - Static Assessment

Loading Condition	Minimum Factor of Safety	Slope
During or at end of construction	> 1.3 depending on risk assessment during construction	Typically downstream
Long term (steady state seepage, normal reservoir level)	1.5	Downstream
Full or partial rapid drawdown	1.2 to 1.3	Upstream slope where applicable

Table 3-5. Target Factors of Safety for Slope Stability in Construction, Operation, and Transition Phases - Seismic Assessment

Loading Condition	Minimum Factor of Safety
Pseudo-static	1.0
Post-earthquake	1.2

3.5.4.2 Upstream Constructed Tailings Dams

Tailings dams that are raised in the upstream direction typically rely on a tailings beach upstream of the dam crest to control the phreatic surface within the dam. This can also be applicable to centerline and modified centerline dams that require upstream beaches for stability. The minimum beach width is established by considering: the margin of dam stability (including under seismic conditions), angle of the beach slope, gradation of the tailings and expected infiltration response, performance of drains that may be incorporated within the dam, and the resulting rise in the phreatic surface within the dam due to pond level fluctuations.

A key design issue is the rate of raising of the dam fill (perimeter and internally) as this can result in static liquefaction of the tailings and failure of the perimeter dam. The maximum allowable rate is dependent on a number of factors (permeability, gradation, density, location of the phreatic surface, etc.) and is unique for each structure.

It is recommended that upstream constructed tailings dams not be built in high seismic areas.

3.5.4.3 Potential For Flow of Solids From an Impoundment

As noted in Section 2.1 and 2.2.5, the potential for flow of the impoundment contents beyond the perimeter containment is a determining factor on whether the containment needs to be considered as a dam. An evaluation of the flow potential should consider the following:

- Degree of saturation
- Contractive vs. dilatant behaviour of tailings
- Compaction and other densification methods
- Removal of ponded surface water, drawdown, and desaturation
- Comparison of flow slides between active and inactive tailings dam failures
- Saturation-induced collapse behaviour of dry-stack materials.

Methods may be undertaken to stabilize the impoundment contents and reduce the flow potential.

3.5.4.4 Other Considerations

Some other unique aspects of mining dams with respect to geotechnical design are listed below.

- The design, construction, and operation of tailings dams often use the observational method due to the long construction period and opportunities to review actual conditions.
- Loading on a dam shell from an upstream tailings beach needs to be accounted for in stability assessments.
- Liquefaction of tailings upstream of the dam needs to be considered in stability assessments.
- Mine waste is often used in the structural portion of a mining dam and this requires special care with respect to the design of filters and transition zones to protect the seepage control elements of the dam.
- Geochemical processes (often acid rock drainage or metal leaching) can clog filters and drains through precipitate accumulation. While this can also occur with conventional dams, it is more prevalent in mining dams that contain materials with acid rock drainage generation potential. The rate of clogging and the time that the drains are required to operate may greatly exceed those typical of conventional water storage dams. Cementing of soil into a "hard pan" can affect the seepage conditions in a dam.
- Decant structures and/or pipes embedded in embankments in general are potential pathways for seepage. The deterioration of pipes through dams is a well known cause of several mining dam failures. Development of preferential seepage paths and arching zone(s) are also notable safety hazards. For decant pipes with intermittent discharge, frost action can also create seepage pathways around the pipes. Hence, these structures need to either be avoided or designed and constructed with a high level of care, including redundant protective measures.
- Mining dams are often located near other infrastructure such as open pits and underground workings. The consequences of failure of such mining dams require careful consideration. Also, the potential interaction of the mining operations (i.e. blasting or large waste rock dumps) on the mining dams must be assessed.
- Subsidence of ground beneath a mining dam can occur due to underground workings that may not have been detected prior to the design and construction of the dam.

- Piping can occur into underground workings with caving occurring upward into the tailings.
- Design for thickened tailings discharge facilities.
- Geosynthetics are often considered for mining dams because of limited construction materials, but these must be used judiciously when considering structures that will have to last a long time.
- Design should be flexible to accommodate variability and availability of construction materials throughout the life of a tailings dam.
- Instrumentation monitoring, recording between raises, damage to instrumentation during construction or mine operations.
- The use of impervious membranes for lined ponds that also require measures to prevent wildlife from getting trapped in the ponds and causing damage to the liners.
- Vandalism, particularly recreational vehicles that can cause damage to closed site dams.

4.0 Active and Passive Care Phases

4.1 Dam Safety Management

For those mining dams that cannot be decommissioned and have to be maintained as functional dams for a very long time, *Dam Safety Guidelines* (CDA, 2013) does not provide specific guidance. This section provides such guidance for the Closure – Active and Closure – Passive Care Phases.

The dam classification scheme described above in Section 3.1 applies to mining dams in the Closure – Active and Closure – Passive Care Phases. However, the designer should consider measures to reduce the consequences of dam failure and thus the dam classification, such as the following:

- Remove the water level in the impoundment. (A discussion on covers is provided in Section 5.)
- Improve the strength of liquefiable materials contained by the dam to reduce potential for and extent of a flow failure, and ultimately change the structure from a dam to, effectively, a waste dump.
- Lower the height of the area contained by the mining dam by reshaping the surface and the perimeter dam slopes to reduce the consequences of failure. Settlement of the contents would need to be considered in this design.
- Consider effects of changes to the quality of water contained by the dam and the chemical and physical properties of the solids.

On the other hand, changes or potential changes in the downstream environment (i.e. development, ecosystem establishment) could cause an increase in the consequences of failure. The designer should consider the potential for these changes in the long term.

Section 3.1 provided information on the Engineer of Record (EOR) and records management. Because of the extended time frame of closure, these items are very important and systems need to be put in place to ensure that these items are adequately addressed.

4.2 Operations, Maintenance, and Surveillance

Prior to entering the Closure – Active Care Phase, the OMS Manual should be updated to reflect the conditions in this phase. The OMS Manual should include the maintenance and surveillance requirements. These would reflect the consequence classification of the dam and the associated risks.

To support modifications to the inspection frequency, a risk assessment should be undertaken that would consider the performance of the dams during the Operation and Transition Phases. It is likely that the guidance provided in Section 3.2 can be reduced.

Prior to entering the Closure – Passive Care Phase, the OMS Manual should be updated as well. The following items would be considered:

- Routine inspections may not normally be done as the site will typically not be staffed. If an owner wishes to utilize routine inspections to help manage the risks and reduce costs associated with capital improvements, then that could be an acceptable approach.
- Instrumentation monitoring may not be conducted due to site access or resource limitations. Remote observation systems could be considered.
- Engineering inspections may not have to be the same as for the Transition Phase and Closure - Active Care Phase.

Special inspections may be required after extreme events and the OMS Manual should prescribe the conditions under which this inspection should be done.

A key objective of the design and closure measures that are implemented for the Closure – Passive Care Phase is to reduce the effort associated with the operations, maintenance, and surveillance activities to as low as reasonably practical.

4.3 Emergency Preparedness and Response

For sites that require on-going water management and water treatment, site personnel are typically present during the Closure – Active Care Phase. Other sites may only have intermittent surveillance during this phase. The ability to respond to emergencies effectively during this phase needs to be evaluated as part of the closure planning process.

For sites in the Closure – Passive Care Phase, there are typically no staff on site and there is no ability to respond in a short time frame to problems with the dams or emergencies. The Emergency Preparedness and Response Manual for the Closure – Passive Care Phase still should develop an approach for dealing with possible emergencies related to dam stability issues.

4.4 Dam Safety Reviews

The Dam Safety Review process is an important means of managing risk associated with dams in the Closure – Active and Closure - Passive Care Phases. By undertaking a Dam Safety Review at regular intervals, the owner ensures that changes to the dam and surrounding environment are considered, their effects on the safety of the dam defined, and the potential consequences of failure re-evaluated.

The surveillance and inspection frequency should be re-assessed and the OMS Manual reviewed with consideration to these evolving changes. This is also an effective means of managing risks associated with climate change as it is not possible to make accurate predictions of climate change in the long term. The Dam Safety Review should identify the need for updates to the OMS Manual to reflect the changing environment, if appropriate.

The dam classification and risk profile of the dam (including the additional risks that are not captured in the dam classification scheme) should be revisited as part of the Dam Safety Review process to reflect changes in the downstream environment and land use. The design criteria should be reviewed in the context of the classification as well as the state of practice at the time of the Dam Safety Review. As part of the Dam Safety review the design life and design interval for the structure should be considered.

If modifications to the design are required as a result of the Dam Safety Review, the dam would return to the Transition Phase and then move through to the Closure – Active Care and possibly the Closure - Passive Care Phase.

The frequency of future Dam Safety Reviews should be developed as part of the OMS Manual that is prepared prior to entering the Closure – Active or the Closure – Passive Care Phases. This frequency should then be reviewed during each Dam Safety Review and the dam specific frequency established with the associated conditions. Risk assessment methods can be used to assist with the Dam Safety Reviews and prescribing frequency of future dam safety inspections (DSIs) and Dam Safety Reviews.

4.5 Analysis and Assessment

Section 3.0 presented the concept of the design interval. For the Closure – Active Care Phase, the design interval could last for decades or hundreds of years, but as noted above, if the dams are being monitored on a regular basis, there are ongoing DSIs, and there is an ability to effectively respond to warning signs and emergencies, then the target levels and approaches described in Section 3.5 would apply. For Closure - Passive Care Phase, the design interval could extend for hundreds of years and there may not be regular monitoring or an opportunity to effectively respond to warning signs and emergencies. There is an intermediate condition in the Closure – Active Care Phase where the surveillance is intermittent and the ability to respond to emergencies might be limited. This will have a bearing on setting the design criteria and surveillance program and the guidance in Section 3.5 may not strictly apply.

The extended design interval needs to be considered when developing the criteria for dam safety. A longer design interval (or exposure period) increases the likelihood of an event occurring. Since design criteria are established to reduce the probability of failure, the design criteria for the Closure – Passive Phase may need to be more stringent to account for the longer design interval and the limited monitoring and opportunity to respond to warning signs and emergencies. For failure modes that have a probability of failure associated with them, a design interval (or exposure period) of perpetuity would result in a probability of unity.

Assuming that the other variables will not change over the life of a structure, then the design criteria for flooding and seismic events can be made more stringent. The resulting suggested target levels for the flood and earthquake hazards are shown in Tables 4-1 and 4-2. It is noted that the ranges shown for the Significant and High consequence dams illustrate that the criteria should be commensurate with the range of potential consequences for the particular dam. A risk assessment may be necessary to justify the selection of criteria.

Table 4-1. Target Levels for Flood Hazards, Standards-Based Assessments, Closure – Passive Care Phase

(Initial Consideration and Consultation Between Owner and Regulator)

Dam Classification	**Annual Exceedance Probability – Floods** (note 1)
Low	1/1,000
Significant	1/3 Between 1/1,000 and PMF (note 2)
High	2/3 Between 1/1,000 and PMF (note 2)
Very High	PMF (note 2)
Extreme	PMF (note 2)

Notes:

Acronyms: PMF, Probable Maximum Flood; AEP, annual exceedance probability

1. Simple extrapolation of flood statistics beyond 10^{-3} AEP is not acceptable.
2. PMF has no associated AEP.

Table 4-2. Target Levels for Earthquake Hazards, Standards-Based Assessments for Closure – Passive Care Phase

(Initial Consideration and Consultation Between Owner and Regulator)

Dam Classification	**Annual Exceedance Probability – Earthquakes** (note 1)
Low	1/1,000
Significant	1/2,475 (note 2)
High	1/2 Between 1/2,475 (note 2)and 1/10,000 AEP or MCE (note 3)
Very High	1/10,000 AEP or MCE (note 3)
Extreme	1/10,000 AEP or MCE (note 3)

Acronyms: MCE, Maximum Credible Earthquake; AEP, annual exceedance probability

Notes:

1. Mean values of the estimated range in AEP levels for earthquakes should be used. The earthquake(s) with the AEP as defined above is (are) then input as the contributory earthquake(s) to develop Earthquake Design Ground Motion (EDGM) parameters as described in Section 6.5 of *Dam Safety Guidelines* (CDA 2013).
2. This level has been selected for consistency with seismic design levels given in the National Building Code of Canada.
3. MCE has no associated AEP.

It is important to note that the designer (EOR) and owner can increase beyond these target levels when setting the criteria if they wish to further reduce the risk. The designer can also go lower if they have done a comprehensive risk assessment to support such a decision and the regulator concurs with the assessment.

Tables 4-1 and 4-2 could also be applicable for dams that are expected to remain in the Closure – Active Care Phase for an extended period (many decades or centuries) if the owner is conducting infrequent surveillance or would not have sufficient resources to respond to warning signs or emergencies.

Risk assessment methods can be used to provide informed guidance on criteria development. Items such as erosion of the downstream and upstream slopes; spillway sizing not only to pass the IDF but to handle blockage due to fallen trees, ice, and beaver activity; access, etc. need to be considered with respect to the Closure – Passive Care Phase when personnel are not on site on a regular basis and there is reduced surveillance and inspection.

With respect to hydrotechnical matters, the guidance provided in Section 3.5 is considered acceptable for Closure – Passive Care Phase as well, again assuming that other variables will not change over the life of the structure. An item that warrants attention is diversion ditches that are used to divert fresh water away from an impoundment to limit treatment requirements. For closure, it is typical to assume that these diversion ditches are not functioning during the IDF.

With respect to factor of safety, the guidance provided in Section 3.5 is considered acceptable for Closure – Passive Care Phase as well, again assuming that other variables will not change over the life of the structure.

Erosion protection on side slopes of the dams is an important consideration for closure, especially for the Closure – Passive Care Phase, where significant erosion gullies could form without being detected. This is not erosion related to overtopping of the dam, this is erosion occurring on the downstream slope of an earthen dam as a result of runoff flowing down the slope from the local catchment of the slope. A design precipitation event must be established to support the design of the erosion protection system on the slopes (from vegetation to rockfill). The design precipitation event for this can range from the 1 in 200 year event to the PMP depending on the consequences of the erosion feature. Also, the effect of animal burrows should be considered.

Geosynthetics are often considered as design elements for the dams at closure and the use of these materials needs to be carefully evaluated for dams that are being prepared for the Closure – Passive Care Phase.

In addition to the extended design interval, additional factors should be considered when developing design criteria for the Closure – Passive Care Phase, such as the following:

- The inherent limitations associated with estimating changes over extended time periods based on 20 to 50 years of data.
- The effect of climate change on extreme events.
- The effect of changes in the condition of the facility (i.e. vandalism, reduced maintenance, natural hazards such as fire and drought).
- The effect of potential changes in ownership of the facility or personnel and the degree of vigilance/inspection of the structure.
- The effect of changes in water table and water chemistry of the impounded fluid or materials that could alter the seepage conditions within the dam and foundation.
- The potential for future settlement and land developments in the area.
- Changes to filters over time that could reduce their effectiveness in the long term. In some jurisdictions, the designs have to demonstrate that the dam is stable assuming that filter is fully clogged, regardless of the mechanism that could result in such clogging.

The design criteria for the Closure – Passive Care Phase may, in fact, be the primary criteria that are adopted for design during the Operation, Transition, or the Closure – Active Care Phases.

Studies can be done to determine which phase is the optimal phase for implementing the designs required to meet the Closure – Passive Care Phase.

This sub-section focused on design criteria which are intended to address the probability part of the risk equation. Section 4.1 discussed means of reducing the classification (the consequence part of the risk equation). Tradeoff studies can be undertaken when designing for closure to determine the optimal combination.

5.0 Considerations for Covers

For closure, the impoundment contents are typically covered either with a dry cover or a wet cover. A dry cover can range from a simple soil cover that supports vegetation to a complex dry cover with multiple layers that are designed to impede infiltration of surface water and/or oxygen. The containment dams around the impoundment are still expected to provide containment in perpetuity, unless it can be demonstrated that the contents will not flow if the dam breaches and the perimeter containment no longer needs to be considered as a dam.

When dealing with acid rock drainage (ARD) and metal leaching (ML), many mines have opted to construct "wet covers" that create a pond over the ARD/ML material (typically tailings, but also other process residues, etc.) that is contained by low permeability dams. In some cases, the dam and facility is constructed to support an elevated water table (EWT) that can maintain acid generating materials in a saturated state while not resulting in a free water pond. Such structures are often also expected to exist in perpetuity, providing a wet cover over ARD/ML tailings forever. These strategies have proven to be effective in controlling ARD/ML.

When comparing dry covers to wet covers, it is important to conduct a careful evaluation of both options as they have direct ramifications on the design of the containment dams. The following lists some of items that should be considered in this evaluation:

- The consequences of failure of a wet cover system can be more severe than for a dam containing a dry cover system. Not only will a dam break include the water forming the wet cover, but the tailings that are contained will be more mobile because they are saturated.
- The OMS requirements will be greater for a dam supporting a wet cover than a dry cover.
- A wet cover is more susceptible to variations in climate change.
- It is less likely that the dam could reach the Closure – Passive Care Phase and the dam may be in the Closure – Active Care Phase for perpetuity.
- The potential for creating a landform that is effectively a "walk away" closure solution is very difficult with a wet cover, more so than a dry cover.
- The regional ground water system could be affected as a result of long term seepage from the wet cover and through the tailings.
- Long term geochemical reactions and their effect on the elements within the dam will be more prevalent for a wet cover system than a dry cover system, particularly filters.

The challenges associated with water covers are described in a State of the Art Report on Water Cover Closure Design for Tailings Dams Bjelkevik (2005).

A tradeoff study should be undertaken to fully compare all that is required to maintain a wet cover and the associated dam safety obligations (as outlined in this Bulletin and other guidance) against other options that do not call for a wet cover. The study should look at other options as well such as storage in mine workings.

6.0 Future Ownership, Liability and Custodial Transfer

It is recognized that for mining dams in the Closure – Active Care Phase or Closure – Passive Care Phase, the ownership and liability associated with the dams may not be clear as time passes.

For a mining dam on a property owned by a mining company, the ownership and liability will transfer with the property ownership, but it is recognized that provincial or territorial governments may ultimately become liable for these dams as some mining corporations cease to exist. This is addressed in part by financial assurance packages that a mining company must put in place either prior to or during their operation. This is an important issue that is beyond the scope of this Bulletin but needs to be recognized in the design of the mining dam and in establishing criteria that are suitable to stakeholders including future owners, landowners, and the provincial/territorial governments.

When a mining dam is located on land owned by the provincial or federal government (the Crown), under a mining lease (or through surface rights or patents), then ultimately, when the lease expires, the Crown will become the owner of the mining dam through the process of Custodial Transfer in accordance with the lease terms. Financial assurance packages are still required and the design also has to consider this end point.

In Alberta, there is a formal process for transferring disturbed lands back to the Crown (Richens and Purdy, 2011). The Institutional Control Program (ICP) in Saskatchewan, is outlined as follows (Saskatchewan 2009):

> "The ICP consists of those actions, mechanisms and arrangements implemented in order to maintain control or knowledge of a remediated site after project closure and custodial transfer to some form of responsible authority. This control may be active (e.g. by means of monitoring, surveillance, remedial work, fences, etc.) or passive (e.g. land use restrictions, markers, records, etc.). Activities undertaken by the post-transfer custodian (i.e. the province is the responsible authority) could range from the simple act of permanently recording the location of a remediated site all the way to conducting regular inspections that may or may not include active measurements and the collection of samples for analysis and potentially the eventual maintenance of certain aspects of the property."

The Native Orphaned and Abandoned Mines Initiatives (NOAMI) produced the "Policy Framework in Canada for Mine Closure and Management of Long Term Liabilities" (Cowan Minerals Ltd., 2010). In assessing the role of perpetual care, long-term monitoring and maintenance, the report stated the following with respect to mining dams:

> "We know that there are elements of sites closed out under acceptable technical standards and guidelines that now require long-term monitoring and maintenance in order to ensure the safeguards remain intact and are performing as intended in the closure process. These safeguards can range significantly depending on the complexity of the original mining operations."

That document provides further guidance on issues to consider for custodial transfer, including the following Policy Guidance:

- "Ensure all closed out site features that may present a future hazard and cost are identified in all the closure plan process.
- Develop a site land return process that focuses on these features/hazards to provide a degree of certainty of impacts, potential for occurrence, level of risk acceptance and method of costing. This should include worst case scenarios to assist in emergency response planning and costing.
- Establish or identify a jurisdictional body that coordinates agency/stakeholder inputs and has authority to negotiate final assurance requirements and develop appropriate inspection programs.
- Establish a recognized authority for receipt of assurance and tracking and consistent application of funds for monitoring, maintenance and emergency requirements. This should include funds dedicated to site specific features as well as funds established for unforeseen incidents.
- Ensure funds are held in dedicated accounts with appropriate investment growth potential.
- Establish a secure archiving/filing system to store mine site data for ready access.
- Ensure all land use restrictions are applied, recorded, enforced and appropriately identified in all land use planning systems such as GIS."

Morgenstern (2012) stated that these approaches are "untested on the complex issues associated with reclamation of lands disturbed by oil sands mining." This would also be true for non-oil sands mining. Morgenstern further states that "Strategies based on perpetual care are attractive... and should be assessed." The guidance provided in this Bulletin with respect to Closure – Active Care and Closure – Passive Care fits with this approach.

7.0 References

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APPENDIX A.
COMPARISON TO MAC AND ICOLD GUIDELINES

MAC and ICOLD provide guidance with respect to the phases of a mining dam. This sub-section compares the framework discussed in this Bulletin with the guidance from MAC and ICOLD with a focus on closure.

Figure A.1 shows the "stages in the life cycle of a tailings facility" from MAC (1998). The stages are site selection and design, construction, operation, and decommissioning and closure. As noted above, we have adopted the term "phases of life" instead of "life cycle". MAC does not provide detailed guidance on "decommissioning and closure" and this Bulletin addresses this.

Figure A.1. Stages in the Life Cycle of Tailings Facility (from MAC 1998)

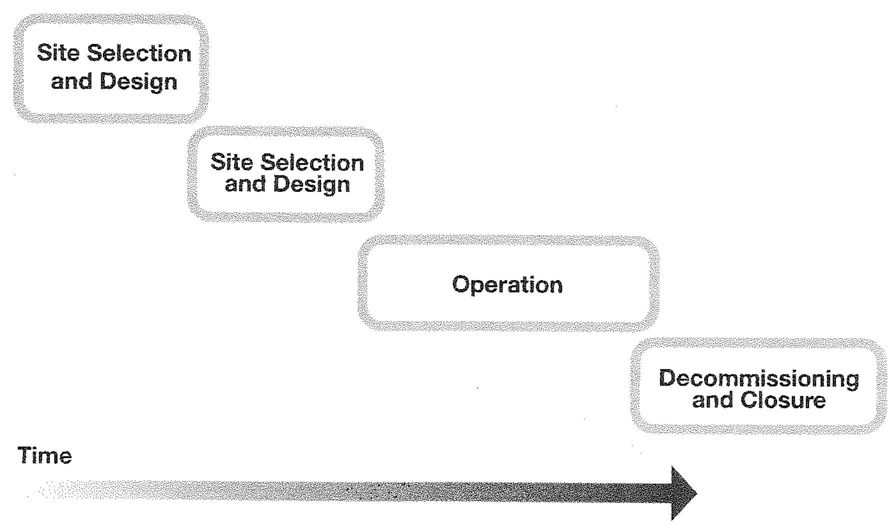


Figure A.2 shows the "phases of tailings management" from ICOLD (2011) which begins with planning and ends with long term care.

Figure A.2. Phases of Tailings Management (from ICOLD 2011)

Time	Phase	Detailed Phase
↓	Planning	Environmental Assessment Preliminary Design Hazard Rating
	Design	Applying and Receiving Permits Detail Design
	Construction	Initial Construction
	Operation	Operation & ongoing Construction
	Closure	Decommissioning Remediation After Care
	Long term	

ICOLD (2011) provides the following definitions associated with the terms provided in Figure A.2:

> **Closure** is the shutting down and decommissioning of a mine and tailings dams when production has ceased including the transition of the mining area and dam into long-term stable structures. Normally, closure includes decommissioning, remediation (reclamation or rehabilitation) and after care at the site and the tailings dam.
>
> **Decommissioning** is the closing down of operations and removal of unwanted structures.
>
> **Remediation** refers to measures required to secure the long-term stability and to ensure environmental safety of structures such as tailings dams and disturbed ground. It often includes measures to encapsulate tailings in order to restrict the potential for toxic materials entering the wider environment.
>
> **After Care** is the last phase of closure that is required to verify that the measures taken are performing according to the design and expectations. When verified, the **Long Term Monitoring phase** starts.
>
> **Long term monitoring** is the period of time for which closure is designed and commences after completion of the after care phase.

When developing the framework described in Section 2.2 in this Bulletin, we considered these definitions and addressed them as follows:

- The term "Closure" as defined by ICOLD was modified as per the definition in Section 2.2.4 as the ICOLD definition was focused on tailings dams and this Bulletin extends to other mining dams.

- The term "Decommissioning" was extended to include the removal of a dam (breach, partial removal, or full removal).
- "Remediation" is part of the Operation and Transition Phases described in Section 2.2.
- "After Care" is part of the Active Care Phase described in Section 2.2.
- "Long Term Monitoring" is part of the Passive Care Phase described in Section 2.2.

ICOLD (2013) provided further clarification to the terminology to be used for closure. In that Bulletin, **Closure** is defined as the planned cessation of tailings disposal into the tailings dam and the modification/engineering of the tailings dam with the objective of achieving long term physical, chemical, ecological, and social stability and a sustainable, environmentally appropriate after use.

ICOLD (2013) also states that **Post closure** is the period following cessation of operation of the tailings into its final form. The post closure period is generally divided into active and passive care periods. **Active care** is the period when intervention and monitoring is required to achieve a final sustainable form concurrently with stabilization of the structures and environmental elements. **Passive care** is the period following active care during which the performance of the tailings dam is monitored to ensure its compliance with the closure objectives. This period has no time limit, but can be defined as being necessary until the tailings dam, in the opinion of the regulatory authorities, is considered to be physically , chemically, ecologically, and socially stable and no longer poses a risk to life or the environment. This is an important point that is described below in the sub-section entitled Landforms.

When developing the phases described in this Bulletin, we considered the ICOLD (2013) definitions and addressed them as follows:

- The term "Closure" was focused on tailings dams and we modified it to include other mining dams, but retained the sustainability concept put forward by ICOLD (2013).
- The term "Post Closure" was not used as we adopted the term "Closure" to address the "Active and Passive Care". The term "Post Closure" may be best used for the time when the dam could be considered a landform.
- The concept of "Active Care" was retained, but we established a Transition Phase between "Operations" and Active Care Phase.
- The concept of "Passive Care" was retained.

It is interesting to note that ICOLD (2013) allows for the possibility of a dam becoming a landform through their statement "no longer poses a risk to life or the environment." This would be similar to the landform concept discussed in Section 2.4.

Figure A.3 provides a comparison between the guidance provided in this Bulletin, MAC and ICOLD (2011, 2013).

Figure A.3. Comparison of Life Phases – CDA, MAC, ICOLD

<table>
<tr><th></th><th colspan="2">CDA Mining Dams Bulletin</th><th>MAC (1998)</th><th colspan="2">ICOLD (2011)</th><th colspan="2">ICOLD (2013)</th></tr>
<tr><td rowspan="9">Time</td><td colspan="2" rowspan="2">Site Selection and Design</td><td rowspan="2">Site Selection and Design</td><td colspan="2">Planning</td><td colspan="2" rowspan="4">Not addressed in this ICOLD bulletin</td></tr>
<tr><td colspan="2">Design</td></tr>
<tr><td colspan="2">Construction</td><td>Construction</td><td colspan="2">Construction</td></tr>
<tr><td colspan="2">Operation</td><td>Operation</td><td colspan="2">Operation</td></tr>
<tr><td rowspan="4">Closure</td><td rowspan="2">Transition</td><td rowspan="4">Decommissioning and Closure</td><td rowspan="3">Closure</td><td>Decommissioning</td><td rowspan="4">Post Closure</td><td rowspan="3">Active Care</td></tr>
<tr><td>Remediation</td></tr>
<tr><td>Active Care</td><td>After Care</td></tr>
<tr><td>Passive Care</td><td colspan="2">Long Tem Monitoring</td><td>Passive Care</td></tr>
<tr><td colspan="2">Landform (not considered a dam)</td><td>Not addressed by MAC</td><td colspan="2">Not addressed by ICOLD (2006)</td><td colspan="2">No longer poses a risk to life or environment</td></tr>
</table>

A Guide to the

Management of Tailings Facilities

VERSION 3.1

The Mining Association of Canada

A Guide to the

Management of Tailings Facilities

VERSION 3.1

Version date: February 2019

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 (2019) 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*".

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.

The Mining Association of Canada

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.

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.

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.

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).*

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

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.

Implementation of the Tailings Guide is supported by checklists that provide a starting point for developing a site-specific tailings management system. The checklists also assist Owners in exposing gaps within existing procedures, identifying training requirements, obtaining permits, conducting internal audits, and aiding conformance and due diligence, at any phase of the life cycle. It is expected that at each facility the Owner will augment and/or modify these checklists to meet the specific requirements for each specific tailings facility.

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.

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

- employees;
- Aboriginal or Indigenous peoples;
- mining community members;
- suppliers;
- neighbours;
- customers;
- contractors;
- environmental organizations and other non-governmental organizations;
- governments;
- the financial community; and
- shareholders.

Definition from MAC's *TSM Aboriginal and Community Outreach Protocol*

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:

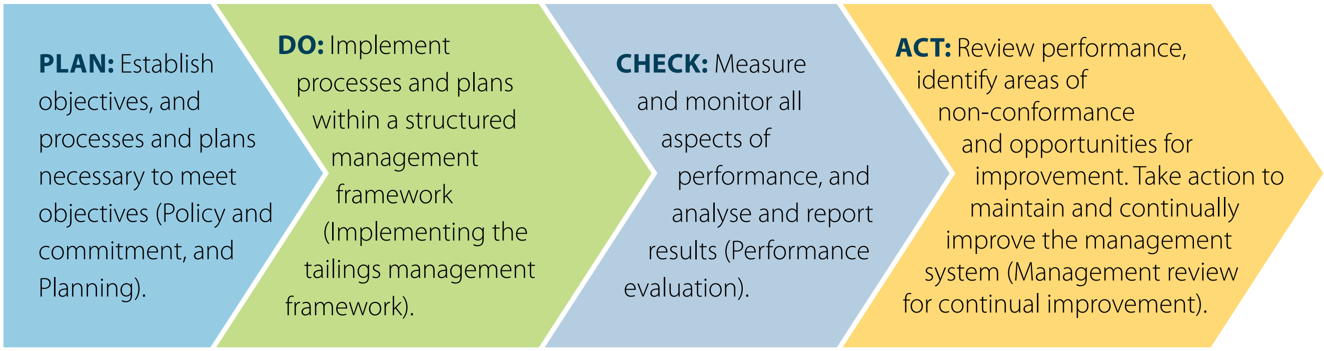
- Policy and commitment (*see Section 3*);
- Planning (*see Section 4*);
- Implementing the tailings management framework (*see Section 5*);
- Performance evaluation (*see Section 6*); and
- Management review for continual improvement (*see Section 7*).

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)

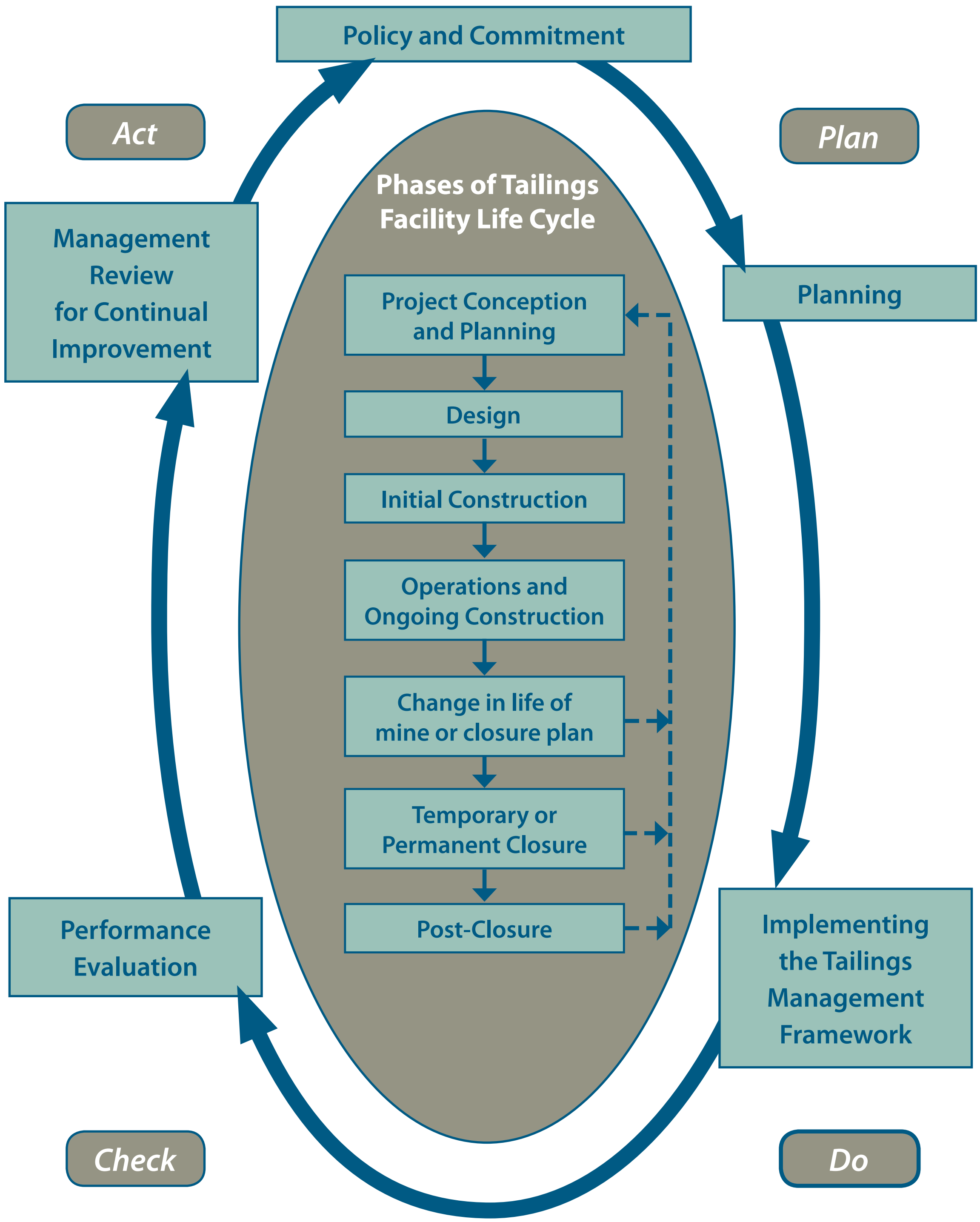
The tailings management framework is based on the *ISO 14001* definition of an environmental management system which includes: an organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining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

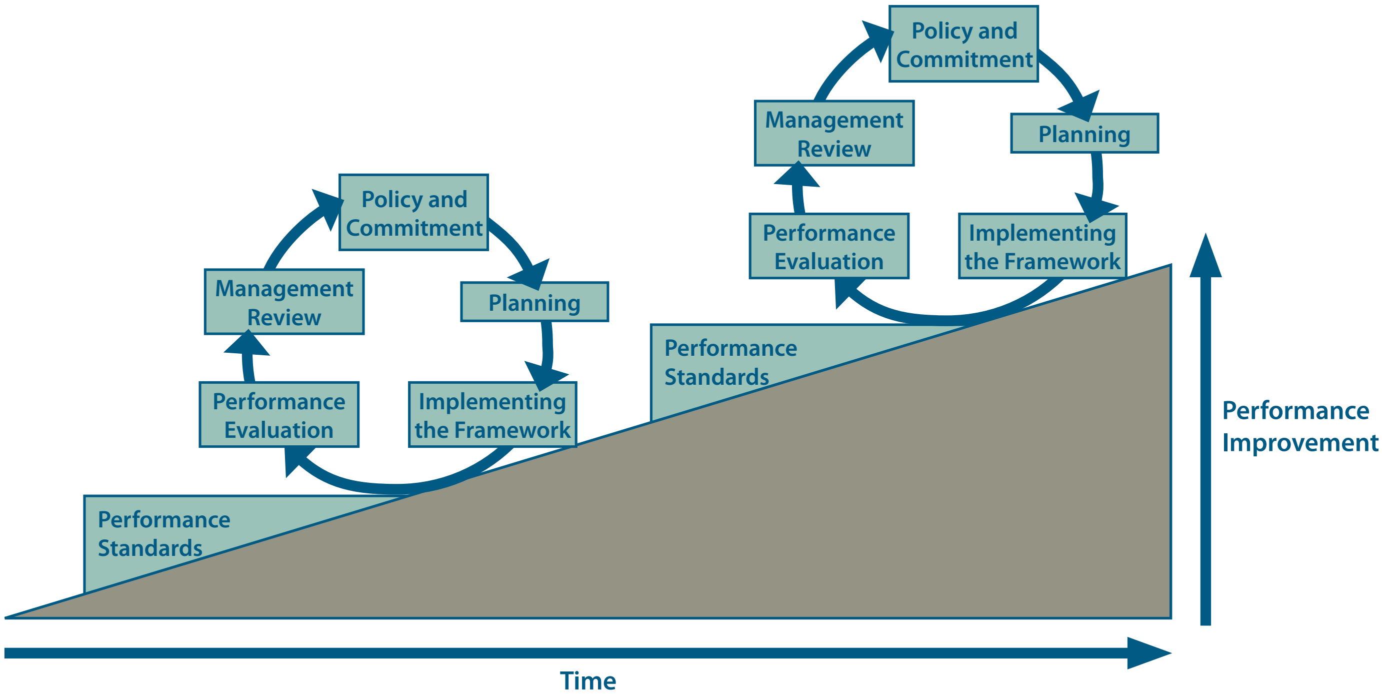
Closure: begins when placement of tailings into the facility ceases permanently. The facility and associated infrastructure are decommissioned, and the closure plan is implemented, including:

- 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.

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 4.3*.

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 (IR) is recognized as a BAP for responsible tailings facility management.

IR 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 IR is to provide an opinion to the Owner's **Accountable Executive Officer** (*see Section 4.3*) 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, IR is applicable across all elements of the framework. It is also applicable across the entire life cycle of a tailings facility. The input of IR 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 IR should be re-adjusted to ensure it remains relevant and effective.

IR 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 IR is provided in *Appendix 4.*

2.2.4 Designing and Operating for Closure

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.

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.

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]

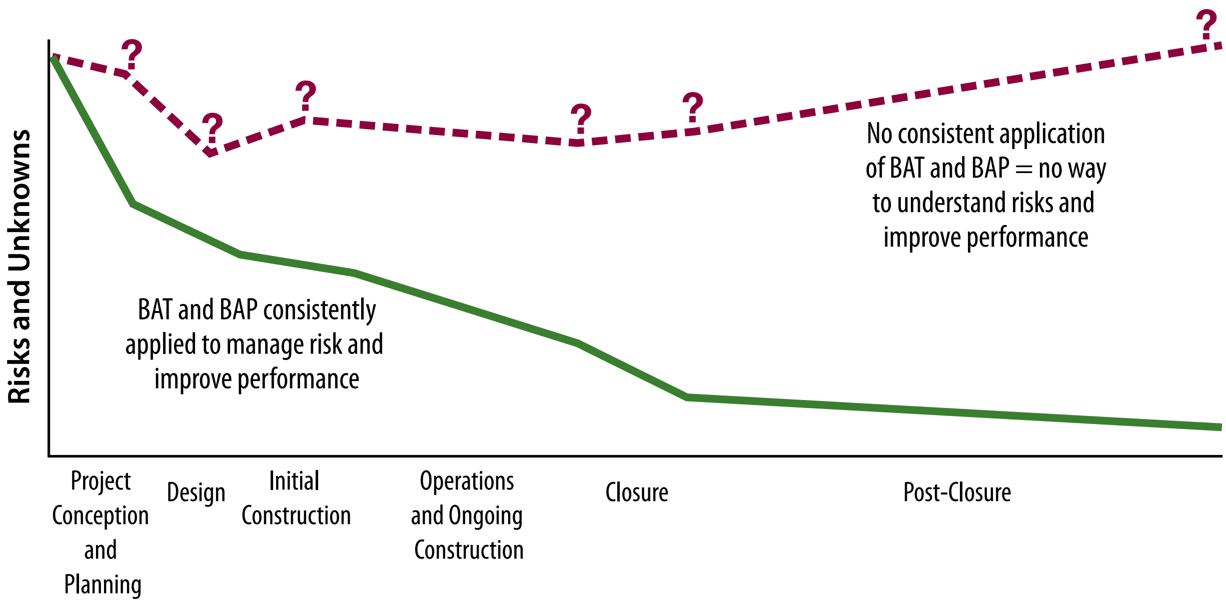


Figure 3 captures the importance of good decisions early in the life cycle of a tailings facility, but does not consider the financial accounting practices used in mine planning, particularly the application of discount rates to longer-term costs. Use of such practices can minimize, from a financial 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 IR 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*.

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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; and
- implementing a tailings management system through the actions of its employees, contractors, and consultants.

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*);
- 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

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 risks 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.

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 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*)

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.

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).

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.

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.

The role and accountability of the Board of Directors or Governance Level versus the Accountable Executive Officer is determined by the Owner, and should be documented.

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.

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 of the tailings facility life cycle; and
- demonstrates to the Board of Directors/Governance Level whether tailings are managed responsibly.

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. 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.

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 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).

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 Management Process

4.4.1 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.

4.4.2 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 external 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 external roles in the event of change.

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 all 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 (IR) 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.

4.4.3 Controls

Critical Controls

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. Critical control management is a governance approach to managing high-consequence risks relating to an operation or business. It is designed to provide a high level of assurance against the occurrence of high-consequence events, as defined by the Owner and its EoR, with input from IR.

Risk controls are 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.

In the context of tailings management, critical controls are a subset of risk controls that prevent high-consequence events.

The designation of critical controls is an Owner and tailings facility-specific exercise. Risk controls are typically designated as critical controls if:

- 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.

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.

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.

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 management should address a wide range of aspects related to the tailings facility, including construction, operation, maintenance and surveillance practices through the life of the facility.

Control of documented information is addressed below, but one specific aspect of this form of control is linked to quality management. It is important that both design records and as-built records be retained for all aspects of construction of tailings facilities. These records should be retained throughout the life cycle of the facility. This should include revisions to construction drawings, test results, meeting minutes, construction photographs, monitoring records, and any other pertinent information.

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.

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.

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.

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 6*):

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

4.4.4 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.

Control of Documented Information

Current Documents:

Access to, and use of, current and accurate documented information is a critical component to enable the safe management of a tailings facility. Information that is determined by the organization as being necessary to the effectiveness of the tailings management system, throughout the life cycle, should be controlled. Owners should establish and implement a process to ensure that documented information is created, maintained, retained, and archived.

When creating and maintaining documented information, the Owner should ensure appropriate:

- identification and description (e.g., title, date, author, reference number); and
- review and approval.

Documented information should be accessible, and adequately protected. Obsolete versions of current documents should be removed and archived.

Records Retention:

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. Records that are retained should be adequately protected and archived so that they are preserved and retrievable in the future.

Training and Competence

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.

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.

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.

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.

Communications

Establish and implement two-way communication processes for personnel who have accountability or responsibility for implementing the tailings management system, including reporting of significant information (e.g., results of Performance Evaluation) and decisions to senior management, the EoR, regulators, and COI, as appropriate.

As described below in *Section 5.2*, an **emergency** response plans and emergency preparedness plans are essential components of a tailings management system. These plans should be developed by the Owner, in collaboration with local first responders, COI, and relevant regulators as appropriate, and are components of an effective communications strategy.

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 4.4.3* 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. Owners of tailings facilities must 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.

Document Control

ERPs and EPPs need to be controlled documents, including:

- defining the process for reviewing and updating the plans;
- identifying persons with authority to revise the plans;
- describing mechanisms for approval of revisions to the plans;
- for electronic documents, implementing measures to prevent unintended changes, or to prevent any changes by personnel without the appropriate authority; and
- defining procedures for:
    - providing relevant persons/authorities with access to the plans;
    - informing relevant persons/authorities of changes to the plans;
    - restricting access to out-of-date versions;
    - identifying out-of-date materials to be retained; and
    - archiving or disposing of out-of-date materials, as appropriate.

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)

5.3 Checklists

The tailings management framework is intended to be flexible in how it is applied to suit the requirements of specific sites, Owner policies, legal requirements, and commitments to COI. To aid in the implementation of the tailings management framework, MAC has developed a checklist tool which is available for download from the MAC website at *http://mining.ca/tailings-guide*.

The checklist provides a basis for developing customized, site-specific tailings management systems. Completing the checklist can help identify gaps and/or deficiencies in tailings management. It is intended to be a tool to help in the implementation of the tailings management framework. Use of the checklist is not a "box-checking" or audit exercise – it is a tool to help ensure that the Owner has addressed all relevant aspects of the framework. By completing the checklist, the Owner is provided with a snapshot of the state of implementation of the tailings management framework for their tailings facilities, recognizing that the state of implementation continues to evolve through the life cycle of the facility.

The master checklist is provided in Microsoft Excel, allowing users flexibility in adapting the checklist to their specific circumstances. The master checklist encompasses all aspects of the tailings management framework across all phases of the life cycle. Users can tailor the checklist to the specific life cycle phase of the facility to which the checklist is being applied, ignoring or deleting those items on the checklist not relevant to that life cycle phase.

The master checklist is provided in *Appendix 5* to illustrate, but users are encouraged to download and use the Excel version.

For MAC members applying *TSM*, MAC has also developed a *Table of Conformance* which is used in conjunction with the *Tailings Management Protocol* to assess performance against the Indicators described in the Protocol. While the master checklist and the Table of Conformance are similar, these tools serve different purposes. The checklist is intended as a planning tool and is applicable to the development and implementation of tailings management systems across all phases of the life cycle of a tailings facility. With respect to the Tailings Guide, the Table of Conformance is narrower in scope than the checklist and identifies those elements of the Tailings Guide tied to performance measurement for the Indicators in the Protocol. However, the Table of Conformance is broader in scope in that it also identifies elements of the OMS Guide that are tied to performance measurement. Since *TSM* does not apply until the beginning of the operations and ongoing construction phase of the life cycle, elements of the Tailings Guide related to the **project conception and planning** phase, and the **design phase** of the life cycle are not addressed in the Table of Conformance.

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; and
- adequacy of resources committed to tailings management.

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 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; and
- changes in the risk profile of the tailings facility.

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 IR.

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 (IR): one of the overarching principles of the framework, IR is described in *Section 2.1* 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): All individuals and groups who have an interest in, or believe they may be affected by, decisions respecting the management of operations. They include, but are not restricted to:

- employees;
- Aboriginal or Indigenous peoples;
- mining community members;
- suppliers;
- neighbours;
- customers;

- contractors;
- environmental organizations and other non-governmental organizations;
- 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.

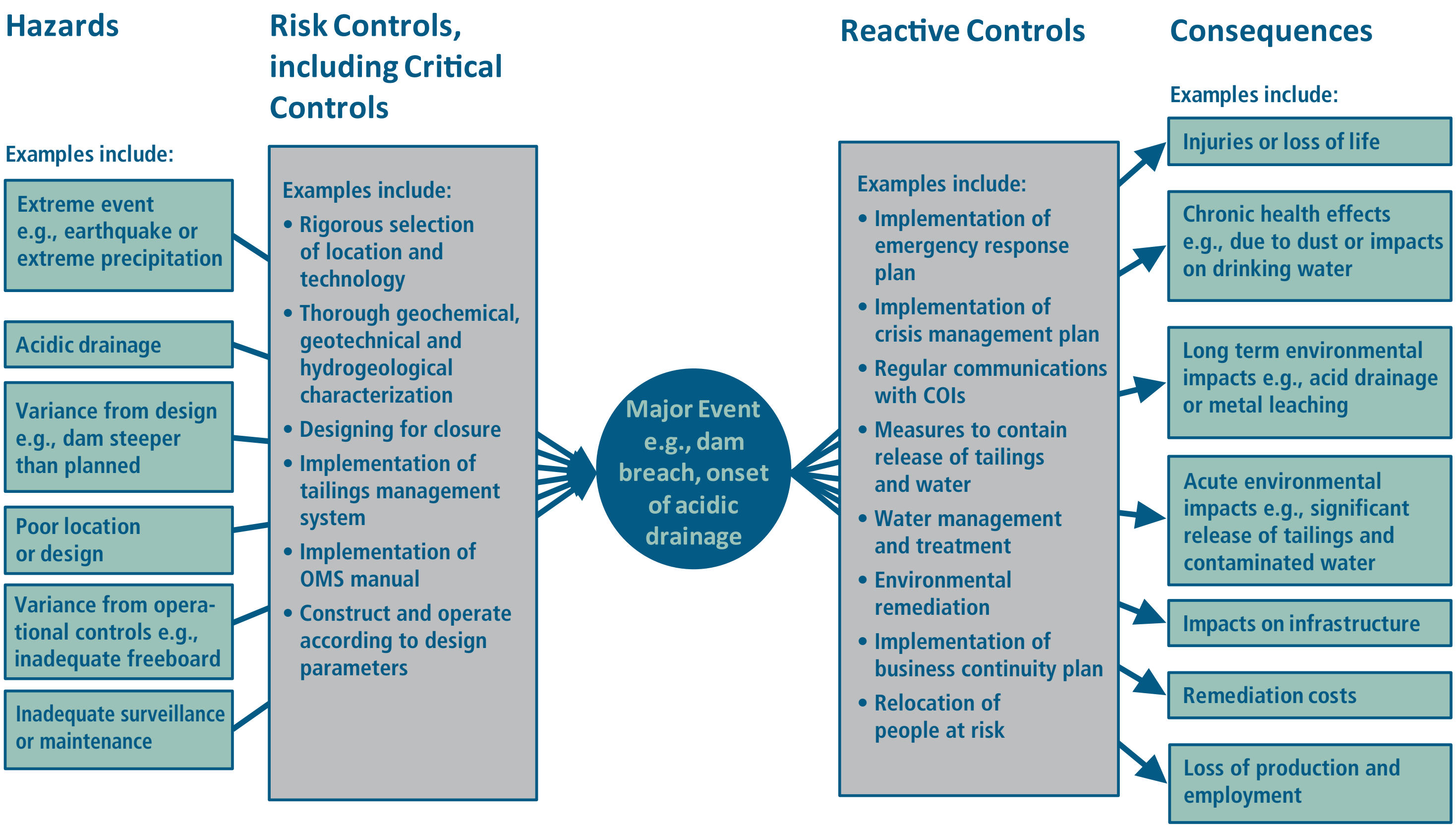
Increasing likelihood ↑

	Negligible	Minor	Moderate	Major	Catastrophic
Very Likely	M	H	H	E	E
Likely	M	M	H	H	E
Possible	L	M	M	H	H
Unlikely	L	L	M	M	H
Rare	L	L	L	M	M

Increasing consequence →

L: low risk
M: moderate risk
H: high risk
E: extreme risk

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.

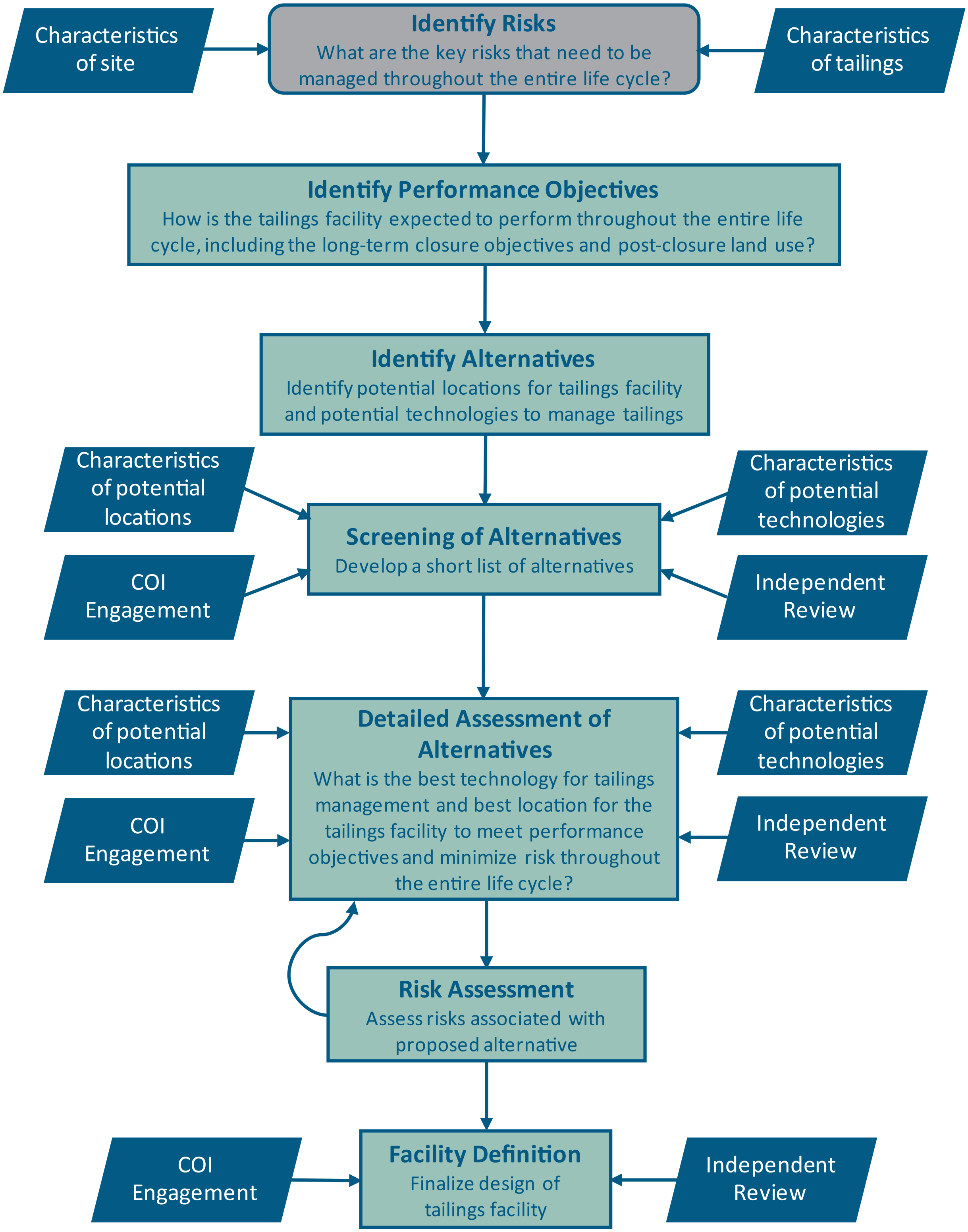
MAA is part of a broader toolbox of methods referred to as multiple criteria decision analysis. The strength of such tools is that they provide a method of integrated assessment of different characteristics of alternatives, for example, for comparing potential impacts on wildlife with capital costs. 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 *Appendix 6*):

- 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 *Appendix 6*):

- 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.

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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 (IR) 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 IR processes to demonstrate responsible risk management. Insurance companies may offer premium reductions if IR is part of a facility's risk management program.

There is no specific method or formula for conducting effective IR. This appendix describes principles and elements that would be common to any effective IR 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 IR 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.

IR may also provide recommendations to improve tailings facility management, although IR 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 IR 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.

IR 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 IR efforts with designers, operations staff and senior management.

Benefits

IR 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.

IR 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 IR is to identify and address potential deficiencies before they occur and is fundamentally a preventative risk control measure. The preventative focus of IR fosters continual improvement and mitigates complacency.

The IR 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.

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

Detail Level of IR

The level and detail of IR 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

IR is a component of an effective risk management system. As such, the degree of IR 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 IR on an annual basis, the frequency of IR 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 IR 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, IR frequency should be determined in consultation with the IR body, Owner and EoR. As a site approaches a "steady state" of operation, IR frequency may be reduced. The IR frequency during closure may vary according to risk.

An IR body may comprise a single reviewer or several individuals. The IR 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 IR involvement for niche disciplines (e.g., paleo seismology, seismic hazard assessment) outside the expertise of the core IR body may be required. Redundancy of technical disciplines within the IR body should be considered in accordance with a facility's risk profile.

IR Program

The terms of reference for IR should be carefully considered in accordance with the facility risk profile. Recommended terms of reference are provided in Appendix 4.1. Effective IR 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 IR process should involve both site-personnel (e.g., Responsible Person), the EoR, and key consultants to be most effective. The IR 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 IR (if IR has been done previously);
- other relevant studies and assessments;
- summary of previous IR recommendations and status of implementation; and
- pertinent information on medium to long-range planning for the facility.

The IR 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 IR to best function as an effective risk management tool, the IR process should be confidential. A lack of confidentiality could undermine the IR 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 IR typically considers future mining plans and "forward-looking information". If required, the IR process and findings can be summarized for disclosure.

In response to any recommendations from the IR process, 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 IR program, a process summary is appended to this document. The following publications are recommended resources to provide further context and examples of IR:

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 IR

IR Mandate: To provide IR 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. IR 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 IR 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

Section 5.3 describes a checklist that may be customized to help implement the tailings management framework throughout the life cycle. A master checklist is available for download from the MAC website at *www.mining.ca/tailings-management*. The master checklist is illustrated in *Appendix A.5.1*.

In addition to applying the checklist, additional considerations for 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.

A.5.1: Illustrative Sample of the Master Checklist, to be Used as a Tool for Owners in Implementing the Tailings Management Framework

Section in Tailings Guide	Management Action	Responsibility	Performance Measure	Schedule	References
Overarching Principles					
Risk Assessment and Management					
2.2.1	Addressed below under Planning				
BAT and BAP for Tailings Management					
2.2.2	Have the following factors been considering in selecting the tailings management technology for a specific tailings facility:				
	• 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?				
	Has a rigorous decision-making tool such as multiple accounts analysis been used to select the most appropriate tailings management technology for a new facility, or to expand the capacity of an existing facility?				
	Has a rigorous decision-making tool such as multiple accounts analysis been used to select the most appropriate location for a new tailings facility?				
	In selecting the tailings management technology, have the potential risks of the alternatives assessed been considered across the life cycle of the facility, and have performance objectives and criteria been considered across the life cycle, including closure objectives?				
	In selecting the tailings facility location, have the potential risks of the alternatives assessed been considered across the life cycle of the facility, and have performance objectives and criteria been considered across the life cycle, including closure objectives?				
	Are best available/applicable practices for tailings management being implemented across the full spectrum of tailings management, including:				
	• confirming geochemical and physical design parameters during the operations and ongoing construction, closure, and post-closure phases, and adjusting accordingly;				
	• structural monitoring of tailings facilities to detect movement or change;				
	• implementing a tailings management system;				
	• implementing a system to identify and manage critical controls;				
	• monitoring to assess performance against water balance requirements; and				
	• conducting Independent Review?				
Independent Review					
2.2.3	Has a mechanism been established for conducting Independent Review on a routine basis?				
	Is Independent Review being implemented according to the established mechanism?				
	Is Independent Review providing advice on:				
	• 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?				
	Is Independent Review being applied across all elements of the tailings management system, and across all phases of the life cycle of a tailings facility?				

Section in Tailings Guide	Management Action	Responsibility	Performance Measure	Schedule	References
Designing and Operating for Closure					
2.2.4	Have long-term closure objectives and potential post-closure land uses been considered in the conceptual planning and design of the tailings facility?				
	Has the tailings facility been designed to remain physically and chemically stable for the long-term?				
	For older facilities not designed for closure, have options to adjust their tailings management practices or adopt newer technologies been considered to reduce risk and better position the tailings facility for closure?				
	Is the tailing facility being constructed in a manner consistent with the closure objectives?				
	Is the tailings facility being operated in a manner consistent with the closure objectives?				
	Is the closure plan being updated, considering changes in the mine plan, legal requirements, the risk profile of the tailings facility, status of progressive reclamation activities, and changes in COI expectations?				
Policy and Commitment					
3	Does the Owner have a demonstrated 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; and				
	• implementing a tailings management system through the actions of its employees, contractors and consultants?				
	On a facility-specific basis, has the Owner made more specific commitments to:				
	• plan, design, construct and operate the tailings facility 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 the tailings facility commensurate with the risks it poses 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 the tailings facility; and				
	• implement the level of accountability, authority and competency for decision making appropriate to the level of risk that the decision entails?				
	Is the policy and/or commitments:				
	• approved by senior management and endorsed at the governance level;				
	• communicated to employees;				
	• understood to a degree appropriate to their roles and responsibilities by employees, contractors and consultants whose activities may affect tailings management either directly or indirectly;				
	• communicated to COI; and				
	• implemented with budget allocation?				

Section in Tailings Guide	Management Action	Responsibility	Performance Measure	Schedule	References
Planning					
Risk Management					
	Are risk assessments completed and/or updated at a frequency that supports the aims of the tailings management activities for that facility?				
	Have the outcomes of the risk assessment been documented?				
	Do the risk assessment and management measures take into account:				
	• physical and chemicals risk of the tailings facility;				
	• environmental risks 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)?				
	Has a risk management plan been prepared and documented that describes mitigation measures 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?				
	Has the risk management plan been implemented?				
	For a new tailings facility or the expansion of the capacity of an existing facility, has development of a conceptual risk management plan begun at the project conception and planning phase of the life cycle?				
	For a new tailings facility or the expansion of the capacity of an existing facility, has the conceptual risk management plan been refined and developed in greater detail during the design phase?				
	Is the risk management documentation, including the risk assessment record, reviewed and updated as necessary in the event of any changes not anticipated at the beginning of mine life (e.g. mine life extensions, suspensions to care and maintenance, re-starts, and process and technology changes)?				
Performance Objectives					
4.2	Have performance objectives and criteria been developed that are aligned with the Owner's tailings management system, policy and/or commitments, standards/guidelines, legal requirements, commitments to COIs, and sound engineering and environmental practices?				
	Are 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?				
	Have performance objectives and criteria been developed for the entire life cycle of the tailings facility, including planning for both potential temporary and eventual permanent closure, and including:				
	• 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?				

Section in Tailings Guide	Management Action	Responsibility	Performance Measure	Schedule	References
4.2	For a new tailings facility or the expansion of the capacity of an existing facility:				
	• Have performance objectives been established in the conceptual planning phase?				
	• Did the assessments of alternatives for facility location and tailings management technology take these performance objectives into account?				
Accountability and Responsibility					
4.3	Do personnel with accountability, responsibility and/or authority for tailings management have an understanding, appropriate to their accountability, responsibly and/or authority, of how the tailings facility is designed, constructed and operated, including risk posed by the facility, the risk management plan, critical controls management, and operational constraints?				
	Are accountabilities, responsibilities, authority, and roles defined and documented for:				
	• Owner's Board of Directors or Governance Level;				
	• Accountable Executive Officer;				
	• Responsible Person(s);				
	• Engineer of record; and				
	• Independent Reviewer?				
Management Process					
	Conformance Management				
4.4.1	Do conformance management processes ensure that:				
	• Applicable legal requirements and commitments (including commitment/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 their duties and have the necessary training and competence; and				
	• processes to assess the state of conformance have been established, documented and communicated as required?				
	In cases of non-conformance, did the Owner:				
	• 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?				
	Managing Change				
4.4.2	Have processes to manage change been documented and implemented 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 the tailings facility;				
	• facility ownership;				
	• employees, contractors and consultants with key duties related to the tailings facility, including the Accountable Executive Officer, Responsible Person, operating and maintenance personnel, roles and responsibilities, including those of the EoR and Independent Reviewers;				
	• conditions that may impact tailings management, including temporary suspension of mining operations;				

Section in Tailings Guide	Management Action	Responsibility	Performance Measure	Schedule	References
4.4.2	• 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 any of its component parts)?				
	Do change management processes include succession planning for key roles related to tailings management, including the Responsible Person(s), EoR, and Independent Reviewers?				
	Are changes which could impact the risk profile of the tailings facility reviewed and are potential impacts evaluated?				
	Are changes which could impact the risk profile of the tailings facility approved by all the relevant persons (e.g., EoR, Responsible Person(s), personnel involved in tailings management and related activities, and the Accountable Executive Officer) as appropriate?				
Controls					
Critical Controls					
4.4.3	Has a process been developed and implemented to manage critical controls, including:				
	• identifying potential failure modes and causes using risk assessment techniques;				
	• identifying risk controls associated with potential failure modes and causes;				
	• identifying those risk controls deemed to be critical on an Owner or facility-specific basis;				
	• appointing a “risk owner” and “critical control owner” for that risk;				
	• defining the critical controls and their performance criteria, measurable performance indicators, and surveillance requirements;				
	• identifying pre-defined actions to be executed if control is lost;				
	• verifying execution of critical controls by the critical control owner or designate, at a frequency commensurate with the frequency of control execution;				
	• reporting deficiencies in critical controls to the Responsible Person(s) and, where appropriate, the Accountable Executive Officer, and identifying actions and a schedule to address those deficiencies;				
	• tracking implementation of actions to address critical control deficiencies, and reporting to the Responsible Person(s) and, where appropriate, the Accountable Executive Officer; and				
	• periodically reviewing and updating risk controls and critical controls, based on updated risk assessments, risk management plans, and past performance?				
Quality Management					
4.4.3	Has a quality management plan/process been developed and implemented, including separate quality assurance and quality control plans/processes?				
	Does quality management address an appropriate range of aspects related to the tailings facility, including construction, operation, maintenance and surveillance practices through the life of the facility?				
Operation, Maintenance, and Surveillance Manual					
4.4.3	Has an operation, maintenance and surveillance (OMS) manual been developed in a site-specific manner?				
	Does the OMS manual 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;				
	• and clearly communicate requirements to implement OMS activities to employees, contractors, and consultants involved in tailings management;				

Section in Tailings Guide	Management Action	Responsibility	Performance Measure	Schedule	References
4.4.3	• risk controls and critical controls, and pre-defined management actions necessary to retain or regain control;				
	• performance indicators and criteria for risk controls and critical controls, and the ranges of performance linked to specific pre-defined management actions; and				
	• 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?				
	Does the OMS manual provide the necessary information to implement OMS activities on a daily basis?				
	Is the OMS manual easily accessible to all relevant personnel?				
	Does the OMS manual document and clearly communicate responsible operating practices to operators and staff responsible for the tailings facility?				
	Does the OMS manual include or refer to other plans specific to various aspects of tailings management, including:				
	• tailings transport and placement plan;				
	• water management plan; and				
	• closure plan?				
Resources					
4.4.4	Has the Owner identified, secured and regularly reviewed the adequacy of:				
	• human resources and external contractors;				
	• condition, function and suitability of equipment;				
	• financial resources; and				
	• schedules of activities that integrate the required resources related to tailings management?				
Financial Control					
4.4.4	Has a budget for tailings management been established and documented that considers both short-term and long-term needs for effective tailings management throughout the life cycle?				
	Has budget approval been obtained?				
Control of Documented Information					
4.4.4	Has a process been developed and implemented to ensure that documented information is created, maintained, retained, and archived?				
	Has a process been developed and implemented to identify records related to the tailings facility that should be retained?				
Training and Competence					
4.4.4	Has a training program for relevant employees, contractors and/or consultants been developed and implemented?				
	Are records for training for employees, contractors or consultants that is funded by or provided by the Owner maintained?				
Communications					
4.4.4	Have communications processes been established and implemented to report significant information and decisions to senior management, the EoR, regulators and COI, as appropriate?				
Implementing the Tailings Management Framework					
Operation, Maintenance and Surveillance Manual					
5.1	Has the OMS manual been implemented?				
	Is the OMS manual regularly reviewed and revised, as appropriate, throughout the operations and ongoing construction phase of the tailings facility's life cycle, as well as beyond?				

Section in Tailings Guide	Management Action	Responsibility	Performance Measure	Schedule	References
Emergency Preparedness					
	Emergency Response Plan (ERP)				
5.2.1	Has an emergency response plan (ERP) been prepared for the tailings facility that provides the following information:				
	• potential emergencies that may occur and the conditions that would trigger implementation of the ERP, including, where applicable, potential effects of inundation;				
	• 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;				
	• surveillance requirements;				
	• procedures to test the ERP; and				
	• procedures for the administration and update of the ERP?				
	Emergency Preparedness Plan (EPP)				
5.2.2	Has an emergency preparedness plan (EPP) been prepared for the tailings facility that provides the following information:				
	• 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;				
	• 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;				

Section in Tailings Guide	Management Action	Responsibility	Performance Measure	Schedule	References
	• 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?				
	Have copies of the EPP been provided to potentially affected COI with roles or responsibilities related to emergency response?				
Addressing Inundation Risks (applicable if there is a risk of inundation of downstream areas)					
5.2.3	Are inundation risks addressed in the ERP and the EPP?				
	Has the area that could be inundated been defined, describing the maximum extent of flooding, flood depths, and time to maximum depth?				
	Have maps of potentially inundated areas been developed, identifying any downstream mine site infrastructure, communities, residences, farms, recreational facilities, roads, railways, bridges, powerlines, other infrastructure, or other features that could be impacted in the event that an emergency occurs?				
	Does the scope of the EPP encompass all COI and local authorities that could be potentially impacted by an inundation event?				
Testing of the ERP and EPP					
5.2.3	Have procedures been established and implemented for periodic review and testing of the ERP and the EPP?				
	Have the review and testing of the ERP and the EPP involved potentially affected COI such as local first responders and relevant government agencies?				
	Have the results of tests been evaluated to identify any deficiencies or opportunities for improving the ERP or EPP, and the plans updated accordingly?				
Performance Evaluation					
6	Do performance evaluations include results of surveillance and reviews (both internal and independent) and address:				
	• operating performance against objectives 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;				
	• need for changes or updates to the OMS manual, including evaluating the effectiveness of surveillance activities and the utility of the information being collected, and identifying any gaps in information collection; and				
	• need for changes or updates to the ERP and EPP?				
	Do performance evaluations 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?				
	Are results and recommendations of performance evaluations documented and reported to the Responsible Person(s), the Accountable Executive Officer and the Board of Directors or Governance Level, at a pre-defined frequency and level of detail?				
Management Review for Continual Improvement					
7	Has an annual review of tailings management been conducted to evaluate the:				
	• status of actions from the previous management review; and				
	• suitability, adequacy, effectiveness, and the need for changes to the:				
	○ tailings management system;				
	○ ERP and EPP; and				
	○ OMS manual;				
7	• performance of the tailings facility;				
	• effectiveness of risk management; and				

Section in Tailings Guide	Management Action	Responsibility	Performance Measure	Schedule	References
	• adequacy of resources committed to tailings management?				
	Does the management review process include identification and evaluation of the potential significance of any changes since the previous management review that are relevant to tailings management, 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 of potential impacts to or of the tailings facility; and				
	• changes in the risk profile of the tailings facility?				
	Does the management review provide a summary of significant issues related to the performance of the tailings facility, the tailings management system, the ERP, the EPP, and the OMS manual, updated since the previous management review, that includes:				
	• compliance with legal requirements, conformance with standards, policies and commitments, and status of any corrective actions;				
	• tailings facility maintenance;				
	• tailings facility surveillance; and,				
	• inspections, internal or external audits, evaluations of effectiveness, and independent reviews?				
	Are the outcomes of the management review documented and does it include:				
	• conclusions regarding the performance of the:				
	○ tailings facility;				
	○ tailings management system;				
	○ ERP and EPP; and				
	○ OMS manual;				
	• If needed, action plans to:				
	○ ensure performance objectives are met;				
	○ address non-conformance with requirements, standards, policy, or commitments; and				
	○ implement recommendations for continual improvement;				
	• recommendations for modifications to the tailings management system, ERP, EPP, or OMS manual; and				
	• any recommendations for additional resources for tailings management?				
	Have the results of the annual tailings management review been reported to the Accountable Executive Officer and the EoR?				
	Is progress towards implementing action plans tracked and reported at least annually to the Accountable Executive Officer?				
Assurance					
8	Have assurance processes been implemented as an oversight process to provide an outside perspective on whether tailings are being managed effectively and responsibly?				
	Have the outcomes of assurance activities been considered in the Management Review for Continual Improvement?				
Audits					
8	Has an internal audit been conducted to provide a formal, systematic and documented examination of the tailings facility's conformance with prescribed criteria, legal requirements, and the Owner's tailings management system?				
	Has an external audit been conducted?				

Section in Tailings Guide	Management Action	Responsibility	Performance Measure	Schedule	References
Evaluation of Effectiveness					
8	Has an evaluation of been conducted to assess whether tailings management is achieving the intended results?				
8	In establishing the scope of the evaluation of effectiveness, have the following been considered:				
	• changes in external conditions that could affect the system and achievement of performance objectives; and				
	• changes in internal conditions that could affect the system and achievement of performance objectives?				
8	Have the following performance results and trends been evaluated to determine the effectiveness of tailings management:				
	• 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					
8	Addressed above under Overarching Principles				

Appendix 6: 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 *Appendix 3.1*, Section 1. 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

Developing an

Operation, Maintenance, and Surveillance Manual

for Tailings and Water Management Facilities

SECOND EDITION

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Version date: February 2019

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 (2019) 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://mining.ca/oms-guide*".

The Mining Association of Canada

Foreword

It is with pleasure that I present, on behalf of the Mining Association of Canada (MAC), the second edition of *Developing an Operation, Maintenance, and Surveillance Manual for Tailings and Water Management Facilities* (the OMS Guide).

The first edition of the OMS Guide was released in 2003 as a companion piece to MAC's 1998 ***A Guide to the Management of Tailings Facilities*** (the Tailings Guide). The OMS Guide provides guidance on developing site-specific operation, maintenance, and surveillance (OMS) manuals which are essential to implementing the tailings management framework described in the Tailings Guide.

The Tailings Guide and the OMS Guide are stand-alone best practice documents that can be applied by MAC members and non-MAC members alike, for the responsible management of tailings facilities anywhere in the world.

In 2015, MAC undertook a review of the Tailings Guide and the OMS Guide, as well as the *Towards Sustainable Mining® Tailings Management Protocol*. The revised Protocol and the third edition of the Tailings Guide were released in 2017, and this second edition of the OMS Guide builds on the best practices described in the third edition of the Tailings Guide. The second edition provides strengthened guidance on the development of site-specific OMS manuals that, when implemented throughout the life cycle of a tailings facility:

- provide a mechanism for the effective implementation of a tailings management system;
- provide a mechanism to meet tailings management performance objectives and manage risk;
- support effective decision-making for responsible tailings management; and
- support the management of changes associated with tailings management.

Revisions to the Tailings Guide and the OMS Guide were undertaken by MAC's Tailings Working Group (TWG), which consists of more than 50 representatives of MAC members and associate members. Collectively, TWG members have a tremendous depth and breadth of experience and expertise in tailings management in Canada and around the world. We are extremely grateful to the members of the TWG for their dedication and commitment to responsible tailings management, and for the contributions of their knowledge, wisdom and time, without which the updated Tailings Guide and OMS Guide would not be possible.

Updating the Tailings Guide and OMS Guide is an important step in continual improvement, providing best practices to optimize tailings facility performance and manage risk. I trust that MAC members and others will find both documents to be invaluable tools for improving tailings management. Our industry is continually working towards the goal of minimizing harm: zero catastrophic failures of tailings facilities, and no significant adverse effects on the environment and human health, in Canada and abroad.

Pierre Gratton

President & CEO

The Mining Association of Canada

Preface

Context

The first edition of MAC's *Guide to the Management of Tailings Facilities*, released in 1998, was developed to:

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

In 2003 MAC introduced *Developing an Operation, Maintenance, and Surveillance Manual for Tailings and Water Management Facilities* (the OMS Guide) as a companion document to the Tailings Guide, providing guidance on preparing site-specific manuals that outline procedures for the responsible **operation**, **maintenance**, and **surveillance** (OMS) of tailings and water management facilities.

MAC established the *Towards Sustainable Mining® (TSM®)* initiative in 2004. *TSM* is a performance system that helps mining companies evaluate and manage their environmental and social responsibilities. It provides a set of tools and indicators to drive performance and ensure that mining **risks** are managed effectively. Additional information on TSM is available at *www.mining.ca/towards-sustainable-mining*.

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 engineering capability within an effective management system and throughout the full **life cycle** of a facility.

In 2011, the second edition of the Tailings Guide was released, aligning the original Tailings Guide with *TSM* principles and terminology, and with the OMS Guide. The OMS Guide was also re-released in 2011, although the document was not revised.

Review of the Tailings Management Component of *TSM*

In August 2014, a tailings dam foundation failure occurred at the Mount Polley Mine in British Columbia. Soon after, the MAC Board of Directors initiated a review of the tailings management component of *TSM*, to identify any improvements 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
- an internal review by MAC's Tailings Working Group.

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 for improvements to the Protocol, Tailings Guide and OMS Guide.

Once both reviews were complete the Tailings Working Group revised the Tailings Guide, leading to the third edition of the Guide. The Protocol was also revised, and both were released in 2017.

The third edition of the Tailings Guide retains a strong emphasis on management systems, and it has an increased emphasis on technical aspects, especially those critical to the physical and chemical stability of tailings facilities. The third edition also updates the tailings management framework presented in the Tailings Guide as a tool to help in the implementation of site-specific tailings management systems. Descriptions of the elements of the framework are strengthened and clarified, and the framework is more aligned with the *ISO 14001 Environmental Management System* standard. The third edition also strengthens concepts that were described in previous editions and introduces others.

Second Edition of the OMS Guide

This second edition of the OMS Guide reflects the experiences of developing and implementing OMS manuals since the first edition was released and embodies lessons about what makes an OMS manual an effective and useful document. The most important consideration is that an OMS manual must be developed on a site-specific basis, reflect the unique conditions of the tailings facility to which it is applied, is used on a continuous basis, and is up-to-date. An effective OMS manual cannot be written using a generic, "cookie cutter" approach, nor can it be effective if it is out-of-date, or goes unused on a day-to-day basis.

The second edition of the OMS Guide emphasizes that, to be effective, OMS manuals need to be:

- written with input from those who will use them, and incorporate their specialized knowledge of the site, to make the manual more useful, and to help prevent that specialized knowledge from being lost through personnel changes;
- written in a clear, comprehensible manner; and
- written, organized, and made available in a manner that is readily accessible, such as the use of modules, and taking advantage of the capabilities of electronic documents.

This edition of the OMS Guide is closely aligned with the third edition of the Tailings Guide and builds on themes described in the Tailings Guide, creating a stronger conceptual framework for OMS manuals to integrate with tailings management systems.

Risk-Based Approach: The Tailings Guide emphasizes the importance of managing tailings facilities in a manner commensurate with the risks they may pose across the life cycle. The OMS Guide links OMS activities to the risk profile of a specific tailings facility, with the risk management plan included as a key consideration in developing and implementing an OMS manual.

Critical Controls: The Tailings Guide describes a framework for implementation of critical controls, which are risk controls that are crucial to preventing high-consequence events or mitigating the consequences of such an event. The OMS Guide emphasizes that critical controls and associated performance indicators need to be considered in developing and implementing an OMS manual, while also providing a basis for decision-making based on surveillance data.

Managing Change: The Tailings Guide emphasizes the fundamental importance of having systems in place to manage change, including organizational or personnel changes, as well as changes which could impact the risk profile of a tailings facility. The OMS Guide stresses that an effective OMS manual that is implemented as intended can be a valuable tool to help manage change.

Life Cycle Approach: The Tailings Guide emphasizes the importance of a life cycle approach to tailings management, with conceptual planning for tailings management beginning early in the planning cycle of a proposed mine and driven by the risks that need to be managed, as well as the closure objectives. The OMS Guides emphasizes that conceptual plans for OMS activities should also be developed during conceptual planning, and OMS manuals need be updated regularly throughout the life cycle of a facility. An out-of-date OMS manual creates risk.

The OMS Guide is written as a stand-alone document which can provide value even at sites not implementing a tailings management system as described in the Tailings Guide. Developing and implementing a site-specific OMS manual in the absence of a tailings management system can be an important step to improving tailings management and reducing risks.

The development and implementation of a site-specific tailings management system is a best practice for tailings management. However, the development and implementation of an OMS manual is essential to the implementation of a tailings management system. Thus, it is best practice to implement a tailings management system and OMS activities in a coordinated, aligned manner as the most effective means of managing risk, improving performance, and driving continual improvement in tailings management. MAC strongly encourages the implementation of the Tailings Guide and the OMS Guide together to optimize performance and manage risk.

To ensure alignment with the second edition of the OMS Guide, and to strengthen guidance regarding emergency preparedness, the third edition of the Tailings Guide was also updated. Version 3.1 of the Tailings Guide was released at the same time as the second edition of the OMS Guide. An updated version of the Protocol was also released which reflects a shift in emergency preparedness guidance from the OMS Guide to the Tailings Guide.

Implementation of *TSM* is required for MAC members for their Canadian operations. Thus, for MAC members applying *TSM*, implementation of the Tailings Guide and the OMS Guide is required, together with implementation of the *TSM Tailings Management Protocol,* to provide an even greater level of assurance of effective and responsible tailings management.

Non-MAC members have full access to all *TSM* documents, including those related to tailings management. Any Owner of a tailings facility, at any life-cycle phase, is encouraged to use these guidance documents to support their tailings management activities.

Table of Contents

1 Introduction

Tailings and associated water management facilities (hereafter referred to collectively as **"tailings facilities"** as per the definition below) are integral components of mining and ore processing operations. They must be managed throughout their **life cycle** to ensure their safe and environmentally responsible management. Responsible management includes the prevention of adverse impacts to human health and safety, the environment, and infrastructure.

Operation, **maintenance**, and **surveillance** (OMS) are fundamental to the day-to-day management of tailings facilities. To be effective in contributing to responsible tailings management, OMS activities must be:

- planned in a manner that considers the performance objectives and **risk** management plan of the tailings facility;
- designed to support and be integrated with a site-specific tailings management system;
- clearly documented in a site-specific OMS manual;
- consistently implemented as described in an OMS manual;
- linked to a decision-making framework for tailings management; and
- reviewed and updated, as appropriate, on a regular basis.

An effective OMS manual:

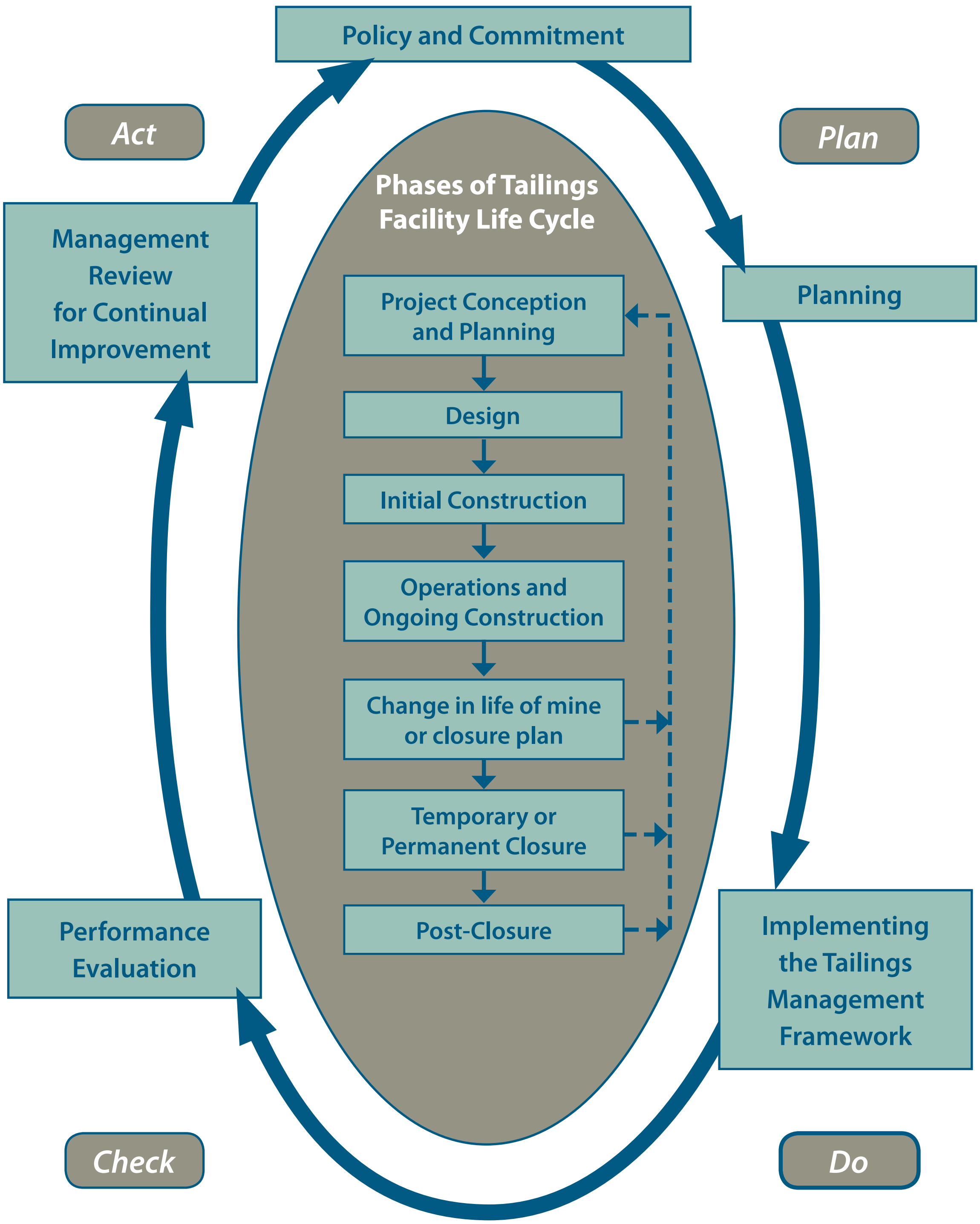
- provides a framework for OMS activities related to tailings management;
- documents and communicates OMS practices to **Owners**, their employees, contractors, and consultants involved in tailings management;
- provides a basis for measuring performance of the facility and for effective decision-making for tailings management; and
- documents the roles, responsibilities, and levels of authority of personnel who perform key activities related to tailings management.

1.1 The Tailings Guide

The Mining Association of Canada's (MAC's) *A Guide to the Management of Tailings Facilities* (the Tailings Guide) describes a tailings management framework that provides the basis for Owners to implement a site-specific tailings management system. Elements of this framework, illustrated in Figure 1, are:

- Policy and Commitment;
- Planning;
- Implementing the Tailings Management Framework;
- Performance Evaluation; and
- Management Review for Continual Improvement.

Figure 1: Elements of the Tailings Management Framework



1.2 The OMS Guide

This OMS Guide recommends rationale, organization and contents for developing an effective site-specific OMS manual. Owners of tailings facilities are encouraged to use this OMS Guide to prepare their own site-specific OMS manuals.

The OMS Guide emphasizes that OMS activities must be planned, designed, and implemented in an integrated manner, consistent with the design intent, performance objectives, risk management plan, **critical controls,** the current conditions, and closure objectives of the tailings facility. Outcomes of OMS activities are used to support decision-making for responsible tailings management across all phases of the life cycle.

The objective of the OMS Guide, together with the Tailings Guide, is to continually work towards optimizing tailings facility performance and managing risk. This approach will also minimize potential harm attributable to tailings management.

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.

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

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.

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.

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.

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.

2 Life Cycle Management of an OMS Manual

2.1 What is an OMS Manual?

2.1.1 Objective of an OMS Manual

An OMS manual is intended to facilitate improved **risk** management and **tailings facility** performance, achieving the design intent, and meeting legal requirements, corporate policy, and commitments to **communities of interest (COI)**. To achieve this, an OMS manual defines and describes:

- roles, responsibilities, and levels of authority of personnel who perform activities related to **tailings** management;
- the components of the facility covered in the scope of the OMS manual; and
- plans, procedures and processes for:
  - the **operation**, **maintenance**, and **surveillance** of the tailings facility to ensure that it functions in accordance with its design, meets performance objectives, regulatory and corporate policy obligations, supports the risk management plan, and links to **emergency** preparedness;
  - evaluating performance of the facility, and reporting performance results; and
  - managing change.

2.1.2 Elements of an Effective OMS Manual

An OMS manual is developed by and for those responsible for tailings management. It is a "hands on" practical document used by personnel involved in tailings management. OMS manuals are written in a clear, accessible manner, such that they are effective tools used by personnel on a day-to-day basis. An OMS manual is as concise as practical and includes information regarding how more detailed information can be accessed. Regular review and updating of an OMS manual are required to ensure it is up-to-date at all times.

Personnel includes employees, contractors and consultants (e.g., designer, Engineer-of-Record) and includes those with direct responsibilities for tailings management as well as those with indirect responsibilities whose roles may be related in some manner to tailings management (e.g., heavy equipment operators working on or adjacent to tailings facilities).

An OMS manual is not written for regulators or the public, although an Owner may share components of an OMS manual. Specific components may address legal requirements, but these requirements must not drive the development, content, or implementation of the manual.

It is essential that an OMS manual be aligned with the risk profile of the tailings facility to which it is applied, as further discussed in *Section 2.2.2*. Linking the facility's risk management plan with OMS activities is at the core of an effective OMS manual. This includes specifying actions to be taken if performance criteria or critical controls are not met, including the potential implementation of the site's emergency response plan (see Section 5.2 of the Tailings Guide).

There are a range of other factors that also need to be considered in developing an OMS manual, including the design intent of the facility, legal requirements, corporate policy, and commitments to COI.

OMS manuals require regular reviews and updates. This is consistent with the evolving nature of the risk profile of tailings facilities throughout their life cycle. Additional guidance on reviewing and updating OMS manuals is provided in *Section 2.6*.

An OMS manual clearly describes the boundaries of its scope of application. The scope needs to include all operational controls that can influence the performance and risk management of the tailings facility (e.g., tailings transport, placement of tailings in the facility, physical containment of the tailings, water management and reclaim, erosion and dust control). The scope is defined on a site-specific basis, taking into account the characteristics and life cycle stage of the tailings facility and linkages with other relevant plans and procedures (see *Section 2.4.3*). Scope may be defined geographically (e.g., all activities within a specified geographic area are defined as within the scope of the OMS manual). The scope may also be defined organizationally (e.g., road maintenance may be outside the scope of the OMS, even for roads required to access the tailings facility).

An OMS manual for a tailings facility is one of many documents that describe plans and procedures for various activities at a mine site. As described further in *Section 2.4.3*, linkages between the OMS manual and these other plans and procedures need to be clearly described.

In summary, an effective OMS manual:

- is site-specific, not "off-the-shelf" and:
  - aligned with the design intent and the life cycle phase of the facility;
  - addresses the specific conditions and circumstances of the site;
  - reflects the risk profile of the facility, build upon the risk management plan, and integrates critical controls;
  - contains or links to all information needed to conduct OMS activities; and
  - integrates the knowledge and experience of personnel who have worked on the site;
- defines roles, **responsibilities**, and levels of **authority** for personnel involved in tailings management;
- is integrated with overall site plans and procedures;
- provides a basis to make informed decisions about tailings management;
- is written:
  - by employees with specific and detailed knowledge of the tailings facility, with input from consultants or other third-parties as appropriate;

  - for personnel directly involved in tailings management, and not for other audiences such as regulators, senior management, or COI;
  - in a clear, concise, easily understandable manner;
- is easily accessible to users, including in electronic format;
- is accurate and up-to-date;
- is a controlled document, with mechanisms to ensure that all personnel are working with the most up-to-date version;
- is improved over time, reflecting feedback from performance evaluations, action plans to address deficiencies or for **continual improvement**, and lessons learned by personnel involved in tailings management; and
- it GETS USED.

It should be noted that this OMS Guide is not intended to be prescriptive. However, the term "need" is used in many places to emphasize elements that the authors believe an OMS manual needs to include or address to be effective.

2.1.3 Life Cycle Approach

As described in Section 2.3 of the Tailings Guide, Owners face the challenge of responsible management of tailings facilities throughout all phases of their life cycle. The progression of the life cycle of a tailings facility is often not linear. For example, changes such as enlargements of the footprint of tailings facilities, care and maintenance suspensions (and subsequent re-starts), or process and technology changes may occur. The dynamic nature of the life cycle of tailings facilities means that a systematic, risk-based management approach is essential, with OMS activities planned and implemented to address the particular risk management needs of each life cycle phase.

An OMS manual needs to be in-place and ready to be implemented at the beginning of the **operations and ongoing construction** phase. An OMS manual may also be implemented during the **initial construction** phase. An effective OMS manual is also an invaluable tool for any planned or unplanned interruptions in operations that may occur. The life cycle of an OMS manual is further discussed in *Appendix 1*.

2.2 Overarching Principles

2.2.1 Linkages to Tailings Management Systems

As described in the Tailings Guide, implementation of a site-specific tailings management system is a best practice for responsible tailings management, providing a rigorous, systematic approach to facilitate:

- implementation of appropriate levels of corporate **accountability** and operational responsibility and authority for tailings management;
- improved facility performance, and conformance with facility performance objectives, legal requirements, corporate policy, and commitments to COI;
- effective risk management; and
- continual improvement in tailings management.

Implementing site-specific OMS activities is an essential tool to implement a tailings management system. The tailings management system provides an overall framework, but an OMS is needed to make that framework function on a day-to-day basis.

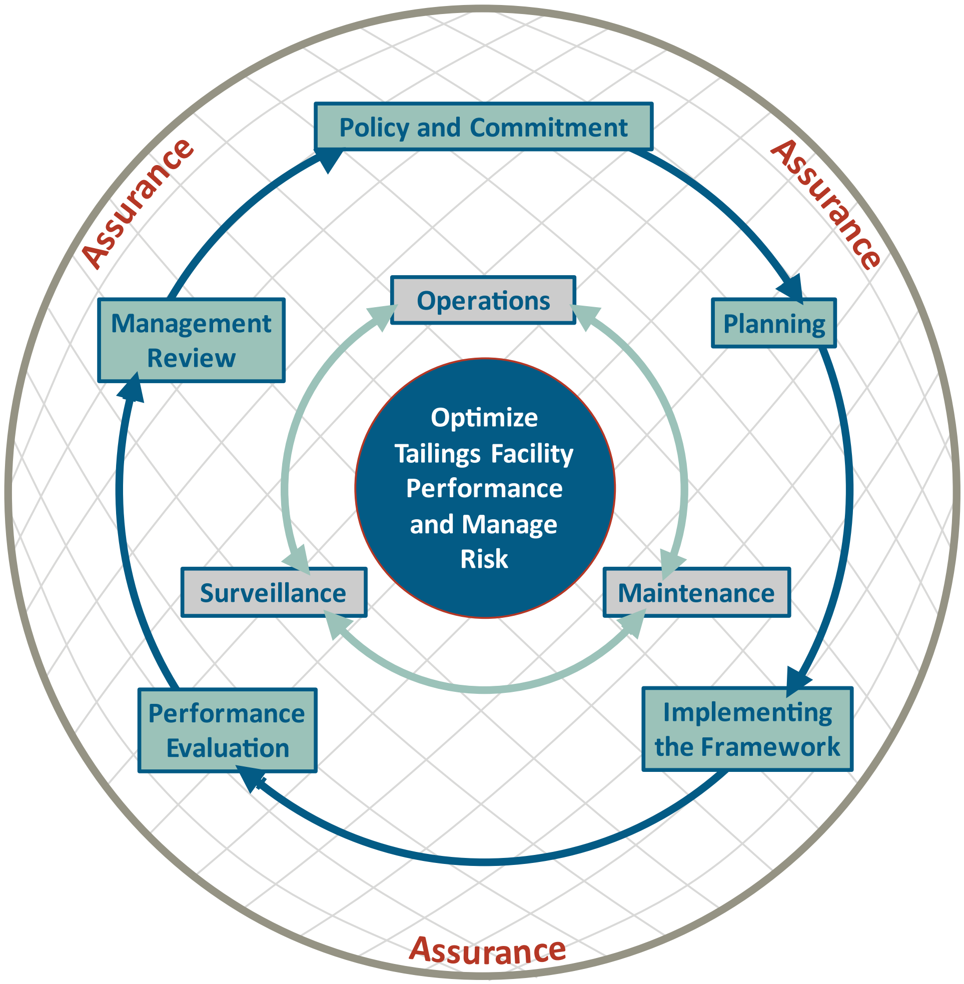
An OMS manual can be implemented in the absence of a tailings management system, but without such an overall framework it will be more difficult to:

- manage risk;
- set and meet performance objectives;
- know if performance objectives are being met;
- make informed and timely decisions; and
- improve performance.

To optimize tailings facility performance and manage risk, it is best practice to implement a site-specific tailings management system supported by an OMS manual. When implemented together, a tailings management system and OMS are intimately linked, as illustrated in Figure 2. The tailings management system, including the risk management plan and critical controls, define OMS activities. In turn, OMS activities operationalize the tailings management system and inform the Performance Evaluation element of the management system. The Management Review for Continual Improvement may lead to the development of action plans to improve both the tailings management system and the OMS manual. The grid pattern underlying Figure 2 signifies the many layers and directions of linkages between the two.

At sites implementing both a tailings management system and an OMS manual, activities described in the OMS manual must be aligned with and support the tailings management system. However, an OMS manual needs to remain a practical document, with those linkages to the tailings management system not explicitly described in the OMS manual.

Figure 2: Linkages between as tailings management system and OMS activities



2.2.2 Risk Management and Critical Controls

The assessment and management of risk and subsequent development and implementation of risk management plans are essential to effective tailings management (see Sections 2.2.1, 4.1 and Appendix 1 of the Tailings Guide). An OMS manual must be aligned with the risk management plan as OMS activities are essential to the implementation of the plan. As the risk management plan is revised throughout the life cycle, the OMS manual must be revised accordingly.

A risk management plan identifies mitigation measures 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.

A critical control is defined in the Tailings Guide as "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." Those risk controls defined as critical will be determined on a site-specific basis, based on the risk assessment. Critical controls are further described in Section 4.4.3 of the Tailings Guide, and examples of possible critical controls are provided in *Appendix 2* of this Guide. The key steps in the identification, development, and implementation of critical controls are to identify and evaluate:

- potential high-consequence events and associated 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.

An OMS manual defines all critical controls for that facility, and for each control describes:

- associated OMS activities;
- performance criteria, measurable performance indicators, and surveillance requirements; and
- actions to be taken if performance is out of specified ranges, indicating that control has been lost or that a loss of control may be imminent.

Operation and maintenance activities for critical controls are inextricably linked to surveillance: without surveillance, there is no control. Consequently, implicit in the description of operation and maintenance components of critical controls management are the associated surveillance activities.

If control is lost, this may constitute an emergency and the emergency response plan (see Section 5.2 of the Tailings Guide and *Section 4* of this Guide) would be implemented. Circumstances that would constitute an emergency must be identified during the risk assessment and linkages to the emergency response plan need to be described in the corresponding critical control procedures.

For some performance criteria a series of trigger levels of increasing concern/severity may be described, rather than a single trigger level. Using this approach, surveillance results would be categorized as reflecting normal, upset or emergency conditions. Emergency conditions would trigger the implementation of the emergency response plan. Upset conditions may represent a range of performance between normal and emergency. An Owner may define various alert or action levels within upset conditions. This concept is described further in *Appendix 3* using the example of a Trigger Action Response Plan (TARP).

> 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.

2.2.3 Managing Change

Change is a source of risk and needs to be effectively managed. Tailings facilities change on an ongoing basis throughout their life cycle, and the broader environment within which tailings facilities exist is also changing. Changes in personnel or organizational structure, including the **Owner's** employees, contractors and consultants, as well as changes in ownership.

Changes may be substantial and their potential implications for tailings management evident and planned for, such as a decision to extend the life of a mine and the associated tailings facility. However, the cumulative impacts on risk of incremental or gradual changes can be underappreciated or unanticipated. This ties to the concept of normalization of deviance, in which people become so accustomed to deviations from normal or expected behaviour that deviation becomes the norm[1]. In the context of tailings management, this can mean that over time, repeated deviations from performance criteria (e.g., a less than acceptable freeboard) can become the norm as personnel become accustomed to these deviations. In the face of a lack of consequences (e.g., the dam didn't fail) a complacent attitude can take hold. Vigilance, training, and effective communications are vital to avoiding complacency and ensuring that deviations from performance criteria do not become the accepted norm.

Section 4.4.2 of the Tailings Guide provides guidance on the development and implementation of processes to manage change. In the context of OMS manuals, there are two facets to managing change:

- OMS manuals are tools to help manage change; and
- OMS manuals need to reflect change.

OMS Manuals as Tools to Manage Change

The development and ongoing review of OMS manuals address transitions between life cycle phases. Other potential changes, such as the potential for temporary shutdown of operations, also need to be addressed (see *Appendix 1*). The development and review process also addresses the need to revise OMS activities to reflect planned changes, such as increase an in mining rate, increases in tailings dam height, or progressive reclamation activities. It is difficult to plan for every plausible change that may occur, but an effective OMS manual provides a basis from which to manage change, whether anticipated or not. In the event of changes, including deviations of performance, that were not anticipated and not addressed in an OMS manual, relevant sections of an OMS manual should be referred to, to guide and inform an effective response to the change.

OMS manuals are valuable in helping to manage changes in personnel. An OMS manual documents the site-specific knowledge of OMS activities acquired by personnel. In addition, an OMS manual is a tool for training personnel to understand the tailings facility and their specific roles and responsibilities related to tailings management.

OMS, particularly surveillance activities, helps identify changes that must be managed, including those linked to performance objectives, risk controls, and critical controls. These may include gradual or incremental changes such as changes in performance.

1. "Normalization of deviance means that people within the organization become so much accustomed to a deviant behavior that they don't consider it as deviant, despite the fact that they far exceed their own rules for the elementary safety" *http://www.consultingnewsline.com/Info/Vie%20du%20Conseil/Le%20Consultant%20du%20mois/Diane%20Vaughan%20(English).html*

OMS Manuals Need to Reflect Changes

An outdated OMS manual is a risk to any tailings facility. If OMS activities being implemented are not reflective of current conditions, resulting management actions may be at odds with the risk management plan and associated critical controls required for intended performance of the facility. Review and updating of OMS manuals is further discussed in *Section 2.6*, and control of **documented information** is further discussed in *Section 2.7*.

2.3 Informing Decision-Making

To **minimize harm**, optimize tailings facility performance and manage risk, Owners must make informed decisions about tailings management. A tailings management system provides a governance framework for decision-making and OMS activities play an essential role in providing information. Without a rigorous approach to decision-making for tailings management, informed by surveillance results, there is an increased risk that decisions:

- are based on incomplete or inaccurate information;
- are ad hoc and short-sighted in nature; and
- may fail to support the objectives of optimizing performance and managing risk.

Outcomes of OMS activities provide a basis to make informed decisions, based on the performance objectives and the risk management plan, and informed by a range of inputs, including:

- design intent/criteria of the facility;
- updated risk assessment;
- closure and post-closure objectives;
- performance of the facility;
- the life cycle phase of the facility;
- legal requirements;
- corporate policy; and
- commitments to COI.

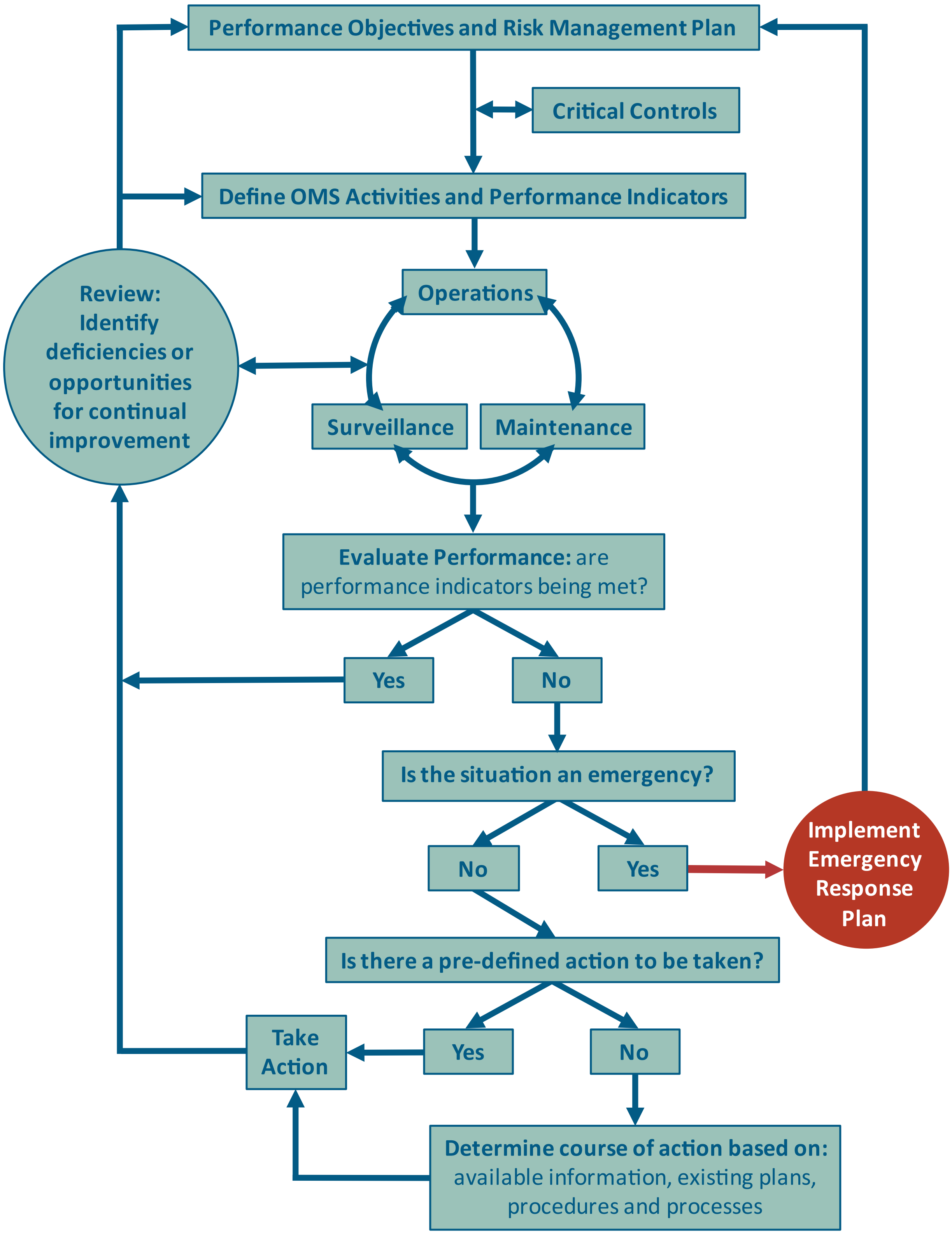
A rigorous approach to decisions provides a structured, consistent mechanism for decision-making, helping to ensure that decisions are taken by persons with the appropriate authority and competencies, and are based on relevant information. Such an approach can be inclusive of the full range of decisions associated with tailings management, including those with pre-defined management actions based on surveillance results. In the case of an un-anticipated event or surveillance outcome, an OMS manual and decision-making framework can help inform an appropriate response.

To facilitate decision-making an OMS manual describes the accountability, roles, and responsibilities of those making decisions, including the limits of their decision-making authority, and the lines of communications across the organization. These aspects are addressed further in *Section 3.1*.

A generic decision-making framework for tailings management is illustrated in Figure 3. This is an illustrative example only, with simplified "yes/no" decision points. The reality may be more complex, but the intent is to visually capture how decisions are made, and where OMS fits in that process.

The observational method offers one possible conceptual approach and framework for decision-making. This method is summarized in *Appendix 4*.

Figure 3: Decision-making framework for tailings management



2.4 Developing an OMS Manual

2.4.1 Owner-led Development Team

Development of an OMS manual is led by a team of employees (as opposed to contractors or consultants) with responsibilities for various aspects of tailings management at the site[2], and there needs to be one person with designated lead responsibility for the OMS manual – the owner of the OMS manual.

Specific third-party expertise should be sought for certain aspects of an OMS manual. For example, input from the designer and **Engineer-of-Record (EoR)** is necessary. If members of the development team do not have sufficient experience in developing an OMS manual, then it would be appropriate to hire a contractor to work with them in a supporting or advisory role, rather than hire a third-party to take over its development.

The development team must be multidisciplinary and reflect all aspects related to tailings management and coordinated with other aspects of site operations that relate to tailings. For the development of an initial OMS manual for a new tailings facility, the team would include those involved in planning the tailings facility. Once operational experience is gained, the team includes those directly involved in tailings management so that the updated OMS manual reflects actual conditions and practices.

An effective OMS manual must not be written from a single technical perspective. Rather, it needs to be reflective of the risk profile of the facility and identify OMS activities to address those risks, be they physical or chemical, or both. For example, an OMS manual must not focus solely on geotechnical aspects of tailings management if there are chemical risks to be managed.

To prepare an OMS manual, the development team may draw on information from a wide range of sources, as described in *Appendix 5*.

2.4.2 Usability and Accessibility of OMS Manuals

An OMS manual needs to provide the right information in a clear, well-written manner, and it needs to be presented in a usable structure and format that is readily accessible to personnel involved in tailings management.

> The target audience for an OMS manual is all personnel involved in tailings management, including those new to the tailings facility and those who are less experienced or have less specialized competencies, and who may not be fully aware of the "big picture" of tailings management and the potential consequences of not conducting OMS activities in accordance with design intent and performance objectives.

The development team needs to write an OMS manual in a manner that addresses the needs of the intended audience, including:

- writing an OMS manual in clear, concise language, using maps, figures, photos or tables as appropriate to illustrate;

2. The development team should engage personnel with responsibilities related to permitting activities and regulatory affairs. This will help to ensure communications between these groups and help ensure that the OMS activities address legal requirements.

- providing the right level of detail, with links to how more detailed information can be accessed (e.g., surveillance section addresses the need to calibrate instruments, but calibration procedures can be provided through links to documentation from the instrument manufacturer);
- identifying the potential risks and consequences of not conducting OMS activities as prescribed in the OMS manual; and
- focusing on information directly related to OMS activities, avoiding unnecessary description of broader concepts related to tailings management (e.g., tailings management system).

The information contained in an OMS manual needs to be sufficiently detailed to allow personnel to properly operate and maintain the facility and to understand through surveillance when situations are developing that may require action, and whom to contact.

One key consideration in making an OMS manual accessible is how it is structured. In this regard, "manual" may not be the most appropriate term since it implies a single document. Given the complexity and variety of OMS activities across the life cycle of tailings facilities, compiling an OMS manual as a single document may be a barrier to making the manual accessible. It may be better to structure an OMS manual as a series or system of linked modules, with each module addressing a specific topic or type of activity and reflecting input from personnel involved in that activity. For example, a short module specific to surveillance of piezometers in a tailings dam is more accessible to personnel responsible for that surveillance than embedding that information in a larger and more all-inclusive manual. Similarly, OMS activities specific to a temporary shut-down and subsequent re-start could be described in a separate module that would be implemented only in the event of such a shut-down.

For a modular approach to be effective, each module must clearly state where it fits in relation to other modules and what the linkages are. Flowcharts showing the linkages and communication pathways between the different modules may be used to help ensure proper flow of information and an understanding amongst users of who is responsible for what activities associated with the facility.

Although a modular approach is potentially more decentralized in structure than having a single manual, there must still be a designated owner of the OMS manual, and the modules need to be managed as controlled documents, as described in *Section 2.7*.

The final consideration in accessibility of an OMS manual is the format in which it is made available to personnel. The most appropriate format will depend on the site, the degree of information management support available, on-site availability of portable computers or mobile devices, and availability of mobile networks or wireless internet connectivity on-site.

In some cases, the most appropriate format may be to have an OMS manual available in paper copy only, even if a modular approach is used. However, providing an OMS manual only as a paper document has significant limitations:

- Document control is more challenging (see *Section 2.7*). If personnel have paper copies, it is challenging to ensure that all paper copies are up-to-date when changes are made.
- Using paper copies makes it impossible to hyper-link to relevant documents, so the development team will have to decide if those documents are to be included in the OMS manual. In the example above about instrument calibration procedures, if paper copies are used the development team may opt to include those procedures in the paper copy of the OMS manual, adding to the size of the OMS manual.

If the Owner has the technologies in place to do so, it is preferable to distribute an OMS manual electronically. This will make it easier to address document control and linking with other documents and makes it easier to distribute the manual. An electronic version available on a range of devices will make it easier for personnel to access relevant content and associated reference materials. Potential options that allow document control include:

- a PDF (portable document format) document with hyperlinks to other sections or modules and to reference documents, and automatically updated when a device is connected to the Owner's network; or
- a web-based system of OMS modules, accessible via mobile network or wireless internet (e.g., a "wiki" type of structure, such as that used for the *Global Acid Rock Drainage (GARD) Guide)*.

2.4.3 Linkages to Other Systems

An OMS manual needs to clearly describe linkages with other relevant plans and procedures, how these other plans and procedures (see examples below) relate to tailings management and OMS activities, and associated roles, responsibilities and communications procedures across the various personnel or groups responsible, in order to:

- avoid duplication;
- ensure consistency of implementation of related activities;
- prevent any gaps that can impact tailings management; and
- provide clear documentation of these linkages to ensure continuity in the event that personnel, or that plans and procedures outside the scope of the OMS manual, change.

The development team needs to collaborate with other groups on site to ensure that these other plans and procedures (see examples below) do not conflict with those in the OMS manual, and with the broader objectives of responsible tailings management.

Examples of Linkages:

- If mine water is managed in the tailings facility, and aspects of the risk profile are related to water, then the OMS manual needs to reflect this and linkages with plans and procedures for mine water management needs to be clearly described. Those responsible for tailings management will need to collaborate with those responsible for ore extraction operations to ensure alignment of plans and procedures and ensure that the overall environmental management objectives are met.
- Tailings characteristics, such as grain size and in many cases the percentage of solids, are determined in the ore processing facility. Specifications regarding these parameters are important to meeting the design intent of the tailings facility, and deviations can impact the risk profile. Those responsible for tailings management need to collaborate with those responsible for ore processing to ensure that these specifications, and the implications of not meeting these specifications, are understood, and that changes in tailings characteristics do not compromise tailings facility performance.

2.5 Implementation of an OMS Manual

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

- are aware of its purpose and importance;
- know how to access the OMS manual;
- understand their roles, responsibilities, and level of authority related to tailings management;
- have the knowledge and competence to fulfill their roles and responsibilities; and
- understand the OMS activities they are engaged in.

Training is needed to help ensure that personnel have the necessary knowledge, skills and competencies to fulfill their roles and responsibilities related to tailings management. There are three components to training:

- training for new personnel;
- refresher training at a frequency determined by the Owner, taking into account the risk profile of the facility; and
- training associated with updates to the OMS manual.

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.

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

It may be more appropriate to address these training requirements in a separate training program, as described in Section 4.4.4 of the Tailings Guide. Regardless of where an Owner describes these training requirements, is it essential that appropriate training be provided.

2.6 Reviews and Updates of an OMS Manual

Regular reviews of an OMS manual must be undertaken. The frequency of reviews will vary depending on the risk profile of the facility and the life cycle phase. Frequency needs to be prescribed by the Owner to ensure that reviews are conducted on a pre-determined schedule. Annual reviews are considered a best practice for tailings facilities in the operating and ongoing construction phase. Given the range of activities occurring as the closure plan is implemented, it may be appropriate to continue with annual reviews during the **closure** phase. Reviews of OMS manuals may be less frequent during the **post-closure** phase, depending on the risk profile and site conditions.

In addition to scheduled reviews, a review may be triggered by a significant event or departure from expected conditions (e.g., a significant increase in ore production rate, leading to an increase in the volume of tailings being produced).

In conducting reviews, the development team needs to consider a wide range of information, including:

- performance of the facility;
- deviations from the approved design;
- the current life cycle phase of the facility (see *Section 2.1.3* and *Appendix 1*);
- status of progressive reclamation activities;
- relevant advice and recommendations from site inspections, **Independent Review**, **audit**, and **evaluation of effectiveness**;
- changes since the last review in:
  - site conditions;
  - ore processing or tailings characteristics;
  - characteristics of the tailings facility (e.g., increased dam height since the last review);
  - performance objectives and indicators;
  - risk profile of the tailings facility;
  - critical controls;
  - personnel or organizational structure;
  - methodologies and technologies for OMS activities;
  - legal requirements;
  - COI perspectives; and
  - closure plan;
- plans to address any gaps or deficiencies in performance;
- plans for **continual improvement**; and
- future plans for the tailings facility.

An OMS manual must document site-specific knowledge, experience, and lessons-learned of personnel. This helps to manage changes in personnel, by documenting site memory and accumulated knowledge so that it can be passed on to new personnel.

When reviewing an OMS manual, the development team needs to consider practical experiences and lessons related to OMS activities by obtaining input from a range of users of the OMS manual including key roles such as the EoR and personnel involved in day-to-day OMS activities.

At sites where a tailings management system is in place (see *Section 2.2.1*) the Performance Evaluation and the Management Review for Continual Improvement may inform the review of the OMS manual, including identifying deficiencies or opportunities for continual improvement.

When reviewing an OMS manual and considering changes, the potential impacts of proposed changes on the risk profile of the tailings facility need to be considered (see Section 4.4.2 of the Tailings Guide). This includes consideration of the potential cumulative impacts of past changes or deviations. This helps to reduce the risk of complacency in the conduct of OMS activities, and to reduce the potential for short-term operational decisions to increase risk. If any changes are made to the OMS manual which could impact the risk profile, the rationale for these changes need to be documented, and the decision to make these changes needs to be taken at a level commensurate with the associated change in the risk profile.

Reviews of an OMS manual may lead to updates to the entire manual, or to certain modules. An OMS manual may also need to be updated in response to:

- planned changes, such as changes in surveillance instrumentation or methodologies, or introduction of new instrumentation or methodologies;
- changes in personnel or roles referred to in the OMS manual; and
- other changes that may occur that need to be addressed prior to the next scheduled review of the OMS manual.

Updates, such as those related to changes in personnel, need to be completed in a timely manner, and may be more frequent than updates to address outcomes of reviews of an OMS manual.

2.7 Control of Documented Information

Information necessary for effective tailings management and the development and implementation of an OMS manual needs to 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.

An OMS manual needs to be a controlled document, including:

- defining the process for reviewing and updating the OMS manual, including both major (e.g., change in surveillance procedures) and minor (e.g., changes in personnel) updates;
- identifying persons with authority to revise the OMS manual and the scope of their authority (e.g., some may only have the authority to amend certain sections or modules);
- describing mechanisms for approval of revisions to the OMS manual; 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 OMS manual and supporting documents (i.e., distributing paper copies or providing access to electronic versions, as discussed in *Section 2.4.2*);
- informing personnel of changes to the OMS manual relevant to their roles and responsibilities;
- control of reference information used to develop and update the OMS manual, or referred to in the manual;

- 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.

Access to an OMS manual 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 that are accessed electronically. There may be OMS components 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 the OMS manual 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 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 date storage medium.

3 Contents of an Effective OMS Manual

This section addresses aspects to be considered by an OMS manual development team in developing a site-specific OMS manual. The structure of this section may provide a potential outline of the structure of an OMS manual, but as described in *Section 2.4.2,* it is up to the development team to identify the best way to structure their OMS manual.

The sections below provide guidance for an OMS manual development team. However, given the wide range of conditions under which **tailings facilities** are operated, and the different OMS requirements across the **life cycle** of any given facility, there are few specific OMS activities that may be considered universally applicable.

3.1 OMS Governance

3.1.1 Roles, Responsibilities, and Authority

Personnel involved in **tailings** management need to understand their roles and their lines of communications and relationships with others with direct or indirect roles related to tailings management. An OMS manual describes:

- tasks and functions related to OMS activities;
- roles, **responsibilities**, and level of **authority** of personnel or groups that assume these tasks and functions, including the **Responsible Person(s)** and the **EoR**, and other key personnel involved in tailings management; and
- functional relationships and lines of communications:
  - between personnel and groups involved in OMS activities;
  - with personnel and groups outside the scope of the OMS manual and involved in activities that may affect tailings management; and
  - with external parties, including regulators and **COI**s.

Table 1 presents examples of roles and responsibilities for a tailings facility.

In describing roles, responsibilities, levels of authority, and relationships, an OMS manual development team should focus on functional relationships, rather than organizational relationships as typically described in organizational charts. This approach may be useful for overcoming functional and communications silos that may be unintentionally reinforced by organizational structures.

An OMS manual development team may opt to use a responsibility assignment matrix or RACI (responsible, accountable, consulted, informed) matrix to describe roles and relationships between employees, and also with contractors and consultants, including the designer and EoR (see *Appendix 6*).

An OMS manual clearly describes the relationship between the **Owner** (specifically the Responsible Person(s)) and their contractors and consultants. This is particularly important with respect to the collection and analysis of **surveillance** data linked to **critical controls** management.

An OMS manual needs to clearly address:

- Who is responsible for surveillance data acquisition and analysis?
- What are the lines of communications for reporting in the event that results are outside the range specified for the critical control performance criterion?
- If critical control performance criteria are exceeded:
  - What actions are the Responsible Person(s) and other personnel expected to take?
  - What actions are the contractor or consultant expected to take?

Actions to be taken by the Responsible Person(s) and other employees must be clearly described so that appropriate action can be taken in the event that the contractor or consultant cannot be contacted in a timely manner.

Table 1: Examples of potential roles and responsibilities

Responsible Person(s)
■ Establish a budget for approval ■ Establish an organizational structure with roles and responsibilities that meets the operational needs ■ Establish a formal relationship with the designer and EoR to ensure construction and operation are compliant with design ■ Ensure facility surveillance is undertaken in accordance with design intent, performance objectives, the risk management plan and critical controls ■ Maintain records related to design, construction, and operation, maintenance, and surveillance ■ Ensure inspections (e.g., dam safety inspections or dam safety reviews) are completed ■ Review and update the OMS manual ■ Comply with operational boundaries set out in the design (by following the OMS manual) ■ Maintain and test emergency response plans, or components of site-wide emergency response plans directly related to tailings management ■ Implement measures to remedy deviations from performance objectives, or criteria specified in the risk management plan ■ Implement an Independent Review process ■ Identify when/where contemplated operational changes are a potential deviation from the design intent and engage the designer or EoR as part of processes to manage change
Engineer-of-Record
■ Input into the OMS activities in accordance with the design ■ Receive and review the OMS manual on a regular basis ■ Receive and review facility performance data at a frequency determined based on the risks ■ Either confirm operation is compliant or identify deviations from performance objectives and advise the Owner with recommendations ■ Advise on contemplated changes to the facility’s operation ■ Maintain records relating to design construction and operation ■ Participate in inspections and Independent Review

3.1.2 Communications

An OMS manual needs to clearly describe lines and expectations for communications as they relate to the inputs to and outputs from OMS activities. However, there are limits to what can be achieved in this regard within the text of an OMS manual. 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**. An OMS manual, effectively implemented with clear communications, clear roles and responsibilities, linked to a tailings management system and a decision-making framework (see *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*.

3.1.3 Tracking of OMS Activities

An OMS manual describes processes and procedures to track the implementation of OMS activities, including identifying:

- Who is accountable for ensuring the activity is conducted as required?
- Who is responsible for carrying out the activity?
- What is the schedule at which the activity is to be conducted?
- How is implementation of the activity tracked, and how and when is that information reported to the accountable person?

The tracking system provides a mechanism to assure the accountable person that the activity has been conducted as scheduled. The tracking system needs to include a mechanism to flag occurrences when the activity has not been conducted as scheduled, providing the accountable person with the information they need, in a timely manner, to be able to take appropriate action.

3.1.4 Quality Management

A quality management plan needs to be in place to address a wide range of aspects related to tailings management, including OMS activities. There are two components to quality management: quality assurance (QA) and quality control (QC).

An OMS manual needs to describe quality management requirements, processes, and procedures for OMS activities. For **maintenance**, this could include, for example, describing procedures to verify that maintenance activities have been conducted as specified (e.g., the correct amount of oil was added during an oil change). For surveillance, the quality management plan would include information such as:

- required frequency and methodology for calibration of instruments; and
- protocols or **standard operating procedures** to collection of samples for laboratory analysis to prevent cross-contamination, sample preservation requirements, and procedures to document chain of custody.

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 requirements.

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 require.

3.1.5 Reporting

An OMS manual describes reporting relationships between different individuals and business units with direct and indirect roles related to tailings management. An OMS manual also describes, in a more detailed manner, reporting relationships and how information related to specific OMS activities needs to flow. An OMS manual also needs to describe processes and procedures for reporting outcomes of OMS activities.

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

3.1.6 Training and Competence

An OMS manual describes minimum knowledge and competency requirements for each position with defined responsibilities. These requirements can be described using attributes for each position, which can assist in recruiting personnel with the appropriate knowledge and competencies and can also help personnel identify career development goals and opportunities which may help with staff retention.

As discussed in *Section 2.5* and in Section 4.4.4 of the Tailings Guide, training requirements need to be identified to ensure that competencies are met and updated or renewed as appropriate. Training programs need to be developed and implemented to ensure that appropriate training is provided to personnel working at the facility.

3.1.7 Succession Planning

Changes in personnel can be a source of risk for tailings management, and succession planning is a tool to help manage that risk. The development and implementation of succession plans would typically be outside the scope of an OMS manual. However, an OMS manual development team needs to identify roles or positions for which succession planning would be important to manage risks. An OMS manual describes knowledge and competency requirements, transition plans, and handover procedures for those roles or positions.

3.1.8 Resources and Scheduling

For effective development and implementation of an OMS manual, and for reviews and updates, the Owner needs to identify, secure, and regularly review adequacy of:

- human resources, external contractors, and consultants;
- condition, function, and suitability of equipment;
- financial resources; and
- schedules of OMS activities.

Descriptions of resource requirements, such as personnel and financial resources, should not be described in an OMS manual. However, an OMS manual can be used as a basis to estimate, justify, and secure required resources.

Schedules of OMS activities are described in an OMS manual. See *Sections 3.3*, *3.4* and *3.5*.

3.1.9 Occupational Health and Safety

The conduct of OMS activities can present unique occupational health and safety challenges. For example, surveillance activities may present risks not typically faced by other personnel working at mine sites, from working on or around water, to the risk of encounters with large animals. In conducting OMS activities, as in all other activities on mine sites, safety must be paramount.

It is essential that all OMS activities be conducted in accordance with best practices for occupational health and safety, and in conformance with the Owner's standards and requirements. Such activities must also be conducted in compliance with applicable legal requirements. Personnel must be provided with appropriate training.

3.2 Tailings Facility Description

There are many factors that could affect the performance and risk profile of a tailings facility throughout its life cycle, including (see *Appendix 8* for further examples):

- site conditions, including climate;
- COI perspectives;
- legal requirements and commitments;
- tailings facility characteristics;
- tailings facility performance; and
- future plans and how they may impact the tailings facility.

Understanding such information is essential to the responsible management of tailings and effective management of change. This information needs to be clearly documented, maintained, and retained.

An OMS manual refers to or summarizes this information and, if referenced, provides direction (potentially in the form of electronic links) to facilitate access and retrieval of pertinent information. The objective of this summary is to provide context, linking OMS activities to the risk profile of the facility, performance objectives, critical controls, legal requirements, etc., to help ensure that personnel understand the potential implications for tailings management of their individual role, responsibilities, level of authority, and actions.

3.3 Operation

Tailings facility 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.

This component of an OMS manual defines and describes plans and procedures for implementing operating controls that enable the tailings facility to be operated in accordance with the design intent, performance objectives, risk management plan, and critical controls for the facility.

3.3.1 Performance Objectives

Performance objectives are overall goals, arising from the Owner's policy and commitment, which are quantified where possible. Performance objectives are established based on:

- design intent of the tailings facility;
- environmental requirements;
- risk assessment and the level of acceptable impact and risk;
- risk management plan; and
- closure plan and post-closure land use.

Performance objectives need to be developed in collaboration with the EoR, Responsible Person(s), and other key personnel. Table 2 provides examples of possible operational controls to be addressed by performance objectives.

Performance indicators are measurable and quantifiable performance requirements that arise from the performance objectives that need to be defined and met to achieve the objectives. Performance criteria specify the expected or acceptable range of performance for each indicator and ranges of performance that may require that some specific corrective action be taken (i.e., link to critical controls, **TARPs**, etc.).

Table 2: Examples of operational controls to be addressed by performance objectives

Tailings transportation and placement
■ placement schedule and calibration
■ performance of dewatering systems
■ tailings characteristics (e.g., grain size, water content, chemical properties, sub-aerial and sub-aquatic beach angle, tailings dry density, strength, etc.)
■ performance of tailings transportation systems (e.g., pipeline, conveyor belt)
■ performance of associated electrical and mechanical systems (e.g., pumps, motors)
■ placement requirements (e.g., compaction, water content, trafficability)
Tailings containment
■ foundation specifications
■ construction specifications
■ construction material availability and scheduling of expansions (e.g., stack armoring, increases in dam height, new cells)
■ perimeter slopes
■ compaction activities
■ erosion control measures
■ dust control measures
■ measures to prevent wildlife access (e.g., bird deterrents)
Water management
■ water balance audits and calibration
■ freeboard and beach width
■ water discharge, volume and quality (normal operating conditions and special circumstances)
■ seepage control and collection
■ reclaim water management
Surveillance
■ surveillance requirements for operational performance indicators
■ thresholds for performance criteria to trigger pre-defined actions
Other
■ procedures to respond to unusual operating conditions (e.g., extreme cold, high rainfall, drought, high winds)
■ progressive reclamation activities

3.3.2 Operating Procedures

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

A standard operating procedure (SOP) is a set of established or prescribed methods to be followed routinely for the performance of designated operations or in designated situations. They may include procedures, standards, practices, protocols, instructions, rules, etc. The use of SOPs is intended to achieve quality outputs and consistent performance, while reducing the potential for misunderstanding and miscommunication. To be effective, SOPs must be consistently applied by all relevant personnel, and any changes to SOPs must be clearly documented and communicated.

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

SOPs are controlled documents that are reviewed as required and are included or referenced in an OMS manual.

Occupational health and safety and environmental considerations need to be described in SOPs and underpinned in the underlying risk assessment for a given tailings facility.

SOPs will vary from site-to-site and can be broadly classified into three general areas as described in the following subsections.

3.3.2.1 Tailings Transportation and Placement

A tailings transportation and placement plan needs to be developed based on the design intent, performance objectives and risk management plan, and is referenced and summarized in the OMS manual. Specific practices to implement the plan are described in SOPs and in an OMS manual, such as practices to:

- mitigate potential dust generation from the transport and placement of stacked tailings[3] (e.g., seasonal deposition restrictions);
- prevent freezing of tailings pipelines (e.g., specific pumping or placement practices for cold weather conditions); and
- adjust practices if there is a short-term lack of suitable cyclone sand to construct containment structures, due to variations in the ore feed.

3. Stacked tailings refers to a tailings facility where the tailings have been sufficiently dewatered that they can be transported by truck or conveyor belt. This includes tailings that have been dewatered by filtering, centrifuging, air drying, or other means.

The summary provided in the OMS manual covers the expected life of the plan and either demonstrates adequate capacity for the mining plan or emphasizes remaining capacity and the expected update frequency and date of latest update. The short-term (e.g., up to 24 months) tailings transportation and placement plan is implemented through SOPs.

SOPs for tailings transportation and placement describe the relevant elements of the tailings facility and performance objectives and indicators for tailings transportation and placement, such as:

- the expected tailings and/or water characteristics;
- the tailings and/or water transport and handling system;
- personnel and equipment required to effectively meet the performance objectives; and
- a summary of the life-of-mine placement plan, together with detailed, current-year annual plans identifying discharge locations, discharge schedule and planned construction, with reference to supporting reports and plans.

> During operation of a facility, the tailings may vary in physical, chemical and mineralogical characteristics. Representative samples of tailings need to be collected periodically for analysis. These analyses will be useful to verify any change in the physical, chemical and mineralogical characteristics of the tailings that could impact the transportation and placement plan (e.g., a change in the tailings specific gravity can affect the deposition slope of the material), effluent quality or the closure plan.

3.3.2.2 Ongoing Construction of Tailings Facility

An OMS manual identifies requirements and plans for staged tailings facility construction during the operations and ongoing construction phase of the life cycle, to maintain adequate solids storage capacity and water management, including:

- method(s) of stacking, hydraulic placement, and/or dam construction;
- schedule of facility expansions;
- material and equipment required;
- construction management procedures; and
- quality assurance and quality control measures and activities (e.g., documentation, as-built survey records).

An OMS manual describes performance objectives and indicators that the tailings facility construction plan and schedule are based on, and acceptable performance ranges for those indicators.

An OMS manual may also be developed for the **initial construction** phase of the life cycle.

3.3.2.3 Management of Water

Water must be effectively managed for all tailings facilities, regardless of the type of facility (e.g., stack, impoundment of slurry or thickened tailings). An OMS manual describes procedures for management of water associated with a tailings facility (see the definition of **tailings facility**) under normal operating conditions, as well as under circumstances such as abnormal runoff, severe precipitation events, rapid snow melt, or drought. An OMS manual must include a description of the expected water balance, including identification of all inputs, inventory of pond and interstitial water, and outflows.

An OMS manual describes the operating controls required to manage water under all operating and upset conditions. It also describes performance objectives and indicators for water management, and acceptable performance ranges for those indicators.

3.3.3 Site Access

An OMS manual describes procedures to control access to the tailings facility to assure facility integrity and safety of personnel and the general public. Hazards or safety restrictions related to human or wildlife contact with tailings and associated water need to be addressed, including risk to personnel working on or adjacent to the tailings facility. An OMS manual also describes procedures for third-party access where this is required for traditional uses or under landholder agreements.

3.4 Maintenance

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

The maintenance component of an OMS manual identifies and describes:

- all infrastructure (e.g., civil, mechanical, electrical, instrumentation, etc.) within the scope of the OMS manual (see *Section 3.3*) that has maintenance requirements; and
- preventative, predictive, and corrective maintenance activities.

There are three categories of maintenance activities:

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

- regularly scheduled oil change on a pump, as per manufacturers specifications; and
- calibration and maintenance of surveillance instruments.

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

- replacement of a section of tailings pipeline based on monitoring of the pipe thickness;
- removal of debris from a spillway based on debris accumulation; and
- removal of trees from dams or other structures.

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

- repair of erosion gullies;
- settling of a section of a dam or other containment structure, such that it is lower than the designed elevation;
- unplugging of toe drains; and
- replacement of a broken pump or failed section of pipeline.

The distinction between predictive and corrective maintenance may be arbitrary in some cases. However, both underscore the importance of ensuring that the maintenance section describes procedures for the timely analysis and communication of surveillance results so that maintenance activities can be undertaken.

Maintenance requirements are informed by the performance objectives and risk management plan. For example, failure modes and effects analysis (FMEA) combined with a bow-tie assessment (see Appendix 1 of the Tailings Guide) can be used to help identify requirements for preventative and predictive maintenance. This approach can also be used to identify potential corrective maintenance for events which have a high likelihood of occurring during the life of the facility, such as:

- power or communications failures;
- precipitate fouling;
- plugging of toe drains;
- deteriorating condition of surveillance equipment;
- damage from burrowing animals; or
- erosion gullies.

Examples of tailings facility components that should be considered for inclusion in the maintenance plan on a site-specific basis are provided in Table 3.

An OMS manual identifies maintenance activities that are within the scope of the manual and identifies those maintenance activities that could impact tailings management and are addressed in other related plans or procedures. For maintenance activities not addressed in the OMS manual, the OMS manual describes roles, responsibilities, and communications to ensure that those maintenance activities are carried out in a manner consistent with the requirements for tailings management. Examples of maintenance activities that may be outside the scope of an OMS manual include maintenance of:

- access roads;
- electrical system and supply;
- trucks for construction or hauling of filtered tailings;
- tailings thickener or filters; and
- pipelines.

Table 3: Examples of tailings facility components that may require maintenance

Some of these examples, such as maintenance of surveillance equipment, are applicable to any tailings facility. Other examples are specific to certain types of facilities using specific technologies (e.g., conveyors or filters).

Tailings transportation and placement
■ dewatering infrastructure (e.g., thickeners, filters) ■ tailings pipeline (e.g., wear and thickness) ■ paste plant ■ pumps ■ conveyors ■ classifiers ■ haul trucks
Tailings containment
■ dams, embankments or other containment structures (e.g., repair erosion, remove unwanted vegetation) ■ drains ■ seepage barriers
Water management
■ ditches and diversions ■ associated water storage facilities (e.g., seepage collection ponds, settling ponds) ■ evaporators ■ water control structures ■ pipelines ■ pumps, including reclaim
Surveillance
■ geotechnical instruments ■ air quality monitoring equipment ■ meteorological data instrumentation ■ data management, access and retention
Access and required equipment
■ roads, trails ■ heavy equipment and light vehicles ■ power supply and transmission ■ communications infrastructure

3.4.1 Description of Maintenance Activities

For all categories of maintenance activities, an OMS manual describes (or links to relevant references):

- the nature of the activity and the specific maintenance requirements (e.g., refer to manufacturers maintenance specifications, SOPs);
- location of the infrastructure requiring maintenance;
- qualifications or competencies required to conduct the maintenance (e.g., must be an electrician, must be certified to work in enclosed spaces);
- safety hazards and procedures;
- personnel or groups responsible for carrying out the maintenance;
- resources required to conduct the maintenance (e.g., equipment, materials, personnel);
- communications procedures associated with maintenance activities that potentially affect other activities;
  - e.g., for maintenance that requires that power be disrupted, what other infrastructure will be affected, when will it be affected, for how long, and when will power be restored, and who will need to know this.
- tracking and documentation requirements, such as:
  - tracking to ensure activity was completed in a timely manner;
  - documentation of the condition of the equipment or other observations made by personnel doing the maintenance;
  - documentation to demonstrate the activity was carried out appropriately; and
  - recommendations from personnel doing the maintenance;
- reporting requirements:
  - information to be reported;
  - how information should be reported;
  - to whom information needs to be reported; and
  - reporting timelines

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

For predictive maintenance an OMS manual also describes:

- pre-defined maintenance activities that are conducted based on results of surveillance activities (e.g., clearing of snow, clearing of debris from spillways); and
- linkages with surveillance activities, including:
  - associated surveillance parameters;
  - performance criteria linked to the need to carry out the maintenance; and
  - communications procedures to ensure that results of surveillance activities, and recommendations for maintenance, are documented and reported in a timely manner so that the maintenance activity can be carried out.

For corrective maintenance, an OMS manual also describes:

- likely, credible events based on risk assessment and critical controls;
- for each event, the pre-defined corrective maintenance activities;
- surveillance activities associated with those events;
- communications procedures to ensure that:
  - results of surveillance activities are documented and reported in a timely manner;
  - necessary resources are mobilized; and
  - corrective maintenance is carried out.
- procedures to return to normal operation (if applicable).

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

An OMS manual identifies materials (e.g., parts, filter material, rip rap) that must be kept in inventory on site to prevent delay in maintenance of components tied to critical controls. In addition, resources identified in emergency response plans must be kept in inventory on site, in the event that an emergency occurs.

> A key component of maintenance planning is preparedness to respond to breakdowns, incidents or conditions requiring maintenance. It is important; however, to distinguish between requirements for maintenance and emergency response: maintenance actions do not address emergency situations, which are covered in emergency response plans.

3.4.2 Documentation Associated with Maintenance

An OMS manual describes the information to be collected and recorded as part of the conduct of maintenance activities. Checklists or report forms may be included in an OMS manual or referenced. Examples of maintenance documentation include:

- equipment logs;
- work history;
- frequency and cause of problems;
- component reliability;
- quality control records;
- communications and activity records;
- photographic summaries and/or videos;
- inventory of spares, materials, tools and equipment; and
- change orders.

3.5 Surveillance

Surveillance involves 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. Surveillance results are used to identify trends and behaviours that are indicative of the tailings facility's actual performance.

An effective surveillance program is:

- conducted by a range of personnel with direct and indirect responsibilities related to tailings management;
- applied across the life cycle of a tailings facility, while adapting to the specific surveillance needs of each phase and changing site conditions;
- based on site-specific performance objectives and the risk management plan; and
- used to inform decision-making related to tailings management, based on the clear, timely reporting of surveillance results.

3.5.1 Design Considerations for a Surveillance Program

Surveillance activities must be aligned with the design intent, performance objectives and risk management plan, including critical controls. A failure to conduct surveillance of the necessary parameters or conducting surveillance at an inadequate frequency could result in a failure to identify instances where action needs to be taken. Similarly, a failure to analyze and report results in a timely manner could result in actions being taken too late, if at all, leading to a loss of control.

On the other hand, the collection of too much data or unnecessary data can increase the burden of data analysis, add to the amount of data that must be stored and managed, increase costs, and be a distraction. Collection of data that is not helpful to understand the performance of the tailings facility can make it more difficult to understand the "story" that the data are describing and may be a hindrance to taking action in a timely manner when action is needed.

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

- What do you need to know? Why do you need to know it? What will this information or data tell you?
  - What information do you need to understand the performance of the tailings facility?
  - What are the performance objectives, criteria and indicators for the risk controls and critical controls for the tailings facility?
- Who needs to know it, and why?
  - In some cases, different business units may need the same data, but for different reasons and at different frequencies. For example, those responsible for ore processing may need to know the grain size of material coming out of the grinding circuit on an hourly basis. Those responsible for tailings management need similar data, but on a much less frequent basis.

- What types of information do you need that can be acquired through direct, visual observation of the tailings facility? For this type of information:
  - How often should visual observations or inspections be made to give you the information you need?
  - What should the person(s) observing or inspecting be looking for?
  - Who should they tell if they see something of potential concern?
- What types of information do you need that can only be acquired indirectly, through measurement of associated parameters or analysis of samples? For example, if you need to know if water is moving through a tailings dam, what do you need to measure?
  - What methodologies can be used to collect the data needed to provide this information?
  - How frequently does this data need to be collected to provide the information you need?
- How does this data need to be analyzed? How frequently does it need to be analyzed to provide the information you need?
- What form do the results need to be presented in to allow you to understand what the information is telling you, how it relates to other information, and what it is telling about the performance of the tailings facility?

Personnel involved in surveillance must understand the expected range of observations or performance of surveillance parameters relevant to their role, so that they can identify any observations or performance outside that expected range, indicating the potential for upset or emergency conditions or a loss of control. They must also understand:

- reporting requirements in such circumstances; and
- pre-defined actions, if any, that they are to take in response to such circumstances.

As described in *Section 2.3*, surveillance results are used to make informed decisions about tailings management. As such, results are compared with specific performance criteria, such as those defined for critical controls or TARPs. A TARP may be developed and implemented which defines trigger levels for each operational and critical control of the tailings facility. A TARP should provide clear guidance on how to react under the identified deviating conditions reported. Outcomes of surveillance activities may trigger action required to improve or mitigate observed conditions or to initiate the emergency response plan.

3.5.2 Surveillance Activities

There are two types of surveillance activities, which are further discussed below:

- site observation and inspections; and
- instrument monitoring.

3.5.2.1 Site Observation and Inspections

Site observation and inspections are used to identify and track visible changes in the condition of the tailings facility. Site observation and inspections include the direct observations by personnel on or adjacent to tailings facilities and may also include observations from helicopters, and photos/videos taken from unmanned airborne vehicles (UAVs/drones and satellites), or surveillance cameras. Examples are provided in Table 4.

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

Site Observation

Site observation is conducted by all personnel working on or adjacent to a tailings facility as part of their daily activities, maintaining awareness of the facility in the course of carrying out their duties. While primarily visual in nature, site observation could also include other observations, such as sound (e.g., sound of running water). Personnel, including those who do not have specialized training and competencies related to tailings management (e.g., equipment operators, security personnel) need to be provided with training in site observation to ensure that they understand what is "normal" for the tailings facility, and understand the types of changes that, if observed, need to be documented and reported.

This whole-team approach to site observation can be invaluable. Every person observing a tailings facility can make meaningful observations, as those seeing the facility on a daily basis are often not tailings management specialists. Changes or potentially adverse conditions can develop rapidly between inspections.

Table 4: Examples of changes that may be observed through site observation and inspections

Changes potentially related to physical risks
■ changes in pond level and freeboard ■ evidence of deformation or changes in the condition of dams or other containment structures (e.g., bulges, cracks, sinkholes) ■ evidence of newly formed or expanding areas of erosion ■ evidence of piping or unexpected water movement through dams or other containment structures
Changes potentially related to chemical risks
■ evidence of newly formed seeps, or changes in seeps, and evidence of any changes in seepage characteristics (e.g., higher turbidity, indicated higher suspended solids in the seepage)
Changes related to tailings or water transport
■ condition of tailings lines, spigots and associated infrastructure for tailings transport and deposition ■ condition of pumps for tailings or water ■ any indications of leaks from tailings or water lines ■ condition of the water reclaim infrastructure (e.g., reclaim barge)
Changes related to flora and fauna
■ evidence of wildlife activity or changes in wildlife activity (e.g., birds using tailings ponds, animal burrows, animals grazing on reclaimed areas) ■ changes in nature or extent of vegetation (e.g., tree seedlings growing on a tailings dam)
Changes related to surveillance instrumentation
■ condition of surveillance instruments and associated protections around surveillance instruments (e.g., covers, barriers to prevent vehicle damage) ■ condition of power supplies for instruments (e.g., damage solar panels or above ground power lines) ■ condition of communications infrastructure associated with instruments (e.g., damage to antennas)

For site observation an OMS manual describes:

- processes and procedures for documenting observations;
  - e.g., a checklist may be provided to personnel with instructions for written and photographic documentation of observed conditions; and
- processes for reporting any observations that have been documented.

Inspections

Inspections are conducted by engineers or other personnel with appropriate training and competency and are more rigorous than site observation. These may be ground-based or airborne, depending on the scope and objectives of the inspection.

Routine inspections are conducted on a pre-defined schedule (e.g., a weekly inspection of perimeter dams), and may target specific activities (e.g., daily inspection of tailings pipelines). Their objective is to identify any conditions that might indicate changes in tailings facility performance and therefore require follow-up. Of particular significance are new occurrences or observed changes in erosion, sinkholes, boils, seepage, slope slumping or sliding, settlement, displacements or cracking of structural components, clogging of drains and relief wells, etc.

Special inspections are conducted during (if safe and practical to do so) and after unusual or extreme events that may impact the facility (e.g., heavy rainfall, windstorms, rapid snow melt, seismic events, exceedance of minimum freeboard). Significant changes to normal operations, nearby construction activity, or other unusual events might also trigger special inspections.

For routine and special inspections, an OMS manual describes the:

- scope and objective of the inspection;
- frequency for conducting routine inspections (e.g., could be once or more per shift for some types of inspections, weekly, monthly or quarterly for others);
- circumstances that would trigger the need for special inspections;
- conditions or aspects to be observed as part of the inspection; and
- processes and procedures for documenting and reporting results of inspections.

More comprehensive technical inspections, integrating inspections and results of instrument monitoring, may be conducted by the Responsible Person(s), other qualified personnel, the EoR, third party experts, or **Independent Reviewers,** to have a more complete understanding of the facility's performance and identify deficiencies in performance or opportunities for improvement. Such technical inspections include **dam safety inspections (DSIs)**, **dam safety reviews (DSRs)**, **audits**, **evaluations of effectiveness**, and Independent Reviews.

An OMS manual defines the frequency and scope of DSIs, DSRs, and any other technical inspections.

3.5.2.2 Instrument Monitoring

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

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

Examples of types of information that can be collected through instrument monitoring are provided in Table 5.

For instrument monitoring, an OMS manual describes:

- parameters to be included as part of instrument monitoring, including those not directly related to the tailings facility (e.g., meteorological data, seismic monitoring);
- the frequency of data acquisition for each parameter;
- instrument(s) to be used for each parameter;
- who is responsible for data acquisition for each parameter;
- locations of instruments, or locations where samples are to be collected (e.g., sampling of pore water quality);
- methodology and procedures for data acquisition, including those related to quality management (e.g., instrument calibration, sample collection and preservation protocols);
- processes and procedures for documenting the results of instrument surveillance, and the interpretation of results; and
- who is responsible for documenting the results.

The design and implementation of instrument monitoring needs to consider the implications of disruptions to the acquisition of data linked to critical controls. Contingency plans need to be developed to ensure continuity of data acquisition in the event of a disruption (e.g., damage or malfunction of the instrument, inability to access the instrument location, or a loss of power).

3.5.3 Analysis of Surveillance Results, Communications, and Decision-Making

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

For all surveillance activities, an OMS manual describes:

- the expected range of observations or performance of surveillance parameters, so any results outside that range can be identified and reported;
- methodology and procedures for data analysis, including comparisons with expected performance and critical controls;
- who is responsible for data analysis for each parameter;
- form in which surveillance results and analysis need to be reported (e.g., written report, graph, table);
- timeframes for data analysis and reporting; and
- procedures for reporting results if:
  - observations and performance are within the expected range; and
  - any observations or performance are outside the expected range.
- who is responsible for reporting; and
- to whom the reports are to be provided.

Table 5: Examples of information that can be collected using instrument monitoring

Direct collection of information
■ instruments within or adjacent to the tailings facility, providing information on movement (deformation and stability) within the facility, dam, or other containment structures, movement of water through or under the facility, and pore pressure with the tailings facility and dams or other containment structures
■ instruments to measure in-situ tailings characteristics, such as density and degree of compaction
■ instruments in the ore processing facility providing information on tailings characteristics (e.g., grain size and percent solids)
■ instruments to measure temperature profiles within tailings facilities or dams or other containment structures
■ instruments to measure flow rates of tailings or water in pipelines, and pressure within pipelines
■ instruments on and off site to assess air quality (e.g., amount of particulate matter in the air)
■ surveys conducted to measure: ● ice or snow cover ● extent of vegetation cover ● bathymetry of tailings ponds ● beach slope ● height and slope of dams or other containment structures
Collection of information from remote sensing
■ satellite-based radar used to measure movement or deformation of tailings dams
■ data acquired from airborne surveys (e.g., LIDAR (Light Detection and Ranging) to generate detailed topographical maps)
Collection of information based on laboratory analyses
■ water quality analysis of tailings porewater, seepage, surface runoff, etc.
■ chemical and mineralogical characteristics of tailings (e.g., acid generating potential)
■ characteristics of materials to be used for construction of dams or other containment structures
Collection of information not directly related to the tailings facility but relevant to tailings management
■ meteorological data
■ seismic monitoring
■ monitoring of hazards, such as avalanche risk
Collection of information related to the conduct of OMS activities:
■ power supply for pumps, surveillance instruments and other infrastructure related to tailings management
■ communications systems, including communications with surveillance instruments

The frequency of certain surveillance activities may be increased if results are outside the expected range and such an increase in frequency is one of the pre-defined actions to be taken. In addition, there may be other circumstances where it would be appropriate to increase the frequency of surveillance (e.g., surveillance of certain geotechnical parameters if there is a seismic event above a specified magnitude). An OMS manual describes the conditions under which the frequency of monitoring of certain parameters needs to be increased, and the conditions under which normal frequency can be resumed. Personnel responsible for taking these actions are also identified, as are the reporting requirements.

In analyzing and reviewing the results of surveillance it is important to avoid tunnel vision, and carefully consider the information that surveillance results provide. Those reviewing results need to think beyond the potential outcomes identified through risk assessment and be open to the possibility that the information provided by surveillance is pointing to a potential risk that had not been anticipated.

4 Linkages with the Emergency Response Plan

As described in Section 5.2 of the Tailings Guide, the development and testing of emergency response plans (ERPs) are essential to responsible **tailings** management.

An **emergency** is a situation that poses an impending or immediate risk to health, life, property, or the environment and which requires urgent intervention to prevent or limit the expected adverse outcomes.

Examples of possible emergencies associated with **tailings facilities** include:

- slope or foundation failure;
- extreme precipitation events;
- earthquakes;
- overtopping from storm events or erosion from a tailings pipeline;
- seepage;
- internal erosion;
- uncontrolled release of water;
- a sudden change in instrument monitoring results that are identified as outside the expected, normal or questionable parameter range and indicates that any of the above critical conditions (or other potential failure modes) may be imminent; and
- other events typically linked to the loss of one or more **critical controls**.

Circumstances that would constitute an emergency are site-specific. The definition of an emergency that would trigger implementation of emergency response measures is linked to the **risk** profile of the facility. Depending on the nature of the failure modes and controls, there may be a rapid transition from "normal" conditions to an emergency, or there may be a series of warning levels with pre-defined actions to retain control and prevent an emergency. Thus, like OMS manual development, development of an ERP is driven by the risk assessment for the tailings facility, the risk management plan, and performance criteria for critical controls, **TARPs**, etc.

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. An ERP is distinctly different than an OMS manual, but closely linked. An ERP describes:

- potential emergencies and associated impacts that could occur;
- measures to prepare for a potential emergency;
- measures to respond to emergency situations and to prevent and mitigate on and offsite environmental and safety impacts associated with emergency situations;
- procedures related to site access and communications in the event of an emergency;
- roles and responsibilities; and
- notification procedures and warning systems.

An ERP must be developed for each tailings facility and can be integrated with the overall site-wide ERP. An ERP for tailings facilities may be included in an OMS manual, but it may in many cases be best practice to maintain the ERP as a separate document, to ensure that it is:

- 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.

OMS manuals typically address conditions related to operation under normal or upset conditions, as opposed to emergency situations, but an OMS manual and ERP for a given tailings facility must be aligned and the OMS manual must contain necessary information to facilitate the transition from normal or upset conditions to an emergency. In particular, an OMS manual needs to describe, for each plausible potential emergency situation:

- the performance, occurrences, or observations that would result in an emergency being declared;
- roles and responsibilities of key personnel in transition from normal or upset conditions to an emergency; and
- actions to be taken to transition from normal or upset conditions to an emergency situation.

It may not be possible to anticipate all potential emergency situations. However, an OMS manual and ERP need to be sufficiently robust to be adaptable to unanticipated emergencies.

Glossary

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

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

- 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.

Audit: The formal, systematic and documented examination of a tailings facility's conformance with explicit, agreed, prescribed criteria, often requirements stipulated in law, 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.

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): All individuals and groups who have an interest in, or believe they may be affected by, decisions respecting the management of operations. They include, but are not restricted to:

- employees;
- Aboriginal or Indigenous peoples;
- mining community members;
- suppliers;

- neighbours;
- customers;
- contractors;
- environmental organizations and other non-governmental organizations;
- 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 control: 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.

Dam Safety Review (DSR): A systematic review and evaluation, carried out at scheduled intervals, of all aspects of design, construction, operation, maintenance, and surveillance, and other relevant processes and systems affecting a dam, to evaluate the design criteria with current standards, operational compliance with design intent, stability and functionality of the dam, and to identify appropriate remedial measures.

Dam Safety Inspection (DSI): An inspection of a dam to observe its condition relative to its performance objectives. A DSI is intended to be more thorough than a routine inspection, and includes detailed visual examination of the dam, surveillance instrumentation, and a review of surveillance results. The report of a DSI may include recommendations for maintenance, repairs, investigation, or further surveillance. DSIs are generally carried out by engineers and may be carried out by the Engineer-of-Record.

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 ers, and, for facilities with retention structures, dam safety reviews. The EoR provides these activities as part of the Owner's broader assurance process.

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 and indicators have been achieved.

Independent Review: Provides 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 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.

Operation: Includes the 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
- reduce 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.

Standard operating procedure (SOP): A set of established or prescribed methods to be followed routinely for the performance of designated operations or in designated situations. They may include procedures, standards, practices, protocols, instructions, rules, etc.

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.

Trigger Action Response Plan (TARP): A TARP is a tool to manage risk controls, including critical controls. TARPs provide pre-defined trigger levels for performance criteria that are based on the risk controls and critical controls of the tailings facility. The trigger levels are developed based on the performance objectives and risk management plan for the tailings facility. TARPs describe actions to be taken if trigger levels are exceeded (performance is outside the normal range), to prevent a loss of control. A range of actions is pre-defined, based on the magnitude of the exceedance of the trigger level.

Appendix 1: Life Cycle of an OMS Manual

As stated in *Section 2.1.3*, an OMS manual needs to be in place and ready to be implemented at the beginning of the operations and ongoing construction phase. However, there are important considerations for OMS manual development, implementation, and updates across the life cycle of a tailings facility, from project conception and planning through to post-closure.

Project Conception and Planning Phase

The outcome of the project conception and planning phase is the identification of a single alternative for tailings management that represents the optimum combination of tailings management technology and tailings facility location.

For new tailings facilities or life extensions of existing facilities, development of a conceptual plan for OMS should begin during the project conception and planning phase. The intent at this phase is not to develop a detailed OMS manual – this would be out of step with the overall planning and design process. Rather, the objective is to consider, at a high level, the OMS requirements of each tailings management alternative considered in this phase.

This facilitates the development of an OMS manual that is aligned with the risk management plan, the closure plan and post-closure land use, and is appropriate to the facility location and technologies used. It also allows consideration of the conceptual OMS activities in the context of the alternatives under consideration, providing an opportunity to identify potential OMS challenges that could be considered in the decision about the tailings management technology or facility location selected, or be averted through refinements to the facility design.

Design Phase

During the design phase aspects relevant to the intended construction and operation of the tailings facility are planned and designed in detail. For some tailings facilities there may be more than one design phase through the life cycle of the facility. During the design phase, specific OMS requirements for each life cycle phase should be identified, and a preliminary version of the OMS manual should be developed. This version of the manual provides a foundation for OMS across the life cycle.

It is recommended that the preliminary version of the OMS manual include components (e.g., modules as per *Section 2.4.2*) for each subsequent life cycle phase, since the OMS requirements of each phase would be different. This includes:

- a detailed module for initial construction, if the Owner intends to apply OMS at this phase;
- a detailed module for the operations and ongoing construction phase;
- modules for the closure and post-closure phases, developed at a level of detail commensurate with the level of detail of the closure plan; and
- a module to address temporary shut-down of mine operations, and associated care and maintenance of the tailings facility.

During the design phase, the OMS manual development team should consider surveillance needs (including consideration of the risk management plan and critical controls) and identify surveillance methods and technologies. It is crucial that planning for surveillance begin before the initial construction phase, since some surveillance instrumentation may need to be installed during the initial construction phase, and some surveillance activities may need to commence during that phase.

Initial Construction Phase

As stated in *Section 2.1.3*, some Owners may choose to develop and implement OMS during the initial construction phase. OMS activities for this phase would be distinct, and although some would carry through into the operations and ongoing construction phase, this would be a separate OMS component or module. At the end of this phase, this module may be removed from the OMS manual and archived. However, it is essential that surveillance information, and information on "as-built" conditions be retained and accessible, as necessary through subsequent life cycle phases.

During the initial construction phase, the OMS module for the operations and ongoing construction phase may be refined and updated, particularly to reflect "as-built" conditions and surveillance results, and to reflect any changes to other relevant aspects of the operation, such as refinements to plans for ore processing as the ore processing facility is constructed and commissioned.

Operations and Ongoing Construction Phase

The transition from the initial construction phase to the operations and ongoing construction phase can be a particularly dynamic period in the life cycle, and the OMS manual should be updated accordingly and implemented through this transition.

During the operations and ongoing construction phase the OMS modules for closure and post-closure should be updated and refined as the closure plan is refined and developed in greater detail. These updates should also reflect the status of progressive reclamation activities that have been undertaken.

If the company expects to continue in the operations and ongoing construction phase of the life cycle for several decades, then the closure and post-closure modules of the OMS manual can be more conceptual than in the case of a facility expected to enter the closure phase within a decade or less. At the same time, unforeseen occurrences can impact the timing of mine closure so some form of closure/post-closure planning from an OMS perspective needs to be reflected throughout the life cycle of the tailings facility even if only at a conceptual level.

As the permanent closure of the facility approaches, the closure plan and the OMS module for closure should be finalized to ensure a smooth transition and appropriate risk management during the closure phase, as well as effective management of change as responsible personnel and contractors change.

At the permanent end of the operations and ongoing construction phase, the OMS modules for this phase and for temporary shutdown may be removed from the OMS manual and archived.

Temporary Suspension of Operations

The OMS manual should address the potential for temporary shut-down of mine operations, and associated care and maintenance of the tailings facility. This should include OMS activities in the event of a short-term, emergency such down (e.g., due to wildfires in close proximity to the facility), and OMS activities in the event of a longer-term shutdown of unknown duration (e.g., due to low commodity prices). This component of the OMS manual may never be implemented but having a plan for OMS in the event of a temporary shutdown is essential to ensure that risks are appropriately managed during this transition, which can be quite sudden, and during the period of the shut down. This component of the OMS manual should also address the re-start of operations.

Closure and Post-Closure Phases

The post-production OMS manual should address closure and post-closure OMS activities. This is an important aspect that should not be overlooked or left to be developed soon before closure. As described in Section 2.2.4 of the Tailings Guide, designing and operating tailings facilities for closure is a key tool to managing risks after operations cease, meeting closure objectives, and achieving planned post-closure land uses. The OMS manual should reflect the evolution of the closure plan, from the project conception and planning phase through to the end of operations. This is important to ensure that OMS activities during operations and ongoing construction are consistent with the closure plan, lay the foundation for the implementation of the closure plan, and address progressive reclamation activities to be implemented prior to closure.

The OMS activities for the closure phase will be distinct. Some, such as certain maintenance and surveillance activities, will carry forward from the operations and ongoing construction phase. Some OMS activities during previous phases will not be relevant to the closure phase, while others may be unique to the closure phase, such as OMS activities associated with the removal of infrastructure.

During the closure phase, the OMS module for post-closure should be updated and refined to reflect actual closure conditions.

At the end of the closure phase, the OMS module for that phase may be removed from the OMS manual and archived.

The component of the OMS manual for the post-closure phase takes a very long-term view but should be reviewed and updated periodically, based on outcomes of maintenance and surveillance activities, and changing conditions.

For post-closure, the OMS manual should consider OMS requirements associated with a potential relinquishment of the tailings facility to government responsibility. In the event of relinquishment, the OMS manual and other records would be handed over to the responsible government authorities to ensure that risks are appropriately managed through that transition, and to provide the necessary information to inform appropriate risk management following relinquishment.

Appendix 2: Examples of Critical Controls for OMS Activities

As described in Section 4.4.3 of the Tailings Guide, the designation of critical controls is an Owner and tailings facility-specific exercise. Risk controls are typically designated as critical controls if:

- implementation of the control would significantly reduce the likelihood or consequence of an unwanted event or condition that poses unacceptable risk;
- 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.

Examples of possible critical controls for OMS activities are provided below.

Operation

- Minimum beach length
- Appropriate tailings properties (pulp density and fines content)
- Maximum beach length (if dust management is a need)
- Tailings pipeline location from dam crest (prevent erosion of the crest if pipe breaks)
- Minimum dam crest raise to ensure adequate dam safety freeboard
- Tailings deposition patterns to avoid excessive fines
- Tailings beach compaction
- Maximum rate of rise: monthly/annually
- Minimum freeboard
- Minimum decant and water treatment rates
- Emergency response resources

Maintenance

- Dam crest repair
- Erosion gully repair
- Tailings slope erosion removal from drainage infrastructure
- Access availability (snow removal)
- Tailings line movement or replacement cycle
- Ditch maintenance/sediment removal
- Tailings pond decant system (normal conditions and emergency)

Surveillance

- Appropriate types and spacing of instruments
- Defined instrument alarm levels
- Defined instrument reading frequencies
- Pipe rupture alarms (visual monitoring, flow rate and pressure)
- Tailings pond levels
- Precipitation and snow pack
- Decant settings/rates
- Seepage rates and turbidity

Management

- Defined roles and responsibilities
- Defined budget
- Construction authorizations (fill placement or excavation)
- Protocols to address management of unusual or upset conditions or problems
- Emergency response plans

Appendix 3: Trigger Action Response Plans

Surveillance results are used to make informed decisions about tailings management. These results may be used in a trigger action response plan (TARP) that has defined trigger levels for performance indicators that are based on the critical controls of the tailings facility. The critical controls and their trigger levels are based on the performance objectives and risk management plan for the tailings facility.

The TARP describes pre-defined risk management actions to be taken if trigger levels are exceeded (performance is outside the normal range) to prevent a loss of control.

A series of escalating qualitative risk levels are described for each performance indicator. For each performance indicator and each risk level there are pre-defined risk management actions. The number of risk levels are dependent upon the performance indicator, the risk management plan, and the associated critical control. An example of a four risk-level framework is:

- **Green – Acceptable Situation.** Performance is in line with performance objectives.
- **Yellow – Minor Risk Situation.** There may be a pre-defined risk management action that can be taken, or the pre-defined action may be to increase the frequency of surveillance and analysis. Other surveillance activities may be undertaken. Surveillance results and corresponding actions are documented and reported.
- **Orange – Moderate Risk Situation.** Pre-defined risk management actions are implemented. Surveillance activities may be intensified to monitor the performance indicator in question, related performance criteria, and the effectiveness of the risk management action implemented. Expert advice may be sought as appropriate, including from the designer and EoR. Risk management actions are implemented, and results of follow-up surveillance activities are documented and reported. The accumulation or combination of moderate risk situations could lead to a high-risk situation and threshold values will need to be assessed accordingly.
- **Red – High Risk Situation.** An imminent loss of control or a loss of control has occurred. Depending on the potential consequence, this may trigger a very significant pre-defined risk management action (e.g., ceasing ore processing operations) or it may trigger the implementation of the ERP. It is important to note that the accumulation or combination of moderate risk situations could lead to a high-risk situation and threshold values will need to be assessed accordingly.

The concept of defining risk levels is illustrated in *Figure A.3.1*.

The overall process for establishing TARPs is similar to that described in *Section 2.2.2* for critical controls:

- define the hazards or failure modes;
- for each failure mode define the risk levels; and
- describe pre-defined actions for each trigger level.

An example TARP with performance indicators related to critical controls for a tailings facility is shown in Table A.3.1. It is noted that the information shown in the example TARP is not exhaustive or tailored for any specific site. The risk controls for which TARPs are developed, the performance indicators and criteria, risk levels, pre-defined actions, and notification procedures are determined on a site-specific basis.

Figure A.3.1: Illustration of the concept of defining risk levels to establish TARPs. Note that performance for a given parameter may not be normally distributed, and there may only be performance at the high or low end of the curve which is defined as outside the acceptable situation (e.g., freeboard of a tailings dam).

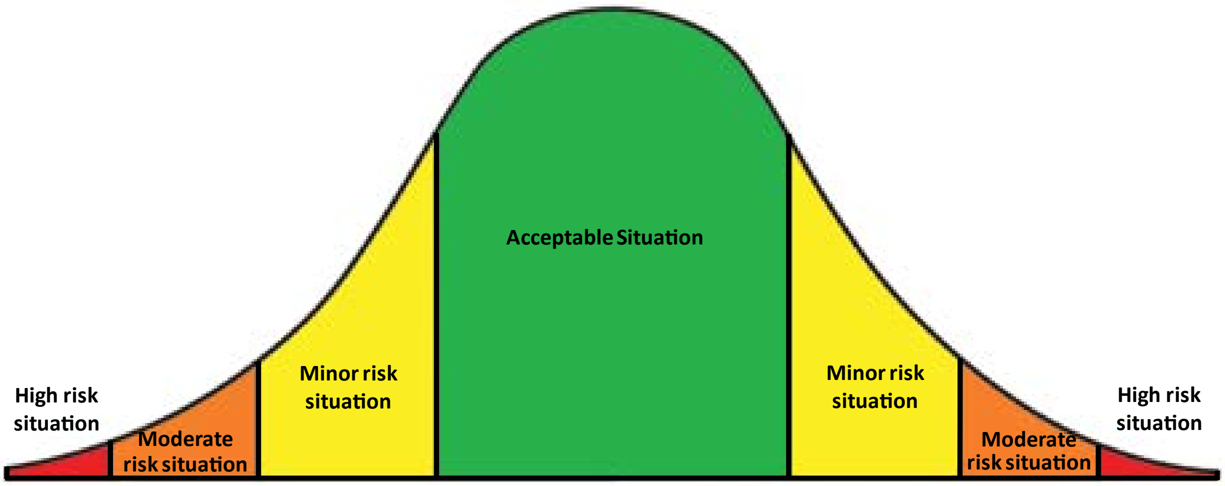


Table A.1.1: Example TARPs with performance indicators related to critical controls, and pre-defined actions for various risk-levels.

Indicator/ Control	Acceptable situation	Low risk situation	Moderate risk situation	High risk situation
Tailings facility freeboard	Water level stable and below maximum operating level	Water level exceeds maximum normal operating level	Water level exceeds 50% of the maximum emergency storage volume	Water level exceeds the maximum emergency storage volume
Beach length	Within design requirements.	Minimum beach length violated for less than 1 week per quarter.	Minimum beach length violated for less than 1 week per month.	Minimum beach length violated for more than 2 consecutive weeks.
Displacement, sloughing, or bulging of dam crest and/or downstream slope	None visible. Surveillance results within design limits and range of historic trends.	Visible displacement, sloughing, or bulging. Surveillance results increasing from range of historic trends.	Toe displacement related to sloughing. Bulging of downstream slope >0.5 m in height. Surveillance results continuously increasing from range of historic results.	Toe displacement related to sloughing >3 m from original location. Bulging of downstream slope >2 m in height.
Sinkhole in dam crest or downstream slope	Not visible.	Visible	Sinkhole diameter > 0.5 m in diameter.	Sinkhole diameter >1 m in diameter.
Seepage through dam	Seepage is clear. Seepage in location of historic locations. Seepage rate is within design limits and range of historic trends.	Seepage is turbid. Seepage is new area relative to historic performance. Seepage rate is higher than historic trends.	Same as previous situation plus ongoing increased seepage rate from historic trends.	Accumulation or combination of moderate-risk situations could lead to a high-risk situation and threshold values need to be assessed accordingly
Examples of Pre-Defined Actions				
	Surveillance activities and frequencies according to OMS manual.	Increased surveillance frequencies. • Surveillance results to be immediately provided to EoR for review. • EoR to visit site to assess the situation. • Document location, photograph, and survey area of concern. • Identify potential cause(s). • Implement engineering review. • Plan and take appropriate mitigation measures with engineering review.	All items from previous situation plus: • Suspend activities in area of concern. • Reassess thresholds and conditions for high risk situation taking into account the conditions observed and interactions of various items.	All items from previous situation plus: • Temporary evacuation of non-essential personnel from tailings facility. • Prepare to initialize ERP.
Personnel Notified				
	• Responsible Person • Process Plant Manager Environmental Manager • EoR	All personnel from previous situation plus: • COIs • Regulators • Independent Reviewer(s) • Accountable Executive Officer	All personnel from previous situation plus: • First Responders • Emergency Response Personnel	All personnel from previous situation.

Appendix 4: Overview of the Observational Method

The Observational Method is a design approach most often used in geotechnical engineering, which is sometimes applied through the construction and operating phases of the life cycle of a tailings facility. When correctly applied it becomes a key consideration in the development of critical controls or TARPs.

For mine tailings facilities that are designed, constructed and operated using the Observational Method, the surveillance program is a core component. Baecher and Christian (2003) provide a succinct summary of the essential aspects of the Observational Method:

"The observational method grew out of the fact that it is not feasible in many geotechnical applications to assume very conservative values of the loads and material properties and design for those conditions. The resulting design is often physically or financially impossible to build. Instead the engineer makes reasonable estimates of the parameters and the amounts by which they could deviate from the expected values. Then the design is based on expected values – or on some conservative but feasible extension of the expected values – but provision is made for action to deal with the occurrence of loads or resistances that fall outside the design range. During construction and operation of the facility, observations of its performance are made so that appropriate corrective action can be made. This is not simply a matter of designing for an expected set of conditions and doing something to fix any troubles that arise. It involves considering the effects of the possible range of values of the parameters and having in place a plan to deal with occurrences that fall outside of the expected range. It requires the ongoing involvement of the designers during the construction and operation of the facility."

To properly apply the Observational Method, the anticipated behaviour of the structure (deformations, pore-water pressures, etc.) must be understood, as well as the range of potential deviations from the anticipated behaviour and the likely causes of those deviations. It requires having an engineering model (mathematical or conceptual) that is regularly tested against the surveillance observations.

The Observational Method can be applicable to physical (structural) components of a tailings facility such as overall stability, as well as environmental controls such as seepage mitigation.

Peck (1969) and Morgenstern (1994) note pitfalls in application of the Observational Method:

- The engineer must select in advance appropriate courses of action for all foreseeable deviations of the real conditions, and devise solutions to all problems that could arise, but that will remain undisclosed until the field observations are made. If those hypothetical problems cannot be resolved, the design must be based on the least favourable conditions, and the owner cannot gain the advantages in cost or time associated with the Observational Method.
- If the phenomena governing the performance of the system are complex, extra effort is required in designing the surveillance system to avoid incorrectly measuring the parameters and arriving at an incorrect conclusion regarding the performance of the system.

The Observational Method is not applicable in cases where the failure mechanism is brittle (e.g., static or dynamic liquefaction of critical stability elements of a facility) and could evolve more rapidly than could be observed or responded to with contingency measures, or where other physical or economic constraints preclude the timely and effective application of contingency measures.

References:

Baecher and Christian. 2003. *Reliability and Statistics in Geotechnical Engineering*. Wiley.

CEN. EN 1997-1:2004 Eurocode 7: *Geotechnical design – Part 1: General rules*. Brussels: European Committee for Standardisation; 2004.

Christian, J.T. 2004. *Geotechnical Engineering Reliability: How Well Do We Know What We Are Doing?* Journal of Geotechnical and Geoenvironmental Engineering, ASCE. 130(10): 985-1003.

Morgenstern, N.R. 1994. *The observational method in Environmental Geotechnics*. First International Congress on Environmental Geotechnics – Edmonton. 963-976.

Peck, R.B. 1969. *Advantages and Limitations of the Observational Method in Applied Soil Mechanics*. Géotechnique. 19(2): 171-187.

Appendix 5: OMS Manual Information Sources

The information needed to inform the development of an OMS manual can be drawn from a variety of sources. The conceptual design and conceptual closure plan, and later the detailed design, as well as information from the environmental assessment and permitting of the facility will provide much of the initial information for the first version of an OMS manual, along with information on how the Owner intends to operate the facility.

As the facility evolves this information will be supplemented with a variety of information including but not limited to:

- operational information (e.g., tailings grind-size and percent solids, reagents used and present in the tailings, geochemical characteristics of the tailings);
- operational water balance;
- current design reports;
- as-built documentation (including drawings);
- performance objectives;
- risk assessment, risk management plan and critical controls;
- best practices for surveillance (e.g., methods, instruments, frequency, data analysis);
- best practices related to SOPs;
- manufacturers documentation on maintenance of equipment, calibration of surveillance instruments, etc;
- behavior of the facility; and
- other resources, depending on the jurisdiction and Owner's requirements, such as:
  - *Canadian Dam Association (CDA)*:
    - CDA Dam Safety Guidelines 2007 (2013 Edition); and
    - Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams (2014);
  - *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*; and
- *European Union directive* and *BAT reference document* on mine waste management.

Further, while every OMS manual needs to be site-specific, effective OMS manuals from other facilities can be excellent starting templates, provided that they are not used in a "cut and paste" manner, resulting in the inclusion of activities that are not compatible with or appropriate to the tailings facility to which the new OMS manual is to be applied.

Appendix 6: RACI Matrix Approach for Describing Roles and Relationships

One of the essential elements of effective tailings management is how the various individuals involved in tailings management relate to one another in their day-to-day function. Having a formal process that describes how these relationships should best occur based upon the roles of the individuals involved is considered a best practice. One form of this best practice is to use a

A RACI (**R**=Responsible, **A**=Accountable, **C**=Consulted, **I**=Informed) Matrix or Responsibility Assignment Matrix. A RACI matrix is a delegation tool used to identify each task, milestone, or decision point, and develop, document and communicate roles and responsibilities for each.

The components of the matrix are:

R	**Who is Responsible?** The person(s) assigned to do the work	**The doers**
A	**Who is Accountable?** The person who makes the final decision and is ultimately answerable	**The buck stops here!**
C	**Who is Consulted?** The person(s) who must be consulted before a decision or action is taken	**Two-way communications**
I	**Who is Informed?** The person(s) who must be informed that a decision or action has been taken	**One-way communications**

The steps to developing a RACI matrix are:

1) Identify all the tasks involved in tailings management and list them on the left-hand side of the matrix.
2) Identify who is collectively involved in tailings management (either functional roles or specific individuals) and list them across the top of the matrix.
3) For each task, identifying who has the responsibility, the accountability, and who will be consulted and informed. Fill in the cells of the matrix accordingly.
4) Ensure every task has a role responsible and a role accountable for it – a task without an "R" and an "A" is an unmanaged task that creates risk.
5) No tasks should have more than one role accountable (the "A"). Resolve any conflicts where there is more than one for a particular task.
6) Share, discuss and agree on the RACI Matrix with appropriate personnel.

An example of a RACI matrix is provided in Table A.6.1.

There are a number of potential advantages to using a RACI approach for roles and relationships related to tailings management. Developing and implementing a RACI matrix for tailings management and OMS activities can help:

- clarify and simplify lines of communications and mitigate the risk of communications breakdowns (see *Section 3.1.2*);
- the Responsible Person(s) in delegating responsibility for various tasks, potentially reducing the work-load or stress-load on that person;
- ensure that roles and responsibilities are clearly described across organizational silos, helping to ensure effective function across those siloes; and
- establish clear expectations for all involved in the various tasks, milestones and decision points:
  - everyone needs to clearly understand where they are involved, and with which tasks;
  - everyone needs to understand who is ultimately accountable for a task, which can help avoid confusion or communications problems; and
  - it sets clear expectations for those who will be consulted or informed, so that they understand their roles and what information they will receive.

To be effective, there are a number of factors that should be considered in developing and implementing a RACI matrix:

- There should not be too many roles or personnel identified as responsible for each task. This will create confusion and communications problems.
- All tasks must have assigned roles or personnel:
  - someone needs to be accountable for each task;
  - at least one person needs to be responsible for each task; and
  - it may not always be necessary to identify persons who should be consulted or informed. This can be determined on a task-specific basis.
- Do not assign the Responsible Person(s) as responsible for too many tasks:
  - they need to delegate to be effective; and
  - give careful consideration to what responsibilities can be delegated to other personnel, but clearly define their functional relationship with the Responsible Person(s).
- Do not confuse responsible and accountable:
  - have a clear understanding of each term and be consistent in the application of those terms in assigning who is accountable and responsible for each task.
- Carefully consider who needs to be consulted and who needs to be informed:
  - if someone does not need to be consulted, inform them;
  - however, persons may want a greater role and want to be consulted rather than informed; and
  - involve those persons in the development process and negotiate their roles as necessary to avoid problems in implementation.

Table A.6.1: Example of a template for a RACI matrix. The level of detail in both the tasks and roles identified is up to the Owner to determine on a site-specific basis.

	Roles							
Tasks	**Accountable Exec. Officer**	**Responsible Person(s)**	**EoR**	**Independent Reviewer(s)**	**Ore Processing**	**Operation Personnel**	**Maintenance Personnel**	**Surveillance Personnel**
Operation								
Tailings transport								
Tailings placement								
Water management								
Ongoing construction								
Progressive reclamation								
Maintenance								
Tailings transport								
Containment structures								
Water management								
Surveillance								
Site observation								
Routine inspections								
Dam safety inspections								
Instrument monitoring								
Data analysis								

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.

1. Martin, T. (2001). *Pearl Harbor: Lessons for the Dam Safety Community*. Presented at the annual conference of the Canadian Dam Association.

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: Factors that Could Influence Tailings Management

As described in *Section 3.2*, there is a range of factors that could affect tailings managements and tailings facility performance. Examples are listed below.

Site Conditions Outside the Owner's Control

- climate impacts of climate change, and future projections for climate change;
- local and regional hydrology and hydrogeology;
- topography and landforms;
- bedrock and surficial geology and geochemistry;
- natural hazards that could impact the tailings facility;
- local and regional aquatic and terrestrial ecosystems;
- communities potentially impacted by the tailings facility, including those downstream and downwind;
- infrastructure off the mine site that could be impacted;
- commercial and recreational land use; and
- archeological resources.

COI Considerations

- COI concerns related to tailings management, including potential effects on:
  - water quality, including drinking water;
  - wildlife, including birds and large mammals that may use tailings facilities;
  - fish, including the safety of fish for consumption; and
  - air quality.
- Indigenous considerations, including:
  - land claims;
  - agreements with Indigenous communities;
  - traditional land use in the area for harvesting, cultural and spiritual purposes; and
  - Indigenous engagement in environmental management and monitoring.
- risks of the tailings facility to nearby communities, including risks in the event of a catastrophic failure of the tailings facility.

Legal Requirements and Commitments

Understanding relevant legal requirements and the Owner's commitments related to tailings management is necessary to:

- provide context for OMS activities that are related to legal requirements and commitments;
- help ensure that those responsible for tailings management are aware of legal requirements and commitments; and
- align OMS activities towards ensuring conformance with all legal requirements and commitments related to tailings management.

Tailings Facility Characteristics

Basic information:

- location and physical setting of the tailings facility;
- type of ore and rate of ore processing;
- ore processing methods used, including reagents used;
- treatments applied to tailings before transportation to the tailings facility (e.g., cyanide destruction, desulphurization);
- tailings management technology used, and the water content of the tailings;
- tailings characteristics, particularly the potential for acid generation and metal leaching;
- tailings transportation method used (e.g., pipeline, truck);
- tailings deposition methods;
- size of the tailings facility and anticipated life; and
- methods/structures used to contain the tailings and any associated water.

Design and history of the tailings facility:

- the rationale for selection of technology and facility location;
- the original design intent of the facility, including:
    - how the design addressed the site conditions, and legal requirements and commitments described above;
    - engineering basis for the design; and
    - conceptual closure plan and post-closure land-use.
- relevant details related to initial construction, and operations and ongoing construction;
- any deviations from the original design of the tailings facility and associated infrastructure, and the rationale for those deviations;
- water management plan;
- any salient problems, or unique or unanticipated circumstances that have been encountered; and
- status of implementation of the closure plan, including progressive reclamation.

Risk profile and risk management:

- the risk profile of the facility;
- how risks are managed, including:
  - how risks are addressed through the design of the facility;
  - how risks continue to be managed in light of any deviations from the original design;
  - risk management plan; and
  - risk controls and critical controls;
- performance objectives; and
- emergency response plan.

Closure:

- closure objectives and post-closure land-use; and
- the closure plan, including updates to the closure plan.

Information available for old tailings facilities may be quite different compared to new facilities. Some of the information above may not be available for older facilities, while there may be other information not listed above that is relevant to those facilities. It is up to the Owner to determine the most relevant information to be included for each tailings facility.

Tailings Facility Performance

- tailings facility performance against performance objectives;
- effectiveness of risk management measures, including critical controls;
- compliance with legal requirements, and conformance with plans and commitments;
- status of action plans to address:
  - actions to ensure performance objectives are met;
  - actions to address non-conformity with requirements, standards, policy, or commitments; and
  - opportunities for continual improvement.
- Changes to the OMS manual made in response to Performance Evaluation, and Management Review for Continual Improvement, including changes to implement action plans.

Future Plans

- expansions of capacity as per the original design (e.g., increases in height of tailings dams or other containment structures, expansion into new tailings cells);
- expansions of capacity not included in the original design (i.e., expansion of capacity for mine life extension);
- changes in ore characteristics (e.g., different acid generating potential in ore from a newly mined ore zone);
- changes in ore processing (e.g., processing rate, reagents used);

- changes in tailings management technology (e.g., reductions in water content of tailings, desulphurization of tailings);
- progressive reclamation;
- changes made in response to changes in legal requirements or commitments;
- changes made in response to past or current performance of the tailings facility;
- changes in the closure plan and risk management plans during closure and post-closure; and
- other plans that could affect the performance or risk profile of the tailings facility.

The Mining Association of Canada

www.mining.ca

NEVADA ADMINISTRATIVE CODE
CHAPTER 445A - WATER CONTROLS
MINING FACILITIES
http://www.leg.state.nv.us/NAC/NAC-445A.html#NAC445ASec350

General Provisions

Permits for Facilities

MINING FACILITIES

General Provisions

NAC 445A.350 Definitions. (NRS 445A.425, 445A.465) As used in NAC 445A.350 to 445A.447, inclusive, unless the context otherwise requires, the words and terms defined in NAC 445A.351 to 445A.385, inclusive, have the meanings ascribed to them in those sections.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.242)

NAC 445A.351 "Area of review" defined. (NRS 445A.425, 445A.465) "Area of review" means the area surrounding a facility which is to be evaluated.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24202)

NAC 445A.352 "As-built drawings" defined. (NRS 445A.425, 445A.465) "As-built drawings" means engineering drawings which reflect all changes made from original engineering drawings during the construction of a facility so that a representation of the facility as constructed is portrayed.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24204)

NAC 445A.353 "Beneficiation" defined. (NRS 445A.425, 445A.465) "Beneficiation" means the dressing or processing of ores for:

1. Regulating the size of a desired product;
2. Removing unwanted constituents; and
3. Improving the quality, purity or assay grade of a desired product.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24206)

NAC 445A.354 "Best engineering judgment" defined. (NRS 445A.425, 445A.465) "Best engineering judgment" means that decision by the Department which, after evaluating the available alternatives and levels of technology presented by the applicant, results in an acceptable design for containing contaminants from a facility in order to protect the waters of the State.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24208)

NAC 445A.355 "Commission" defined. (NRS 445A.425, 445A.465) "Commission" means the State Environmental Commission.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.2421)

NAC 445A.356 "Contaminant" defined. (NRS 445A.425, 445A.465) "Contaminant" has the meaning ascribed to it in NRS 445A.325.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24212)

NAC 445A.357 "Degrade" defined. (NRS 445A.425, 445A.465) "Degrade" means to alter the physical or chemical properties of or to cause a change in the concentration of any substance in the waters of the State in violation of the standards established pursuant to NAC 445A.424.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24214)

NAC 445A.358 "Department" defined. (NRS 445A.425, 445A.465) "Department" means the State Department of Conservation and Natural Resources.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24216)

NAC 445A.359 "Facility" defined. (NRS 445A.425, 445A.465) "Facility" means all portions of a mining operation, including, but not limited to, the mine, waste rock piles, or piles, beneficiation process components, processed ore disposal sites, and all associated buildings and structures. The term does not include any process component or nonprocess component which is not used for mining or mineral production, and has not been used in the past for mining or mineral production as part of an operation which is active as of September 1, 1989.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24218)

NAC 445A.360 "Fluid management system" defined. (NRS 445A.425, 445A.465) "Fluid management system" means that portion of a facility which has been constructed to contain or transport process fluids.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.2422)

NAC 445A.361 "Groundwater" defined. (NRS 445A.425, 445A.465) "Groundwater" means all subsurface water comprising the zone of saturation, including perched zones of saturation, which could produce usable water.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24222)

NAC 445A.362 "Liner" defined. (NRS 445A.425, 445A.465) "Liner" means a continuous layer of man-made or reconstructed natural materials, or a combination thereof which restricts the downward or lateral movement of liquids.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24224)

NAC 445A.363 "Meteoric waters" defined. (NRS 445A.425, 445A.465) "Meteoric waters" means any form of precipitation falling from the earth's atmosphere.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24226)

NAC 445A.364 "Mining" defined. (NRS 445A.425, 445A.465) "Mining" means the process of extracting ores from the earth.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24228)

NAC 445A.365 "Modify materially" defined. (NRS 445A.425, 445A.465) "Modify materially" means to make:

1. A change in the design or location of a process component, or the characteristics of the waste stream which significantly alters the potential to degrade the waters of the State; or

2. A significant change in the environmental monitoring systems which results in a reduction in the effectiveness of that monitoring system.

➥ The term does not include changes necessitated during construction to suit field conditions, or changes which do not affect point sources.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.2423)

NAC 445A.366 "Ore" defined. (NRS 445A.425, 445A.465) "Ore" means the naturally occurring material from which a metallic mineral of economic value can be extracted.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24232)

NAC 445A.367 "Permanent closure" defined. (NRS 445A.425, 445A.465) "Permanent closure" means that time in the operating life of a facility when activities for the final stabilization, removal or mitigation of sources are initiated.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24234)

NAC 445A.368 "Permit" defined. (NRS 445A.425, 445A.465) "Permit" means a written document issued pursuant to NRS 445A.300 to 445A.730, inclusive, which describes the responsibilities and obligations of the holder of the permit during the construction, operation, and temporary or permanent closure of a facility.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24236)

NAC 445A.369 "Person" defined. (NRS 445A.425, 445A.465) "Person" has the meaning ascribed to it in NRS 445A.390.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24238)

NAC 445A.370 "Pilot facility" and "testing facility" defined. (NRS 445A.425, 445A.465) "Pilot facility" or "testing facility" means a facility which is constructed principally to obtain data on the effectiveness of the beneficiation process to determine:

1. The feasibility of developing a body of ore; or
2. The optimum operating conditions of the process.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.2424)

NAC 445A.371 "Placer mining" defined. (NRS 445A.425, 445A.465) "Placer mining" means the extraction and processing of ores solely by gravity separation methods.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24242)

NAC 445A.372 "Point source" defined. (NRS 445A.425, 445A.465)

1. "Point source" has the meaning ascribed to it in NRS 445A.395.
2. The term includes wheeled, track, stationary or floating equipment used for earth-moving activity from which pollutants are or may be discharged.

(Added to NAC by Environmental Comm'n, eff. 9-1-89; A by R096-01, 1-18-2002)

NAC 445A.373 "Pollutant" defined. (NRS 445A.425, 445A.465) "Pollutant" has the meaning ascribed to it in NRS 445A.400.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24246)

NAC 445A.374 "Pond" defined. (NRS 445A.425, 445A.465) "Pond" means a process component which stores, confines or otherwise significantly impedes the horizontal movement of process fluids. The term does not include tailings impoundments, vats, tanks or other nonearthen containers.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24248)

NAC 445A.375 "Process component" defined. (NRS 445A.425, 445A.465) "Process component" means a distinct portion of a constructed facility which is a point source.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.2425)

NAC 445A.376 "Process fluid" defined. (NRS 445A.425, 445A.465) "Process fluid" means any liquids, including meteoric waters, which are intentionally or unintentionally introduced into any portion of the beneficiation process components.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24252)

NAC 445A.377 "Small-scale facility" defined. (NRS 445A.425, 445A.465) "Small-scale facility" means a facility which chemically processes less than 36,500 tons of ore per year and no more than 120,000 tons of ore for the life of the project at any one permitted site.

(Added to NAC by Environmental Comm'n, eff. 9-1-89; A 9-6-91)—(Substituted in revision for NAC 445.24254)

NAC 445A.378 "Source" defined. (NRS 445A.425, 445A.465) "Source" means any building, structure, facility or installation from which there is or may be the discharge of pollutants.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24256)

NAC 445A.379 "Stabilized" defined. (NRS 445A.425, 445A.465) "Stabilized" means the condition which results when contaminants in a material are bound or contained so as to prevent them from degrading the waters of the State under the environmental conditions that may reasonably be expected to exist at a site.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24258)

NAC 445A.380 "Storm event" defined. (NRS 445A.425, 445A.465) "Storm event" means a precipitation event with a specified frequency of return and specified period of duration as defined in *Precipitation-Frequency Atlas of the Western United States,* vol. VII-Nevada.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.2426)

NAC 445A.381 "Tailings impoundment" defined. (NRS 445A.425, 445A.465) "Tailings impoundment" means a process component which is the final depository for processed ore discharged from a mill.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24262)

NAC 445A.382 "Temporary closure" defined. (NRS 445A.425, 445A.465) "Temporary closure" means the cessation of the operation of a process component for more than 30 days as a result of a planned or unplanned activity.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24264)

NAC 445A.383 "WAD cyanide" defined. (NRS 445A.425, 445A.465) "WAD cyanide" means the cyanide concentration as determined by Method C, Weak Acid Dissociable Cyanide, D2036-082, Part 31 of *American Society of Testing Materials Book of Standards.*

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24266)

NAC 445A.384 "Waters of the State" defined. (NRS 445A.425, 445A.465) "Waters of the State" has the meaning ascribed to it in NRS 445A.415.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24268)

NAC 445A.385 "Zero discharge" defined. (NRS 445A.425, 445A.465) "Zero discharge" means the standard of performance for the protection of surface waters which requires the containment of all process fluids.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.2427)

NAC 445A.386 Adoption of publication by reference. (NRS 445A.425, 445A.465) The Department hereby adopts by reference *Precipitation-Frequency Atlas of the Western United States*, vol. VII-Nevada, stock number 0317-00161, prepared by the National Weather Service and National Oceanic and Atmospheric Administration, United States Department of Commerce. The publication may be obtained by mail from the Superintendent of Documents, U.S. Government Printing Office, P.O. Box 979050, St. Louis, Missouri 63197-9000, or by toll-free telephone at (866) 512-1800, at a cost of $8.45.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24272)

NAC 445A.387 Scope; effect of noncompliance. (NRS 445A.425, 445A.465)

1. NAC 445A.350 to 445A.447, inclusive, apply to facilities that have the potential to degrade the waters of the State. Surface disturbance activities such as stripping and the stockpiling of ore, when conducted in a manner which presents an insignificant potential to degrade waters of the State are not subject to those sections. NAC 445A.350 to 445A.447, inclusive, do not apply to facilities involved solely in the mining and processing of sand and gravel, cinders, diatomaceous earth, slate, shale, gypsum, clay or crushed stone.

2. NAC 445A.350 to 445A.447, inclusive, do not replace or in any way affect the responsibility of a person to comply with any other regulations and rules of practice and procedure administered by the Department or any other governmental agency.

3. A permit issued pursuant to NAC 445A.350 to 445A.447, inclusive, may be revoked for noncompliance with the provisions of NAC 445A.350 to 445A.447, inclusive, in accordance with the procedures established in NRS 445A.600.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24274)

NAC 445A.388 Appeal of action taken by Department. (NRS 445A.425, 445A.465, 445A.605) Any person aggrieved by an action taken by the Department pursuant to NAC 445A.350 to 445A.447, inclusive, may appeal to the Commission in accordance with NRS 445A.605.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24276)

Permits for Facilities

NAC 445A.390 Permit required; operation under existing permit. (NRS 445A.425, 445A.465)

1. All facilities in existence on September 1, 1989, must obtain a valid permit within 3 years after September 1, 1989.

2. After July 1, 1990, no person may begin construction of a new process component, or materially modify an existing process component, without first obtaining a permit or permit modification, or the concurrence of the Department that the construction or modification is in conformance with the existing permit.

3. The operator of a process component for which a permit has been obtained may continue to operate that process component under the conditions of the existing permit. This applies to all process components which have been reviewed and approved by the Department but have not yet been issued a permit and are either in the process of being constructed or are operating in accordance with an approval granted as of September 1, 1989. Where detailed plans have not yet been submitted to the Department for a process component that has been conceptually approved under either an existing permit or approved without an existing permit, the process component must meet the regulations in effect when construction of the new process component is initiated.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.2428)

NAC 445A.391 Application for permit: Preliminary meeting with representative of Department. (NRS 445A.425, 445A.465) Before submitting an application for a permit, a prospective applicant must meet with a representative of the Department to discuss:

1. The proposed location of the facility;
2. The operating plans for the process components; and
3. The physical characteristics of the facility's proposed site as required on the application for the permit.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24282)

NAC 445A.392 Application for permit: Construction or modification of process component; abbreviated application. (NRS 445A.425, 445A.465)

1. Except as otherwise provided in subsection 2, a person wishing to construct or modify materially a process component at a facility must file an application for a permit pursuant to NAC 445A.394.

2. Persons wishing to construct a small-scale, pilot, testing, placer or other facility which relies solely on physical separation methods to process ore may file an abbreviated application for a permit pursuant to NAC 445A.410, 445A.412 and 445A.414. The application must be accompanied by the appropriate fee as required by NAC 445A.232.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24284)

NAC 445A.393 Application for permit: Definition of site conditions, process materials, characteristics of waste and impacts. (NRS 445A.425, 445A.465) The failure or the inability to define adequately site conditions, process materials and the probable characteristics of the waste in the application for a permit may result in the Department requiring a higher standard of engineered containment or monitoring, or both. Persons wishing to materially modify a facility must submit all information necessary to define and describe the probable impacts of the modification or new process components on the area of review.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24286)

NAC 445A.394 Application for permit: Submission; contents. (NRS 445A.425, 445A.465)

1. To obtain a permit to construct, operate and close permanently a facility, the owner or operator of the proposed facility or the designated agent of the owner or operator must submit to the Department a written application signed by the owner or, if the owner does not operate the facility, the operator of the facility or his or her designated agent. The application must be accompanied by the appropriate fee established pursuant to NAC 445A.232.

2. An application for a permit must contain:

(a) The name, location and mailing address of the:

(1) Facility.

(2) Owner.

(3) Operator.

(4) Authorized agent.

(b) The legal structure of the applicant, including, but not limited to, whether the applicant is a sole proprietorship, partnership or corporation.

(c) The name of the owner of the land or mining claim or claims on which the facility will be located.

(d) Documentation that notice of the proposed development has been provided to the local board of county commissioners.

(e) The rate at which the facility is anticipated to be chemically processing ore in tons of ore per year.

(f) An assessment of the area of review as required by NAC 445A.395.

(g) A meteorological report as required by NAC 445A.396.

(h) An engineering design report as required by NAC 445A.397.

(i) A copy of the draft operating plans for the facility as required by NAC 445A.398.

(j) A report of the sample analysis as required by NAC 445A.396.

3. New applications or requests for major modifications to existing permits must be submitted to the Department at least 165 days before the date on which the applicant wishes to initiate construction.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24288)

NAC 445A.395 Contents of application: Assessment of area of review. (NRS 445A.425, 445A.465)

1. An assessment of the area of review must include:

(a) Hydrogeological and lithological information which defines the subsurface conditions of the site beneath and adjacent to all point sources to a minimum depth of 100 feet.

(b) A geological map covering the area within a 1-mile radius of the process components.

(c) A topographic map which identifies:

(1) All known surface waterways, streams, springs and seeps within a 1-mile radius of the facility;

(2) All existing habitable buildings within a 1-mile radius of the facility;

(3) The boundaries and area of the upgradient watershed and the degree to which the 100-year, 24-hour storm event will affect the process components; and

(4) All wells constructed for supplies of drinking water within 5 miles downgradient of the site identified in the records of the Division of Water Resources of the Department or known to the applicant.

2. The Department may require that a greater or lesser area of review be prescribed in an application for a permit based upon:

(a) The ability of the geologic formation at the site of the facility to inhibit contaminant migration;

(b) The size of the human population in the area;

(c) The depth from the surface to all groundwater;

(d) The distance to all surrounding bodies of surface water; and

(e) The quality, uses and potential uses of the ground and surface water within the area of review.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.2429)

NAC 445A.396 Contents of application: Meteorological report; analysis of samples. (NRS 445A.425, 445A.465) An application for a permit must include:

1. A summary of the historical monthly averages of rainfall obtained from the nearest recording station to the site adjusted for conditions at the site;

2. The 24-hour storm events with an interval of recurrence of 10 years, 25 years, and 100 years;

3. The diurnal temperature variation from the nearest recording station to the site adjusted for conditions at the site; and

4. Results from testing samples from the facility's mine site which are representative of the overburden, waste rock and ore at the proposed mine site that have:

(a) Characterized the samples by a multi-element spectrographic assay or an equivalent analytical procedure; and

(b) Evaluated the samples for their potential to release pollutants.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24292)

NAC 445A.397 Contents of application: Engineering design report; specifications for fluid management system. (NRS 445A.425, 445A.465)

1. An engineering design report must be prepared and submitted to the Department by a professional engineer registered in Nevada. The report must include the following information, if applicable:

(a) Engineering plans for the process components used for beneficiation;

(b) The general specifications and calculations for the process components;

(c) Topographic maps showing the location of all potential sources at the facility including, but not limited to:

(1) The extraction sites;

(2) The process components used for beneficiation;

(3) The disposal sites for waste rock; and

(4) The disposal sites for spent ore;

(d) Drawings which indicate the layout of the structures and devices for controlling process fluids;

(e) Methods for the control of storm flow runoff;

(f) The existing geological and hydrogeological conditions beneath and adjacent to the site of the fluid management system and waste rock disposal sites and the degree to which these conditions provide natural containment, preferential flow pathways and structural stability;

(g) A description of the liner material and installation procedures for all leach pads, ponds and ditches, including a description of the subbase preparation;

(h) Details of leak detection and site-monitoring systems; and

(i) Process schematics of the facility.

2. Specifications for constructing the fluid management system and for the material to be used must be submitted to the Department with the application for a permit, and must include, but not be limited to, the methods to be utilized for inspecting, testing, and quality assurance and control.

3. The information required by subsections 1 and 2 must be of sufficient detail to allow the Department to make the following factual determinations:

(a) Which of the potential sources at the facility are to be considered process components for the purposes of NAC 445A.350 to 445A.447, inclusive;

(b) That the design of the process components is sufficient to protect the waters of the State from degradation; and

(c) That the monitoring system is adequate to determine if the process components are operating so as to protect the waters of the State from degradation.

➥ Any material modification to a process component requires the approval of the Department before construction begins.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24294)

NAC 445A.398 Contents of application: Proposed operating plans. (NRS 445A.425, 445A.465) The proposed operating plans for a facility must include:

1. A description of the mineral processing circuit which includes a flow chart of the facility and the range of operating conditions for which the process components were designed.

2. A plan for the management of process fluids which describes the methods to be used for the monitoring and controlling of all process fluids. The plan must provide a description of the means to evaluate the conditions in the fluid management system so as to be able to quantify the available storage capacity for meteoric waters and to define when and to what extent the designed containment capacity has been exceeded.

3. A plan for monitoring the facility which describes:

(a) The water quality in the area;

(b) The monitoring locations the applicant proposes to sample routinely in order to evaluate surface and groundwater at the site that may be affected by the operation of the facility;

(c) An analytical profile of each surface and groundwater that may be affected by the operation of the facility; and

(d) The locations of the leak detection systems, the frequency for sampling these systems and the analytical profile to be used for evaluation of the samples.

4. A plan for responding to emergencies which:

(a) Describes what actions must be initiated and by whom as a result of various possible failures in the fluid management system which would result in releases of pollutants; and

(b) Is designed to minimize the environmental impact resulting from the release of process fluids.

5. A temporary closure plan resulting from conditions described in subsection 1 of NAC 445A.444 which describes the activities which must be maintained during the time of closure.

6. A tentative plan for the permanent closure of the facility which describes the procedures, methods and schedule for stabilizing spent process materials. The plan must include:

(a) Procedures for characterizing spent process materials as they are generated; and

(b) The procedures to stabilize all process components with an emphasis on stabilizing spent process materials and the estimated cost for the procedures.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24296)

NAC 445A.399 Preparation of plan for seasonal closure of process components. (NRS 445A.425, 445A.465) If the facility is located in an area where the mean diurnal temperature does not exceed 0 degrees Centigrade for 30 days or more a plan for the seasonal closure of the process components must be prepared. The plan must describe:

1. The impact this change in the weather will have on the process components, including, but not limited to, a discussion of the possible closure of individual process components;

2. Those activities which must be undertaken to prepare those process components which may be potentially affected by the low temperatures;

3. The activities which will be maintained during this time of closure; and

4. The conditions that would allow operations to resume.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24298)

NAC 445A.400 Initial review of application and notification of applicant; failure to provide information; submission of incorrect information. (NRS 445A.425, 445A.465)

1. The Department shall, within 30 days after receiving an application for a permit, notify the applicant in writing:

(a) That the application is procedurally complete or specify any deficiencies; and

(b) Which nonfluid management system sources will not initially be considered as process components for the purposes of NAC 445A.350 to 445A.447, inclusive.

➥ This review is solely to determine if all the information required by NAC 445A.394 to 445A.398, inclusive, has been submitted and is not a determination as to the adequacy of the information.

2. Failure to provide all information required for a determination of completeness within 1 year after the application date renders an application void and requires the submittal of a new application and fee. A new application and fee will not be required if the Department fails to act in a timely manner or if the applicant can demonstrate that circumstances beyond the applicant's control prevented him or her from developing the additional information.

3. If an applicant becomes aware that he or she failed to submit any relevant information or submitted incorrect information in an application, the applicant must promptly submit such information to the Department.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.243)

NAC 445A.401 Action by Department upon application. (NRS 445A.425, 445A.465)

1. After determining that an application is procedurally complete, the Department shall, within 90 days, determine whether the application is technically complete, and prepare and issue:

(a) A draft permit or a notice of intent to deny the application;

(b) A fact sheet which:

(1) Identifies the location of the facility;

(2) Describes the proposed sources;

(3) Provides a description of the facility and monitoring systems;

(4) Identifies the probable receiving water; and

(5) Describes the procedures for public comment; and

(c) A public notice for each draft permit or intent to deny an application for a permit to construct, operate and close a mining and beneficiation facility.

2. The 90-day time for action by the Department may be extended by the amount of time necessary for the applicant to submit additional information necessary to make the application technically complete.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24302)

NAC 445A.402 Notice of intent to issue permit or deny application. (NRS 445A.425, 445A.465, 445A.590)

1. The Department shall, at least 30 days before the issuance of a permit or denial of an application:

(a) Circulate a public notice in a manner intended to inform interested and potentially interested persons.

(b) Cause to be published in a newspaper of general circulation within the geographic area of a proposed facility, a notice of the intent to issue the permit or deny the application.

(c) Mail to the applicant and the landowner, if other than the applicant, members of the board of county commissioners of the county in which the facility is to be located, the Division of Minerals, the Division of Water Resources of the Department, and any other person or group who so requests, written notice of the intent to issue a permit or deny the application.

2. Notice given pursuant to subsection 1 must include:

(a) The name, address and telephone number of the Department;

(b) The name and address of the applicant;

(c) The location of the proposed facility;

(d) The tentative decision of the Department to issue a permit or deny the application;

(e) A description of the procedure for:

(1) Making a final decision, which must include 30 days for interested persons to submit to the Department written comments on the tentative decision to issue a permit or deny the application; and

(2) Requesting a public hearing, if one has not been scheduled; and

(f) The specific location where interested persons may obtain further information or inspect and copy the draft permit, statement and fact sheet, and other relevant forms or documents.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24304)

NAC 445A.403 Request for hearing on application; submission of comments on draft permit. (NRS 445A.425, 445A.465, 445A.595) The applicant or any interested person may:

1. Request a public hearing on any application for a permit during the 30 days allowed for public comment if a hearing has not been scheduled. The request must be in writing and state the nature of the issues to be raised at the hearing.

2. Submit written comments on the draft permit to the Department within 30 days after notice is given pursuant to NAC 445A.402.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24306)

NAC 445A.404 Scheduling of public hearing on application. (NRS 445A.425, 445A.465, 445A.595) The Department:

1. Shall schedule a public hearing on an application for a permit if it determines that there is a significant degree of public interest in the matter; or

2. May schedule a public hearing on its own initiative.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24308)

NAC 445A.405 Notice of hearing: Publication; contents. (NRS 445A.425, 445A.465, 445A.595) The Department shall cause to be published a notice for a hearing at least 30 days before the hearing in the manner prescribed by NAC 445A.402. In addition to the information required by NAC 445A.402, the notice must include:

1. The date on which the previous public notice was given concerning the permit pursuant to NAC 445A.402;

2. The date, time and place of the hearing; and

3. A brief description of the nature and purpose of the hearing and the applicable rules and procedures.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.2431)

NAC 445A.406 Submission of testimony at hearing. (NRS 445A.425, 445A.465, 445A.595)

1. Any person may submit to the Department at a public hearing held by the Department on the application for a permit, an oral or written statement or other information which relates to the draft of the permit.

2. The Department may:

(a) Set reasonable limits upon the time allowed for oral statements; and

(b) Require persons submitting oral statements to submit statements in writing.

3. The 30-day period for comment is automatically extended to the close of the hearing on that matter.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24312)

NAC 445A.407 Issuance of statement responding to comments on draft permit. (NRS 445A.425, 445A.465) If a final permit is issued, the Department shall issue a statement responding to the comments received on the matter. A copy of the statement must be sent to the applicant and persons submitting comments, and will be made available for inspection by the public. This statement must:

1. Specify which provisions, if any, in the draft of the permit that have been changed in the final permit, and the reasons for the change;

2. Briefly describe and respond to all significant comments submitted during the time established for public comment on the draft of the permit; and

3. Provide that any person aggrieved by the Department's decision may appeal the decision pursuant to NRS 445A.605.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24314)

NAC 445A.408 Action by Director of Department after period for public comment. (NRS 445A.425, 445A.465) Within 15 days after the end of the time for public comment regarding the issuance or renewal of a permit, the Director of the Department shall issue the final permit or provide written notice to the applicant why the final permit will not be issued at that time. This notice must set forth the time allowed for an aggrieved party to appeal the Department's decision.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24316)

NAC 445A.409 Issuance and maintenance of permit; maximum term and renewal of permit. (NRS 445A.425, 445A.465, 445A.495)

1. If an application is approved, a single permit must be issued for the construction, operation and closure of the facility. A valid permit must be maintained until permanent closure is complete.

2. A permit may be issued for a maximum term of 5 years, at which time the holder of the permit may apply for renewal.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24318)

NAC 445A.410 Permit for small-scale facility: Contents of application; limitation on holding; applicability of minimum design criteria. (NRS 445A.425, 445A.465)

1. An application for a permit to construct, operate and close permanently a small-scale facility must contain:

(a) The information required by paragraphs (a) to (e), inclusive, of subsection 2 of NAC 445A.394;

(b) Site information consisting of:

(1) The distance from the surface to groundwater;

(2) A topographic map which identifies all surface waters, waterways and springs within 1/2 mile of the site; and

(3) A description of the general character of the soil and geologic formations which lie beneath and adjacent to the proposed processing site;

(c) A description of and the criteria for the design of the containment system for the individual process components, including plans, schematics and cross-section diagrams of the process components which identify those components which provide for the containment of process fluids; and

(d) A copy of the draft operating plan for the facility which describes:

(1) The chemicals to be used in the beneficiation process;

(2) The methods which are proposed for controlling process fluids so that no discharges occur;

(3) The systems which are proposed for detecting leaks and monitoring the facility;

(4) The actions that will be taken if process fluids escape the fluid management system;

(5) The methods which are proposed to stabilize processed materials before they are disposed of or during the permanent closure of the facility; and

(6) The procedures which are to be instituted to ensure that the facility poses no threat to the environment when there is no activity at the facility or when there is a temporary closure.

2. A person may not concurrently hold more than one permit for a small-scale facility if the facilities are within 1 mile of each other.

3. The minimum design criteria in NAC 445A.433 to 445A.438, inclusive, apply to small-scale facilities.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.2432)

NAC 445A.411 Pilot facility or testing facility: Conditions for issuance of permit. (NRS 445A.425, 445A.465) The Department may issue a permit to construct, operate and close permanently a pilot facility or testing facility if:

1. The facility is to evaluate less than 10,000 tons of ore, except that a greater amount may be permitted if the applicant demonstrates that the greater amount is necessary for a specific purpose in the testing program; and

2. The applicant has clearly shown that the facility will not degrade the waters of the State.

➥ A permit to operate a pilot facility or testing facility may not exceed 1 year for a single test or 2 years for a facility that has several tests to conduct.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24322)

NAC 445A.412 Pilot facility or testing facility: Contents of application for permit. (NRS 445A.425, 445A.465) An application for a permit to construct, operate and close permanently a pilot facility or testing facility must include:

1. The information required in paragraphs (a) to (d), inclusive, of subsection 2 of NAC 445A.394;

2. The quantity of the material to be evaluated;

3. The time required to complete all testing;

4. The type and quantity of chemicals to be utilized in the testing process;

5. A copy of the plans for the system and individual process components;

6. A description of the monitoring systems which are to be used to satisfy the requirements of NAC 445A.424;

7. A description of the procedures to be used to stabilize and dispose of the spent ore;

8. A topographic map of the area for the test site;

9. A description of hydrogeologic conditions at the site; and

10. A draft plan for the permanent closure of the facility, including a plan to stabilize areas disturbed by the operations of the facility.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24324)

NAC 445A.413 Pilot facility or testing facility: Construction of application indicating need to conduct testing beyond 2 years. (NRS 445A.425, 445A.465) An application for a permit to operate a pilot facility or testing facility which indicates a need to conduct testing beyond 2 years will be construed to be a request to operate a facility subject to the filing requirements of NAC 445A.394 to 445A.398, inclusive.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24326)

NAC 445A.414 Permit for facility using physical separation methods. (NRS 445A.425, 445A.465)

1. An applicant for a permit to construct, operate and close permanently a facility which utilizes physical separation methods of concentrating ore such as placer mining and flotation methods and which uses only coagulants, flocculants and reagents submitted to and approved by the Department, must submit to the Department:

(a) The information required by paragraphs (a) to (e), inclusive, of subsection 2 of NAC 445A.394;

(b) An abbreviated area of review which covers only the site and the adjacent area, including an identification of all surface water within 1/2 mile of the site and the depth and quality of all groundwater beneath the site;

(c) A draft operating plan which describes the circuit for concentrating the ores and identifies all process components;

(d) A multi-element spectrographic assay or other approved method of analysis which characterizes the ore body;

(e) The results of an analysis of the process make up water and process water for the inorganic constituents listed in NAC 445A.453 and 445A.455 to determine which and to what extent the process water burden of these elements is increased; and

(f) A certification that the applicant will not utilize any chemicals in the process except those submitted to and approved by the Department.

2. The use of a chemical not approved by the Department removes the facility from this category of operation and requires the holder of the permit to meet the requirements established in NAC 445A.394 to 445A.398, inclusive.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24328)

NAC 445A.415 Granting of permit which allows lower level of engineered containment than required by minimum design criteria. (NRS 445A.425, 445A.465) After receiving a petition from an applicant, the Department may grant a permit which allows a lower level of engineered containment than is required in NAC 445A.434 to 445A.438, inclusive, if the applicant clearly demonstrates:

1. That the groundwater at the facility is exempted from the standards established in paragraphs (b) and (c) of subsection 1 of NAC 445A.424;

2. The following:

(a) The depth from the surface to groundwater is greater than 200 feet and the upper portion of the existing geologic formation has a coefficient of permeability which is not more than that exhibited by 50 feet of material with a coefficient of permeability of 1x10-6 cm/sec;

(b) No open fractured or faulted geologic conditions exist from the surface to the groundwater; and

(c) All exploratory and condemnation borings beneath the site have been adequately sealed; or

3. That the conditions which exist at the site may allow a lower level of designed containment and still ensure that the waters of the State will not be degraded by providing, in addition to the information required by NAC 445A.394 to 445A.398, inclusive:

(a) An assessment of the combined effect of all relevant characteristics, including:

(1) The depth to all groundwater and the distance to all surface water;

(2) The hydrogeology and stratigraphy of the site; and

(3) The quality, characteristics, and existing and potential beneficial uses of any ground and surface water which may be potentially affected by the proposed facility.

(b) An engineering assessment of the combined effect of such relevant factors as:

(1) The proposed design of each process component, including the type and thickness of the liner or base;

(2) Other construction specifications;

(3) The type of materials to be used and the methods for placement of those materials;

(4) All structures, devices and techniques for controlling drainage and minimizing solution loss;

(5) The method to be used for controlling the internal hydraulic head;

(6) The system to detect and monitor leaks; and

(7) The types of quality assurance and quality control procedures to be used.

(c) An assessment of the potential for the facility to degrade the waters of the State, including an analysis of the potential for process fluids from each component to reach waters of the State, and the potential impact of such fluids on these waters.

➥ The Department may require the applicant to bear the cost of a third-party review of the application to determine whether it meets the requirements of this subsection. The Department shall develop and maintain a list of qualified reviewers from which the applicant can select. The Department must concur with the selection and all direction to the third party must be given by the Department. The time allotted to the Department to determine the completeness of an application pursuant to NAC 445A.401 may be extended by the amount of time necessary to complete the third-party review.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.2433)

NAC 445A.4155 Conditions pursuant to which modification to design of facility with existing permit does not require new public notice; extension of term of existing permit disallowed. (NRS 445A.425, 445A.465)

1. A modification to the design of a facility for which a permit has been granted by the Department does not require a new public notice if:

(a) The modification requires review by the Department pursuant to NAC 445A.350 to 445A.447, inclusive; and

(b) The Commission determines that the modification is not a modification of such significance as to constitute a "minor modification" or a "major modification," as those terms are described in NAC 445A.416 and 445A.417, respectively.

2. Such a modification may not extend the term of the permit.

(Added to NAC by Environmental Comm'n, eff. 10-29-97)

NAC 445A.416 Minor modification of existing permit; modification of operating plans. (NRS 445A.425, 445A.465, 445A.600)

1. A minor modification to an existing permit does not require a new public notice.

2. A minor modification to an existing permit may not extend the term of the permit.

3. A modification to the operating plans does not require a modification to the permit if the change will not result in an increased potential for the facility to degrade waters of the State.

4. For the purposes of this section, "minor modifications" include, but are not limited to:

(a) The phased expansion of the milling and tailings impoundment or the leach pads using the same or equivalent technologies that presently exist at a site which was adequately characterized in the original application but for which detailed design plans were not submitted in the original application.

(b) A significant modification to a monitoring system which does not result in a lessening of the effectiveness of that system.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24332)

NAC 445A.417 Major modification of existing permit. (NRS 445A.425, 445A.465, 445A.600)

1. A major modification to an existing permit requires a public notice.

2. A major modification to an existing permit may extend the term of the permit for not more than 5 years.

3. For the purposes of this section, "major modifications" include:

(a) The addition of a new beneficiation process which includes, but is not limited to, heap leaching and process components for milling, which was not identified in the original application.

(b) A significant change in the location of a proposed process component or site condition which was not adequately described in the original application.

(c) A change in the proposed beneficiation process that significantly alters the characteristics of the waste stream which significantly increases the potential to degrade the waters of the State.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24334)

NAC 445A.418 Fee for modification of permit. (NRS 445A.425, 445A.430, 445A.465)

1. The fee for a minor modification to a permit is one-half the amount of the renewal fee for a permit, up to a maximum fee of $5,000.

2. The fee for a major modification to a permit is equal to the amount of the renewal fee for a permit.

3. The fee for the type of a modification described in NAC 445A.4155 is $500.

(Added to NAC by Environmental Comm'n, eff. 9-1-89; A 10-29-97)

NAC 445A.419 Transfer of permit to new owner or operator. (NRS 445A.425, 445A.465)

1. A permit may be transferred to a new owner or operator.

2. Before the ownership or operation of a facility may be transferred during the term of a permit, the holder of the permit must inform the new owner or operator in writing of the requirements of the current permit and the requirements of NAC 445A.350 to 445A.447, inclusive.

3. A copy of that written notice must be sent to the Department.

4. The new owner or operator must state in writing to the Department that he or she will comply with the existing operating plans or provide revised plans to the Department for review and approval.

5. Until notice is given by the Department that the permit has been transferred, the current operator or owner named on the permit is responsible for complying with NAC 445A.350 to 445A.447, inclusive.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24338)

NAC 445A.420 Renewal of permit; operation of facility pending issuance of new permit. (NRS 445A.425, 445A.465, 445A.495)

1. A permit may be renewed by the Department if the holder of the permit submits an application to renew the permit. The application must:

(a) Be filed at least 120 days before the expiration of the existing permit;

(b) Include the renewal fee required by NAC 445A.232; and

(c) Include any new information to update information previously submitted to the Department.

2. A permit for a facility which is inactive because of an unplanned closure may be renewed once if the holder of the permit demonstrates that the conditions under which the permit was issued will continue and the design life of the process components will not be exceeded.

3. If the Department has not issued a new permit as of the expiration of the existing permit, the holder of the permit may continue to operate the facility pursuant to the terms and conditions of the existing permit until a new permit is issued by the Department.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.2434)

Operation and Design of Facilities

NAC 445A.424 Limitations on degradation of water; exemptions. (NRS 445A.425, 445A.465)

1. A facility, regardless of size or type, may not degrade the waters of the State to the extent that:

(a) The quality of surface water is lowered below that allowed by NRS 445A.565.

(b) For groundwater:

(1) The quality is lowered below a state or federal regulation prescribing standards for drinking water; or

(2) The concentration of WAD cyanide exceeds 0.2 mg/l.

➥ The Department may establish a numerical limit for any constituent not regulated by subparagraphs (1) and (2) which may reasonably be expected to be discharged by the facility in sufficient volume and concentration to cause an adverse impact on human health.

(c) The quality of those waters of the State which already exceed the criteria established by subsection 2 is lowered to a level that the Department finds would render those waters unsuitable for the existing or potential municipal, industrial, domestic or agricultural use.

2. The Department may exempt a body of groundwater or portion thereof from the standards established in subsection 1 if the request for an exemption to the groundwater standards and the supporting information is submitted as part of the application for the permit. The following criteria will be considered by the Department in determining whether to exempt a potentially impacted body of groundwater from the standards in subsection 1:

(a) The impacted groundwater does not currently serve as a source of drinking water and because of the following reasons the groundwater will not serve as a source of drinking water:

(1) The groundwater produces a mineral, hydrocarbon or geothermal fluid which the applicant can demonstrate to the satisfaction of the Department exists at a concentration that is expected to be capable of commercial production and that releases by the facility will not affect this production;

(2) The groundwater is situated at a depth or location which makes recovery of water for drinking economically or technologically impractical; or

(3) It would be economically or technologically impractical to render the water fit for human consumption; or

(b) The total dissolved solids in the groundwater is more than 10,000 milligrams per liter and the groundwater is not reasonably expected to become a supply of drinking water.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24342)

NAC 445A.425 Process components in existence on September 1, 1989: Standards; additional monitoring. (NRS 445A.425, 445A.465)

1. A process component in existence on September 1, 1989, is not required to meet more stringent engineering containment standards during the design life of that component if the applicant can demonstrate that:

(a) The process component meets and will continue to meet its design criteria; and

(b) There have been no significant changes in the characteristics of the material to be contained by the process component which would increase the potential to degrade the waters of the State.

2. Upon issuing a permit for a process component in existence on September 1, 1989, the Department may require additional monitoring of the site to verify that the conditions of this

section are being met. A process component found to have had releases of process fluid as a result of this monitoring must comply with the requirements of NAC 445A.441.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24344)

NAC 445A.426 Notice of intent to commence active operation of process component. (NRS 445A.425, 445A.465) At least 30 days before the introduction of process solutions into a new process component or an existing process component which has been materially modified, the holder of the permit must notify the Department of the intent to commence active operation of that process component.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24346)

NAC 445A.427 Duties of holder of permit upon construction or modification of process component. (NRS 445A.425, 445A.465) Within 30 days after completing construction on a new process component or materially modifying an existing process component, the holder of the permit shall submit to the Department:

1. As-built drawings of the process component;

2. A summary of the quality control procedures which were carried out during construction; and

3. The final operating plans required by NAC 445A.398 which have been revised to reflect modifications made during construction.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24348)

NAC 445A.428 Level of containment required for placer mining or flotation facilities. (NRS 445A.425, 445A.465) For placer mining or flotation facilities, the level of containment required by the Department for process fluids will depend upon the characteristics of the ore and process water.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.2435)

NAC 445A.429 Procedures required to prevent release of contaminants; requirements concerning impoundments. (NRS 445A.425, 445A.465)

1. The holder of the permit must institute appropriate procedures to ensure that all mined areas do not release contaminants that have the potential to degrade the waters of the State.

2. Open pit mines must, to the extent practicable, be free-draining or left in a manner which minimizes the impoundment of surface drainage and the potential for contaminants to be transported and degrade the waters of the State.

3. Bodies of water which are a result of mine pits penetrating the water table must not create an impoundment which:

(a) Has the potential to degrade the groundwaters of the State; or

(b) Has the potential to affect adversely the health of human, terrestrial or avian life.

4. The holder of a permit may apply to the Commission to establish a beneficial use with a level of protection less than that required by paragraph (b) of subsection 3 for water impounded in a specific mine pit.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24352)

NAC 445A.430 Stabilization of spent ore. (NRS 445A.425, 445A.465)

1. Spent ore which has been left on pads or which will be removed from a pad must first demonstrate stability of the discharge effluent from the pads or from the spent ore such that:

(a) WAD cyanide levels in the effluent are less than 0.2 mg/l;

(b) The pH level of the effluent is between 6.0 and 9.0; and

(c) Contaminants in any effluent from the processed ore which would result from meteoric waters would not degrade waters of the State.

2. If the requirements established in subsection 1 cannot be achieved, the Department will grant a variance to those conditions if the holder of the permit can demonstrate that:

(a) The remaining solid material, when representatively sampled, does not contain levels of contaminants that are likely to become mobile and degrade the waters of the State under the conditions that will exist at the site; or

(b) The spent ore is stabilized in such a fashion as to inhibit meteoric waters from migrating through the material and transporting contaminants that have the potential to degrade the waters of the State.

3. The Department may approve an alternate method for stabilizing ore that has been leached if the holder of the permit can clearly demonstrate that the condition in which the materials will be left will not create a potential for the waters of the State to be degraded.

(Added to NAC by Environmental Comm’n, eff. 9-1-89; A by R141-06, 10-31-2007)

NAC 445A.431 Stabilization of tailings. (NRS 445A.425, 445A.465) Upon termination of the active use of a tailings impoundment, representative samples of the material deposited in the impoundment must be collected and characterized. The tailings must be stabilized during the final closure of a facility so as to inhibit the migration of any contaminant that has the potential to degrade the waters of the State.

(Added to NAC by Environmental Comm’n, eff. 9-1-89)—(Substituted in revision for NAC 445.24356)

NAC 445A.432 Minimum design criteria: Generally. (NRS 445A.425, 445A.465) NAC 445A.433 to 445A.438, inclusive, define the minimum design criteria required of each process component and the site and operating conditions which are considered to exist when these criteria are applied. These provisions establish minimum contaminant control technologies and define the site and operating conditions which must be evaluated. Based on site characterization, best engineering judgment will be applied to determine the degree to which designs must provide more or less protection through engineered containment.

(Added to NAC by Environmental Comm’n, eff. 9-1-89)—(Substituted in revision for NAC 445.24358)

NAC 445A.433 Minimum design criteria: Universal requirements; areas where groundwater is near surface; proximity of new process components to dwellings; liability for degradation of water. (NRS 445A.425, 445A.465)

1. The following minimum design requirements apply to all process components:

(a) In areas where annual evaporation exceeds annual precipitation, a process component must achieve zero discharge.

(b) All sources must be designed to minimize releases of contaminants into groundwaters or subsurface migration pathways so that any release from the facility will not degrade waters of the State.

(c) All process components must be designed to withstand the runoff from a 24-hour storm event with a 100-year recurrence interval.

(d) The primary fluid management system must be designed to be able to remain fully functional and fully contain all process fluids including all accumulations resulting from a 24-hour storm event with a 25-year recurrence interval. The Department may require additional containment based on the following factors:

(1) Proximity to surface water bodies;

(2) Depth to groundwater; and

(3) Proximity to population.

➥ Contingency plans for managing process contaminated flows in excess of the design quantity must be described in the appropriate operating plans.

(e) The fluid management system must be designed to be functional for 5 years after the projected operating life of the process component and permanent closure period.

(f) The design of the process components must take into consideration the proposed range of operating conditions for each component and the history of seismic events at the site in order to preclude any differential movement or shifting of the subbase, liner or contained material which endangers primary or secondary containment integrity.

2. Additional containment of process fluids may be required in areas where groundwater is considered to be near the surface. Groundwater is considered to be near the surface if:

(a) The depth from the surface to groundwater is less than 100 feet and the top 100 feet of the existing formation has a coefficient of permeability greater than that exhibited by 100 feet of 1x10-5 cm/sec material;

(b) Open fractured or faulted geologic conditions exist in the bedrock from the surface to the groundwater; or

(c) There is an inability to document that all exploratory and condemnation borings beneath the site have been adequately sealed.

3. No new process component containing process fluids may be located within 1,000 feet of any dwelling which is occupied at least part of the year and which is not a part of the facility. This restriction does not apply to modifications at a facility which predate such a dwelling.

4. The application of minimum design criteria does not release the holder of a permit from liability for degradation to waters of the State caused by the facility.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.2436)

NAC 445A.434 Minimum design criteria: Leach pads and other nonimpounding surfaces designed to contain and promote horizontal flow of process fluids. (NRS 445A.425, 445A.465)

Leach pads and other nonimpounding surfaces which are designed to contain, not impound, process fluids and to promote the horizontal flow of process fluids must meet the following requirements:

1. Process fluids must exert only minimal hydraulic head on the liner.

2. Containment of process fluids must consist of an engineered liner system which provides containment equal to or greater than that provided by a synthetic liner placed on top of a prepared subbase of 12 inches of native, imported or amended soil, which has a maximum recompacted in place coefficient of permeability:

(a) Of 1x10-6 cm/sec; or

(b) Of 1x10-5 cm/sec when combined with a system for the detection of leaks which must be located at least beneath those portions of the liner which have the greater potential for leakage. The potential for leakage must be determined by:

(1) The extent of the hydraulic head exerted on a portion of the liner; and

(2) The period of time a portion of the liner is exposed to process fluids.

3. If leach pads or other nonimpounding surfaces are located above areas where groundwater is considered near the surface, the Department may require a liner system with a higher level of engineered containment.

4. When a material or system which provides hydraulic relief is installed beneath a single liner, including, but not limited to, sand, french drains and geotextiles, regardless of the intent of its design, it must function as a leak detection system and include a means for recovering process fluids.

5. Depending on the methods and materials used for their construction, the Department may require all open channels which routinely transport process fluids to be traced by a leak detection system.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24362)

NAC 445A.435 Minimum design criteria: Ponds. (NRS 445A.425, 445A.465)

1. All ponds which are intended to contain process fluids must have a primary synthetic liner and a secondary liner. Between the liners there must be a material which has the ability to rapidly transport any fluids entering it to a collection point which:

(a) Is accessible; and

(b) Has a system for recovering those fluids.

2. When the material between the liners is unable to collect, transport and remove all liquids at a rate that will prevent hydraulic head transference from the primary liner to the secondary liner, the pond must be shut down.

3. Ponds which are primarily designed to contain excess quantities of process fluids that result from storm events for limited periods may be constructed with a single liner if approved by the Department.

4. Ponds containing nonprocess fluids may be required to be lined depending on their potential to degrade waters of the State.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24364)

NAC 445A.436 Minimum design criteria: Vats, tanks and other containers which confine process fluids. (NRS 445A.425, 445A.465) Vats, tanks and other containers which confine process fluids and can be inspected for leaks visually do not require double liners if an area for secondary containment equal to 110 percent of the largest container is provided. Vats, tanks or other containers that are partially buried and cannot be visually inspected must have a system to detect leaks.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24366)

NAC 445A.437 Minimum design criteria: Tailings impoundments. (NRS 445A.425, 445A.465)

1. A tailings impoundment must utilize a system of containment equivalent to:

(a) Twelve inches of recompacted native, imported, or amended soils which have an in place recompacted coefficient of permeability of no more than 1x10-6 cm/sec; or

(b) Competent bedrock or other geologic formations underlying the site which has been demonstrated to provide a degree of containment equivalent to paragraph (a).

2. An alternate level of containment may be required by the Department for all of the tailings impoundment or for a portion thereof after considering the following factors:

(a) The anticipated characteristics of the material to be deposited;
(b) The characteristics of the soil and geology of the site;
(c) The degree to which the hydraulic head on the impoundment liner is minimized;
(d) The extent and methods used for recycling or detoxifying fluids;
(e) Pond area and volume;
(f) The depth from the surface to all groundwater; and
(g) The methods employed in depositing the impounded material.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24368)

NAC 445A.438 Minimum design criteria: Liners. (NRS 445A.425, 445A.465)

1. When placed on native materials, soil liners must have a minimum thickness of 12 inches and be compacted in lifts which are no more than 6 inches thick. Except when used in tailing impoundments, a soil liner must have a permeability of not more than that exhibited by 12 inches of 1x10-7 cm/sec material.

2. Synthetic liners must be rated as having a resistance to the passage of process fluids equal to a coefficient of permeability of 1x10-11 cm/sec.

3. The Department shall review for completeness the applicant's evaluation of the following design parameters, where applicable, for a liner:
(a) The type of foundation, slope and stability;
(b) The over liner protection and provisions for hydraulic relief;
(c) The load and means of applying load;
(d) The compatibility of a liner with process solutions;
(e) The complexity of the leak detection and recovery systems;
(f) The depth from the surface to all groundwater; and
(g) The liner's ability to remain functionally competent until permanent closure has been completed.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.2437)

NAC 445A.439 Program required to control quality of construction of liner systems. (NRS 445A.425, 445A.465) A quality assurance and quality control program must be developed and carried out for the construction of all liner systems. A summary of the quality control data must be submitted to the Department with the as-built drawings.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24372)

NAC 445A.440 Monitoring: Site of facility. (NRS 445A.425, 445A.465)

1. The program to monitor the site of a facility must be designed to monitor the quality of all ground and surface water which may be affected by the facility. The type, number and location of the monitoring points must be described in the application as part of the monitoring plan and must be approved by the Department.

2. Final monitoring requirements must be established by the Department.

3. Baseline data must be collected before operation of the facility.

4. In areas where there is a substantial separation between the process components and the groundwater, a system for monitoring highly probable escape pathways in the unsaturated zone may be required by the Department.

5. The decision where to locate the monitoring points for the site must be made after considering the site's geology and hydrogeology.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24374)

NAC 445A.441 Monitoring: Procedure upon variation in parameter or element being monitored. (NRS 445A.425, 445A.465) If the Department determines that there has been a variation in a parameter or element being monitored by the site-monitoring system as required in NAC 445A.440 which is caused by the facility and has the potential to degrade the waters of the State:

1. The holder of the permit shall conduct and submit an evaluation to the Department which:

(a) Identifies the source and escape pathways of the elements of concern;

(b) Determines the type, extent and ability of a system needed to contain or confine any migrating contaminant; and

(c) Identifies methods which can be carried out to remediate the contamination during the continued operation of the facility or at permanent closure.

2. The Department shall, based on the information provided pursuant to subsection 1:

(a) Require the immediate shut down of the process component and the immediate initiation of cleanup activities;

(b) Allow continued operation of the process component which is the source of the elements of concern with concurrent cleanup activities;

(c) Allow continued operation of the process component which is the source of the elements of concern while requiring the facility to continue to control the migration of the contaminant while cleanup activities are postponed; or

(d) Determine that no remedial action is warranted at the present time.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24376)

NAC 445A.442 Monitoring: Process components. (NRS 445A.425, 445A.465)

1. The Department shall determine the extent and complexity to which the holder of a permit must monitor individual process components for the release of contaminants after reviewing site and process controlled design conditions. Systems designed to detect and control leaks from process components must be located at the interface of the unit process components and the adjacent environment and be able to provide the first indication that pollutants or contaminants have escaped their primary containment.

2. The program to monitor the process components must include:

(a) A schedule of activities;

(b) A roster of current job titles for persons responsible for and involved in the monitoring program; and

(c) The form and frequency of reports to be submitted to the Department.

➥ The Department may randomly collect information or samples for reference. The cost of analyzing samples may be placed upon the holder of the permit.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24378)

NAC 445A.443 Monitoring: Beneficiation process. (NRS 445A.425, 445A.465) Monitoring of the beneficiation process must include the routine characterization of those process materials which will be disposed. The data obtained must be used by the holder of the permit to evaluate periodically and, when necessary, to refine the plan for the permanent closure of the facility.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.2438)

NAC 445A.444 Examples of planned and unplanned temporary closures. (NRS 445A.425, 445A.465)

1. The following are examples of planned temporary closures which have specific conditions defining their beginning and end:

(a) Seasonal closures because of normal weather cycles.

(b) Interruptions in the active beneficiation processes to provide planned periods of quiescence for metallurgical or operating reasons.

(c) Any other planned process condition which will interrupt the active beneficiation process.

2. The following are examples of unplanned temporary closures:

(a) A closure because of unforeseen weather events.

(b) A failure in a major system component or a process failure which causes the fluid management system or a portion thereof to shut down.

(c) The discontinuation of a facility's operations because of litigation.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24382)

NAC 445A.445 Procedure upon unplanned temporary closure of process component. (NRS 445A.425, 445A.465)

1. In the event of an unplanned temporary closure of one or more process components, the holder of the permit shall:

(a) Within 30 days after an unplanned temporary closure begins, inform the Department of the closure and describe the procedures and controls which have been carried out to maintain the process components during this period.

(b) Within 90 days after the Department has been notified of the unplanned temporary closure:

(1) Begin to evaluate the procedures which will be required to carry out a permanent closure of the process components affected and petition the Department to approve one or more procedures needed for the permanent closure of the process components affected; or

(2) For just cause, request that the Department grant an extension and delay permanent closure. Except as otherwise provided in subsection 2 of NAC 445A.420, the extension may not be longer than the remaining term of the existing permit or for 3 years, whichever is greater.

2. The Department shall approve or disapprove the proposed procedures for permanent closure within 30 days after they are submitted to the Department.

3. Unless the Department has granted an extension pursuant to subparagraph (2) of paragraph (b) of subsection 1 within 270 days after the Department has been notified of the unplanned temporary closure, the holder of the permit shall initiate the approved procedures for permanent closure.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24384)

NAC 445A.446 Permanent closure of facility. (NRS 445A.425, 445A.465)

1. The permanent closure of a facility must be initiated:

(a) Following the request of the holder of the permit;

(b) For a facility which is under a temporary closure, no later than at the end of one renewal of a 5-year permit which has been issued pursuant to subsection 2 of NAC 445A.420; or

(c) When the end of the design life of that process component is reached.

2. Permanent closure is complete when the requirements contained in NAC 445A.429, 445A.430 and 445A.431 have been achieved.

3. The time required for monitoring the facility following permanent closure depends upon the particular site and process characteristics, but in no event may the time required exceed 30 years.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24386)

NAC 445A.447 Plans for permanent closure; sources not classified as process components. (NRS 445A.425, 445A.465)

1. Plans for permanent closure are required for all sources at a facility.

2. A final plan for permanent closure of any source which has been identified as a process component must be submitted to the Department at least 2 years before the anticipated permanent closure of that process component.

3. Sources which have not been classified as process components must be evaluated at the end of their operating life to determine the potential for pollutants from these sources to migrate and degrade the waters of the State under the final proposed site conditions and must be closed in accordance with the *State Handbook of Best Management Practices* prepared pursuant to NAC 445A.336.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24388)

INTERNATIONAL CYANIDE MANAGEMENT INSTITUTE

The International Cyanide Management Code

www.cyanidecode.org

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SCOPE

The Cyanide Code is a voluntary initiative for the gold and silver mining industries and the producers and transporters of the cyanide used in gold and silver mining. It is intended to complement an operation's existing regulatory requirements. Compliance with the rules, regulations and laws of the applicable political jurisdiction is necessary; the Cyanide Code is not intended to contravene such laws.

The Cyanide Code focuses exclusively on the safe management of cyanide that is produced, transported and used for the recovery of gold and silver, and on mill tailings and leach solutions. The Cyanide Code addresses production, transport, storage, and use of cyanide and the decommissioning of cyanide facilities. It also includes requirements related to financial assurance, accident prevention, emergency response, training, public reporting, stakeholder involvement and verification procedures. Cyanide producers and transporters are subject to the applicable portions of the Cyanide Code identified in their respective Verification Protocols.

It does not address all safety or environmental activities that may be present at gold and silver mining operations such as the design and construction of tailings impoundments or long-term closure and rehabilitation of mining operations.

The term "cyanide" used throughout the Cyanide Code generically refers to the cyanide ion, hydrogen cyanide, as well as salts and complexes of cyanide with a variety of metals in solids and solutions. It must be noted that the risks posed by the various forms of cyanide are dependent on the specific species and concentration. Information regarding the different chemical forms of cyanide is found at *http://www.cyanidecode.org/cyanide-facts/cyanide-chemistry* .

CYANIDE CODE IMPLEMENTATION

As it applies to gold and silver mining operations, the Cyanide Code is comprised of two major elements. The Principles broadly state commitments that signatories make to manage cyanide in a responsible manner. Standards of Practice follow each Principle, identifying the performance goals and objectives that must be met to comply with the Principle. The Principles and Practices applicable to cyanide production and transportation operations are included in their respective Verification Protocols. Operations are certified in compliance with the Cyanide Code upon the International Cyanide Management Institute's announcement on the Cyanide Code website that an independent third-party audit has verified that they have met the Standards of Practice, Production Practices or Transport Practices.

For implementation guidance, visit *http://www.cyanidecode.org/become-signatory/implementation-guidance*

The programs and procedures identified by the Cyanide Code's Principles and Standards of Practice and in the Cyanide Production and Transportation Verification Protocols for the management of cyanide can be developed separately from other programs, or they can be integrated into a site's overall safety, health and environmental management programs. Since mining operations typically do not have direct control over all phases of cyanide production, transport or handling, mines that are undergoing Verification Audits for certification under the Cyanide Code will need to require that other entities involved in these activities commit to and demonstrate that they adhere to the Cyanide Code's Principles and meet its Standards of Practice for these activities.

The Cyanide Code, the implementation guidance, mine operators' guide, and other documents or information sources referenced at *www.cyanidecode.org* are believed to be reliable and were prepared in good faith from information reasonably available to the drafters. However, no guarantee is made as to the accuracy or completeness of any of these other documents or information sources. The implementation guidance, mine operators guide, and the additional documents and references are not intended to be part of the Cyanide Code. No guarantee is made in connection with the application of the Cyanide Code, the additional documents available or the referenced materials to prevent hazards, accidents, incidents, or injury to employees and/or members of the public at any specific site where gold or silver is extracted from ore by the cyanidation process. Compliance with the Cyanide Code is not intended to and does not replace, contravene or otherwise alter the requirements of any specific national, state or local governmental statutes, laws, regulations, ordinances, or other requirements regarding the matters included herein. Compliance with the Cyanide Code is entirely voluntary and is neither intended nor does it create, establish, or recognize any legally enforceable obligations or rights on the part of its signatories, supporters or any other parties.

PRINCIPLES AND STANDARDS OF PRACTICE

1. PRODUCTION Encourage responsible cyanide manufacturing by purchasing from manufacturers who operate in a safe and environmentally protective manner.

Standard of Practice

1.1 Purchase cyanide from manufacturers employing appropriate practices and procedures to limit exposure of their workforce to cyanide and to prevent releases of cyanide to the environment.

2. TRANSPORTATION Protect communities and the environment during cyanide transport.

Standards of Practice

2.1 Establish clear lines of responsibility for safety, security, release prevention, training and emergency response in written agreements with producers, distributors and transporters.

2.2 Require that cyanide transporters implement appropriate emergency response plans and capabilities, and employ adequate measures for cyanide management.

3. *HANDLING AND STORAGE* **Protect workers and the environment during cyanide handling and storage.**

Standards of Practice

3.1 Design and construct unloading, storage and mixing facilities consistent with sound, accepted engineering practices and quality control and quality assurance procedures, spill prevention and spill containment measures.

3.2 Operate unloading, storage and mixing facilities using inspections, preventive maintenance and contingency plans to prevent or contain releases and control and respond to worker exposures.

4. *OPERATIONS* **Manage cyanide process solutions and waste streams to protect human health and the environment.**

Standards of Practice

4.1 Implement management and operating systems designed to protect human health and the environment including contingency planning and inspection and preventive maintenance procedures.

4.2 Introduce management and operating systems to minimize cyanide use, thereby limiting concentrations of cyanide in mill tailings.

4.3 Implement a comprehensive water management program to protect against unintentional releases.

4.4 Implement measures to protect birds, other wildlife and livestock from adverse effects of cyanide process solutions.

4.5 Implement measures to protect fish and wildlife from direct and indirect discharges of cyanide process solutions to surface water.

4.6 Implement measures designed to manage seepage from cyanide facilities to protect the beneficial uses of ground water.

4.7 Provide spill prevention or containment measures for process tanks and pipelines.

4.8 Implement quality control/quality assurance procedures to confirm that cyanide facilities are constructed according to accepted engineering standards and specifications.

4.9 Implement monitoring programs to evaluate the effects of cyanide use on wildlife, surface and ground water quality.

5. *DECOMMISSIONING* **Protect communities and the environment from cyanide through development and implementation of decommissioning plans for cyanide facilities.**

Standards of Practice

5.1 Plan and implement procedures for effective decommissioning of cyanide facilities to protect human health, wildlife and livestock.

5.2 Establish an assurance mechanism capable of fully funding cyanide-related decommissioning activities.

6. *WORKER SAFETY* **Protect workers' health and safety from exposure to cyanide.**

Standards of Practice

6.1 Identify potential cyanide exposure scenarios and take measures as necessary to eliminate, reduce and control them.

6.2 Operate and monitor cyanide facilities to protect worker health and safety and periodically evaluate the effectiveness of health and safety measures.

6.3 Develop and implement emergency response plans and procedures to respond to worker exposure to cyanide.

7. *EMERGENCY RESPONSE* **Protect communities and the environment through the development of emergency response strategies and capabilities.**

Standards of Practice

7.1 Prepare detailed emergency response plans for potential cyanide releases.

7.2 Involve site personnel and stakeholders in the planning process.

7.3 Designate appropriate personnel and commit necessary equipment and resources for emergency response.

7.4 Develop procedures for internal and external emergency notification and reporting.

7.5 Incorporate into response plans monitoring elements and remediation measures that account for the additional hazards of using cyanide treatment chemicals.

7.6 Periodically evaluate response procedures and capabilities and revise them as needed.

8. TRAINING **Train workers and emergency response personnel to manage cyanide in a safe and environmentally protective manner.**

Standards of Practice

8.1 Train workers to understand the hazards associated with cyanide use.

8.2 Train appropriate personnel to operate the facility according to systems and procedures that protect human health, the community and the environment.

8.3 Train appropriate workers and personnel to respond to worker exposures and environmental releases of cyanide.

9. DIALOGUE **Engage in public consultation and disclosure.**

Standards of Practice

9.1 Provide stakeholders the opportunity to communicate issues of concern.

9.2 Initiate dialogue describing cyanide management procedures and responsively address identified concerns.

9.3 Make appropriate operational and environmental information regarding cyanide available to stakeholders.

CYANIDE CODE MANAGEMENT

Administration

The International Cyanide Management Institute ("The Institute" or "ICMI") is a non-profit corporation established to administer the Cyanide Code through a multi- stakeholder Board of Directors consisting of representatives of the gold and silver mining industries and participants from other stakeholder groups. For additional information on the Institute, see: *http://www.cyanidecode.org/about-icmi*.

The Institute's primary responsibilities are to:

- Promote adoption of and compliance with the Cyanide Code, and to monitor its effectiveness and implementation within the world gold and silver mining industries.
- Develop funding sources and support for Institute activities.
- Work with governments, NGOs, financial interests and others to foster widespread adoption and support of the Cyanide Code.
- Identify technical or administrative problems or deficiencies that may exist with Cyanide Code implementation, and
- Determine when and how the Cyanide Code should be revised and updated.

Cyanide Code Signatories

Gold and silver mining companies and the producers and transporters of cyanide used in gold and silver mining can become signatories to the Cyanide Code. By becoming a signatory, a company commits to follow the Cyanide Code's Principles and implement its Standards of Practice, or in the case of producers and transporters, the Principles and Practices identified in their respective Verification Protocols. Cyanide Code signatories' operations will be audited by an independent third-party auditor to verify their compliance with the Cyanide Code.

When becoming a signatory, a company must specify which of its operations it intends on having certified. Only those cyanide production and transportation facilities that are related to the use of cyanide in gold and/or silver mining are subject to certification.

Signatories pay annual fees to support the Institute's activities. Failure to pay the required fee results in the company's termination from participation in the Cyanide Code program. See: http://www.cyanidecode.org/signatory-companies/directory-of-signatory-companies.

Cyanide Code Verification and Certification

Active operations must be audited to verify their compliance with the Cyanide Code within three years of being designated for certification. This requirement is met if the site inspection portion of the audit has been conducted by the applicable deadline. A certified operation must have the site inspection portion of its next audit conducted within three years of the effective date of its previous audit, which is the date the Institute posts its Summary Audit Report and announces its certification on the Cyanide Code website.

During an *initial* verification audit, an operation's compliance at the time of the audit will be evaluated. Subsequent *recertification* audits also will evaluate compliance during the period between the preceding and current audits.

Audits are to be conducted by independent, third-party professionals. Auditors are selected and hired by the signatory or operation but must meet the Institute's criteria for their experience and expertise. Auditors evaluate an operation against the applicable Cyanide Code Verification Protocol to determine if its management of cyanide achieves the Code's Principles and Standards of Practice, or the Production or Transport Practices for these types of operations. Operations must make all relevant data available to the auditors, including the complete findings of their most recent independent Cyanide Code Verification Audit, in order to be considered for certification.

<u>Submission of audit results; finding of full compliance</u>: Before finalizing an audit report, the auditor must review the audit findings with the operation to ensure that the information presented is accurate. Within 90 days of completing the inspection of the operation, the auditor must submit: (1) a Detailed Audit Findings Report responding to the questions in the Verification Protocol; (2) a Summary Audit Report that includes the auditor's conclusion regarding the operation's compliance with the Cyanide Code; and (3) the auditor's credentials to the signatory, the operation and to the Institute.

ICMI will review the audit report to ensure that appropriate responses have been provided for all Verification Protocol questions and that adequate evidence has been included in support of the auditor's findings, and will advise the auditor and the operation when the report has been accepted as complete.

The operation will then be certified by the auditor as complying with the Cyanide Code if the auditor concludes that it is in full compliance with the Code's Principles and Standards of Practice, or its Principles and Practices for cyanide production or transportation, as applicable. The certification becomes effective when the Institute announces the certification and posts the Summary Audit Report on the Cyanide Code website.

The Detailed Audit Findings Report is the confidential property of the operation and shall not be released by the Institute in any fashion without the written consent of the signatory and/or audited operation. The Summary Audit Report and the credentials of the auditor(s) will be made available to the public on the Cyanide Code website. The operation may submit its comments regarding the Summary Audit Report to the Institute, which will be posted along with the Summary Audit Report on the Institute's website.

Finding of substantial compliance: Operations that are found in substantial compliance with the Cyanide Code are conditionally certified, subject to the successful implementation of a Corrective Action Plan. Substantial compliance means that the operation has made a good-faith effort to comply with the Cyanide Code and that the deficiencies identified by the auditor can be readily corrected and do not present an immediate or substantial risk to employee or community health, safety, or the environment.

Operations that are found in substantial compliance with a Standard of Practice, Production Practice or Transport Practice must develop and implement a Corrective Action Plan to correct the deficiencies identified by the verification audit. The operation shall request that the auditor review the Corrective Action Plan or assist in its development so that there is agreement between the operation and the auditor that its implementation will bring the operation into full compliance. The Corrective Action Plan addressing a finding of substantial compliance must include a time period, mutually agreed to by the operation and the auditor, to bring the operation into full compliance with the Cyanide Code. In no case shall this time period be longer than one year from the date on which ICMI posts the operation's Summary Audit Report on the Cyanide Code website. The auditor must submit the Corrective Action Plan to the Institute for posting on the Institute's website along with the Summary Audit Report.

Finding of non-compliance: Operations that were audited and found in non-compliance with one or more Standards of Practice, Production Practices or Transport Practices, and those that have not fully implemented a Corrective Action Plan by the applicable deadline, are in non-compliance with the Cyanide Code. To be certified, these operations must: (1) maintain compliance with those Standards or Practices that were found in full compliance during their audit; and (2) fully implement their Corrective Action Plans. Operations that do not fully implement their Corrective Action Plans within three years of the date their Summary Audit

Report was posted on the Institute's website also must submit to the Institute the report of a new audit with a finding of full compliance in order to be certified.

Corrective Action Plan and Completion Report: The operation must provide evidence to the auditor demonstrating that it has implemented the Corrective Action Plan as specified and in the agreed-upon time frame. In some cases, it may be necessary for the auditor to re-evaluate the operation to confirm that the Corrective Action Plan has been implemented. Upon receipt of the documentation that the Corrective Action Plan has been fully implemented, the auditor must provide a Completion Report to the Institute verifying that the operation is in full compliance with the Cyanide Code.

All operations certified in compliance with the Cyanide Code will be identified on the Code website, *http://www.cyanidecode.org/signatory-companies/directory-of-signatory-companies*. Each certified operation's Summary Audit Report will be posted. Operations found in substantial or non-compliance will have their Summary Audit Reports, Corrective Action Plans and Corrective Action Plan Completion Reports posted.

Pre-operational certification: A mining operation, cyanide production facility or cyanide transport operation that is not yet active but that is sufficiently advanced in its planning and design phases can request pre-operational conditional certification based on an auditor's review of its site plans and proposed operating procedures. An operation audited pre-operationally and found in full compliance will be certified conditionally, and remains so until the findings of its operational audit become effective. An on-site audit is required within one year of a mining operation's first receipt of cyanide at the site to confirm that the operation has been constructed and is being operated in compliance with the Cyanide Code. On-site audits of cyanide production facilities and cyanide transport operations are required within six months of their start of cyanide production or management activities. These operations must advise ICMI within 90 days of the date of the first receipt of cyanide at a mining operation or of the start of cyanide production or management activities at a cyanide production or transport operation. A new three-year certification period begins when the findings of the operational audit become effective.

Mining operations that have been designated for certification before they become active but which do not request pre-operational certification must be audited for compliance with the Cyanide Code within one year of their first receipt of cyanide, and also must advise ICMI within 90 days of the date of their first receipt of cyanide. Cyanide production facilities and cyanide transport operations that have been designated for certification before they become active but which do not request pre-operational certification must be audited for compliance with the Cyanide Code and be certified in full or substantial compliance before providing cyanide to a certified mine.

A mining operation or an individual cyanide facility at an operation is no longer subject to certification after decommissioning of the cyanide facilities. A producer or transporter is no longer subject to certification after it no longer produces or transports cyanide for use in the gold or silver mining industries.

Certification Maintenance

In order to maintain certification, an operation must meet all of the following conditions:

- The auditor has concluded that it is either in full compliance or substantial compliance with the Cyanide Code.
- An operation in substantial compliance has submitted a Corrective Action Plan to correct its deficiencies and has demonstrated that it has fully implemented the Corrective Action Plan in the agreed-upon time.
- There is no verified evidence that the operation is not in compliance with the Cyanide Code.
- An operation has had a verification audit within three years.
- An operation has had a verification audit within two years of a change in ownership, defined as a change of the controlling interest of the operating company.

Re-admission, Re-designation and Re-activation

Signatory companies that have voluntarily withdrawn or have been terminated from participation in the Cyanide Code can seek re-admission to the program. Operations that had been certified or designated for certification but which were subsequently voluntarily withdrawn from the program by the signatory company can return to the program and be re-designated for certification.

Auditor Criteria and Review Process

The Institute has developed specific criteria for Cyanide Code Verification auditors and will implement procedures for review of auditor credentials. Auditor criteria includes requisite levels of experience with gold or silver mining (or chemical production facilities or hazardous materials transport, as appropriate) and in conducting environmental, health or safety audits, certification as a professional health, safety or environmental auditorby a self-regulating organization and lack of conflicts of interest with operation(s) to be audited.

Dispute Resolution

The Institute has developed and implemented fair and equitable procedures for resolution of disputes regarding auditor credentials and certification and/or de-certification of operations. The procedures provide due process to all parties that may be affected by these decisions.

Information Availability

The Cyanide Code and related information and program management documentation are available via the Internet at www.cyanidecode.org. The website is intended to promote an understanding of the issues involved in cyanide management and to provide a forum for enhanced communication within and between the various stakeholder groups with interest in these issues. The website is the repository for Cyanide Code certification and verification information.