BC MINING LAW REFORM

MININGWATCH CANADA

Bridging the Gap:

Towards Best International Standards on Mine Waste Safety in British Columbia

January 2022

Bridging the Gap: Towards Best International Standards on Mine Waste Safety in British Columbia

By Steven H. Emerman, Ph.D.
Malach Consulting, Utah, USA

Produced by BC Mining Law Reform and MiningWatch Canada

January 2022

To cite : Emerman, Steven H., 2021. B*ridging the Gap: Towards Best International Standards on Mine Waste Safety in British Columbia*. BC Mining Law Reform and MiningWatch Canada.

Available online: https://reformbcmining.ca/reports

Table of contents

Acronyms

ANCOLD	Adaptive Management Plan
APEGBC	Association of Professional Engineers and Geoscientists of BC
BAT	Available Technology
BCMLR	BC Mining Law Reform
CDA	Canadian Dam Association
DRIPA	on the Rights of Indigenous Peoples Act
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FMC	Fair Mining Collective
FNEMC	First Nations Energy and Mining Council
FPIC	Free, Prior and Informed Consent
HSRC	Health, Safety and Reclamation Code for Mines in British Columbia
ICMM	International Council on Mining and Metals
ICOLD	International Commission on Large Dams
IEEIRP	Independent Expert Engineering Investigation and Review Panel
IRMA	Initiative for Responsible Mining Assurance
ITRB	Independent Tailings Review Board
MAC	Mining Association of Canada
MCA	Montana Code Annotated
MCE	Maximum Credible Earthquake
MEMLI	Ministry of Energy, Mines and Low Carbon Innovation
NAC	Nevada Administrative Code
OMS	Operations, Maintenance and Surveillance
PMF	Probable Maximum Flood
PRI	Principles for Responsible Investment
TSF	Tailings Storage Facility
UNEP	United Nations Environment Programme
UBCIC	Union of British Columbia Indian Chiefs
UNDRIP	United Nations Declaration on the Rights of Indigenous Peoples
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation

About this report

The objective of this report is to better understand the gap between current British Columbia laws and policy and best practices on mining development in other jurisdictions. This report makes concrete recommendations for revisions to the mining legislation in British Columbia in order to bring it into alignment with best practices and international standards on mine waste safety, including key guidelines from *Safety First: Guidelines for Responsible Mine Tailings Management* (Morrill et al., 2020). The primary pieces of legislation reviewed include the *Mines Act* (2021), the *Environmental Assessment Act* (2021), the Health, Safety and Reclamation Code (HSRC) for Mines in British Columbia (Ministry of Energy and Mines, 2017), and the accompanying *Guidance Document* (Ministry of Energy and Mines, 2016) for Part 10 (Permitting, Reclamation and Closure) of the HSRC. The *Audit of Code Requirements for Tailings Storage Facilities* (Ministry of Energy, Mines and Low Carbon Innovation [MEMLI], 2021b) is also reviewed. For selected guidelines of Safety First, revisions to the mining legislation are recommended in the places where similar topics were discussed. The vast majority of recommendations pertain to the B.C. HSRC. Existing international guidance and regulatory documents that partly or wholly supported the recommended revisions are both summarized and quoted in full. While Dr. Steven Emerman is the lead author of the analysis found in Table 1 of the report, the introductory remarks and the summary of findings were produced by BC Mining Law Reform and MiningWatch Canada.

About the author

Dr. Steven H. Emerman is a retired Associate Professor from Utah Valley University in the United States and is currently the owner of Malach Consulting, a firm that specializes in evaluating the technical and environmental risks of mining projects and policies for mining companies, as well as for governmental and non-governmental organizations. Dr. Emerman has over 30 years of experience in hydrology, geophysics, and mining, and has over 70 peer-reviewed publications in these areas. Dr. Emerman has reviewed mining projects and policies in over a dozen countries in North America, South America, Europe, Africa, Asia and Oceania. Dr. Emerman has testified and presented his assessments before various governmental bodies, including the U.S. House of Representatives Subcommittee on Indigenous Peoples of the United States, the U.N. Permanent Forum on Indigenous Issues, and the European Parliament. Dr. Emerman is currently a member of the U.S. Society on Dams (Tailings Dam Committee, Earthquake Committee, Chair of the Body of Knowledge Subcommittee of the Education and Training Committee), and the Society for Mining, Metallurgy and Exploration (Tailings and Waste Committee). Dr. Emerman is also a member of the Geological Society of America, the American Geophysical Union and the Canadian Dam Association. Dr. Emerman holds a M.A. in Geophysics from Princeton University and Ph.D. in Geophysics from Cornell University.

Summary

Seven years after the Mount Polley Mine disaster – the worst in Canadian history – communities and the environment are still at risk from mine waste failures in British Columbia. The province's legislation is not yet up to par with international standards on mine waste storage safety. This was echoed by the first ever *Audit of Code Requirements for Tailings Storage Facilities* in 2021. While the Audit includes important findings, it also contains significant limitations, raising concerns about the ongoing review of the Health, Safety and Reclamation Code (HSRC) for Mines in British Columbia and other B.C. legislation relating to waste safety and tailing storage facilities.

The government must bring these laws and regulations into alignment with best practices and international standards and strengthen its enforcement of compliance on mine waste safety to protect communities and the environment. In order to do this, B.C. legislation must:

1. prioritize safety above cost considerations in the design, construction, operation, and closure of mine waste facilities;
2. require Indigenous and community consent before building, expanding, or closing facilities;
3. prohibit facilities located immediately upstream from communities and sensitive ecosystems;
4. prohibit the use of upstream dams, especially in high precipitation and seismic areas;
5. mandate best available technologies and practices, including no surface water and the use of filtered tailings;
6. design facilities to withstand the most extreme meteorological and seismic events;
7. require full financial assurances for site closure and post-closure costs, as well as full financial insurance for accidental damages; and,
8. require accountability, transparency, and public disclosure on mine waste risks.

TAILINGS POND FAILURE AT MOUNT POLLEY © CANADIAN PRESS/JONATHAN HAYWARD

Introduction

Mining metals and minerals generates large volumes of solid wastes, amounting to tens of million of tons every year in British Columbia. In the case of base metals like copper, lead, and molybdenum, which are all mined in B.C., as much as 200 tons of solid waste is generated for each ton of metal mined, processed, and used. In the case of gold, over a million tons of waste is generated for each ton of metal produced. Coal mining generates up to 20 tons of solid waste per ton of coal produced (Lapointe, 2020). These volumes are orders of magnitude larger than all of the residential and municipal solid wastes generated on a yearly basis (MiningWatch Canada, 2020).

Much of this waste is toxic and can contaminate entire watersheds if not contained properly. The dams and engineered structures that retain this waste can also fail, releasing catastrophic volumes of waste into the environment. These structures need to be maintained for generations and are subject to failure from a range of factors including engineering and maintenance flaws, changes in water flows (exacerbated by climate change), and seismic events. Research indicates that these structures fail with increasing severity (World Mine Tailings Failures, 2020).

In 2014, the dam breach at Imperial Metals' Mount Polley mine resulted in the largest mine waste disaster in Canadian history. Over 24 billion litres of solid and liquid mine waste rushed downstream into Quesnel Lake watershed, leading to a drinking water ban and destroying kilometres of forest and fish habitats in its wake.

MOUNT POLLEY MINE WASTE SPILL 2014 - HAZELTINE CREEK © CHRIS BLAKE

Long-term effects of this disaster, such as contamination of lake sediments and species, are still being monitored.

An analysis of 35 mine waste dams at 26 sites conducted by the BC First Nations Energy and Mining Council (FNEMC, 2015) showed that up to 8,678 km of waterways lie downstream of contaminants including lead, arsenic, and mercury. More recently, BC Mining Law Reform released maps pointing to over a hundred known and potentially contaminated mine waste sites that threaten to pollute waters, fish habitat, and communities across British Columbia (BC Mining Law Reform, 2021a). In addition to these, at least 25 new mines have already been proposed or are already under construction (Ministry of Energy, Mines and Low Carbon Innovation [MEMLI], 2021a).

Audit Highlights Safety Concerns

In June 2021, the government of British Columbia released its first audit from the new Mine Audits & Effectiveness Unit of the B.C. MEMLI on mine waste safety, entitled *Audit of Code Requirements for Tailings Storage Facilities* (the "Audit" in this report; MEMLI, 2021b). While the Audit includes important findings, it was limited in scope and contained significant limitations.

Notably, the Audit failed to include best practices and international standards in the 13 "key elements" of the B.C. HSRC used to assess how B.C. compares with other jurisdictions (see Table 1). As such, the Audit's overall conclusion that current B.C. requirements are "in alignment with industry best practice" (MEMLI, 2021b; p. 4) is not accurate.

Furthermore, this conclusion contradicts other findings of the Audit itself, which states that the 2016 revisions to the HSRC are already out of date with the evolving science and best practice on mine waste safety: "Best practice for TSFs [Tailings

Storage Facilities] is a rapidly evolving field and the Ministry's regulatory program also needs to evolve to maintain alignment with best practice" (p. 4).

The Audit adds: "While the Code Guidance Document is a useful tool … it has not been updated since its publication in 2016 while industry best practice has continued to evolve" (p. 5), and concludes that, "if B.C.'s regulatory framework for TSFs is to retain its place of relative merit in the world, then it must evolve as well" (p. 17). Since 2016:

> *"Events such as the failures of TSFs at the Germano and Córrego do Feijão mines in Brazil in 2015 and 2019 (commonly referred to as the Fundão/ Samarco and Brumadinho failures, respectively) have raised worldwide awareness of the hazards associated with TSFs impounding saturated tailings. At the global scale, one response to the issue of tailings storage and management was the convening of the Global Tailings Review by the United Nations Environmental Programme and its partners in March 2019. These and other responses by regulators in other jurisdictions and by environmental advocacy groups reflect the evolution of practice and level of interest in tailings storage and management." (p.10)*

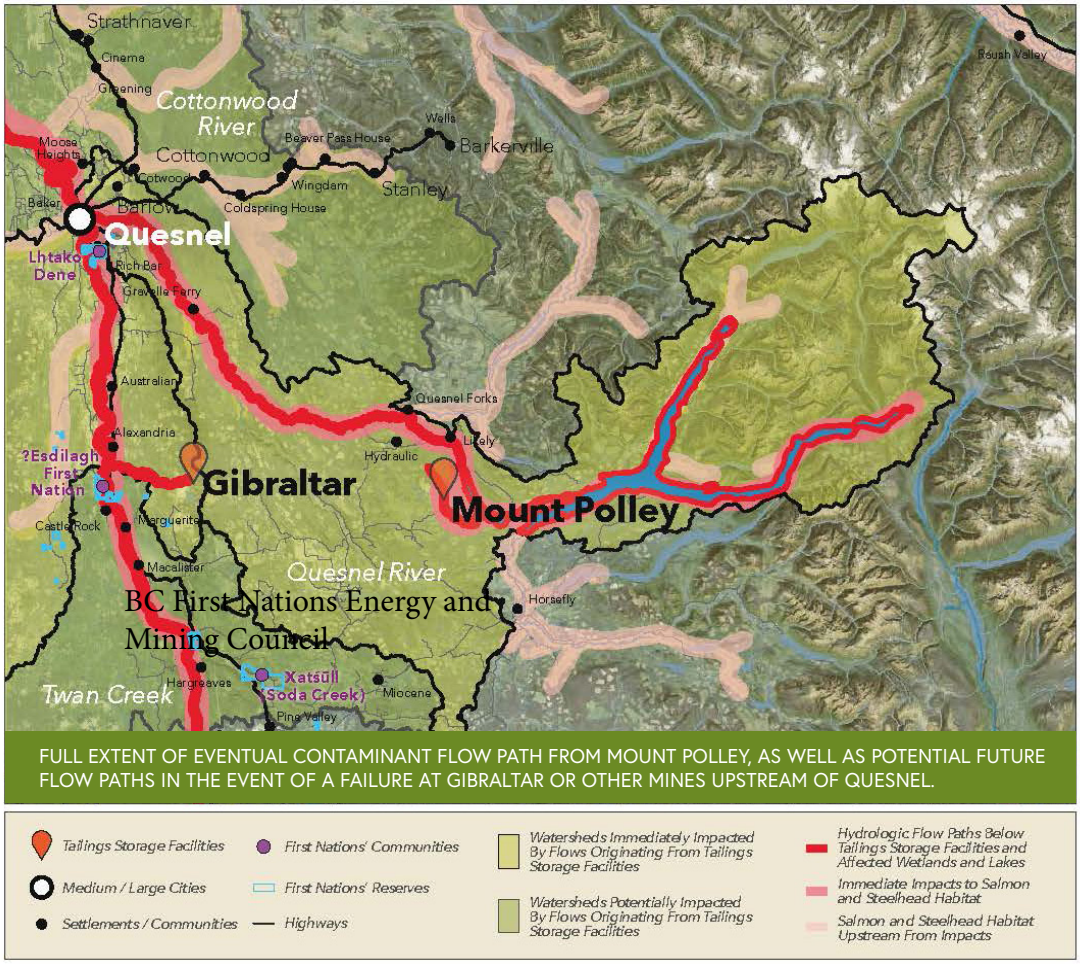
The Audit points specifically to recent standards "that seek to inform industry best practice" (p. 104) including the *Global Industry Standard on Tailings Management* ("Global Industry Standard" in this report), released in August 2020 by the International Council on Mining and Metals (ICMM), the United Nations Environment Programme (UNEP), and Principles for Responsible Investment (PRI), as well as *Safety First: Guidelines for Responsible Mine Tailings Management* ("Safety First" in this report), released in June 2020 by Earthworks and MiningWatch Canada (Morrill et al., 2020).

We support the Audit's Recommendation #2 calling on the B.C. government to update its regulatory framework to reflect best standards, practices and regulations:

> *The Ministry should develop and document a change management process for determining when and how B.C.'s regulatory framework for TSFs (including the Code and the Code Guidance Document) will be updated to reflect new management programs, guidelines, standards, external regulations and other sources that inform or seek to inform industry best practice or regulation relating to TSFs.*

B.C.'s Minister of Energy, Mines and Low Carbon Innovation, Bruce Ralston, has expressed his support for the findings of the Audit, saying, "We are committed to implementing all seven recommendations put forward by the chief auditor and will continue our work to build a world-leading regulatory framework for TSFs here in B.C." (MEMLI, 2021c).

To assist in this process, this report makes recommendations for specific revisions to B.C.'s mining legislation. The primary pieces of legislation reviewed include the *Mines Act* (2021), the *Environmental Assessment Act* (2021), the HSRC (Ministry of Energy and Mines, 2017), and the accompanying *Guidance Document* (Ministry of Energy and Mines, 2016) for Part 10 (Permitting, Reclamation and Closure) of the HSRC. For each guideline identified in Safety First, revisions to the mining legislation are recommended in the places where similar topics were discussed. The vast majority of recommendations pertain to the B.C. HSRC for Mines. Existing international guidance and regulatory documents that partly or wholly supported the recommended revisions were both summarized and quoted in full.



Key Findings

This analysis concludes that there remains a significant gap between existing B.C. legislation and best practices and standards in other jurisdictions. The analysis in this report reveals that B.C. fails to meet best practices and standards found in many other jurisdictions (in Canada and internationally) in at least eight key areas relating to mine waste safety. Four of those areas were recognized as deficient by the MEMLI Auditor, while another four were completely absent from the Audit. Below is a summary of the results (see Table 1 for a more detailed analysis and recommendations).

Areas Excluded from the Audit

1. Safety before costs. **B.C. law and policy do not make safety in design, construction, operation, and closure of mines an overriding requirement.** The B.C. HSRC does not currently meet best practices and international standards recommended by the Mount Polley Independent Expert Engineering Investigation and Review Panel (IEEIRP) (2015), GRID-Arendal and UNEP in the 2017 report "Safety is No Accident," or Safety First (Morrill et al., 2020). These reports all concluded that "safety attributes should be evaluated separately from economic considerations," and that cost/benefit analyses "should not supersede safety considerations" (IEEIRP, 2015). As indicated in Table 1, several other jurisdictions including the UNEP and the U.S. Army Corps of Engineers (USACE) (2014) make safety a priority over cost, stating, "it is not appropriate to refer to balancing or trading off public safety with other project benefits."

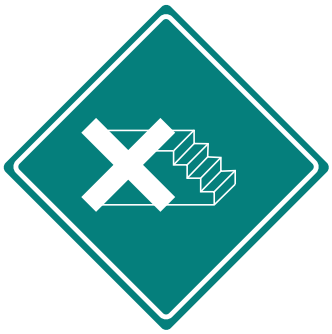
2. Securing Indigenous consent. B.C. law and policy do not require Indigenous and community consent before building, expanding, or closing mine waste facilities. The B.C. HSRC does not currently meet international standards, nor do the *Mineral Tenure Act nor the Mines Act*. Relevant best practices and international standards include those of Safety First (Morrill et al., 2020), the Global Industry Standard (Global Tailings Review, 2020), the Initiative for Responsible Mining Assurance (IRMA) Standard for Responsible Mining (IRMA, 2018), as well as the B.C. *Declaration on the Rights of Indigenous Peoples Act* (DRIPA) (2019) and the *United Nations Declaration on the Rights of Indigenous Peoples* (UNDRIP) (2007).

3. Siting risky mine waste dams near communities. B.C. law and policy do not prohibit mine waste dams immediately upstream from communities and sensitive ecosystems. While B.C. law allows mines to place dams upstream of communities and sensitive ecosystems, other jurisdictions like Brazil, Ecuador, and China limit or exclude mines near communities. Safety First (Morrill et al., 2020) also requires this.

4. Requiring mine operators to cover their costs. B.C. fails to require full financial assurances for mine site closure and post-closure costs, as well as full financial insurance for accidental damages. The B.C. HSRC and legislations do not meet best international standards, including those of Safety First (Morrill et al., 2020) and the IRMA Standard (IRMA, 2018), as well as those already required by Canada's Marine Liability Act, Canada's Pipeline Safety Act, and in other jurisdictions such as in Alaska, Maine, Montana, Ontario, Quebec, and Wyoming. The U.S. Federal Energy Regulatory Commission (FERC) is also considering similar requirements. B.C. is primarily deficient in failing to require mine companies to ensure that 100% of the costs of shutting down and cleaning up a mine after its mine life are covered. B.C. also fails to ensure there is funding available in the event of a catastrophic mine spill.

Deficient Areas

The following four areas were recognized as deficient by the MEMLI Auditor, who acknowledged the B.C. HSRC did not meet best practice standards:



5. Banning upstream dams. B.C. does not prohibit "upstream dams," which are demonstrably more at risk of failures, especially in high seismic and precipitation areas. International standards including those of the Canadian Dam Association (CDA) (2019) and Safety First (Morrill et al., 2020) recommend banning upstream dams, especially in seismic and high precipitation areas. Several countries now ban upstream dams, including Brazil (where new upstream dams are prohibited and existing upstream dams must be safely closed within three to eight years, depending upon the size), Peru (where upstream dams are prohibited), Chile (where upstream dams are prohibited), and Ecuador (where upstream dams are prohibited and centerline dams are allowed only under special circumstances; the standard method allowed is downstream construction). The Audit concluded that the B.C. HSRC does not currently meet best international standards in this area (p. 22, 76-78).

6. Requiring best available technologies. B.C. does not specify adoption of best available technologies and practices that will reduce or eliminate wet tailings technology. The B.C. HSRC states a general requirement for the adoption of best available technologies but does not specifically encourage adoption of technologies that eliminate surface water (especially at closure) or adopt filtered tailings. The State of Maine in the U.S. mandates the use of filtered mine tailings to reduce the risks and consequences of catastrophic spills. The Audit concluded that the B.C. HSRC does not currently meet the best international standards (pp. 15, 24-27), including those recommended by the Mount Polley report (IEEIRP, 2015) and Safety First (Morrill et al., 2020).

7. Designing for the most extreme meteorological and seismic events. B.C. does not require that all tailings dams be built to withstand the most extreme flooding and earthquake events. Other jurisdictions, like Brazil, Indonesia, United Kingdom, Norway, Arizona, Nevada, Idaho, Montana, New Mexico, and Oregon, all require that dams be designed to withstand the strongest earthquakes and floods that are theoretically possible at a given location. The Audit concluded the B.C. HSRC does not currently meet international standards (Appendix F), including those recommended by Safety First (Morrill et al., 2020). When there is at least one life at risk in the event of a dam failure, the U.S. Federal Emergency Management Agency (FEMA), USACE, as well as jurisdictions stated above, all require water-retention dams to withstand the Probable Maximum Flood (PMF) and/or the Maximum Credible Earthquake (MCE). Brazil requires the same standards for mine tailings dams. With climate change resulting in more extreme weather and atypical weather events, such requirements are more important than ever.

8. Ensuring transparency. B.C. does not require full accountability, transparency, or public disclosure of mine waste risks. The Audit concluded the B.C. HSRC does not currently meet best practices or international standards (pp. 24-27, Appendix F), including those recommended by Safety First (Morrill et al., 2020) and the Global Industry Standard (Global Tailings Review, 2020), or on accountability as required by the State of Montana. The IRMA Standard (IRMA, 2018) also requires high levels of public and community disclosure, beyond the B.C. HSRC's current requirements.

Shortcomings in Procedural Compliance

In addition to the above regulatory limitations, the recent Audit found that as many as one in four of the TSFs in B.C. were out of compliance with four basic requirements of the current HSRC that pertain directly to mine waste safety (Appendix G). Those requirements include:

- the completion of a Dam Safety Inspection;
- having an Engineer of Record;
- having a Qualified Person onsite who is responsible for the safety of all tailings storage facilities; and,
- having an Independent Tailings Review Board (ITRB).

The Audit indicates that:

- 14 facilities (or 22%) do not have an ITRB;
- 8 facilities (or 13%) have not completed a Dam Safety Inspection;
- 7 facilities (or 11%) do not have a Qualified Person onsite;
- 5 facilities (or 8%) do not have an Engineer of Record. (The HSRC does not require the Engineer of Record to be external to the mining company, raising concerns about objectivity.)

Of these cases, 61% (11) represent "Significant" to "Very High" consequences in case of failure, including potential loss of life.

To be clear, the Audit did not conduct a comprehensive assessment beyond these four basic Code requirements, and while these four Code requirements are more procedural in nature, they remain fundamental to risk management and compliance assurance. If more than one in four mines could not meet these four basic and procedural requirements, and if most mines do not comply with the regulatory gaps identified in this report, it raises serious questions about the safety of mine waste facilities in British Columbia.

The following table looks at the guidelines from Safety First (Morrill et al., 2020) where significant progress remains to improve mine waste safety. We present the current status of B.C. legislation and propose recommendations to bring legislation into alignment with relevant best practices and international standards.

TABLE 1: TOWARDS BEST PRACTICES AND INTERNATIONAL STANDARDS ON MINE WASTE SAFETY IN BRITISH COLUMBIA

Safety First Guidelines	Best Practices & International Standards	Current B.C. Legislation & Standards	Recommended Revisions to B.C. Legislation & Standards
1. Make safety the guiding principle in design, construction, operation, and closure	IEEIRP: Cost/benefit analyses should not supersede safety considerations.[1] UNEP: Environmental and human safety is a priority. Safety should be evaluated separately from economic considerations.[2] BCMLR: Public, environmental, and economic safety should be the determinative factors in decisions regarding tailings disposal.[3] Global Industry Standard: Goal is zero harm to people and the environment with zero tolerance for human fatality.[4] USACE: It is not appropriate to balance public safety with other benefits of dams.[5]	While the HSRC Guidance Document 2016 states that, "Physical stability is of paramount importance, and options that require a compromise to physical stability should be discarded," it does not make safety the primary consideration. In fact, the Guidance Document opens the door for economics and financial feasibility factors to be invoked to disregard the safest design: "The alternatives assessment provides a comparative analysis of options considering the following sustainability factors: Environment, Society, Economics ... Constraints should be clearly stated, incorporated into the project design criteria or operating or closure performance criteria … Examples of constraints include, but are not limited to, the following: ... Economics and financial feasibility."	In HSRC Guidance Document 2016 Sections 3.1 Alternatives Assessment or 3.2 Risk Assessment: Clearly state in one or both of these sections that: *"The ultimate goal of tailings management must be zero harm to people and the environment and zero tolerance for human fatalities. Given the hazardous nature of mine tailings, safety must be the central design factor guiding decision-making. Operating companies must commit to and document that they have made safety the primary consideration in tailings facilities and dam design, construction, operation, closure, and post-closure. Cost considerations are important, but protecting human health and safety, as well as the environment, must be the primary concern."*

Safety First Guidelines	Best Practices & International Standards	Current B.C. Legislation & Standards	Recommended Revisions to B.C. Legislation & Standards
2. Ban new tailings facilities immediately upstream from inhabited areas	Minas Gerais, Brazil: Tailings facilities cannot be constructed or expanded where there is a populated area within 10 km downstream or within the area that could be reached by the tailings flood within 30 minutes, whichever is greater. The distance may be increased up to 25 km.[6] Ecuador: Same as Minas Gerais, Brazil, but without the option of increasing the distance to 25 km.[7] China: New tailings dams cannot be located within 1 km of residential areas or important facilities, or 3 km from the Yangtze or Yellow rivers.[8]	The current B.C. legislation and standards do not ban new tailings facilities immediately upstream from inhabited areas.	In HSRC Guidance Document 2016 Section 3.2 Risk Assessment: Add two new paragraphs stating that: *"The most effective way to minimize risk to people is to prevent the construction of new tailings facilities where there is a population living or working in close proximity and downstream from the facility. Operating companies must not build infrastructure in which workers are likely to be present—offices, cafeterias, warehouses—in the path of a possible tailings dam failure. Also, new tailings facilities must not be constructed if the operating company is not capable of ensuring the safe and timely evacuation of the communities who live downstream."* *"Affected communities must not be expected to be evacuated without professional support. Even if operating companies carry out training and emergency drills, there are specific social groups (elderly, small children, people with disabilities, etc.) that require special assistance. Based on the principle of zero harm to people, companies must ensure that outside support from professional teams during an emergency is able to reach all affected populations. Minimum distance between communities and new dams must be defined on a case-by-case basis."*

Safety First Guidelines	Best Practices & International Standards	Current B.C. Legislation & Standards	Recommended Revisions to B.C. Legislation & Standards
3. Ban upstream dams at new mines and safely close existing upstream facilities	Brazil: New upstream dams are prohibited. Existing upstream dams must be safely closed within 3-8 years, depending upon the size.[9] Chile: Upstream dams are prohibited.[10] Ecuador: Upstream dams are prohibited. Standard method allowed is downstream dams. Centerline dams are allowed only under special circumstances.[11] Peru: Upstream dams are prohibited.[12] FMC: Calls for upstream and modified-centerline dams to be avoided where possible.[13] ICOLD and UNEP: Upstream dams should not built in areas where there is risk of earthquakes.[14] European Commission: Upstream dams should not be built if there is any risk of liquefaction due to earthquakes.[15] EPA: Upstream dams should not be built in very wet or high seismic areas.[16] CDA: Upstream dams should not be built in high seismic areas.[17] UNEP: Upstream dams should not be built unless justified by independent review.[18]	While the HSRC Guidance Document 2016 states that the CDA guidelines should be considered during the design process, and that the CDA guidelines state that upstream dams should not be built in high seismic areas, it does not make this safety criteria an overriding requirement in B.C. legislation or policy. B.C. does not explicitly ban upstream dams in new or expanding mines.	HSRC 2017: Add a new section 10.1.11 with heading *"Prohibition of Upstream Construction Method"* (and change numbering for subsequent sections as appropriate) with the following text: *"Because of the demonstrated risk associated with upstream dam construction, upstream dams must not be built at any new facilities. A modified centerline design must be considered an upstream dam because it still includes construction of the dam on top of uncompacted tailings. In the same way, a downstream or centerline raise constructed on top of an existing upstream dam still constitutes an upstream dam. Expansion of existing upstream tailings dam facilities must cease, and these facilities must be safely closed as soon as possible. This includes dams where companies have been approved for permits that have not begun or are just beginning construction. The deadline for safe closure must depend primarily on engineering, rather than economic considerations."*

Safety First Guidelines	Best Practices & International Standards	Current B.C. Legislation & Standards	Recommended Revisions to B.C. Legislation & Standards
4. Any potential loss of life is an extreme event and construction design must respond accordingly	Brazil: All tailings dams should be able to withstand the MCE.[19] Indonesia: All dams should be able to withstand the MCE and PMF.[20] FEMA: Dams with the probable loss of a single life in the event of failure should be designed to withstand the PMF and MCE. Other dams should be designed to withstand 10,000-year earthquakes.[21] USACE: Dams for which failure could place human life at risk should be designed to withstand the PMF and MCE. Other dams should be designed to withstand 10,000-year floods and earthquakes.[22] Arizona: Dams for which failure would threaten human life should be able to withstand the MCE and PMF.[23] Nevada: Dams for which failure would result in a high probability of loss of life should be able to withstand the MCE and PMF.[24] Idaho: A tailings dam for which failure could potentially flood a permanent dwelling should be able to withstand the MCE. A tailings dam taller than 40 feet for which failure could potentially flood a permanent dwelling should be designed to be able to withstand the PMF.[25]	B.C. legislation and policy do not require all tailing facilities and dams to be able withstand the most extreme weather and seismic events (PMF and MCE). The B.C. HSRC 2017 and HSRC Guidance Document 2016 require tailings facilities and dams to be able to withstand the most extreme weather and seismic events (PMF and MCE) only if there is a permanent population at risk of loss of more than 100 lives in the event of dam failure. When there is a population at risk with loss of 1 to 100 lives, a lesser, riskier design structure is accepted.	In HSRC 2017: Section 10.1.8 (1) Seismic and Flood Design Criteria should be amended to include: *"(a) for tailings storage facilities for which failure would result in the potential loss of human life,* *(i) the minimum seismic design criterion shall be the Maximum Credible Earthquake,* *(ii) the minimum flood design criterion shall be the Probable Maximum Flood, and* *(iii) a facility that stores the inflow design flood shall use a minimum design event duration of 72 hours;* *(b) for tailings storage facilities for which failure would not result in the potential loss of human life,* *(i) the minimum seismic design criterion shall be a return period of 1 in 10,000 years,* *(ii) the minimum flood design criterion shall be a return period of 1 in 10,000 years …"*

4. Any potential loss of life is an extreme event and construction design must respond accordingly (continued)	Montana: Dams for which failure could place human life at risk should be designed to withstand the MCE.[26] New Mexico: Dams for which failure will result in probable loss of life should be able to withstand the PMF.[27] Oregon: Dams for which loss of life is expected in the event of dam failure should be able to withstand the PMF and MCE.[28] Colorado: Dams for which loss of life is expected in the event of dam failure should be able to withstand 90% of the PMF and either the MCE or the 5,000-year earthquake.[29] United Kingdom: Any dam for which the failure would endanger lives in a community (defined as 10 or more people) should be able to withstand the PMF.[30] Norway: Any dam for which the failure would affect more than 20 houses should be able to withstand the PMF.[31]		

Safety First Guidelines	Best Practices & International Standards	Current B.C. Legislation & Standards	Recommended Revisions to B.C. Legislation & Standards
5. Mandate the use of Best Available Technology for tailings, including no surface water and dry closure	IEEIRP: Tailings deposits should not include surface water. Tailings should be unsaturated and compacted, which can be achieved with filtered tailings technology.[32] Maine: Use of filtered tailings technology is required.[33] BCMLR: Prohibit wet tailings impoundment unless it can be demonstrated that a dry tailings approach would pose greater long-term risk.[34] FMC: The mine plan should include a detailed plan for dewatering of tailings that meets the standards of Best Available Technology (BAT).[35]	The B.C. HSRC Guidance Document 2016 does not mandate the use of BAT as stated in the Mount Polley report (IEEIRP, 2015) and other best standards. Instead, it vaguely encourages some of those standards by stating: "The following guidance on setting objectives and targets are provided for consideration in design and operations: … Effort to reduce and remove water from containment within tailings facilities should be made … Alternatives to water covers should be considered in planning stages."	In HSRC 2017: Add a new section 10.1.12 with heading "Use of Best Available Technology (BAT) for Prevention of Failure of Tailings Storage Facilities" with following text: *"Tailings storage facilities must be designed, constructed and operated so as to achieve the following objectives consistent with Best Available Technology (BAT):* *1. Eliminate surface water from the impoundment.* *2. Promote unsaturated conditions in the tailings with drainage provisions.* *3. Achieve dilatant conditions throughout the tailings deposit by compaction.* *The preceding objectives can be achieved through the use of filtered tailings technology, although other technologies that achieve the same objectives are also permissible."* Change numbering for subsequent sections as appropriate. The following bullet points from HSRC Guidance Document (p. 13) should be removed as redundant: *"Effort to reduce and remove water from containment within tailings facilities should be made, Alternatives to water covers should be considered in planning stages."*

Safety First Guidelines	Best Practices & International Standards	Current B.C. Legislation & Standards	Recommended Revisions to B.C. Legislation & Standards
6. Implement rigorous controls for safety	FEMA: For the design of dams for which there is probable loss of life in the event of dam failure, faults that have not moved in 100,000 years should be regarded as active.36 USACE: No dam should have an annual probability of failure greater than 0.01%.37 USBR: No dam should have an annual probability of failure greater than 0.01%.38 CDA: The annual probability of fatality of the "maximally exposed individual" residing downstream of a dam should be less than 0.01%.39 CDA: Minimum factor of safety should be 1.5 during normal tailings dam operation.40 FMC: Minimum factor of safety should be 2.0 during normal tailings dam operation.41 Brazil: Minimum factor of safety should be 1.1 during an earthquake.42 USBR: Minimum factor of safety during an earthquake should be in the range 1.0-1.3, depending upon the probability of liquefaction.43 USACE: Embankment slopes should be no steeper than 1V:5H.44	B.C. legislation and policy do not mandate the safest design criteria in terms of factor of safety, dam embankment slope, or annual probability of failure. For instance, the B.C. HSRC 2017 and HSRC Guidance Document 2016 refer to a minimum static factor of safety of 1.5, but allow a lesser factor of safety if justified by the Engineer of Record and approved by B.C.'s Chief Inspector. Similarly, B.C. refers to a minimum embankment slope of 1V:2H (1 vertical unit for 2 horizontal units), but allows steeper, riskier slopes if justified by the Engineer of Record and approved by B.C.'s Chief Inspector. B.C. refers to CDA's guidelines mandating that no dam for which failure would endanger human life should have an annual probability of failure greater than 0.01%, while international standards mandate this criteria for all dams (irrespective of the risk of loss of lives).	In HSRC 2017: Add a new section 10.1.13 with heading "Annual Probability of Failure" and include: *"For tailings dams for which failure would not result in the potential loss of human life, an acceptable annual probability of failure would be 0.01% (equivalent to design for a 10,000-year earthquake or 10,000-year flood).* *"For tailings dams for which failure would result in the potential loss of human life, an acceptable annual probability of failure must be no greater than 0.001%."* Re-write the section 10.1.10 "Minimum Static Factor of Safety" with new heading "Minimum Static and Pseudo-Static Factor of Safety" and include: *"As a guidance for safe operation and closure, conservative Factors of Safety (FoS) must be established and enforced for all tailings dams. For operation and closure of a tailings dam, a static FoS of 1.5 (in non-earthquake conditions), and pseudo-static FoS of 1.1 (in response to the design earthquake, which establishes that even during the strongest seismic acceleration theoretically possible, the dam will still have 10% more shear resistance than is necessary to avoid failure), is presently viewed as 'conservative.'*

6. Implement rigorous controls for safety (continued)			*When calculating FoS, single input values must be avoided and a range of values and methods or models applied to assess the various possible FoS values (static and dynamic)."* Rewrite the section 10.1.9 "Design Slopes" with new text: *"The slope of the outer embankment of the tailings dam must be low enough to keep the annual probability of failure due to piping (also called internal erosion) below an acceptable level. New outer embankments must be constructed with slopes 1V:5H or less, and additional fill must be added to existing outer embankments with a slope steeper than 1V:5H in order to reduce the slope to 1V:5H, as per guidance from the USACE. A proposal to construct or maintain an outer embankment steeper than 1V:5H must be justified in writing to both regulators and the public. The justification cannot be based solely on economic considerations, but must demonstrate that, for a particular design, failure by internal erosion is still sufficiently unlikely even with a steeper slope. In all instances, a dam slope should never be steeper than 1V:2H. It should be noted that new upstream dams must be banned and existing upstream dams must be safely closed, regardless of the outer embankment slope."*

Safety First Guidelines	Best Practices & International Standards	Current B.C. Legislation & Standards	Recommended Revisions to B.C. Legislation & Standards
7. Evaluate and characterize the dam foundation and the tailings and estimate their relationship to risk	Global Industry Standard: Facilities that store tailings with low, high, and very high potential for acid mine drainage or metal leaching should be designed to withstand the 2,475-year flood and 2,475-year earthquake, 5,000-year flood and 5,000-year earthquake, and 10,000-year flood and 10,000-year earthquake, respectively.[45]	B.C. legislation and policy are largely compliant with best practices. The B.C. HSRC 2017 and HSRC Guidance Document 2016 require site characterization for support of the design of a TSF in accordance with the guidelines of Association of Professional Engineers and Geoscientists of BC (APEGBC) (2016). However, B.C. legislation and policy do not mandate any particular seismic or flood design criteria for a tailings storage facility that stores potentially acid-generating tailings or tailings with high contaminant leaching potential.	In HSRC 2017: Section 10.1.8 (1) Seismic and Flood Design Criteria should be amended to include: *"(c) for tailings storage facilities that store potentially acid-generating tailings or tailings that have high contaminant leaching potential,* *(i) the minimum seismic design criterion shall be the Maximum Credible Earthquake,* *(ii) the minimum flood design criterion shall be the Probable Maximum Flood…"*
8. Appropriate monitoring systems must be in place to identify and mitigate risk	Global Industry Standard: A preplanned action should be available for responding to every possible adverse observation (called the Observational Method)[46] IEEIRP: Observations are worthless without a plan for responding to the observations.[47] MAC: Critical controls require pre-defined actions to be taken if performance is outside the specified range.[48] Global Industry Standard: The Observational Method is not appropriate for the prevention of brittle failure modes, such as liquefaction.[49] ICMM: The Observational Method is not appropriate for the prevention of brittle failure modes, such as liquefaction.[50]	B.C. legislation and policy are largely compliant with best practices. The B.C. HSRC 2017 and HSRC Guidance Document 2016 require a monitoring and surveillance plan and "quantifiable performance objectives." According to HSRC Guidance Document 2016, the "OMS [Operations, Maintenance and Surveillance] manual will outline specific requirements, frequencies and procedures for the following: … Quantitative performance objectives and associated trigger-action response plans." Aside from the previous sentence, B.C. legislation and policy do not emphasize the need for pre-planned actions for responding to every possible adverse observation.	In HSRC Guidance Document 2016 Section 4.4.1 Surveillance and Monitoring: Add the following: *"In order to identify and reduce uncertainty, tailings facilities must have a clearly defined Adaptive Management Plan (AMP) linked to tailings monitoring results that encompasses a complete set of predictions and pre-planned actions. The AMP must include:* *1. Numeric and measurable expected performance criteria based on predictions of engineering behavior.* *2. Numeric trigger levels between good and worrisome conditions related to monitoring results. For example, measured pressure on the dam, water levels in dam/impoundment piezometers, supernatant pool*

8. Appropriate monitoring systems must be in place to identify and mitigate risk (continued)			*characteristics, tailings chemistry, and other characteristics.* *3. Mitigation measures designed for each performance criterion or trigger aimed at avoiding a catastrophic or other type of facility failure.* *4. An evaluation of the effectiveness of the measures taken.* *5. Reporting responsibilities for the operating company and responses by the regulatory agency and to relevant stakeholders.* *6. An annual AMP report for the tailings facility that reviews any triggers met, actions taken, the effectiveness of the actions, and any modifications that need to be made to the AMP.* *"The report, and its raw data, must be made public, and a meeting must be held to explain the results to any affected communities and other interested stakeholders. The AMP is a way to rigorously implement the Observational Method. The Observational Method must be applied only under the oversight and concurrence of an ITRB and is not simply a license to 'figure things out later.' The Observational Method must not be used for the prevention of liquefaction because liquefaction tends to occur without warning, i.e., with no time to make relevant observations. For the avoidance of liquefaction, all appropriate preventive actions must be carried out from the outset of the project."*

Safety First Guidelines	Best Practices & International Standards	Current B.C. Legislation & Standards	Recommended Revisions to B.C. Legislation & Standards
9. Ensure the independence of reviewers to promote safety	IEEIRP: The ITRB must be free of external influence or conflicts of interest.[51] IRMA: Independent reviewers should be objective, third-party professionals.[52] MAC: Independent reviewers should be objective, third-party professionals.[53] Global Industry Standard: The independent reviewers are third-parties who certify that they follow best practices for avoiding conflicts of interest.[54] Montana: Independent reviewers must not have financial conflicts due to employment.[55] Japan: The role of ITRB is undertaken by the responsible regulatory authorities.[56] FMC: A government-appointed tailings advisory committee should have no connection with the mining company or the Ministry of Mines.[57] Minas Gerais, Brazil: Dam safety auditors can have no employment or consulting relationship with the mining company for the previous three years.[58] FERC: Dam inspectors cannot previously have acted as agents on behalf of the dam operator and cannot have been an employee of the dam operator for the previous two years.[59]	No current B.C. legislation or policy clarifies the meaning of "independent." The B.C. HSRC 2017 and HSRC Guidance Document 2016 only state that the Dam Safety Review Report must be prepared by an "independent" Professional Engineer, including by a firm not previously involved as the Engineer of Record for the facility, and that B.C.'s Chief Inspector must approve the membership and the terms of reference for the ITRB. The B.C. Mines Act (1996) states that an inspector can require an "independent" study of the health and safety of a mine or of the actual or potential environmental damage resulting from mining activity, again without clarifying the meaning of "independent."	In HSRC 2017: In section 10.4.2 remove "c) establish an Independent Tailings Review Board, unless exempted by the chief inspector" and rewrite to read: *"The Chief Inspector of Mines shall appoint an ITRB for each tailings storage facility. The composition of the ITRB shall be commensurate with the complexity of the tailings storage facility in consideration of the HSRC Guidance Document. ITRB members, as individuals or as representatives of organizations, must not have a financial conflict with the mine being reviewed. Financial conflicts include but are not limited to direct financial interest (employment, contracts, stock, etc.), and personal or family connections to the mine or operating company that could incur any kind of benefits."*

Safety First Guidelines	Best Practices & International Standards	Current B.C. Legislation & Standards	Recommended Revisions to B.C. Legislation & Standards
10. Towards zero failure after mine closure	ANCOLD: Closed tailings facilities should be designed to withstand the PMF and the MCE.[60] Global Industry Standard: Tailings facilities in the passive-closure (passive care) stage should be designed to withstand the 10,000-year flood and the 10,000-year earthquake, regardless of the consequences of failure.[61] ICMM: Flood and seismic design criteria should be stricter during closure than during operation.[62]	B.C. legislation and policy do not mandate any particular seismic or flood design criteria for a closed tailings storage facility.	In HSRC 2017: Section 10.1.8 (1) Seismic and Flood Design Criteria should be amended to include: *"(d) for closed tailings storage facilities* *(i) the minimum seismic design criterion shall be the Maximum Credible Earthquake,* *(ii) the minimum flood design criterion shall be the Probable Maximum Flood… "*

Safety First Guidelines	Best Practices & International Standards	Current B.C. Legislation & Standards	Recommended Revisions to B.C. Legislation & Standards
11. Consent of affected communities	UNDRIP: Requires the Free, Prior and Informed Consent (FPIC) of Indigenous peoples prior to the approval of projects affecting their lands.[63] IRMA: Recommends all mining projects obtain FPIC of Indigenous peoples and provide culturally appropriate alternatives and adequate compensation and benefits.[64] Global Industry Standard: Requires obtaining and maintaining FPIC for tailings facilities.[65]	Despite the adoption of DRIPA in 2019, B.C.'s mining laws, especially the Mineral Tenure Act and associated regulations, remain inconsistent with the FPIC standard promoted in international law and best practices, including UNDRIP, the IRMA Standard, and the Global Industry Standard. Neither "First Nation" nor "Indigenous" are mentioned once in B.C.'s Mineral Tenure Act or the Mines Act. The HSRC Guidance Document 2016 requires mine owners only to include "a description" of the First Nations' "established and asserted rights" when preparing a Mines Act permit application or amendment (section 3.5.1). And while "local communities, First Nations, and stakeholders" are to be consulted for the selection of indicators to be used for the Alternatives Assessment of tailings facility options (section 3.1), there are no requirements to consult, let alone obtain the consent of affected First Nations for the actual selection of the tailings facility location, type, or technology. The HSRC 2017 requires only consultation with "affected communities and First Nations" for the establishment of the Mine Emergency Response Plan, including for the "identification of potential hazards, emergency communications, and responses," as well as for "the annual testing of the effectiveness of the Mine Emergency Response Plan" (section 3.7.1).	B.C. legislation and policies must explicitly refer to the right of FPIC of Indigenous peoples and affected communities in the mining sector. As such, sections 3.1 and 3.5 of HSRC Guidance Document 2016, as well as section 3.7.1 of HSRC 2017 should follow best international standards, such as those of the IRMA Standard (IRMA, 2018) and Safety First (Morrill et al., 2020). Specific language should be determined in consultation with First Nations.

Safety First Guidelines	Best Practices & International Standards	Current B.C. Legislation & Standards	Recommended Revisions to B.C. Legislation & Standards
12. Grievance procedures and whistleblowers	Global Industry Standard: There should be a process for reporting and addressing concerns and implementing whistleblower protections, but this can be internal to the mining company.[66] Brazil: Mineworkers have the right to interrupt tasks at any time that there is an imminent risk to health and safety of themselves or others.[67]	B.C. legislation and policy do not discuss grievance procedures or whistleblower protection in the specific context of mining.	In the *Mines Act*: *Add the following section: "Independent grievance procedures must be established and made available in a culturally appropriate way to all employees, contractors, suppliers, and regulators, as well as Indigenous Groups and rights holders, including affected community members. All grievance mechanisms must adhere to the effectiveness criteria outlined in Principle 31 of the United Nations Guiding Principles on Business and Human Rights, which stipulates they be: (a) legitimate, (b) accessible, (c) predictable, (d) equitable, (e) transparent, (f) rights-compatible, (g) a source of continuous learning, and (h) based on engagement and dialogue. Rights holders must have a say in the design and operation of grievance mechanisms. Grievance mechanisms must be functionally independent from the project's operating company, for example by being run by a third party that is trusted by the rights holders for whom they are intended. They must allow the complainants confidentiality and anonymity, if requested. Complainants must have access to independent forms of support (e.g., legal, technical or medical) in all phases of engagement with the procedures. Additionally, a settlement through the operational level grievance procedures must not require the complainant(s) to sign legal waivers prohibiting them from civil legal action at a future date. Whistleblower protection best practices must apply to all workers as well as vendors, contractors, and auditors. Mine workers must be allowed to stop their tasks at any time if they identify imminent risk to health and safety without suffering any punishment."*

Safety First Guidelines	Best Practices & International Standards	Current B.C. Legislation & Standards	Recommended Revisions to B.C. Legislation & Standards
13. Emergency preparedness and response	ANCOLD: Tailings dam break and inundation studies should be updated annually.[68] Global Industry Standard: Tailings dam break and inundation studies should be updated at least every five years and whenever there is a material change in the tailings dam or its social, environmental or local economic context.[69] Brazil: Tailings dam break and inundation studies should be updated every three years for high hazard potential dams.[70] CDA: Tailings dam break and inundation studies should be updated every five to 10 years.[71] MAC: Tailings dam break and inundation studies should be comprehensive and updated regularly.[72] CDA: Dam break and inundation studies should be updated every five years for Very High and Extreme consequence dams and every seven years for High consequence dams.[73]	B.C. legislation and policy are largely compliant with best practices. According to HSRC 2017, "The manager of a mine with one or more tailings storage facilities shall … maintain tailings storage facility emergency preparedness and response plans integrated into the Mine Emergency Response Plan." B.C. legislation and policy mandate the need for a dam break and inundation study prior to commencement of the mining operation, but not the need for regular updating of the study.	In HSRC 2017: Revise Section 10.1.11 to read: *"Breach and Inundation Study/Failure Runout Assessment 10.1.11 A tailings storage facility shall have a breach and inundation study or a failure runout assessment prior to permitting and must be made publicly available. The breach and inundation study must be updated annually throughout the facility lifecycle. Worst-case tailings failure scenarios must be modeled, including the complete loss of stored tailings and water."* Add the following in Part 3 Personnel Safety and Emergency Preparedness: *"Emergency preparedness and response plans or emergency action plans, related to catastrophic failure of tailings facilities must be discussed and prepared together with all communities downstream of the flow of a potential failure, as well as with mine workers, and in collaboration with first responders and relevant government agencies. Additionally, compensation and indemnification criteria in the case of a catastrophic failure must be prepared together with affected communities and made publicly available before construction begins. In the case of catastrophic failure, the operating company is responsible for taking all steps necessary to save lives and provide*

13. Emergency preparedness and response (continued)			*appropriate humanitarian aid. The operating company must provide all needed resources and support to local and national governments. Emergency and evacuation drills related to catastrophic failure of tailings facilities must be held on an annual basis, and its planning and execution should include participation from affected communities, workers, local authorities and emergency management. The operating company must report to stakeholders on tailings facility management actions, monitoring and surveillance results, independent reviews, and the effectiveness of management strategies."*

Safety First Guidelines	Best Practices & International Standards	Current B.C. Legislation & Standards	Recommended Revisions to B.C. Legislation & Standards
14. Information regarding mine safety must be made publicly available	IRMA: Mine safety reports should be provided to stakeholders upon request.[74] FMC: Annual dam safety inspection reports and monitoring reports should be publicly available. The Designated Community Representative shall have at all times access to all environmental monitoring data, all dam safety reports, and open lines of communication with mine employees.[75] Global Industry Standard: Mine safety reports should be publicly available in summary form.[76]	B.C. legislation and policy do not require all safety reports to be made available publicly. For instance, HSRC Guidance Document 2016 requires only that annual tailings facility and dam safety inspection reports be posted and made publicly available.	In HSRC 2017: Add a new section titled 10.8 "Public Availability of Mine Safety Information" which should include: *"Operating companies must make all information relevant to safety and stability of tailings facilities publicly available. Safety practices must be considered 'non-competitive.' Relevant information includes but is not limited to:* • *Dam Safety Reviews (DSRs)* • *Consequence classification and decisions by the Board of Directors or corporate management* • *Design, maintenance and monitoring documents (Design Basis Report, Constructions Record Report, Construction vs. Design Intent Verification Report, Annual Tailings Facility Performance Reports, Deviance Accountability Reports, etc.)* • *Closure and reclamation plans* • *Inundation studies and assessments of social, economic and environmental impacts* • *Environmental Monitoring and Social Management System summaries and reports* • *Independent Tailings Review Board reports* • *AMP reports* • *Impact and mitigation plans for affected communities, including compensation and indemnification criteria*

14. Information regarding mine safety must be made publicly available (continued)			• *Documentation of FPIC and any community consent processes (the information divulged must be agreed to by the affected communities)* • *Complaints and grievance procedures* • *Emergency Preparedness and Response Plans* • *Documentation of financial assurance and public liability insurance (including insurance estimates)* • *Reports that are required by and filed with governmental agencies.* *"This information must be made available at no charge, as soon as possible, in one or more languages as necessary, in an accessible format, and in plain language whenever possible to afford adequate access to interested stakeholders. This must also include all raw data obtained and any updates on the models and simulations carried out as part of the continued environmental monitoring. Operating companies must respond to all stakeholder requests for information regarding the tailings facility to the fullest extent possible in formats and languages that are understandable to stakeholders. If requests are not met in full, or in a timely manner, the company must provide written justification to those filing the requests."*

Safety First Guidelines	Best Practices & International Standards	Current B.C. Legislation & Standards	Recommended Revisions to B.C. Legislation & Standards
15. Addressing financial risks	IRMA: Operators must retain sufficient insurance so as to cover mine waste facility failures.[77] FERC: The Commission can require dam operators to have insurance to cover the costs of dam failure.[78] UBCIC: Mining companies must have sufficient insurance to cover costs of likely environmental damage and third-party losses that arise due to mine related accidents.[79] Ontario: Following the Auditor General of Ontario's 2015 recommendation, Ontario is moving away from self-assurance allowing credit ratings, pledge of assets or other soft forms of bonding.[80] Quebec: Operators must secure full bonding (100%) on closure costs, 50% payable at permitting and 50% two years after the permit; self-assurance, pledge of assets or other forms of soft assurance are not permitted; securities are subject to public consultations and reviewed at least every 5 years.[81] Maine: Operators must retain sufficient insurance so as to cover worst-case catastrophic failures.[82]	B.C. legislation and policy do not mandate full bonding for site reclamation and accidental damages in case of dam failures. Instead, B.C.'s HSRC 2017 allows the Chief Inspector to require, at his/her discretion, a financial security for mine reclamation, including providing for protection of, and mitigation of damage to, watercourses and cultural heritage resources affected by the mine.	In HSRC 2017: Add in section 10 for site closure and reclamation: *"The Chief Inspector of Mines and/or Chief Permitting Officer must [not 'may'] require a full reclamation bond, payable at permitting for new and expanding mines, and within three years for existing mines."* *"Operating companies must have the necessary financial assurance to cover the full cost of closure and post-closure plans. The purpose of financial assurance is to ensure that there is a source of funds available to local regulators if the operator company fails to perform adequate reclamation activities including closure and postclosure maintenance needed when operations cease. All existing facilities must have financial assurance in place. For new facilities, financial assurance must be secured during the permitting process and before construction begins. Any sale or transfer of ownership of the tailings facility must be conditioned on the new operating company retaining such financial assurance. Financial assurance must be independently guaranteed, reliable, and readily liquid to ensure that funds will be available in the event of bankruptcy by the operating company.*

15. Addressing financial risks (continued)	Montana: Under the 'Bad Actor Law,' Montana can deny a permit if the company, or one of its controlling members, has failed to meet legal requirements for any other mining projects it is associated with. Montana also allows public input prior to the release of securities.[83] Wyoming: At closure, Wyoming keeps at least 25% of the security for a minimum period of five years to assure proper reclamation performance.84 Alaska: Operators must secure full bonding, which should at no time be less than the amount required for the state to complete reclamation in the event of a premature closure. The state also has a publicly-run bond pool option for operators to obtain coverage who would otherwise be unable to access third-party-provided financial assurance. Bond estimates are subject to public consultations.[85] Canada's Marine Liability Act: Operators must pay a charge on each barrel of oil shipped to cover the cleanup costs of infrequent but massive accidents and spills.[86] Canada's Pipeline Safety Act: Companies need to show that they can readily access $1 billion to clean up a spill and a backup industry fund is created to further protect taxpayers.[87]		*It must undergo review by third-party analysts, using accepted accounting methods, at least every three years or when there is a significant change to the mine plan.»* Add a new section titled "10.9 Financial Insurance", including: *"Operating companies must have public liability insurance to cover economic, social and environmental damages from sudden, accidental, or gradual pollutant releases including waste dump and tailings dam failures. The amount must be sufficient to financially compensate for harm to people, property, and natural resources that may occur, on or off the mine, including after closure of the tailings facility. The insurance must remain in force for as long as the operating company, or any successor, has legal responsibility for the property."* *"An analysis of public liability resulting from the tailings facility failure must be updated on a yearly basis and made publicly available. It must be based on the worst case outcomes derived from inundation studies, which must account for a complete loss of tailings during a catastrophic failure."* *"Operating companies must not be allowed to self-bond or use corporate guarantees for mine closure, financial assurance or public liability insurance."*

Safety First Guidelines	Best Practices & International Standards	Current B.C. Legislation & Standards	Recommended Revisions to B.C. Legislation & Standards
16. Accountability for risk, minimizing consequences, preventing failure, and the consequences of failure must primarily rest with the Board of Directors	MAC: Ultimate accountability for decisions related to tailings management rests with the Owner's Board of Directors.[88] India: A Board of Directors is required to protect the environment.[89] Montana: All TSFs require a senior ranking agent of the company to hold ultimate responsibility.[90]	B.C. legislation and policy do not put any accountability on the corporate board of directors. Instead, the B.C. HSRC Guidance Document 2016 puts the onus on the local mine site manager as the accountable person for all aspects of the performance and management of tailings facilities, including for the safety of all TSFs on the site.	In HSRC 2017: Add a new section titled "10.10 Accountability of Board of Directors," including: *"The corporate Board of Directors, as the body that is ultimately responsible for the well-being of the operating company, must bear the prime responsibility for the safety of tailings facilities, including the consequences of dam failures. A culture of safety must be upheld at the highest level within a corporation; this can be achieved only if the Board of Directors is held accountable for its actions (or lack thereof). The Board must ensure that this culture of safety extends throughout the entire operating company by approving policies that assess safety as part of performance evaluations for the facility and staff."*

Sources & Citations

[1] "Safety attributes should be evaluated separately from economic considerations, and cost should not be the determining factor … Future permit applications for a new TSF should be based on a bankable feasibility that would have considered all technical, environmental, social and economic aspects of the project in sufficient detail to support an investment decision, which might have an accuracy of ±10%–15%. More explicitly, it should contain the following: … b. Detailed cost/benefit analyses of BAT tailings and closure options so that economic effects can be understood, recognizing that the results of the cost/benefit analyses should not supersede BAT safety considerations" (IEEIRP, 2015).

[2] "The approach to tailings storage facilities must place safety first by making environmental and human safety a priority in management actions and on-the-ground operations. Regulators, industry and communities should adopt a shared zero-failure objective to tailings storage facilities where 'safety attributes should be evaluated separately from economic considerations, and cost should not be the determining factor'" (Roche et al., 2017).

[3] "4. RECOMMENDATION: Ensure that public safety, environmental safety, and economic safety are the determinative factors in governing what tailings disposal system will be implemented" (University of Victoria Environmental Law Centre, 2019).

[4] "The Global Industry Standard on Tailings Management (herein 'the Standard') strives to achieve the ultimate goal of zero harm to people and the environment with zero tolerance for human fatality" (Global Tailings Review, 2020). The statement in the Global Industry Standard (Global Tailings Review, 2020) is logically equivalent to the statements in the Mount Polley report (IEEIRP, 2015) and the UNEP report (Roche et al., 2017) in that the goal of zero harm implies that economic factors cannot be considered until all safety concerns have been satisfied. However, the goal of zero harm is not consistently carried to its logical conclusion in the remainder of the Global Industry Standard.

[5] "A key mission of the USACE dam safety program is to achieve an equitable and reasonably low level of risk to the public from its dams. USACE executes its project purposes guided by its commitment and responsibility to public safety. Since 'Life Safety is Paramount,' it is not appropriate to refer to balancing or trading off public safety with other project benefits. Instead, it is after tolerable risk guidelines are met that other purposes and objectives will be considered" (USACE, 2014).

[6] "*Fica vedada a concessão de licença ambiental para construção, instalação, ampliação ou alteamento de barragem em cujos estudos de cenários de rupturas seja identificada comunidade na zona de autossalvamento. § 1º – Para os fins do disposto nesta lei, considera-se zona de autossalvamento a porção do vale a jusante da barragem em que não haja tempo suficiente para uma intervenção da autoridade competente em situação de emergência. § 2º – Para a delimitação da extensão da zona de autossalvamento, será considerada a maior entre as duas seguintes distâncias a partir da barragem: I – 10km (dez quilômetros) ao longo do curso do vale; II – a porção do vale passível de ser atingida pela onda de inundação num prazo de trinta minutos. § 3º – A critério do órgão ou da entidade competente do Sisema, a distância a que se refere o inciso I do § 2º poderá ser majorada para até 25km (vinte e cinco quilômetros), observados a densidade e a localização das áreas habitadas e os dados sobre os patrimônios natural e cultural da região*" [It is forbidden to grant an environmental license for the construction, installation, expansion or elevation of a dam for which studies of rupture scenarios identify a community in the self-rescue zone. § 1 – For the purposes of the provisions of this law, the portion of the valley downstream of the dam in which there is not enough time for intervention by the competent authority in an emergency situation is considered a self-rescue zone. § 2 – For the delimitation of the extent of the self-rescue zone, the greatest

between the following two distances from the dam will be considered: I – 10 km (ten kilometers) along the course of the valley; II - the portion of the valley that can be reached by the flood wave within thirty minutes. § 3 - At the discretion of the competent body or entity of SISEMA, the distance referred to in item I of § 2 may be increased to up to 25 km (twenty-five kilometers), taking into account the density and location of the inhabited areas and the data on the region's natural and cultural heritage] (Assembleia Legislativa de Minas Gerais [Legislative Assembly of Minas Gerais], 2019).

[7] "*Se prohíbe el diseño y construcción de depósitos de relave en los casos que se identifique una zona poblada ubicada aguas abajo del mismo que pudiera ser afectada por la onda de inundación, la cual queda limitada por la mayor de las dos distancias: • A diez (10) kilómetros de distancia aguas abajo del pie de la presa a lo largo del curso del valle, o; • La porción de territorio que sea alcanzada por la onda de inundación en un plazo de 30 minutos*" [The design and construction of tailings deposits is prohibited in cases where a populated area located downstream of the same is identified that could be affected by the flood wave, which is limited by the greater of the two distances: • Up to ten (10) kilometers downstream from the toe of the dam along the course of the valley, or; • The portion of territory that could be reached by the flood wave within 30 minutes] (Ministerio de Energía y Recursos Naturales No Renovables [Ministry of Energy and Non Renewable Natural Resources] (Ecuador), 2020a).

[8] See Zhang & Daly (2019) and Zhang & Singh (2020). The original Chinese sources are available at the following links:

- https://www.mem.gov.cn/hd/zqyj/201912/t20191219_342497.shtml
- https://www.mem.gov.cn/hd/zqyj/201909/t20190902_336120.shtml
- https://www.mem.gov.cn/xw/bndt/202003/t20200320_345864.shtml
- https://www.mem.gov.cn/gk/tzgg/tz/202003/t20200302_344929.shtml
- http://www.gov.cn/zhengce/zhengceku/2020-03/24/content_5494834.htm
- http://www.moj.gov.cn/news/content/2019-12/20/zlk_3238318.html

The Chinese sources were provided by Reuters reporter Min Zhang and Initium Media reporter Lulu Hui Ning According to Lulu Hui Ning: 有下列情形之一的，禁止作为新建、改建、扩建尾矿库库址：（一）尾矿坝坝脚下游一公里范围内有居民区、工矿企业、集贸市场、休闲健身娱乐广场等人员密集场所，或者有二级及以上等级公路、铁路等生产生活设施的；dams cannot be built within 1 km of settlements, industrial and mining enterprises, markets, or leisure activities, or production and living facilities such as secondary or above grade roads and railways -- this applies to any new dam (new, reconstruction or expansion), meaning, it's prohibited to build new "头顶库" (dams that have settlements within 1 km downstream).

[9] "*Art. 2º Fica proibida a utilização do método de alteamento de barragens de mineração denominado "a montante" em todo o território nacional… Art. 8º Com vistas a minimizar o risco de rompimento, em especial por liquefação, das barragens alteadas pelo método a montante ou por método declarado como desconhecido, o empreendedor deverá:*

- *I - até 15 de dezembro de 2019, concluir a elaboração de projeto técnico executivo de descaracterização da estrutura, que deverá contemplar, no mínimo, sistemas de estabilização da barragem existente ou a construção de nova estrutura de contenção situada à jusante, ambos conforme definição técnica do projetista, com vistas a minimizar o risco de rompimento por liquefação ou reduzir o dano potencial associado, tendo como balizador a segurança e obedecendo a todos os critérios de segurança descritos na Portaria nº 70.389, de 17 de maio de 2017 e na norma ABNT NBR 13.028 e ou normativos que venham a sucedê-las;*
- *II - até 15 de setembro de 2021, concluir as obras do sistema de estabilização da barragem existente ou a construção de nova estrutura de contenção situada à jusante, conforme definição técnica do projetista;*
- *III - concluir a descaracterização da barragem nos seguintes prazos:*

- *i. Até 15 de setembro de 2022, para barragens com volume < 12 milhões de metros cúbicos, conforme Cadastro Nacional de Barragens de Mineração do SIGBM;*
- *ii. Até 15 de setembro de 2025, para barragens com volume entre 12 milhões e 30 milhões de metros cúbicos, conforme Cadastro Nacional de Barragens de Mineração do SIGBM; e*
- *iii. Até 15 de setembro de 2027, para barragens com volume > 30 milhões de metros cúbicos, conforme Cadastro Nacional de Barragens de Mineração do SIGBM"*

["Art. 2 It is prohibited to use the method of raising mining dams called 'upstream' throughout the national territory… Art. 8 In order to minimize the risk of rupture, especially by liquefaction, of the dams raised by the upstream method or by a method declared as unknown, the entrepreneur must:

- I - by December 15, 2019, complete the elaboration of an executive technical project to decharacterize the structure, which should include, at least, stabilization systems of the existing dam or the construction of a new containment structure located downstream, both as per technical definition of the designer, with a view to minimizing the risk of disruption due to liquefaction or reducing the associated potential damage, with safety as a guideline and obeying all the safety criteria described in Ordinance No. 70.389 of May 17, 2017 and in the ABNT NBR standard 13.028 and/or regulations that will succeed them;
- II - by September 15, 2021, complete the works of the existing dam stabilization system or the construction of a new containment structure located downstream, according to the technical definition of the designer;
- III - complete the dam decharacterization within the following deadlines:
  - i. By September 15, 2022, for dams with volume < 12 million cubic meters, according to the National Registry of Mining Dams of SIGBM;
  - ii. By September 15, 2025, for dams with a volume between 12 million and 30 million cubic meters, according to the National Register of Mining Dams of SIGBM; and
  - iii. By September 15, 2027, for dams with a volume > 30 million cubic meters, according to the National Register of Mining Dams of SIGBM" (Agência Nacional de Mineração [National Mining Agency], 2019).

[10] "*Se prohíbe la utilización del método aguas arriba*" [The use of the upstream method is prohibited] (Ministerio de Minería (Chile) [Ministry of Mining (Chile)], 2007)

[11] "***Artículo 14. Métodos de construcción en depósitos de relaves**. Se prohíbe la utilización del método hacia aguas arriba. De manera estandarizada el método de construcción será hacia aguas abajo, incluyendo la presa de arranque. El método de construcción de eje central se aprobará en los casos en que la morfología o espacio del terreno no permitan el crecimiento hacia aguas abajo, siempre y cuando se cumpla con condiciones favorables para la estabilidad física del depósito de relaves*" **[Article 14. Construction methods in tailings deposits.** The use of the upstream method is prohibited. The standard method of construction will be downstream, including the starter dike. The centerline construction method will be approved in cases where the land morphology or land space does not allow for downstream growth, as long as favorable conditions for the physical stability of the tailings deposit are met" [(Ministerio de Energía y Recursos Naturales No Renovables [Ministry of Energy and Non Renewable Natural Resources] (Ecuador), 2020b).

[12] "*Está prohibida la construcción de presas de relave con el método aguas arriba*" [The construction of tailings dams with the upstream method is prohibited] (Sistema Nacional de Información Ambiental (Perú) [National System of Environmental Information (Peru)], 2014).

[13] "The upstream method or modified-upstream method of design for new mine facilities shall be avoided where possible in the design of tailings storage facilities" (Fair Mining Collective [FMC], 2015).

[14] "In general, dams built by the downstream or centreline method are much safer than those built by the upstream method, particularly when subject to earthquake shaking … Dams built by the upstream method are particularly susceptible to damage by earthquake shaking. There is a general suggestion that this method of construction should not be used in areas where there is risk of earthquake" (ICOLD and UNEP, 2001).

[15] The main disadvantage of the upstream method is the risk of physical instability of the dam and its susceptibility to liquefaction … In general, downstream dams are much safer than those built using the upstream method, particularly when subject to seismic loads … [Upstream dams are] not applicable when the slightest risk of liquefaction has been identified after seismic evaluation … Upstream: this option has the highest risk associated to dam wall breaking" (Garbarino et al., 2018).

[16] "A tailings pond that is expected to receive high rates of water accumulation (due to climatic and topographic conditions) should be constructed using a method other than upstream construction … upstream construction is not appropriate in areas with a potential for high seismic activity" (U.S. Environmental Protection Agency [EPA], 1994).

[17] "It is recommended that upstream constructed tailings dams not be built in high seismic areas" (CDA, 2019).

[18] "Adopt a presumption against the use of … upstream and cascading tailings dams unless justified by independent review" (Roche at al., 2018).

[19] The current Brazilian tailings dam regulations are specified in Portaria [Ordinance] No. 70.389 (Agência Nacional de Mineração [ANM], 2017). This ordinance in turn requires the "*análise da estabilidade da Barragem de Mineração a qual concluirá pela Declaração de Condição de Estabilidade tendo por base os índices de fator de segurança descritos na Norma Brasileira ABNT NBR 13.028 ou Norma que venha a sucedê-la, fazendo uso das boas práticas da engenharia* [analysis of the stability of the Mining Dam, which will conclude by the Declaration of Stability Condition, based on the factor of safety values described in the Brazilian Standard ABNT NBR 13.028 or any Standard that will succeed it, taking into account best engineering practices] (ANM, 2017). The factor of safety is the lowest value of the ratio of the shear resistance to the shear stress, considered over all possible failure surfaces within the tailings management facility (CDA, 2013). The factor of safety can be calculated either under static conditions (zero seismic acceleration) or under the seismic acceleration of a design earthquake. ABNT NBR 13.028 then states, "*Os estudos sísmicos devem avaliar o potencial de sismicidade na área de implantação da barragem, com base em bibliografia, incluindo normas existentes e registros. Recomenda-se, para as etapas iniciais de estudo, a utilização do critério sugerido pela Canadian Dam Association (CDA), que indica a adoção da aceleração da gravidade resultante do Sismo Máximo Provável (MCE – Maximum Credible Earthquake) para análise pseudoestáticas [cálculo do fator de segurança sob o sismo de desenho]*" [Seismic studies should assess the potential for seismicity in the area where the dam is located, based on a bibliography, including existing standards and records. It is recommended, for the initial stages of the study, the use of the criterion suggested by the Canadian Dam Association (CDA), which indicates the adoption of the acceleration resulting from the Maximum Credible Earthquake (MCE) for the pseudostatic analysis [calculation of the safety factor under the design earthquake] (Associação Brasileira de Normas Técnicas [ABNT], 2017).

[20] "Consequently, the design must be based on the largest possible events at the site when it comes to the natural hazards of flood and earthquake" (Mayangsari & Adji, 2015).

[21] " Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life … The prescriptive IDF [Inflow Design Flood] for a High

Hazard Potential dam is the PMF" (Federal Emergency Management Agency [FEMA], 2013). "For high-hazard potential dams, the MDE [Maximum Design Earthquake] usually is equated with the controlling MCE. However, for low or significant-hazard dams, the MDE may be determined based on faults active in Holocene time, or according to other agency specified criteria" (FEMA, 2005).

[22] "Standard 1 applies to the design of dams capable of placing human life at risk or causing a catastrophe, should they fail … structural designs will be such that the dam will safely pass an IDF [Inflow Design Flood] computed from probable maximum precipitation (PMP) occurring over the watershed above the dam site (USACE, 1991). "APF [Annual Probability of Failure] ≥ 1 in 10,000 (0.0001) Per Year. Annual probability of failure in this range is unacceptable except in extraordinary circumstances" (USACE, 2014).

[23] "Where human life is potentially threatened, the maximum credible earthquake (MCE) should be used … If exceedance of the design peak flow or volume could result in failure that would pose an imminent risk to human life, then the Probable Maximum Flood (PMF) event should be utilized for both prescriptive and individual BADCT [Best Available Demonstrated Control Technology]" (Arizona Department of Environmental Quality, n.d.).

[24] "The State Engineer will classify a dam as: (a) High hazard if failure of the dam carries a high probability of causing a loss of human life … For the purposes of this section, the inflow design flood used for design purposes must not, except as otherwise provided in subsection 3, be less than: (a) A probable maximum flood, if the dam: (1) Is classified as high hazard or is a large dam and classified as significant hazard… 1. Except as otherwise provided in NAC 535.220, to obtain the approval of the State Engineer pursuant to NRS 535.010, the plans and specifications must, in addition to all other applicable requirements, demonstrate to the satisfaction of the State Engineer that the dam is able to accommodate an earthquake or other extreme motion event without the failure of the dam or any other unintended release of water. 2. Except as otherwise provided in subsection 3, the applicant must calculate the seismic response to a maximum credible earthquake of a dam and its foundation, including, without limitation:(a) Potential liquefaction; (b) Loss of material strength; (c) Settlement; (d) Ground displacement; and (e) Wave action due to landslide or seiche" (Nevada Administrative Code [NAC], 2016).

[25] "Who does this rule apply to? Owners of new or existing dam or mine tailings impoundment structures … The evaluation required of large dams, that are classified significant or high risk, shall use the maximum ground motion/ acceleration generated by the maximum credible earthquake, which could affect the dam site" (Idaho Administrative Procedures Act, 2021). The following tables are taken from Idaho Administrative Procedures Act (2021):

Risk Category	Dwellings	Economic Losses
Low	No permanent structures for human habitation.	Minor damage to land, crops, agricultural, commercial or industrial facilities, transportation, utilities or other public facilities or values.
Significant	No concentrated urban development, 1 or more permanent structures for human habitation which are potentially inundated with flood water at a depth of 2 ft. or less or at a velocity of 2 ft. per second or less.	Significant damage to land, crops, agricultural, commercial or industrial facilities, loss of use and/or damage to transportation, utilities or other public facilities or values.
High	Urban development, or any permanent structure for human habitation which are potentially inundated with flood water at a depth of more than 2 ft. or at a velocity of more than 2 ft. per second.	Major damage to land, crops, agricultural, commercial or industrial facilities, loss of use and/or damage to transportation, utilities or other public facilities or values.

Size Classification	Height (ft)		Storage Capacity
Small	20 ft. or less	and	Less than 100 acre-ft.
Intermediate	More than 20 ft. but less than 40 ft.	or	100 Acre-ft or more, but less than 4000 acre ft
Large	40 ft. or more	or	4000 acre-ft., or more

Downstream Risk Category	Size Classification	Inflow Design Flood
Low	Small	Q50
	Intermediate	Q100
	Large	Q500
Significant	Small	Q100
	Intermediate	Q500
	Large	0.5 PMF
High	Small	Q100
	Intermediate	0.5 PMF
	Large	PMF

[26] "The department will automatically adopt the determination of high-hazard only for those dams classified high-hazard by the corps pursuant to P.L. 92-367 … (1) Designs for construction of high-hazard dams must conform to accepted practices and procedures of the engineering profession … (3) An earthfill dam must be safe and stable during all phases of construction and operation of the reservoir. To accomplish this, the following criteria must be met: … (g) the design must be such that the most severe earthquake that can be reasonably anticipated will not cause catastrophic failure and loss of life" (Administrative Rules of the State of Montana, 2021).

[27] "Dams assigned the high hazard potential classification are those dams where failure or misoperation will probably cause loss of human life … Dams classified as high hazard potential, regardless of size, shall have spillways designed to pass a flood resulting from the probable maximum precipitation (New Mexico Administrative Code, 2015).

[28] "High hazard rating means that the department expects loss of human life to occur if a dam fails" (Oregon Revised Statute, 2021). "The Inflow Design Flood for a High Hazard Dam is the Probable Maximum Flood (PMF) unless the Engineer of Record proposes to determine an Inflow Design Flood based on a quantitative analysis of risk to people … High Hazard Dams shall be designed for the maximum credible earthquake" (Oregon Revised Statute, Water Resources Department, 2021).

[29] "'Small Dam' is a dam with a jurisdictional height greater than 20 feet but less than or equal to 50 feet and/or a reservoir capacity greater than 100 acre-feet, but less than 4,000 acre-feet … 'Large Dam' is a dam greater than 50 feet in jurisdictional height, and/or greater than 4,000 acre-feet in capacity … 'High Hazard Dam' is a dam for which loss of human life is expected to result from failure of the dam. Designated recreational sites located downstream within the bounds of possible inundation should also be evaluated for potential loss of human life … New Large and Small, High Hazard dams and enlargements shall have spillways capable of passing, as a minimum, the Inflow Design Flood (IDF) generated by 90 percent of the Probable Maximum Precipitation, unless an incremental damage analysis demonstrates a lesser inflow design flood is applicable … Dams classified as High Hazard and with a height greater than or equal to 30 feet, other than flood

control structures, shall be designed for the maximum credible earthquake or for an earthquake with a minimum 5000-year return frequency … Dams classified as High Hazard and with a height less than 30 feet, other than flood control structures, shall be designed for either: a) the maximum credible earthquake or an earthquake with a minimum 5000-year return frequency, or b) for a peak ground surface acceleration equal to twice the acceleration for the site with a 2% chance of exceedance in 50 years (approximately 2500-year return frequency), as estimated and published by the U.S. Geological Survey … Dams classified as Significant Hazard or High Hazard dams whose sole purpose is for flood control shall be designed for a 2% chance of exceedance in 50 years (approximately 2500-year return frequency)" (Rules and Regulations for Dam Safety and Dam Construction, 2020).

[30] The Reservoirs Act 1975 did not distinguish between these large raised reservoirs in terms of risk/ consequence of failure, nor did it state any requirements for standards of protection. Instead, the UK reservoir industry has relied on 'Floods and Reservoir Safety' [Institution of Civil Engineers, 2015], a guidance document that sets out a standard approach for consequence categories based on predicted harm to property/people if the dam were to fail catastrophically. This document recommends particular inflow design floods, which are shown in Table 1 for reference" (Vyse, 2012). Vyse (2012) includes the following table:

Table 1. Existing categorisation and inflow design flood[1]

Dam category	Potential effect of a dam breach	Reservoir inflow design flood	
		General	If overtopping is tolerable
A	Lives endangered in a community[b]	PMF[a]	10,000 year flood
B	Lives endangered not in a community or extensive property damage	10,000 year flood	1,000 year flood
C	Limited property damage	1000 year flood	150 year flood
D	Very limited additional flood damage	150 year flood	N/A

[a]Probable Maximum Flood
[b]Generally accepted as 10 or more lives endangered

[31] Vyse (2012)

[32] "While best practices focus on the performance of the tailings dam, best available technology (BAT) concerns the tailings deposit itself. The goal of BAT for tailings management is to assure physical stability of the tailings deposit. This is achieved by preventing release of impoundment contents, independent of the integrity of any containment structures. In accomplishing this objective, BAT has three components that derive from first principles of soil mechanics: 1. Eliminate surface water from the impoundment. 2. Promote unsaturated conditions in the tailings with drainage provisions. 3. Achieve dilatant conditions throughout the tailings deposit by compaction … Filtered tailings technology embodies all three BAT components" (IEEIRP, 2015).

[33] Dry stack tailings' management' means the process of disposing of dewatered, compacted mine tailings into a freestanding, stable structure on an area with an impervious liner designed to shed water to a water collection and treatment system … The mining operation will use dry stack tailings management and will not use wet mine waste units or tailings impoundments for the management of mine waste and tailings, except that the mining operation may involve the placement into a mine shaft of waste rock that is neutralized or otherwise treated to prevent contamination of groundwater or surface water" (Maine Metallic Mineral Mining Act, 2021).

[34] "2. RECOMMENDATION: Prohibit wet tailings impoundment unless it can be demonstrated through a risk assessment process that wet tailings impoundment poses less long-term risk (environmental, financial, and public safety) than a dry tailings approach. 3. RECOMMENDATION: Where wet tailings impoundments are in use, require dry closure (e.g. draining) when mining operations cease — unless it can be demonstrated through a risk assessment process that long-term maintenance of a wet tailings impoundment poses less risk (environmental, financial, and public safety)" (BC Mining Law Reform, 2019).

[35] "The application shall include the following … (3) a mine plan including … (n) a detailed plan for water recovery and de-watering of tailings which meets the standards of Best Available Technology in this code …" (FMC, 2015).

[36] "For high-hazard potential dams, movement of faults within the range of 35,000 to 100,000 years BP is considered recent enough to warrant an 'active' or 'capable' classification … However, for low or significant-hazard dams, the MDE [Maximum Design Earthquake] may be determined based on faults active in Holocene time, or according to other agency specified criteria" (FEMA, 2005).

[37] "APF [Annual Probability of Failure] ≥ 1 in 10,000 (0.0001) Per Year. Annual probability of failure in this range is unacceptable except in extraordinary circumstances" (USACE, 2014).

[38] "A dam with zero chance of failure does not exist. However, in order to maintain public trust, the probability of dam failure must be very low. This ensures a minimum level of safety when the consequences are not high. **Reclamation terms this measure of risk Annualized Failure Probability, and uses a guideline of 1 in 10,000 per year for the accumulation of failure likelihoods from all potential failure modes that would result in life-threatening unintentional release of the reservoir"** (boldface in original) (U.S. Bureau of Reclamation [USBR], 2011).

[39] "In addition to accounting for societal risk in dam safety decisions, the individual risk should be considered in terms of the 'maximally exposed individual' that is permanently resident downstream of the dam. Typically, the maximally exposed individual is exposed to the hazard significantly more than 50% of the time. The maximum level of individual risk is generally given as less than 10-4/ year" (CDA, 2013).

[40] "CDA (2019) includes the following tables:

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

[41] "All tailings impoundments must be built to a minimum operational safety factor of 2.0" (FMC, 2015).

[42] ABNT (2017) presents the following table:

Tabela 1 – Fatores de segurança mínimos para barragens de mineração

Fase	Tipo de ruptura	Talude	Fator de segurança mínimo
Final de construção [a]	Maciço e fundações	Montante e jusante	1,3
Operação com rede de fluxo em condição normal de operação, nível máximo do reservatório	Maciço e fundações	Jusante	1,5
Operação com rede de fluxo em condição extrema, nível máximo do reservatório	Maciço e fundações	Jusante	1,3
Operação com rebaixamento rápido do nível d´água do reservatório	Maciço	Montante	1,1
Operação com rede de fluxo em condição normal	Maciço	Jusante	1,5
		Entre bermas	1,3
Solicitação sísmica, com nível máximo do reservatório	Maciço e fundações	Montante e jusante	1,1

[a] Etapas sucessivas de barragens alteadas com rejeitos não podem ser analisadas como "final de construção", devendo atender aos fatores de segurança mínimos estabelecidos para as condições de operação.

This is the English translation of the preceding table:

Table 1 – Minimum Factors of Safety for Tailings Dams

Phase	Type of rupture	Embankment	Minimum factor of safety
Final construction[a]	Body and foundation	Upstream and downstream	1.3
Operation with flow network under normal condition of operation, maximum reservoir level	Body and foundation	Downstream	1.5
Operation with flow network under extreme condition of operation, maximum reservoir level	Body and foundation	Downstream	1.3
Operation with rapid lowering of the water level of the reservoir	Foundation	Upstream	1.1
Operation with flow network under normal condition	Foundation	Downstream	1.5
		Between berms	1.3
Seismic design criterion with maximum reservoir level	Body and foundation	Upstream and downstream	1.1

[a] Successive raises of tailings dams cannot be analyzed as "final construction" and must meet the minimum safety factors established for the operating conditions.

[43] USBR (2015) includes the following table:

Table B1. Factor of Safety and Corresponding Liquefaction Probability

Probability of Liquefaction (%)	Factor of Safety
15	1.0
5	1.15
2	1.25
1	1.3

[44] "For sand levees, a 1V on 5H landside slope is considered flat enough to prevent damage from seepage exiting on the landside slope (USACE, 2000).

[45] "The High Dam Failure Consequence Classification includes, Llow potential for acid rock drainage or metal leaching effects of released tailings" (Global Tailings Review, 2020). The Very High Dam Failure Consequence Classification includes, "High potential for acid rock drainage or metal leaching effects of released tailings" (Global Tailings Review, 2020). The Extreme Dam Failure Consequence Classification includes, "Very high potential for acid rock drainage or metal leaching

effects of released tailings" (Global Tailings Review, 2020). The corresponding flood and seismic design criteria are given in the tables below (Global Tailings Review, 2020):

Table 2: Flood Design Criteria

Consequence Classification	Flood Criteria[1] – Annual Exceedance Probability	
	Operations and Closure (Active care)	Passive-Closure (Passive Care)
Low	1/200	1/10,000
Significant	1/1,000	1/10,000
High	1/2,475	1/10,000
Very High	1/5,000	1/10,000
Extreme	1/10,000	1/10,000

Table 3: Seismic Design Criteria

Consequence Classification	Seismic Criteria[2,3] – Annual Exceedance Probability	
	Operations and Closure (Active care)	Passive-Closure (Passive Care)
Low	1/200[2]	1/10,000[2]
Significant	1/1,000[2]	1/10,000[2]
High	1/2,475[2]	1/10,000[2]
Very High	1/5,000[2]	1/10,000[2]
Extreme	1/10,000[2]	1/10,000[2]

[46] "Full implementation of the Observational Method shall be adopted for non-brittle failure modes… The key element of the Observational Method is the proactive assessment at the design stage of every possible unfavourable situation that might be disclosed by the monitoring programme and the development of an action plan or mitigative measure to reduce risk in case the unfavourable situation is observed. This element forms the basis of a performance-based risk management approach. The objective is to achieve greater overall safety" (Global Tailings Review, 2020).

[47] "The Observational Method was invoked early on as the basis for design. This commonly accepted approach uses observed performance from instrumentation data for implementing preplanned design features or actions in response. But there were a number of problems in applying this strategy to the Mount Polley dam that are treated in the following section. The first was simple geometry. The Observational Method relies on measuring the right things in the right places … The remaining problem is that the Observational Method is useless without a way to respond to the observations … The lack of recognition of a critical potential failure mode resulted in a misapplication of the Observational Method and, therefore, a false appreciation that the structure was performing as intended during stages of raising. The Observational Method is a powerful tool

to manage uncertainty in geotechnical practice. However, it relies on recognition of the potential failure modes, an acceptable design to deal with them, and practical contingency plans to execute in the event observations lead to conditions that require mitigation. The lack of recognition of the critical undrained failure mode that prevailed reduced the Observational Method to mere trial and error" (IEEIRP, 2015).

[48] "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' ... The key steps in the identification, development, and implementation of critical controls are to identify and evaluate: ... 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: ... 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" (Mining Association of Canada, 2021a).

[49] "Identify and address brittle failure modes with conservative design criteria, independent of trigger mechanisms, to minimise their impact on the performance of the tailings facility … Design, implement and operate a comprehensive and integrated engineering monitoring system that is appropriate for verifying design assumptions and for monitoring potential failure modes. Full implementation of the Observational Method shall be adopted for non-brittle failure modes. Brittle failure modes are addressed by conservative design criteria" (Global Tailings Review, 2020).

[50] "[The Precautionary Approach] extends the Prescriptive approach using the Observational Method to monitor for performance that is indicative of assumed potential failure modes to validate the design basis, and to mitigate if not …The precautionary approach is not appropriate when brittle failure modes are present, especially if they are not recognised and eliminated … [The precautionary approach] is not readily applicable in cases where the failure mechanism is predominantly brittle, which might occur in tailings prone to liquefaction or in cases of strain weakening foundations. Such mechanisms typically evolve more rapidly than could be observed or responded to with contingency measures, or where other constraints preclude the timely and effective application of such measures. Brittle failure mechanisms have been involved in many of the historical catastrophic failures of tailings facilities" (International Council on Mining and Metals, 2021).

[51] "Experience has shown that the effectiveness of an ITRB in specific circumstances depends on the following: … That it be free from external influence or conflict of interest" (IEEIRP, 2015).

[52] "Independent reviewers shall be objective, third-party, competent professionals" (IRMA, 2018).

[53] "Independent Review: independent evaluation of all aspects of the planning, design, construction, operation, maintenance of a tailings facility by competent, objective, third-party review on behalf of the Owner" (Mining Association of Canada [MAC], 2021b).

[54] "The ITRB or the reviewer shall be appointed early in the project development process, report to the Accountable Executive and certify in writing that they follow best practices for engineers in avoiding conflicts of interest … The DSR [Dam Safety Review] contractor cannot conduct consecutive DSRs on the same tailings facility and shall certify in writing that they follow best practices for engineers in avoiding conflicts of interest … The independent reviewers are third-parties who are not, and have not been directly involved with the design or operation of the particular tailings facility" (Global Tailings Review, 2020).

[55] "An independent review engineer may not be an employee of: (a) an operator or permit applicant; or (b) the design consultant, the engineer of record, or the constructor" (Montana Code Annotated 2019, 2019).

[56] "In some highly regulated jurisdictions, notably Japan, the role of ITRB is undertaken by the responsible regulatory authorities" (Global Tailings Review, 2020).

[57] "Where an application … concerns a tailings storage facility, or any work to be carried out on or about a tailings storage facility, the chief inspector shall refer the application or Notice of Work to the tailings advisory committee established pursuant to section 9.1 of the Mines Act … (2) The tailings advisory committee shall be comprised of 3 members with expertise in TSF technology, with no connection to the proponent, the Ministry, or the agency, except by way of assessment of the application" (FMC, 2015).

[58] *Art. 10 – Os profissionais interessados em realizar as auditorias técnicas de segurança em barragens, nos termos da § 3º do art. 17 da Lei nº 23.291, de 2019, deverão se credenciar na Feam [Fundação Estadual do Meio Ambiente]. Fica expressamente vedada a prestação de serviços de auditoria por profissional credenciado pela Feam às empresas com as quais tenha mantido vínculo empregatício ou prestado, a qualquer título, serviços de natureza similar, nos últimos três anos contados da auditoria a ser realizada … Art. 13 – § 1º – A vedação com relação ao vínculo empregatício se estende às empresas subsidiárias ou Coligadas* [Art. 10 - Professionals interested in carrying out technical safety audits on dams, under the terms of § 3 of art. 17 of Law No. 23,291, of 2019, shall be accredited by Feam [State Environment Foundation]. It is expressly forbidden to provide audit services by a professional accredited by Feam to companies with which it has maintained employment or provided, in any capacity, services of a similar nature, in the last three years counted from the audit to be carried out … Art. 13 - § 1º - The prohibition in relation to the employment relationship extends to subsidiary companies or affiliates (Diário Oficial do Estado de Minas Gerais [Official Gazette of the State of Minas Gerais], 2021).

[59] "The revised definition of 'independent consultant' would retain the licensure and 10-year experience requirements. However, the restrictions regarding the professional relationship between the independent consultant and licensee would be separated into three separate elements, requiring that an independent consultant: (1) is not an employee of the licensee or its affiliates; (2) has not been an employee of the licensee or its affiliates within two years prior to performing a periodic inspection or comprehensive assessment; and (3) has not been an agent acting on behalf of the licensee or its affiliates before performing services under this part. The NOPR [Notice of Proposed Rule-Making] explained that the Commission intends to narrowly apply this restriction, with a primary goal of ensuring that independent consultants are not responsible for reviewing work to which they contributed substantially" (Federal Energy Regulatory Commission [FERC], 2021b).

[60] "At the end of mine life, closure spillways should be designed for PMF flows for all Consequence Categories, given the time frame of the expected life in the order of 1000 years … For closure the MCE should be used for design but taking into account expected long term properties of the tailings" (Australian National Committee on Large Dams [ANCOLD], 2012).

[61] "The flood and seismic design criteria are contained in the tables from Global Tailings Review (2020) in footnote 45.

[62] "Closed mine waste facilities will typically have a long or indefinite design life as they will remain in place for the foreseeable future. Closed mine waste facilities often need to be stable in the long term with infrequent or no human intervention. Further, the long/ indefinite duration of the design life means that it is much more likely that the facility will eventually be exposed to extremely infrequent events, such as large earthquakes or floods. Given this, the design criteria used to establish the physical stability of mine waste facilities are usually more stringent after closure than during operation. Some guidance documents recognise this explicitly" (ICMM, 2019).

[63] "Indigenous peoples have the right to determine and develop priorities and strategies for the development or use of their lands or territories and other resources ... [including] their free and informed consent prior to the approval of any project affecting their lands or territories and other resources, particularly in connection with the development, utilization or exploitation of mineral, water or other resources" (Article 32, UN General Assembly, 2007).

[64] "The following rights of indigenous peoples are especially relevant in relation to industrial-scale mining developments:

- The right to self-determination, by virtue of which indigenous peoples freely determine their political status and pursue their economic, social and cultural development;
- Rights to property, culture, religion, and nondiscrimination in relation to lands, territories and natural resources, including sacred places and objects;
- Rights to health and physical well-being in relation to a clean and healthy environment;
- Rights to set and pursue their own priorities for development; and
- The right to make authoritative decisions about external projects or investments.

"Both States and corporations should respect these rights. Corporations may demonstrate such respect by obtaining the Free, Prior and Informed Consent (FPIC) of indigenous peoples and providing culturally appropriate alternatives and adequate compensation and benefits for projects that affect indigenous peoples' rights" (IRMA, 2018, Chapter 2.2, p.1).

[65] "Where a new tailings facility may impact the rights of indigenous or tribal peoples, including their land and resource rights and their right to self-determination, work to obtain and maintain Free Prior and Informed Consent (FPIC) by demonstrating conformance to international guidance and recognised best practice frameworks" (Global Tailings Review, 2020, Requirement 1.2).

[66] "The Accountable Executive shall establish a formal, confidential and written process to receive, investigate and promptly address concerns from employees and contractors about possible permit violations or other matters relating to regulatory compliance, public safety, tailings facility integrity or the environment … In accordance with international best practices for whistleblower protection, the Operator shall not discharge, discriminate against, or otherwise retaliate in any way against a whistleblower who, in good faith, has reported possible permit violations or other matters relating to regulatory compliance, public safety, tailings facility integrity or the environment" (Global Industry Standard, 2020).

[67] "*1.4.3.1 São direitos do Trabalhador: a) interromper suas tarefas sempre que constatar evidências que representem riscos graves e iminentes para sua segurança e saúde ou de terceiros, comunicando imediatamente o fato a seu superior hierárquico que diligenciará as medidas cabíveis; e b) ser informado sobre os riscos existentes no local de trabalho, que possam afetar sua segurança e saúde*" [1.4.3.1 The Worker's rights are: a) to interrupt his tasks whenever he finds evidence that represents serious and imminent risks to his safety and health or that of third parties, immediately communicating the fact to his hierarchical superior who will take the appropriate measures; and b) to be informed about the risks existing in the workplace, which may affect his safety and health] (LegisWeb, 2022).

[68] "A Dam Safety Emergency Plan (DSEP), in conjunction with appropriate emergency authority planning, should be prepared for tailings dams where any persons, infrastructure or environmental values could be at risk should the dam collapse or fail … The DSEP should include an appropriate dam break study with the conservative assumption of liquid tailings flow in the event of dam failure unless a more sophisticated analysis of water and/or tailings flow can be justified. DSEP's are to be updated annually and tested at regular intervals" (ANCOLD, 2012).

[69] "Develop and document knowledge about the social, environmental and local economic context of the tailings facility, using approaches aligned with international best practices. Update this

knowledge at least every five years, and whenever there is a material change either to the tailings facility or to the social, environmental and local economic context. This knowledge should capture uncertainties due to climate change … Develop and document a breach analysis for the tailings facility using a methodology that considers credible failure modes, site conditions, and the properties of the slurry. The results of the analysis shall estimate the physical area impacted by a potential failure. When flowable materials (water and liquefiable solids) are present at tailings facilities with Consequence Classification of 'High', 'Very High' or 'Extreme', the results should include estimates of the physical area impacted by a potential failure, flow arrival times, depth and velocities, and depth of material deposition. Update whenever there is a material change either to the tailings facility or the physical area impacted … In order to identify the groups most at risk, refer to the updated tailings facility breach analysis to assess and document potential human exposure and vulnerability to tailings facility credible failure scenarios. Update the assessment whenever there is a material change either to the tailings facility or to the knowledge base" (Global Tailings Review, 2020).

[70] "*Art. 15. A periodicidade máxima da RPSB [Revisão Periódica de Segurança de Barragem] será definida em função do DPA [Dano Potencial Associado], sendo: I. DPA alto: a cada 3 (três) anos; II. DPA médio: a cada 5 (cinco) anos; e III. DPA baixo: a cada 7 (sete) anos … Art. 33. O PAEBM [Plano de Ação de Emergência para Barragens de Mineração] deve ser revisado por ocasião da realização de cada RPSB*" ["Art. 15. The maximum periodicity of the RPSB [Periodic Review of Dam Safety] will be defined according to the DPA [Associated Potential Damage], being: I. High DPA: every 3 (three) years; II. Average DPA: every 5 (five) years; and III. Low DPA: every 7 (seven) years … Art. 33. The PAEBM [Emergency Action Plan for Mining Dams] must be revised when each RPSB is carried out" (Agência Nacional de Mineração, 2017).

[71] "Dam break and inundation studies are necessary to support assessment of the consequences of potential failure of mining dams, as for conventional dams … The suggested frequency of Reviews ranges from 5 to 10 years, depending on the consequences of failure and changes in the dam or surrounding; any regulatory requirements would 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" (Canadian Dam Association, 2019).

[72] "For tailings facilities that pose a risk of inundation of downstream areas in the event of a failure, the ERP [Emergency Response Plan] and the EPP [Emergency Preparedness Plan] 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 [Communities of Interest] and local authorities that could be potentially impacted by an inundation event … 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" (Mining Association of Canada, 2021b).

[73] "Mapping of inundation areas is used as the basis for estimating the potential consequences of a dam breach. Inundation maps are also used for emergency planning and should show (i) flood and flood peak arrival time; (ii) depth of flow; (iii) significant emergency infrastructure, such as roads and hospitals; and in some cases (iv) velocity of flow … During the Dam Safety Review, the potential consequences of dam failure are to be reviewed. The primary reasons for a change in

the consequences are (i) new development in the floodplain downstream of the dam, which would increase the damage from dam failure; or (ii) identification of environmental or socioeconomic consequences previously unaccounted for" (Canadian Dam Association, 2013). The recommended frequency of dam safety reviews is given in the table below (Canadian Dam Association, 2013):

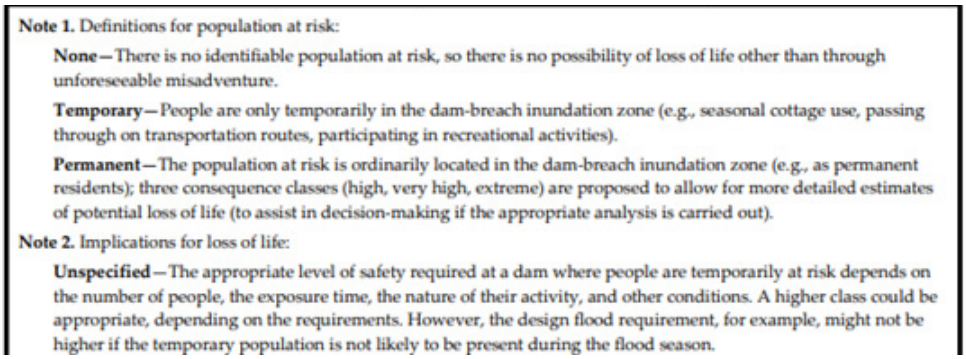
Table 5-1: Suggested Frequency for Dam Safety Reviews

Dam class	Frequency
Extreme	Every 5 years
Very high	Every 5 years
High	Every 7 years
Significant	Every 10 years
Low	— [note 1]
Note 1. A Dam Safety Review is not required for low-consequence dams. However, the consequences of failure should be reviewed periodically, since they may change with downstream development. If the classification increases, a Dam Safety Review is required at that time.	

The dam classification is given in the table below (Canadian Dam Association, 2013):

Table 2-1: Dam Classification

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.

[74] "If requested by stakeholders, the operating company shall report to stakeholders on mine waste facility management actions, monitoring and surveillance results, independent reviews and the effectiveness of management strategies" (IRMA, 2018).

[75] "The manager shall submit an annual dam safety inspection report prepared by a professional engineer on the operation, maintenance and surveillance of the tailings and water management facilities and associated dams to the chief inspector, the Independent Tailings Review Board, communities of interest, and First Nations. Such report shall be made publicly available on the Ministry's website within 30 days of being finalised … The owner, agent, or manager shall undertake monitoring programs, as required by the chief inspector, to demonstrate that reclamation and environmental protection objectives including land use, productivity, ecology, water quality and stability of structures are being achieved … (4) The mine owner, agent or manager shall submit annual reports to the chief inspector, the Independent Tailings Review Board, First Nations, and communities of interest. The reports shall be made publicly available on the Ministry's website within 30 days of being finalized … The Designated Community Representative shall have at all times access to (a) all environmental monitoring data, (b) all dam safety reports, and (c) open lines of communication with mine employees" (FMC, 2015).

[76] "For each existing tailings facility and in accordance with Principle 21 of the UNGP, the Operator shall publish and update at least on an annual basis, the following information: 1. A description of the tailings facility (information may be obtained from the output of Requirements 5.5 and 6.4); 2. The Consequence Classification (Requirement 4.1); 3. A summary of risk assessment findings relevant to the tailings facility (Information may be obtained from the output of Requirement 10.1); 4. A summary of impact assessments and of human exposure and vulnerability to tailings facility credible flow failure scenarios (Information may be obtained from the output of Requirements 2.4 and 3.3); 5. A description of the design for all phases of the tailings facility lifecycle including the current and final height (Information may be obtained from the output of Requirement 5.5); 6. A summary of material findings of annual performance reviews and DSR, including implementation of mitigation measures to reduce risk to ALARP (Information may be obtained from output of Requirements 10.4 and 10.5); 7. A summary of material findings of the environmental and social monitoring programme including implementation of mitigation measures (Requirement 7.5); 8. A summary version of the tailings facility EPRP for facilities that have a credible failure mode(s) that could lead to a flow failure event that: (i) is informed by credible flow failure scenarios from the tailings facility breach analysis; (ii) includes emergency response measures that apply to project affected people as identified through the tailings facility breach analysis and involve cooperation with public sector agencies; and (iii) excludes details of emergency preparedness measures that apply to the Operator's assets, or confidential information (Requirements 13.1 and 13.2); 9. Dates of most recent and next independent reviews (Requirement 10.5); and 10. Annual confirmation that the Operator has adequate financial capacity (including insurance to the extent commercially reasonable) to cover estimated costs of planned closure, early closure, reclamation, and post closure of the tailings facility and its appurtenant structures (Requirement 10.7)" (Global Tailings Review, 2020).

[77] "2.5.3. Public Liability Accident Insurance
- 2.5.3.1. All operations related to the mining project shall be covered by a public liability accident insurance policy that provides financial insurance for unplanned accidental events.
- 2.5.3.2. The public liability accident insurance shall cover unplanned accidental events such as flood damage, landslides, subsidence, mine waste facility failures, major spills of process solutions, leaking tanks, and other potential accidents.
- 2.5.3.3. The accident insurance coverage shall remain in force for as long as the operating company, or any successor, has legal responsibility for the property" (IRMA, 2018)

[78] The Commission could require licensees to obtain insurance policies to cover costs in the event of a safety hazard or dam failure" (FERC, 2021b).

[79] "Summary of Recommendations … 2. Introduce Financial Assurances for Unexpected Environmental Harm Events Require companies to hold sufficient financial assurances to meet the costs of likely environmental damage and third-party losses that arise due to mine related accidents. Establish a limit of liability where fault does not need to be proven, and require unlimited liability above the liability limit when fault or negligence exists. The level of sufficient financial assurances to be determined through risk assessment and to include insurance and other hard security instruments such as bonds or cash. Companies should provide proof on an annual basis that required financial resources are available" (Allan, R., 2016).

[80] The Auditor General of Ontario recommended in 2015: "Acceptance of self-assurance by the Ministry as permitted under the Mining Act exposes the government to some financial risks because if the companies are unable to meet their obligations, rehabilitation costs become the province's responsibility. Manitoba is the only other province in Canada that specifically allows mining companies to self-assure if the companies' credit rating meet specific criteria. RECOMMENDATION 6 ... the Ministry should … reassess its practice of allowing certain companies to self-assure mine close-out costs (we made a similar recommendation in our 2005 Annual Report)" (Office of the Auditor General of Ontario, 2015, p. 459). Self-assurance using credit ratings and other soft bonds represented 25% of mine site liability in Ontario in 2021 (vs. 40% in 2014) (Ministry of Northern Development, Mines, Natural Resources And Forestry (Ontario), 2021).

[81] The Quebec Mining Act includes the following:
- "232.4. A person identified in section 232.1 must furnish a guarantee covering the anticipated cost of completing the work required under the rehabilitation and restoration plan to the extent provided for in this Act and in accordance with the standards established by regulation" (Mining Act, 2021).
- "232.6. Every person whose plan has been approved shall submit a revised plan to the Minister for approval (1) every 5 years, unless a shorter period is fixed by the Minister on approving the plan or revised plan; (2) whenever amendments to the plan are justified by changes in the mining activities; (3) whenever he intends to amend the plan; (4) whenever the Minister has seen fit to request a revision" (Mining Act, 2021).
- "147. The person referred to in any of subparagraphs 2 to 4 of the first paragraph of section 232.1 of the Act whose plan was approved by the Minister before 22 August 2013, must submit the guarantee referred to in section 232.4 of the Act in accordance with the following rules: (1) the guarantee must be submitted in 3 payments; (2) the first payment must be submitted not later than 1 year after 22 August 2013; (3) each subsequent payment must be submitted on the anniversary date of the first payment; (4) the first payment represents 50% of the total amount of the guarantee and the second and third payments, 25% each" (Regulation respecting mineral substances other than petroleum, natural gas and brine, 2021).

[82] "Coverage and form of financial assurance. The financial assurance required under subsection 1 applies to all mining and reclamation operations that are subject to a mining permit. A. The amount of the financial assurance must be sufficient to cover the cost for the department to administer,

and hire a 3rd party to implement, all necessary investigation, monitoring, closure, post-closure, treatment, remediation, corrective action, reclamation, operation and maintenance activities under the environmental protection, reclamation and closure plan, including, but not limited to: … (2) The cost to respond to a worst-case catastrophic mining event or failure, including, but not limited to, the cost of restoring, repairing and remediating any damage to public facilities or services, to private property or to the environment resulting from the event or failure" (Maine Metallic Mineral Mining Act, 2021).

[83] Montana Code Annotated ([MCA], 2021) provides that:

- "A person or company may not receive an exploration license if that person/company's failure, "or the failure of any firm or business association of which that person was a principal or controlling member," to comply with the MMRA, its implementing regulations, or a permit or license issued under the MMRA "has resulted in either the receipt of bond proceeds by [DEQ] or the completion of reclamation by the person's surety or by [DEQ]" (MCA, 2021 § 82-4-331(3)).
- "A person or company may not receive a hard rock operating permit under the same conditions" (MCA, 2021, § 82-4-335(9)).
- A person or company "may not conduct mining or exploration activities in this state" if that person/company "or any firm or business association of which that person was a principal or controlling member had a bond forfeited" under the MMRA, if DEQ "otherwise received bond proceeds from a surety to perform reclamation" on the person's/company's behalf, or if the person's/company's surety completed reclamation on their behalf (MCA, 2021, § 82-4-360(1)).
- An exception from these "bad actor" prohibitions applies only if the person/company seeking to conduct exploration or mining activities pays DEQ (1) the full amount of expenses DEQ incurred for reclamation carried out on behalf of that person/company or that person's former company, (2) the full amount of any penalties assessed under the MMRA, and (3) interest on the expenses incurred and penalties assessed at the rate of 6% per year; and the person/company demonstrates and DEQ determines that the person/company "has remedied the conditions that led to the bond forfeiture or receipt of the bond proceeds and that those conditions no longer exist" (MCA, 2021, § 82-4-360(2); see id. §§ 82-4-331(3)(a), 82-4-335(9)(a) (incorporating exception)).
- "Person" includes "any ... corporation, firm, association, partnership, or other legal entity engaged in exploration for or mining of minerals on or below the surface of the earth, reprocessing of tailings or waste materials, or operation of a hard-rock mill" (MCA, 2021, § 82-4- 303(22)).

[84] "Bonding provisions: … (e) When the reclamation plan for any affected land has been completed, the administrator may recommend to the director the release of up to seventy-five percent (75%) of the bond required for that affected land. The remaining portion of the bond shall be not less than ten thousand dollars ($10,000.00), and shall be held for a period of at least five (5) years after the date of reduction to assure proper revegetation and restoration of groundwater. The retained portion of the bond may be returned to the operator at an earlier date if a release signed by the surface owner and approved by the administrator and director is obtained" (Wyoming Environmental Quality Act, 2010, § 35-11-417).

[85] See Section 5.1 Case study #1: Alaska in FNEMC (2019) for more details (p. 13-15).

[86] The Canadian Ship-Source Oil Pollution Liability and Compensation Framework sets aside funds raised by a charge on each barrel of oil shipped to cover the cleanup costs of infrequent but massive accidents and spills (Transport Canada, 2020).

[87] The Pipeline Safety Act (2015), "(c) establishes the limit of liability without proof of fault or negligence at no less than one billion dollars for companies that operate pipelines that have the capacity to transport at least 250,000 barrels of oil per day and at an amount prescribed by

regulation for companies that operate any other pipelines."

[88] "Ultimately, the accountability for decisions related to tailings management rests with the Owner's Board of Directors or Governance Level" (MAC, 2021).

[89] "A director of a company shall act in good faith in order to promote the objects of the company for the benefit of its members as a whole, and in the best interests of the company, its employees, the shareholders, the community and for the protection of environment" (The Companies Act, 2013).

[90] "(3) The operator or permit applicant shall develop the manual, which must contain: (a) an identification of the roles and responsibilities of the agents of the operator of the tailings storage facility. The specific organizational role with ultimate responsibility for the tailings storage facility must be identified as the senior ranking agent of the operator at the site of the tailings storage facility" (MCA, 2021, § 2-4-379).

References

Administrative Rules of the State of Montana, Chapter 36.14: Dam Safety. (2021). http://www.mtrules.org/gateway/ChapterHome.asp?Chapter=36%2E14

Agência Nacional de Mineração [National Mining Agency]. (2017). Portaria No 70.389, de 17 de Maio de 2017 [Ordinance No. 70.389 of May 17, 2017]. https://www.in.gov.br/materia/-/asset_publisher/Kujrw0TZC2Mb/content/id/20222904/do1-2017-05-19-portaria-n-70-389-de-17-de-maio-de-2017-20222835

Agência Nacional de Mineração [National Mining Agency], 2019. Resolução n° 13, de 8 de agosto de 2019 [Resolution No. 13 of August 8, 2019]. Available online at: https://www.in.gov.br/web/dou/-/resolucao-n-13-de-8-de-agosto-de-2019-210037027

Allan, R., 2016. (Union of British Columbia Indian Chiefs), 2016. Toward financial responsibility in British Columbia's mining industry: Union of British Columbia Indian Chiefs, May 2016, 96 p. Available online at: https://miningwatch.ca/sites/default/files/toward_financial_responsibilty.pdf

Arizona Department of Environmental Quality, n.d. Arizona mining guidance manual BADCT [Best Available Demonstrated Control Technology)]: Publication No. TB 04-01, 298 p. Available online at: http://static.azdeq.gov/wqd/badctmanual.pdf

Assembleia Legislativa de Minas Gerais [Legislative Assembly of Minas Gerais], 2019. Legislação Mineira (Lei 23291, de 25/02/2019) [Mining Legislation (Law 23291 of February 25, 2019)]. Available online at: https://www.almg.gov.br/consulte/legislacao/completa/completa.html?tipo=LEI&num=23291&ano=2019

Associação Brasileira de Normas Técnicas [Brazilian Association for Technical Standards]. (2017). Mineração – e laboração e apresentação de projeto de barragens para disposição de rejeitos, contenção de sedimentos e reservação de água – Requisitos [Mining – Preparation and presentation of design of tailings, sediments and/or water dams – Requirements]. Norma Brasileira ABNT NBR 13.028, 3rd ed.

Association of Professional Engineers and Geoscientists of BC. (2016). Site characterization for dam foundations in BC (Version 1.2). https://www.egbc.ca/getmedia/13381165-a596-48c2-bc31-2c7f89966d0d/2016_Site-Characterization-for-Dam-Foundations_WEB_V1-2.pdf.aspx

Australian National Committee on Large Dams. (2012). Guidelines on tailings dams: Planning, design, construction, operation and closure. https://www.resolutionmineeis.us/sites/default/files/references/ancold-2012.pdf

BC First Nations Energy and Mining Council, 2015. Uncertainty upstream: Potential threats from tailings facility failures in in northern British Columbia. Available online at: http://fnemc.ca/wp-content/uploads/2015/07/Uncertainty-Upstream-2015-compressed.pdf

BC First Nations Energy and Mining Council, 2019. Using financial assurance to reduce the risk of mine non-remediation: Considerations for British Columbia and Indigenous Governments, November 2019, 33 p. Available online at: http://fnemc.ca/wp-content/uploads/2015/07/Using-financial-assurance-to-reduce-the-risk-of-mine-non-remediation.pdf

BC Mining Law Reform. (2021a, January 19). New map shows dozens of mine pollution threats in B.C. [Press release]. https://reformbcmining.ca/uncategorized/2021/01/new-map-shows-dozens-of-mine-pollution-threats-in-bc/

BC Mining Law Reform. (2021b, November). B.C. fails to meet Indigenous consent standard for mining—8 recent cases. https://reformbcmining.ca/wp-content/uploads/2021/11/BCMLR-failing-FPIC-report.pdf

Bill 41: Declaration on the Rights of Indigenous Peoples Act, 2019. 1st Reading October 24th, 2019, 41st Parliament, 4th Session. Available online at: https://www.leg.bc.ca/parliamentary-business/legislation-debates-proceedings/41st-parliament/4th-session/bills/first-reading/gov41-1

Canadian Dam Association. (2013). Dam safety guidelines 2007 (2013 edition). https://cda.ca/publications/cda-guidance-documents/dam-safety-publications

Canadian Dam Association. (2019). Application of dam safety guidelines to mining dams (2019 ed.).

Diário Oficial do Estado de Minas Gerais [Official Gazette of the State of Minas Gerais], 2021. Decreto N° 48.140, de 25 de fevereiro de 2021 [Decree No. 48,140 of February 25, 2021]. Available online at: https://www.jusbrasil.com.br/diarios/1114261783/doemg-executivo-26-02-2021-pg-2/pdfView

Environmental Assessment Act. [SBC 2018] Chapter 51. (2021). https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/18051

Fair Mining Collective, 2015. The path to zero failures—Health, Safety and Reclamation Code—Review, 111 p. Available online at: https://www.fairmining.ca/wp-content/uploads/2016/01/The_Path_To_Zero_Failures.pdf

Federal Emergency Management Agency. (2005). Federal guidelines for dam safety: Earthquake analyses and design of dams [FEMA-65]. https://www.fema.gov/sites/default/files/2020-08/fema_dam-safety_earthquake-analysis_P-65.pdf

Federal Emergency Management Agency. (2013). Selecting and accommodating inflow design floods for dams [FEMA P-94]. https://www.fema.gov/sites/default/files/2020-08/fema_dam-safety_inflow-designs_P-94.pdf

Federal Energy Regulatory Commission. (2021a, January 26). Financial assurance measures for hydroelectric projects: Docket No. RM21-9-000, Federal Register, Vol. 86, No. 15, Notice of Inquiry. https://dams.ussdams.org/resources/FERC_Docket%20No%20RM21-9-000.pdf

Federal Energy Regulatory Commission. (2021b, December 16). Safety of water power projects and project works: Docket No. RM20-9-000, Order No. 880, 18 CFR Part 12. https://www.ussdams.org/wp-content/uploads/2021/12/FERC-Docket-No-RM20-9-000-final_12.16.21.pdf

Garbarino, E., Orveillon, G., Saveyn, H.G.M., Barthe, P., & Eder, P. (2018). Best Available Techniques (BAT) Reference document for the management of waste from extractive industries, in accordance with Directive 2006/21/EC, Joint Research Centre Science for Policy Report [EUR 28963 EN]. European Commission. https://ec.europa.eu/environment/pdf/waste/mining/MWEI%20BREF.pdf

Global Tailings Review. (2020, August). Global industry standard on tailings management. https://globaltailingsreview.org/wp-content/uploads/2020/08/global-industry-standard_EN.pdf

Idaho Administrative Procedure Act, 2021. IDAPA 37 – Department Of Water Resources—Water Allocations Bureau—37.03.06 – Safety of Dams Rules, 18 p. Available online at: https://adminrules.idaho.gov/rules/current/37/370306.pdf

Independent Expert Engineering Investigation and Review Panel, 2015. Report on Mount Polley Tailings Storage Facility breach: Report to Ministry of Energy and Mines and Soda Creek Indian Band, 156 p. Available online at: https://www.mountpolleyreviewpanel.ca/sites/default/files/report/ReportonMountPolleyTailingsStorageFacilityBreach.pdf

Initiative for Responsible Mining Assurance. (2018, June). IRMA standard for responsible mining [IRMA-STD-001]. https://responsiblemining.net/wp-content/uploads/2018/07/IRMA_STANDARD_v.1.0_FINAL_2018-1.pdf

Institution of Civil Engineers. (2015). Floods and reservoir safety (4th ed.). ICE Publishing.

International Commission on Large Dams and United Nations Environment Programme. (2001). Tailings dams risk of dangerous occurrences: Lessons learnt from practical experiences [Bulletin 121]. https://ussdams.wildapricot.org/resources/Documents/ICOLD%202001%20Bulletin%20121.pdf

International Council on Mining and Metals. (2019). Integrated mine closure: Good practice guide (2nd ed.). https://www.icmm.com/website/publications/pdfs/environmental-stewardship/2019/guidance_integrated-mine-closure.pdf

Lapointe, U. (2020, October 5). Mine Waste in Canada: A Growing Liability. MiningWatch Canada. https://miningwatch.ca/blog/2020/10/5/mine-waste-canada-growing-liability

LegisWeb. (2022). Portaria DNPM n° 237 de 18/10/2001 [DNPM Ordinance No. 237 of October 18, 2001]. https://www.legisweb.com.br/legislacao/?id=182620

Maine Metallic Mineral Mining Act. Title 38: Waters and Navigation—Chapter 3: Protection and Improvement of Waters—Subchapter 1: Environmental Protection Board—Article 9. (2021). http://legislature.maine.gov/legis/statutes/38/title38ch3sec0.html

Mayangsari, A. and T.B. Adji, 2015. Implementation of dam safety in Indonesia: Hydropower '15, Stavanger, Norway, 15-16 June 2015, 8 p. Available online at: https://www.ich.no/Opplastet/Dokumenter/Hydropower15/Mayangsari_indonesia.pdf

Mines Act. [RSBC 1996] Chapter 293. (2021). https://www.bclaws.gov.bc.ca/civix/document/id/lc/statreg/96293_01?bcgovtm=20191025_MCFD_AM_CHILD_2__ADW_BCGOV_EN_BC__TEXT#section18

Mining Act. [CQLR c M-13.1]. (2021). http://legisquebec.gouv.qc.ca/en/showdoc/cs/m-13.1

Mining Association of Canada. (2021a). Developing an operation, maintenance, and surveillance manual for tailings and water management facilities (Version 2.1). https://mining.ca/wp-content/uploads/dlm_uploads/2021/04/MAC-OMS-Guide-March-2021.pdf

Mining Association of Canada. (2021b). Guide to the management of tailings facilities (Version 3.2). https://mining.ca/our-focus/tailings-management/tailings-guide/

MiningWatch Canada. (2020, June). Reimagining NAOMI - IMOA [Presentation]. Re-imagine the National Orphaned and Abandoned Mine Initiative (NOAMI), virtual. https://miningwatch.ca/publications/2020/10/2/mine-waste-canada-growing-liability

Ministerio de Energía y Recursos Naturales No Renovables [Ministry of Energy and Non Renewable Natural Resources] (Ecuador). (2020a). Anexo II—Guía técnica para la presentación de proyectos de diseño de los depósitos de relaves [Appendix II—Technical guide for the presentation of tailings deposit design projects]. https://www.mingaservice.com/web/index.php/documento/categoria/legislacion-minera

Ministerio de Energía y Recursos Naturales No Renovables [Ministry of Energy and Non Renewable Natural Resources] (Ecuador). (2020b). Instructivo para la aprobación de proyectos de diseño, construcción, operación y mantenimiento de depósitos de relaves para la mediana y gran minería [Instructions for the approval of projects for the design, construction, operation and maintenance of tailings deposits for medium- and large-scale mining]. https://www.mingaservice.com/web/index.php/documento/categoria/legislacion-minera

Ministry of Energy and Mines. (2016, July). Guidance document—Health, Safety and Reclamation Code for Mines in British Columbia (Version 1.0). https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/mineral-exploration-mining/documents/health-and-safety/part_10_guidance_doc_10_20july_2016.pdf

Ministry of Energy and Mines. (2017, June). Health, Safety and Reclamation Code for Mines in British Columbia. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/mineral-exploration-mining/documents/health-and-safety/code-review/health_safety_and_reclamation_code_2017_rev.pdf

Ministry of Energy, Mines and Low Carbon Innovation. (2021a, January). Provincial overview of exploration and mining in British Columbia, 2020 [Geological Survey Information Circular 2021-01]. http://cmscontent.nrs.gov.bc.ca/geoscience/PublicationCatalogue/InformationCircular/BCGS_IC2021-01.pdf

Ministry of Energy, Mines and Low Carbon Innovation, Mine Audits & Effectiveness Unit. (2021b, April). Audit of code requirements for tailings storage facilities. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/mineral-exploration-mining/documents/mine-audits-and-effectiveness-unit/audit_of_code_requirements_for_tailings_storage_facilities_final_2021_04.pdf

Ministry of Energy, Mines and Low Carbon Innovation. (2021c, June 18). Mines chief auditor releases first audit [Press release]. https://archive.news.gov.bc.ca/releases/news_releases_2020-2024/2021EMLI0042-001170.htm

Ministry of Northern Development, Mines, Natural Resources And Forestry (Ontario). (2021). Financial assurance table. https://www.mndm.gov.on.ca/en/news/mines-and-minerals/financial-assurance-table

Montana Code Annotated 2021, Title 82. Minerals, Oil, and Gas—Chapter 4. Reclamation—Part 3. Metal Mine Reclamation. (2021). https://leg.mt.gov/bills/mca/title_0820/chapter_0040/part_0030/sections_index.html

Morrill, J., Sampat, P., Lapointe, U., Kneen, J., Chambers, D., Emerman, S.H., Maest, A., & Milanez, B. (2020). Safety First: Guidelines for responsible mine tailings management. Earthworks and MiningWatch Canada. https://earthworks.org/publications/safety-first-guidelines-for-responsible-mine-tailings-management/#:~:text=The%20safest%20tailings%20facility%20is,demand%20for%20primary%20raw%20minerals

Natural Resources Canada, 2020. Canada's pipeline safety system. Available online at: https://www.nrcan.gc.ca/our-natural-resources/energy-sources-distribution/clean-fossil-fuels/pipelines/pipeline-facts/canadas-pipeline-safety-system/18858

Nevada Administrative Code, Chapter 535: Dams and Other Obstructions. (2016, June). https://www.leg.state.nv.us/nac/NAC-535.html

New Mexico Office of the State Engineer, 2021. Title 19 Natural Resources and Wildlife—Chapter 25 Administration and Use of Water - General Provisions—Part 12 Dam Design, Construction and Dam Safety. Available online at: http://164.64.110.134/parts/title19/19.025.0012.html

Office of the Auditor General of Ontario, 2015. "Mines and Minerals Program". Annual Report 2015, Chapter 3, pp. 434 - 470. Available online at: https://www.auditor.on.ca/en/reports_en/en15/3.11en15.pdf

Oregon Revised Statute [ORS 540.443—Distribution and Storage of Water—Definitions for ORS 540.443 to 540.491]. (2021). https://www.oregonlaws.org/ors/540.443

Oregon Revised Statute, Water Resources Department [WRS 690.020—Chapter 690—Division 20: Dam Safety]. (2021).

Pipeline Safety Act [S.C. 2015, c. 21]. (2015). https://laws-lois.justice.gc.ca/eng/annualstatutes/2015_21/page-1.html

Regulation respecting mineral substances other than petroleum, natural gas and brine. Mining Act [Chapter M-13.1, r. 2]. (2021). http://legisquebec.gouv.qc.ca/en/ShowDoc/cr/M-13.1,%20r.%202

Roche, C., Thygesen, K., & Baker, E. (eds.). (2017). Mine tailings storage: Safety is no accident. A UNEP Rapid Response Assessment. United Nations Environment Programme and GRID-Arendal. https://gridarendal-website-live.s3.amazonaws.com/production/documents/:s_document/371/original/RRA_MineTailings_lores.pdf?1510660693

Rules and Regulations for Dam Safety and Dam Construction (2 CCR 402-10). (2020). Department of Natural Resources, Division of Water Resources, Office of the State Engineer. https://www.sos.state.co.us/CCR/GenerateRulePdf.do?ruleVersionId=8426&fileName=2%20CCR%20402-1

Sistema Nacional de Información Ambiental (Perú) [National System of Environmental Information (Peru)]. (2014). Decreto Supremo N° 040-2014-EM - Reglamento de protección y gestión ambiental para las actividades de explotación, beneficio, labor general, transporte y almacenamiento minero [Supreme Decree No. 040-2014-EM - Regulation of protection and environmental management for the activities of exploitation, beneficiation, general labor, transport and mineral storage]. https://sinia.minam.gob.pe/normas/reglamento-proteccion-gestion-ambiental-las-actividades-explotacion

The Companies Act. (2013). https://www.mca.gov.in/Ministry/pdf/CompaniesAct2013.pdf

Transport Canada, 2020. Marine liability and compensation: oil spills. Available online at: https://tc.canada.ca/en/marine-transportation/marine-safety/marine-liability-compensation-oil-spills

United Nations Declaration on the Rights of Indigenous Peoples: resolution / adopted by the General Assembly, A/RES/61/295. (2007, October 2). https://www.refworld.org/docid/471355a82.html

University of Victoria Environmental Law Centre. (2019). Waste disposal & management. BC Mining Law Reform. https://reformbcmining.ca/wp-content/uploads/2019/05/BCMLR-Waste-Disposal-and-Management.pdf

U.S. Army Corps of Engineers. (1991). Inflow design floods for dams and reservoirs [Engineer Regulation ER 1110-8-2 (FR)]. Department of the Army. http://www.publications.usace.army.mil/Portals/76/Publications/EngineerRegulations/ER_1110-8-2_FR.pdf

U.S. Army Corps of Engineers. (2000). Design and construction of levees [Manual No. 1110-2-1913]. Department of the Army. https://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_1110-2-1913.pdf

U.S. Army Corps of Engineers. (2014). Safety of dams – Policy and procedures [Engineer Regulation ER 1110-2-1156]. Department of the Army. http://www.publications.usace.army.mil/Portals/76/Publications/EngineerRegulations/ER_1110-2-1156.pdf

U.S. Bureau of Reclamation. (2011). Dam safety public protection guidelines—A risk framework to support dam safety decision-making. https://www.usbr.gov/ssle/damsafety/documents/PPG201108.pdf

U.S. Bureau of Reclamation. (2015). Design standards No. 13—Embankment dams—Chapter 13—Seismic analysis and design. https://www.usbr.gov/tsc/techreferences/designstandards-datacollectionguides/finalds-pdfs/DS13-13.pdf

U.S. Environmental Protection Agency. (1994). Technical Report: Design and evaluation of tailings dams [530-R-94-038 NTIS PB94-201845]. Office of Solid Waste, Special Waste Branch. https://nepis.epa.gov/Exe/ZyPDF.cgi/2000EF89.PDF?Dockey=2000EF89.PDF

Vyse, C.H., 2012. Potential changes to hazard categorisation and inflow design floods for reservoirs in the United Kingdom: In Dams—Engineering in a Social & Environmental Context. Thomas Telford, London, 7 p. Available online at: https://britishdams.org/2012conf/papers/1%20Legislative%20and%20policy%20frameworks%20for%20dam%20professionals/Papers/1.4%20Vyse%20-%20Potential%20changes%20to%20hazard%20categorisation%20and%20inflow%20design%20floods%20for%20reservoirs%20in%20the%20United%20Kingdom.pdf

World MineTailings Failures, 2021. State of world mine tailings failures portfolio 2020. Available online at: https://worldminetailingsfailures.org/

Wyoming Environmental Quality Act [Wyoming Statutes, Title 35: Public Health And Safety—Chapter 11: Environmental Quality (WS 35-11)]. (2010). https://law.justia.com/codes/wyoming/2010/Title35/chapter11.html

Zhang, M. and T. Daly, 2019. China tightens rules on tailings dam safety: Reuters, December 19, 2019. Available online at: https://www.reuters.com/article/us-china-tailings/china-tightens-rules-on-tailings-dam-safety-idUSKBN1YN12S

Zhang, M. and S. Singh, 2020. China to limit new tailings dams to reduce safety, environmental risks: Reuters, March 23, 2020. Available online at: https://www.reuters.com/article/us-china-tailings/china-to-limit-new-tailings-dams-to-reduce-safety-environmental-risks-idUSKBN21A175