Safety First

Guidelines for Responsible Mine Tailings Management

JUNE 2020

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Report available at earthworks.org/safety-first and miningwatch.ca/safety-first

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COVER PHOTOS AND DESIGN

Cover photo: Workers from the Brazilian Ministry of Environment survey the catastrophic damage after the collapse of the Vale tailings dam in Brumadinho, Brazil, in 2019. Minas Gerais, Brazil. By IBAMA from Brazil.

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Executive Summary

The 2019 mine tailings dam collapse near Brumadinho, Brazil, killed over 250 people and decimated houses and buildings for kilometers before flowing into the Paraopeba River. The catastrophe stunned the world, but should not have come as a surprise. Tailings facilities, which contain the processed waste materials generated from mining metals and minerals, are failing with increasing frequency and severity.

Current industry standards, including the draft of the Global Tailings Standard released in 2019, do not go far enough to adequately protect communities and ecosystems from failures. The design, construction, operation and closure of tailings facilities require significant changes to protect people and the environment.

The safest tailings facility is the one that is not built. To avoid the long-term liability of mine waste sites and their social and environmental impacts, we must reduce the volume of tailings produced, as well as the overall demand for primary raw minerals. Over the past 40 years, ore grades have declined on average by half for many minerals, effectively doubling the volume of mine waste tailings generated for each unit of mineral produced. Current trends suggest an additional 2- to 10-fold increase in the extraction and uses of most minerals by 2060. These trends are not sustainable. We need to continue to mine at least some minerals, including to support energy transition technologies, but we need best standards and practices to do so.

Tailings facilities can fail in many ways and with varying degrees of severity. This document outlines guidelines aimed at preventing catastrophic failures: failures where the structural integrity of the storage facility has been compromised.

The ultimate goal of tailings management must be zero harm to people and the environment and zero tolerance for human fatalities. 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. If an operating company identifies any potential loss of life as a

The Doce River, polluted from the Samarco tailings spill, runs through a hydro-electric power plant in July 2016. Minas Gerais, Brazil. Photo: Júlia Pontés.

result of a tailings dam failure, the dam must be designed to withstand the most extreme credible meteorological and seismic events.

Prior to permitting approval and over the life of the mine, operating companies must ensure the meaningful engagement, participation and consent of affected and potentially affected communities for any tailings facility.

The use of upstream dams must be banned in favor of centerline and downstream dams, which are much less vulnerable to all mechanisms of dam failure. Additionally, dams must not be built in close proximity to communities or above mining infrastructure where workers are likely to be present.

Design, construction, operation and closure at any tailings facility must all be subject to the best available technologies and best available practices. This would encourage the use of filtered tailings, which reduce the probability and consequence of failure.

Operating companies must document detailed understanding of the dam foundation as well as the tailings material properties, with special attention to clay content and liquefaction potential. There must be annual reporting that verifies that dam operations and construction adheres to the documented dam design.

Tailings facilities must be reviewed, inspected, monitored, and maintained until they reach a permanent state where the potential for failure is essentially impossible. The initial storage of filtered tailings facilitates an eventual safe closure.

Worst-case tailings failure scenarios must be modeled and made public prior to permitting and regularly updated throughout facility lifecycles. Emergency and evacuation drills related to catastrophic failure of tailings facilities must be held on an annual basis, and their planning and execution must include participation from affected communities, workers, local authorities and emergency management.

A culture of safety and responsibility must be upheld at the highest level within a corporation; this can only be achieved if the Board of Directors is held accountable for its actions (or lack thereof). The Board of Directors must bear the prime responsibility for the safety of tailings facilities, including the consequences of dam failures, and demonstrate that the company has the necessary financial assurance to cover the full cost of closure and post-closure plans as well as public liability insurance to cover the full cost of any catastrophic failures.

Aerial view of mine waste, Catalão, Goiás, Brazil. Photo: Júlia Pontés.

SUMMARY OF GUIDELINES

- Make safety the guiding principle in design, construction, operation, and closure
- Ban new mine tailings facilities immediately upstream from inhabited areas
- Ban upstream dams at new mines and close existing upstream facilities
- Any potential loss of life is an extreme event and design must respond accordingly
- Mandate the use of Best Available Technology for tailings, including the use of filtered tailings, and implement rigorous controls for safety, including after mine closure
- Demonstrate understanding of local conditions and tailings characteristics with robust monitoring systems and develop emergency preparedness/response plans
- Affected communities must provide consent, and safety oversight must be independent, including the establishment of grievance procedures and whistleblower protections
- Information regarding mine safety must be made publicly available
- Corporate boards must assume full responsibility for risk (including financial risk) and accept the consequences of failure

In order to understand how and why failures occur, we must understand the scope of the issue. There is currently no global inventory of the thousands of tailings storage facilities, or a complete registry of dam failures. Compiling and sharing this information, publicly and transparently, is essential. An independent international agency, such as a United Nations-endorsed agency, in collaboration with responsible States, operating companies, and civil society, must drive this process, collect information on tailings dams and tailings dam failures worldwide, and share it with affected communities in order to de-risk these sites and support work to put in place proper emergency action plans.

Ultimately, this nascent international agency must be able to oversee tailings management safety worldwide. It must be a well-resourced agency capable of efficiently updating global standards, certifying their implementation, investigating failures and making publicly available recommendations. In order to determine the reach and scope of such an agency, an independent study should investigate which governance model would be most appropriate for this task.

Language

This document uses the word “must” to indicate an action or guideline that is required. The word “should” is used when the action or guideline is optional or unattainable at this time.

Introduction

In January of 2019 a dam at the Córrego do Feijão mine owned by Vale near Brumadinho, Brazil, collapsed, releasing about 9.7 million cubic meters of tailings. The mine waste traveled eight kilometres over land,[1] killing over 250 people,[2] destroying houses and buildings, and eventually flowing into the Paraopeba River.

The Brumadinho catastrophe stunned the world, including the mining industry and investors, but should not have come as a surprise. It was one of many major disasters of its kind since 2014, following on the heels of massive tailings dam collapses at the Mount Polley gold-copper mine in British Columbia, Canada, operated by Imperial Metals, as well as at the Samarco mine in 2015, a joint venture owned by Vale and BHP Billiton. The failure of the Samarco mine in Mariana, Brazil, killed 19 people and sent tailings over 600 kilometres down the Rio Doce to the Atlantic Ocean. After the Mariana catastrophe, Vale's CEO vowed "never again." And yet, three years later, the dam at Córrego do Feijão collapsed.[3]

As tailings facilities fail with increasing frequency and severity, new regulations and standards emerge in an effort to reign in dangerous practices and prevent future disasters.[4] After the Brumadinho failure, investor intervention spearheaded by the Church of England, led to the swift rollout of the Global Tailings Review (GTR), co-convened by the International Council on Metals and Mining (ICMM), Principles for Responsible Investment (PRI) and the United Nations Environment Programme (UNEP). According to its website, the GTR seeks "to establish an international standard for the safer management of tailings storage facilities."[5] The first iteration of the Global Tailings Standard is to be released in 2020.

Current industry standards, including the draft of the Global Tailings Standard released in 2019, do not go far enough to adequately protect communities and ecosystems from failures. They often

A fjord outside Kirkenes in Norway's northeastern corner, has filled up with tailings after decades of mining companies dumping waste in the harbor. Kirkenes Harbor, Finnmark, Norway. Photo: WikiCommons.

lack clear and mandatory technical guidelines to move away from technologies and practices that present too much risk, as is done in other industries. There must be significant changes made to the current practices in design, construction, operation and closure of tailings facilities. **The following document outlines guidelines for safety, respect for affected communities, and corporate accountability that must be incorporated into any tailings standards or regulations.**

This document is not intended to replace regulations or serve as a comprehensive standard itself. Any standard, regulation or guideline that does not respond to all the guidelines in this document is insufficient. Additionally, there may be circumstances under which a tailings facility can meet all the guidelines below, but should not be built or continue in operation.

This document also recognizes that the safest tailings facility is the one that is not built. We must look for ways of reducing the amount of tailings produced, as well as reducing the overall demand for primary raw minerals to avoid the long-term liability of mine waste sites and their social and environmental impacts. World production has already increased 2- to 10-fold for various minerals over the last 40 years.[6] During the same period, ore grades have declined on average by half for many of those minerals, effectively doubling the volume of mine waste tailings generated for each unit of mineral produced. According to the World Bank and Australia's Institute for Sustainable Futures, demand for mineral use specifically for the energy transition is set to explode between now and 2050, with anticipated increases of 300 to 8000 percent for certain minerals, depending on the scenario.[7,8]

Current trends of population growth, urbanization, consumerism, and metal-intensive energy transition technologies predict an additional 2- to 10-fold increase in mineral extraction and uses by 2060.[9] Clearly, these trends are not sustainable. We need to continue to mine at least some minerals, including to support the energy transition technologies, but we need the best standards and practices to do so. We also need to actively find ways to reduce the overall demand for raw minerals, including eliminating the use of precious metals as value reserve (e.g. bank reserves, stock market derivative products, etc.), and shift away from some of the current mineral uses.

The 2015 collapse of the tailings dam at the Samarco mine, owned by Vale and BHP, created a flash flood of tailings that covered houses in the town of Bento Rodrigues, Brazil. Minas Gerais, Brazil. Photo: Rogério Alves/TV Senado.

Scope

Tailings facilities can fail in many ways and with varying degrees of severity. This document outlines guidelines aimed at preventing catastrophic failures, meaning failures where the structural integrity of the storage facility has been compromised.

However, these are not the only types of failures. Environmental failures, including chronic and acute contamination, can occur even when the tailings facility is intact. Operating companies must identify, prevent and mitigate any environmental and public health impacts in addition to taking steps to prevent catastrophic failures.

Guidelines that Protect Against Some Environmental Failures Include:

- Tailings facilities must use multiple mechanisms, including liners, covers, and stormwater run-on controls, to minimize seepage from the facilities and infiltration to groundwater to the greatest extent possible. Treatment systems for water collected from tailings facilities must be adequate to remove toxic metal contaminants without off-site dilution.
- Concurrent reclamation with covers that will minimize dust production must be required. Tailings dust can affect crops, soil, wildlife, plants, surface water, and human health.
- Tailings must never be discharged into bodies of water (rivers, streams, lakes, oceans, etc.). This practice smothers river beds, seabed floors and coral reefs, decimates fish populations in freshwater and marine environments, and floods wetlands and forests. It is difficult to understand, let alone control, complex underwater ecosystems to remediate pollution.

While environmental, health and safety effects warrant significant guidelines and oversight, addressing the full range of remediations for environmental failures is beyond the scope of this document.

The 2015 collapse of the tailings dam at the Samarco mine, owned by Vale and BHP, created a flash flood of tailings that covered the town of Bento Rodrigues, Brazil. Minas Gerais, Brazil. Photo: Rogério Alves/TV Senado.

Guidelines

1. Make safety the guiding principle in design, construction, operation, and closure

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. Without this commitment, cost reduction will continue to drive the process, putting people and the environment at risk. Cost considerations are important, but protecting human health and safety, as well as the environment, must be the primary concern. Taking lessons from the Mount Polley Mine disaster in Canada in 2014, and citing the Independent Expert Engineering Investigation and Review Panel,[10] the 2017 UNEP-GRID Arendal special report on tailings storage also made safety its first recommendation: "Safety attributes should be evaluated separately from economic considerations, and cost should not be the determining factor."[11] If a mining project is uneconomic due to the costs of a safe tailings storage system, then it is uneconomic - costs and risks must not be transferred to the environment and communities and their host governments.

2. Ban new tailings facilities immediately upstream from inhabited areas

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.

State legislation in Minas Gerais, Brazil, has banned the construction of new dams if there are settlements within 10 km downstream along the course of the valley or if projections indicate that a tailings flood might reach nearby communities in less than 30 minutes. This distance can be increased to 25 km, depending upon the population density and the natural and cultural heritage.[12] Although these limits can be seen as progress compared to a lack of any regulation, they are arbitrary and will not necessarily ensure safe evacuation in every situation. Therefore, minimum distance between communities and new dams must be defined on a case-by-case basis.

When existing facilities are too close to communities to ensure safe evacuation, operating companies must negotiate with communities to close the tailings facility (see Guideline 10). In the case where closure is not possible and no other solutions are available, the operating company must offer a package of voluntary resettlement. Involuntary resettlement must not be allowed under any circumstance. In many cases, however, resettlement that is currently called "voluntary" can be highly problematic and lead to forced relocation and inadequate compensation. Voluntary resettlement must be carried out in a manner that aligns with best practices and the highest international resettlement standards. Voluntary resettlement must include consent from affected communities (see Guideline 11), must provide fair and appropriate compensation for loss of land and other assets, as well as security of tenure in the new location, and must result in improved livelihoods and standards of living for those who are resettled.[13,14,15]

3. Ban upstream dams at new mines and close existing upstream facilities

Because of the demonstrated risk associated with upstream dam construction, upstream dams must not be built at any new facilities.[16,17,18] Upstream construction is especially problematic in areas with moderate or high seismic risk, or in wet climate areas with net precipitation (more precipitation than evaporation), especially as weather events become increasingly severe with climate change.

An increasing number of jurisdictions have banned upstream tailings dams, especially in Latin America. It is theoretically possible to safely construct and operate an upstream tailings dam under the limited conditions of low seismicity and low precipitation. Even under those limited conditions, a very influential tailings industry paper, with many antecedents, has argued that there are ten rules for upstream dams and not a single one can be violated without substantial risk of failure.[19] There is a broad consensus within the engineering community that engineered structures should be robust, with multiple back-ups and defense mechanisms. The need to obey ten rules with no margin for error does not constitute a basis for safe design. Construction of new upstream tailings dams has already been banned in Brazil,[20] Chile,[21] Peru,[22] Ecuador.[23,24]

Centerline and downstream dams are much less vulnerable to all mechanisms of dam failure. 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.[25]

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 (See Guideline 10 for safe closure specifications).

4. Any potential loss of life is an extreme event and design must respond accordingly

If an operating company identifies any potential loss of life as a result of a tailings dam failure, the dam must be designed to withstand the most extreme credible meteorological and seismic events.

In the United States, the U.S. Federal Emergency Management Agency's (FEMA) has three Hazard Potential Classifications, which are Low, Significant and High. High Hazard Potential means "probable loss of life due to dam failure or misoperation." These regulations clarify that "probable loss of life" means "one or more expected."[26] A dam in the High Hazard Potential category must be designed for the Probable Maximum Flood (PMF), which is the largest flood that is theoretically possible at a given location and climate. In addition, the U.S. Army Corps of Engineers (USACE) has four categories of dam safety standards. The strictest, "Standard 1 applies to the design of dams capable of placing human life at risk or causing a catastrophe, should they fail."[27] For Standard 1, "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."

Additionally, according to FEMA (2005), High Hazard Potential dams must also be designed for the Maximum Credible Earthquake (MCE), which is defined as "the largest earthquake magnitude that could occur along a recognized fault or within a particular seismotectonic province or source area under the current tectonic framework."[28] Similarly USACE guidelines from 2016 state,"for critical features, the MDE [Maximum Design Earthquake] is the same as the MCE."[29]

The guidelines established in this document require that any dam whose failure would result in the potential loss of a single life must be designed to withstand the PMF and for the largest earthquake that is theoretically possible at a given location. All modeling and design for floods should take climate change into account - especially for closure design. For design considerations when accounting for acid generation or high contaminant leaching refer to Guideline 7.

Tailings dam at the Red Chris mine operated by Imperial Metals. British Columbia, Canada.
Photo: Garth Lenz ©Garth-Lenz-1486 (courtesy of Salmon Beyond Borders).

Where the failure of a tailings dam would have no potential for the loss of human life, the facility must be designed to withstand a 10,000-year flood event and a 10,000-year earthquake. According to the FEMA regulations, Significant Hazard Potential means "no probable loss of human life but can cause economic loss, environmental damage, or disruption of lifeline facilities due to dam failure or misoperation".[30] For these dams, the FEMA regulation is equivalent to requiring design for a 10,000-year earthquake, or an earthquake for which the annual probability of failure is 1 in 10,000.[31] Similar language is used by the U.S. Army Corps of Engineers.[32]

The corporate Board of Directors must give written reasons for any decision to design a tailings dam for anything other than the most extreme credible meteorological or seismic event. These written reasons must be filed with a governmental agency and be made publicly available.

5. Mandate the use of Best Available Technology for tailings, in particular filtered tailings

The British Columbia Mining Code Guidance asserts, "Physical stability is of paramount importance, and options that require a compromise to physical stability should be discarded."[33] Reducing the water content in tailings increases their safety because as water content decreases, so do the probability and consequences of tailings failures. While paste or thickened tailings are safer than conventional slurry, filtered tailings—tailings for which sufficient water has been removed so that the tailings behave like moist soil—have the lowest water content. Filtered tailings reduce the probability and consequence of failure.

Additionally, the initial storage of filtered tailings facilitates an eventual safe closure. Tailings placed by conventional methods, i.e. slurry, thickened, and paste tailings, can also be drained after placement, but this approach is not as effective in stabilizing the tailings as initial filtering prior to storage (See Guideline 10 for more discussion of safe closure).

All new mine proposals must begin with the analysis of the use of Best Available Technology (BAT) for tailings disposal. Tailings BAT was described by the Mount Polley Independent Expert Engineering Investigation and Review Panel (The Mount Polley Report):

"While best practices [BAP] 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."[34]

The Mount Polley Report goes on to say, "Filtered tailings technology embodies all three BAT components" and that, "[t]here are no overriding technical impediments to more widespread adoption of filtered tailings technology." All three BAT components must be incorporated

into tailings storage. There may be other forms of storage that are able to incorporate the three components.

Additionally, BAT includes reducing the amount of tailings stored above ground as much as possible. BC Mining Code Guidance recommends minimizing the footprint areas of the tailings facilities and maximizing in-pit or underground backfill.[35]

The submergence of tailings for the purpose of prevention of acid mine drainage can no longer be regarded as a best practice. The Mount Polley Report emphasized, "It can be quickly recognized that water covers run counter to the BAT principles [see Guideline 5]...The Mount Polley failure shows why physical stability must remain foremost and cannot be compromised."[36]

Although subaqueous disposal of potentially acid generating tailings has been shown to effectively decrease acid-generation potential (AGP) in some cases, leaching can continue even after being submerged, especially if the wastes have already been oxidized.[37,38] Filtered tailings dramatically reduces the amount of entrained water and also reduces AGP, but the leachate must be managed.[39] Because the presence of excess supernatant and pore water in tailings has caused or contributed to catastrophic tailings failures, filtered tailings disposal is the current best practice for tailings disposal.

6. Implement rigorous controls for safety

Design, construction, operation and closure at any tailings facility must all be subject to the best available technologies and best available practices.

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." When calculating FoS, single input values

Boat Captain Brenda Schwartz-Yeage prepares to travel up the Stikine River, in Wrangell, Alaska. Several mining projects upstream in British Columbia, Canada threaten the thriving salmon fishing industry and Indigenous livelihoods. Photo: ©Garth-Lenz-3441 (courtesy of Salmon Beyond Borders).

must be avoided and a range of values and methods or models applied to assess the various possible FoS values (static and dynamic).

Although the FoS is still included in many regulations and guidelines, it is a poor predictor of the annual probability of failure.[40] In order to more accurately identify risk, dam designs and evaluations must consider the annual probability of failure, in addition to the FoS. Annual probabilities of failure have been relied upon in many industries, such as aviation and aerospace, since the Second World War. 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%.[41]

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.[42] 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.

The water management infrastructure prevents overtopping of the supernatant tailings pond. For tailings dams that could result in the potential loss of one or more lives, the water management infrastructure, including, for example the beach, the required freeboard, spillways, internal drains, and diversion canals, must be wide enough so that the tailings pond will not reach the dam crest even during the PMF. Otherwise, the water management infrastructure must ensure that the tailings pond will not reach the dam crest even during a 10,000-year flood. The operating company must provide documentation in Dam Safety Reviews, overseen by Independent Tailings Review Boards, that show that the entire system of water management of the tailings facility is capable of resisting either the PMF or the 10,000-year flood, depending on hazard classification.

The abandoned Panguna mine, Bougainville, Papua New Guinea. Photo: Damian Baker.

7. Evaluate and characterize the dam foundation and the tailings and estimate their relationship to risk

Prior to permitting approval, operating companies must provide a detailed engineering evaluation of the dam foundation and a physical and chemical characterization of the tailings material properties, with special attention to clay content and liquefaction potential. There must be annual reporting that verifies that dam operations and construction adhere to the documented dam design. If a feature of the design was approved by a regulatory agency, then all requested changes to that design must be submitted to the same regulatory agency for approval. Otherwise, all non-adherence to the original design must be justified, documented and evaluated by an Independent Tailings Review Board (ITRB).

Tailings and tailings water must be characterized and used to estimate the risk and consequence of a potential dam failure. The geochemical characteristics of tailings supernatant and pore water and the tailings themselves can affect the consequence of a dam failure and control the extent and recoverability of ecosystems. As acid generation and contaminant leaching potential increases, the risks associated with dam failure increase. These characteristics must be reviewed at least every three years, or when there is a major change in the ore deposit being processed or the circuits for ore processing are changed.

Because tailings with high acid generation or a high contaminant leaching potential increase the severity of consequences in the event of a failure, tailings with those geochemical characteristics must be designed to withstand the PMF and the MCE. Tailings facilities must be designed to withstand the 10,000-year flood or the 10,000-year earthquake only if the tailings are non-potentially acid generating with low contaminant leaching potential and there is no potential loss of human life. The GARD Guide should be used for tailings geochemical characterization approaches.[43] For design criteria related to potential loss of life refer to Guideline 4.

The 2019 Brazilian Feijão Dam I failure was caused in part by the mineralogic changes in the iron particles that rendered the tailings mass more brittle.[44] Scanning Electron Microscope (SEM) and other mineralogic and geochemical techniques should be used for tailings characterization during mining and after mining ceases, especially at iron ore mines. As more is learned from past failures, best practice characterization measures must be regularly updated to ensure that the most relevant and comprehensive approaches are incorporated in tailings management and assessment guidance.

Destruction from the 2019 Minas Gerais tailings dam collapse near Brumadinho, Brazil. Photo: IBAMA Brazil.

8. Appropriate monitoring systems must be in place to identify and mitigate risk

Tailings facilities must have appropriate monitoring systems in place to identify and mitigate risk.

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.[45] The AMP must include:

- Numeric and measurable expected performance criteria based on predictions of engineering behavior.
- Numeric triggers 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 characteristics, tailings chemistry, and other characteristics.
- Mitigation measures designed for each performance criterion or trigger aimed at avoiding a catastrophic or other type of facility failure.
- An evaluation of the effectiveness of the measures taken.
- Reporting responsibilities for the operating company and responses by the regulatory agency and to relevant stakeholders.
- 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 Independent Tailings Review Board and is not simply a license to "figure things out later."[46]

The 2015 collapse of the tailings dam at the Samarco mine, owned by Vale and BHP, created a flash flood of tailings that covered the town of Bento Rodrigues, Brazil. Minas Gerais, Brazil. Photo: Bruno Milanez.

9. Ensure the independence of reviewers to promote safety

There must be an independent evaluation of all aspects of the design, construction, operation, and maintenance of tailings and other potentially hazardous mine waste facilities by a group of competent, objective, third-party reviewers (e.g., an Independent Tailings Review Board).[47] An ITRB provides ongoing advice on tailings operations as a complement to periodic dam safety reviews. The ITRB must not be used exclusively as a means for obtaining regulatory approval.[48] The independence of those performing reviews is essential for safety. The operating company must not be able to influence decisions made by the Independent Tailings Review Board. Any fees paid to the ITRB must be independent of the conclusions reached during the review.

In order to ensure objective reviews, the ITRB should be chosen by local regulatory agencies and compensated by the operating company. Ideally, each country should have a regulatory agency with the expertise and capacity to appoint independent reviews to ITRBs. However, this is not currently feasible in many jurisdictions. When operating companies appoint their own reviewers, 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.),[49] and personal or family connections to the mine or operating company that could incur any kind of benefits. Operating companies must not hire the same independent reviewers for multiple projects simultaneously or for subsequent reviews of the same facility in the short term. Reviewers must not be dependent on a single operating company for the majority of their income.

In the case where an operating company does not accept or act on a recommendation of the ITRB, including findings that indicate a change that could affect safety, the company must document and report the decision and its rationale to the local regulatory agency. The operating company must also publicly disclose the recommendation as well as its rationale for non-acceptance or inaction and demonstrate accountability and the ability to fund cleanup and remediation should they prove to be wrong and a disaster occurs.

Additionally, operating companies must conduct an independent DSR (*Dam Safety Review*) yearly.

10. Towards zero failure after mine closure

Tailings facilities must be reviewed, inspected, monitored, and maintained until they reach a permanent state where the potential for failure is essentially impossible. Operating companies must not be allowed to walk away from tailings facilities until the closed tailings facility can withstand, without failure, the Probable Maximum Flood (PMF) and the Maximum Credible Earthquake (MCE) (as outlined in Guideline 4), and can remain in that state indefinitely with no further inspection, monitoring or maintenance. Because tailings facilities exist in perpetuity, any facility that is deemed closed without being able to withstand PMF and MCE creates unmonitored and unregulated liability for future generations. In the cases where tailings facilities are unable to close under these conditions with current technology, they must have permanent monitoring, inspection and maintenance. Perpetual monitoring and maintenance must be self-funding from financial resources and demonstrably large to ensure sufficient funding in perpetuity (See Guideline 15 on Financial Assurance).

11. Consent of Affected Communities[50]

Operating companies must ensure the meaningful engagement, participation and consent of all affected communities for any tailings facility. This engagement must be conducted in local languages aligned with the cultural norms and communication styles of any affected communities and stakeholders.

For Indigenous Peoples, international law recognizes that Free, Prior and Informed Consent (FPIC) must be in place in order for a mine to be developed, operated and closed. The rights of Indigenous Peoples are human rights and are indivisible from their cultural, territorial and self-governance rights.[51] Indigenous People have both self-governance rights as distinct, self-determining peoples with specific decision-making processes, laws, practices and institutions, and collective territorial, self-governance, and cultural rights. An FPIC process cannot be carried out where Indigenous or Tribal Peoples are living in voluntary isolation, such as uncontacted tribes in the Amazon.[52]

Indigenous Peoples and affected communities must be afforded the opportunity to establish "no-go zones" and land-use plans.[53] This acknowledges that certain areas must never be considered for tailings storage, no matter how they are designed, monitored or operated. "No-go zones" may include potentially affected areas located downstream of tailings facilities (e.g. sacred sites) that would not allow for construction of a facility upstream.

Consent must be achieved through an ongoing dialogue over the life of the mine for both proposed and existing facilities. It must be free of external manipulation, coercion or extortion. It must be obtained through culturally appropriate processes, timeframes and mechanisms that are determined by the affected peoples or communities. These may include customary decision-making processes, local democratic processes and local governance mechanisms, or other processes such as referenda. Indigenous and Afro-Descendant peoples are increasingly documenting their governance rules for consultations and FPIC in the form of Autonomous FPIC Protocols with which they demand all external actors comply.[54]

After a rigorous Environmental, Social and Cultural Impact Assessment led by local Indigenous protocols, the Stk'emlupsemc Te Secwepemc Nation rejected in 2017 a large tailings facility proposed by the company KGHM near their sacred Pipsell site area. Pipsell, Secwepemc Territory, British Columbia, Canada.
Photo: Stk'emlupsemc Te Secwepemc Nation (SSN).

At the request of affected communities, the operating company must facilitate access to independent legal or other expert advice from the earliest stages of project design and assessment, through monitoring and closure plans.[55] Affected communities must be able to select the experts in order to ensure they are trusted.

If the representatives of affected communities clearly communicate, at any point during engagement with the operating company that they do not wish to proceed with consent-related discussions, the company shall recognize that it does not have consent, and shall cease to pursue any proposed activities affecting the rights or interests of affected communities. The company may approach affected communities to renew discussions only if, and when invited to do so by the communities' representatives.

Operating companies must document and report all steps taken towards community consent and FPIC. Those reports must be made publicly available and filed with state agencies, however any public disclosures of FPIC or community consent must be approved by Indigenous Peoples and affected peoples before their release.

12. Grievance procedures and whistleblowers

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.[56] 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.[57] 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, as already stipulated in Brazilian regulation.[58]

Community members standing on a mine waste pile at the Porgera mine in Papua New Guinea. Photo: Porgera Alliance.

13. Emergency preparedness and response

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.[59,60] 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 appropriate humanitarian aid. The operating company must provide all needed resources and support to local and national governments.

Worst-case tailings failure scenarios must be modeled and made public prior to permitting and regularly updated throughout the facility lifecycles. Worst-case scenarios must model the complete loss of stored tailings and water, as occurred, for example, in the failure of the tailings dam at the Córrego do Feijão Mine in Brazil. 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.

Contamination of the Paraopeba River after the 2019 tailings dam collapse near Brumadinho, Brazil. Photo: Maria Otávia Rezende.

14. Information regarding mine safety must be made publicly available

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
- Adaptive Management Plan reports
- Impact and mitigation plans for affected communities, including compensation and indemnification criteria
- 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.

15. Addressing financial risks

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. 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.[61]

Also, 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.[62] As per Guideline 10, tailings facilities must be inspected, monitored and maintained until they can withstand the PMF and MCE indefinitely with no further monitoring or maintenance, and therefore must have public liability insurance until that point.

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. Assessments of previous catastrophic tailings dam failures indicate that financial responsibilities can exceed US$1 billion.[63]

Operating companies must not be allowed to self-bond or use corporate guarantees for mine closure, financial assurance or public liability insurance.[64]

Safety risks are not separate from financial risks. It is of paramount importance that operating companies be able to pay for the safest technologies and practices. In addition to financial assurance and insurance mechanisms, financially risky operations must be identified and fully considered as part of tailings safety prior to permitting and throughout the mining lifecycle.

As stated by in the Mount Polley Report: "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%... [including] a detailed evaluation of all potential failure modes and a management scheme for all residual risk [and a] 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."[65,66]

16. Accountability for risk, minimizing consequences, preventing failure, and the consequences of failure must primarily rest with the Board of Directors

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.[67] 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.

Additionally, the Board of Directors must be responsible for approving and overseeing the implementation of company procedures to ensure that no employee or contractor is participating in, promoting or facilitating bribery. For example, facilitation payments to government officials to fast-track tailings facility permits must be prohibited, and there must be zero tolerance of any bribery by mine employees or contractors of auditors, consultants and government officials that could compromise the integrity or safe operation of the tailings facility.

Destruction from the 2019 tailings dam collapse near Brumadinho, Brazil. Photo: Maria Otávia Rezende.

Next Steps

Worldwide, there are many thousands of tailings storage facilities and dams, some under the responsibility of private corporations, others under the responsibility of States. Because there is currently no global inventory of tailings storage facilities, there is an urgent need for a transparent assessment, in which the results are made publicly available in a global tailings database. Ecosystems, livelihoods, and human lives are at stake.

This inventory must include the technical characterization, the associated hazard level indicating the consequences of failure, and the annual probability of failure for each tailings storage facility. The National Mining Agency of Brazil currently maintains a national inventory of tailings dams monitored in the country and publicly presents the information through their website. Although some crucial information is not properly disclosed, it could serve as an example for a proposed inventory.[68]

The database must also include a registry of dam failures. It is essential to better understand how and why each failure occurred in order to prevent them in the future. The work being compiled by the World Mine Tailings Failure database can serve as a model for this type of documentation and analysis.[69]

An independent international agency, such as a United Nations-endorsed agency, in collaboration with responsible States, operating companies, and civil society, must drive this process, collect information on tailings dams and tailings dam failures worldwide, and share it with affected communities in order to de-risk these sites and support work to put in place proper emergency action plans.

In addition to overseeing a global inventory of tailings facilities, tailings management itself must be overseen by this international agency.

It is crucial that United Nations agencies and international partners, including States, industry, labor representatives, civil society organizations, and independent experts, establish or endorse a credible, transparent, and independent international agency capable of certifying safe tailings

The Mount Polley (Imperial Metals) 2014 tailings spill in British Columbia created a 100 m wide flow path for over 10 km downstream before dumping 24 billion litres of mine tailings and other debris into Quesnel Lake, in the Fraser River watershed, home to one of the largest salmon runs in North-America. Secwepemc Territory, British Columbia, Canada. Photo: Chris Blake, Quesnel River Watershed Alliance.

disposal worldwide. This must be a well-resourced agency capable of efficiently updating global standards, certifying their implementation, investigating failures and making publicly available recommendations. This agency must not rely solely on industry experts, must include broad State or civil society engagement and must be accountable to the public and affected communities.

In order to determine the reach and scope of such an agency, an independent study should be conducted into which governance model would be more appropriate for this task.

This study should consider the International Civil Aviation Organization (ICAO) as a potential model. ICAO is a United Nations specialized agency and has proven effective at improving the safety of the aviation industry for decades. The ICAO works with Member States and industry groups, in collaboration with the public and independent experts, to reach consensus on international civil aviation standards. These standards are then used by ICAO Member States to ensure that their local industry, authorities and regulations conform to global norms. Flying has become incredibly safe precisely because each accident is thoroughly investigated and the results are made publicly available. In this way, each safe flight has built on the experience of all of the previous accidents. The ICAO also coordinates assistance and capacity building for States in support of the industry's safety; monitors and reports on performance metrics; and audits States' industry oversight capabilities in the areas of safety and security. Global tailings management needs a similar well-funded, accountable, independent approach that builds on Best Available Technology and Best Available Practices.

The polluted Doce River after the 2015 Samarco mine tailings dam failure. Minas Gerais, Brazil. Photo: Júlia Pontés.

Glossary

Adaptive Management

A structured, iterative process of robust decision-making in the face of uncertainty, with an aim to reducing uncertainty over time via system monitoring. It includes the development of management practices based on clearly identified outcomes, and monitoring to determine if management actions are meeting desired outcomes. If outcomes are not being met, the process requires development and implementation of management changes to ensure that outcomes are met or re-evaluated.

Source: Initiative for Responsible Mining Assurance, 2018. IRMA Standard for Responsible Mining IRMA-STD-001, Glossary of Terms.

Affected Community

A community that is subject to potential risks or impacts from a project.

Source: Initiative for Responsible Mining Assurance, 2018. IRMA Standard for Responsible Mining IRMA-STD-001, Glossary of Terms. IRMA Standard Adapted from IFC. IFC Policy & Performance Standards and Guidance Notes. Glossary of Terms.

Board of Directors

The ultimate governing body of the operating company typically elected by the shareholders of the operating company's firm. The Board is the entity with the final decision-making authority for the operating company and holds the authority to, among other things, set the firm's policies, objectives, and overall direction, and oversee the firm's executives. Where the State serves as the operating company, the Board of Directors shall be understood to mean the government official with ultimate direct responsibility for the final decisions of the operating company.

Source: Adapted from the Global Tailings Review, 2019. Global Tailings Standard Draft.

Centerline Construction

A tailings dam construction method in which the centerline of the dam is raised vertically and does not shift upstream or downstream during subsequent raises. Typically, structure fill is placed on the downstream side of the centerline and the upstream side of the core is supported by fill or tailings that slope downwards towards the tailings surface.

Source: Klohn Crippen Berger, 2017. Study of tailings management technologies: Report to Mining Association of Canada and Mine Environment Neutral Drainage (MEND) Program, MEND Report 2.50.1, 164 p.

Contaminant Leaching Potential

The potential for tailings samples to release contaminants based on short- and long-term leach tests (see GARD Guide for recommended testing procedures). The potential for adverse water quality effects from a tailings dam breach can also be determined from the quality of supernatant and pore fluids in the impoundment. If leach test results or tailings produce water do not exceed water quality standards (e.g., aquatic life criteria), the contaminant leaching potential would be considered low; if concentrations exceed standards by 1 to 10 times, the potential would be intermediate; and if concentrations exceed standards by more than 10 times the potential would be high.

Source: The International Network for Acid Prevention (INAP), 2009. Global Acid Rock Drainage Guide (GARD Guide).

Dam Safety Review

A systematic review of all factors affecting the safety of a dam during design, construction, and operation.

Source: Adapted from Federal Emergency Management Program (FEMA), 2004. "Federal Guidelines for Dam Safety." 17 p.

Downstream Construction

A method of dam construction in which the centerline of the dam is shifted downstream with subsequent raises, resulting in a core inclined in the downstream direction. This method requires that the structural fill be placed in the downstream shell during raising to support the inclined core.

Source: Klohn Crippen Berger, 2017. Study of tailings management technologies: Report to Mining Association of Canada and Mine Environment Neutral Drainage (MEND) Program, MEND Report 2.50.1, 164 p.

Facilitation Payments

Facilitation payments are sums of money paid to get preferential treatment for something the receiver is otherwise still required to do—for example, paying an official to speed up, or "facilitate," an authorisation process.

Source: Responsible Jewelry Council, 2019. Code of Practices Guidance. 105 p.

Factor of Safety (FoS)

The ratio of available shear resistance along a potential plane of failure to the activating shear forces along the same plane. Factors of safety take into account the reliability of inputs to the stability analysis, the probability of the loading condition, and the consequences of potential failure.

Source: Canadian Dam Association, 2013. Dam safety guidelines 2007 (2013 edition).

Filtered Tailings

Tailings dewatered such that they behave like a soil; solids content of 75% to 90%; achieved by thickening followed by vacuum or pressure filtration.

Source: Klohn Crippen Berger, 2017. Study of tailings management technologies: Report to Mining Association of Canada and Mine Environment Neutral Drainage (MEND) Program, MEND Report 2.50.1, 164 p.

Free, Prior and Informed Consent (FPIC)

Consent based on: engagement that is free from external manipulation, coercion and intimidation; notification, sufficiently in advance of commencement of any activities, that consent will be sought; full disclosure of information regarding all aspects of a proposed project or activity in a manner that is accessible and understandable to the people whose consent is being sought; acknowledgment that the people whose consent is being sought can approve or reject a project or activity, and that the entities seeking consent will abide by the decision.

Source: Initiative for Responsible Mining Assurance, 2018. IRMA Standard for Responsible Mining IRMA-STD-001, Glossary of Terms.

Grievance

A perceived injustice evoking an individual's or a group's sense of entitlement, which may be based on law, contract, explicit or implicit promises, customary practice, or general notions of fairness of aggrieved communities.

Source: Ruggie, J., 2011. Guiding Principles on Business and Human Rights.

Grievance Mechanism

Any routinized, State-based or non-State-based, judicial or non-judicial process through which mining-project related complaints or grievances, including business-related human rights abuses, stakeholder complaints, and/or labor grievances, can be raised and remedy can be obtained.

Source: Ruggie, J., 2011. Guiding Principles on Business and Human Rights.

Independent

In order for an individual, institution, mechanism or agency to be considered independent it must be objective, impartial, consistent, financially independent, transparent and accountable to all stakeholders. Financial independence requires that payment for services, funding of work, long term financial stability and the potential for future contracts do not depend on outcomes or conclusions that are favorable to an operating company or the mining industry.

Source: Adapted from The Organisation for Economic Co-operation and Development, Creating a Culture of Independence: Practical Guidance against Undue Influence.

Independent Review

The Mining Association of Canada defines independent review as "independent evaluation of all aspects of the design, construction, operation, maintenance of a tailings or other mine waste facility by competent, objective, third-party review on behalf of the operating company/mine owner." In addition to the MAC's definition, independent review must demonstrate financial independence from the operating company/mine owner (see above definition of independence).

Source: Adapted from Mining Association of Canada, 2017. A Guide to the Management of Tailings Facilities.

Indigenous Peoples

An official definition of "indigenous" has not been adopted by the United Nations system due to the diversity of the world's indigenous peoples. Instead, a modern and inclusive understanding of "indigenous" includes peoples who: identify themselves and are recognized and accepted by their community as indigenous; demonstrate historical continuity with pre-colonial and/or pre-settler societies; have strong links to territories and surrounding natural resources; have distinct social, economic or political systems; maintain distinct languages, cultures and beliefs; may form non-dominant groups of society; and resolve to maintain and reproduce their ancestral environments and systems as distinctive peoples and communities. In some regions, there may be a preference to use other terms such as: tribes, first peoples/nations, aboriginals, ethnic groups, Adivasi and Janajati. All such terms fall within this modern understanding of "indigenous."

Source: Adapted from Initiative for Responsible Mining Assurance, 2018. IRMA Standard for Responsible Mining IRMA-STD-001, Glossary of Terms.

Maximum Credible Earthquake (MCE)

The largest earthquake magnitude that could occur along a recognized fault or within a particular seismotectonic province or source area under the current tectonic framework.

Source: FEMA ((U.S.) Federal Emergency Management Agency), 2005. Federal guidelines for *dam safety—Earthquake analyses and design of dams: FEMA-65, 75 p.*

Meaningful Engagement

Described by the United Nations (UN), The World Bank, the International Finance Corporation (IFC), the Organization for Economic Cooperation and Development (OCED), the Inter-American Bank, amongst other international and multilateral organizations and agencies, as a process whereby project proponents not only have an obligation to consult and listen to stakeholder perspectives, but also have an obligation to take their perspectives into account. Meaningful engagement involves understanding and addressing structural and practical barriers to the active participation of diverse groups of people, for example: women, ethnic minorities, people who live in remote areas, and/or different language groups. Access to relevant information that can be reasonably understood by the external party is a precondition of meaningful engagement.

Source: Adapted from the Global Tailings Review, 2019. Global Tailings Standard Draft.

Modified Centerline Construction

Modified centerline construction is similar to conventional centerline construction, but with the contact between the compacted fill and the tailings sloping slightly upstream. Since modified centerline construction still involves constructing a portion of the dam on top of the uncompacted tailings, it must be considered a variant of upstream construction, similarly subject to the cautions and restrictions associated with upstream-type dams presented in this document.

Source: Adapted from J.P. Haile & K.J. Brouwer, Knight Piesold Ltd, Modified Centreline Construction of Tailings Embankments, 3rd International Conference on Environmental Issues and Waste Management in Energy and Mineral Production, August, 1994. Perth, Australia; and Independent Expert Engineering Investigation and Review Panel, 2015. Report on Mount Polley Tailings Storage Facility Breach, Province of British Columbia.

Observational Method

A project management method in which observed performance from instrumentation data is used for implementing preplanned design features or actions in response. The Observational Method is useless without a way to respond to the observations. The Observational Method is similar to Adaptive Management (see definition above), and sometimes the terms are used interchangeably.

Source: Independent Expert Engineering Investigation and Review Panel, 2015. Report on Mount Polley Tailings Storage Facility Breach.

Operating Company

Any person, corporation, partnership, owner, affiliate, subsidiary, joint venture, or other entity, including any State agency, that operates or controls a tailings facility.

Source: Adapted from the Global Tailings Review, 2019. Global Tailings Standard Draft.

Potentially Acid Generating (PAG)

An indication, based on laboratory testing, that the mine sample could produce acid drainage under field conditions. Under ideal conditions, samples are considered PAG if the neutralizing-potential (NP) to acid production potential (AP) ratio (NP:AP) is <1 and non-PAG if NP:AP is >2. Samples with NP:AP between 1 and 2 have an uncertain potential to generate acid (GARD Guide, Section 5.4.16; INAP, 2009). Site-specific and mineralogic evaluations and longer-term testing are needed to set appropriate ratios. Safety factors may be needed to address limitations in sampling, material handling, or prediction (INAP, 2009). Conservative non-PAG ratios ranging from 1.3 to 5 have been recommended by some practitioners (Maest et al., 2005). See the GARD Guide (INAP, 2009) for definitions and testing methods.

Source: Adapted from The International Network for Acid Prevention(INAP), 2009. Global Acid Rock Drainage Guide (GARD Guide), and Maest, A.S. and J.R. Kuipers (primary), C.L. Travers, and D.A. Atkins (contributing). 2005. Predicting Water Quality at Hardrock Mines: Methods and Models, Uncertainties, and State-of-the-Art. Earthworks, Washington, DC.

Piping (also called Internal Erosion)

A phenomenon where seeping water progressively erodes or washes away soil particles, leaving large voids (pipes) in the soil. These voids simply continue to erode and work their way backward under the structure, or they may collapse. Either way, if piping is not stopped promptly, failure is imminent. The critical place for piping is usually right at the corner of the toe of a dam.

Source: R.D. Holtz, Kovacs, W.D., and Sheahan, T.C., 2011. An Introduction to Geotechnical Engineering, 2nd ed., Pearson, 863 p.

Probable Maximum Flood

The flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that is reasonably possible in the drainage basin under study.

Source: FEMA ((U.S.) Federal Emergency Management Agency), 2013. Selecting and accommodating inflow design floods for dams: FEMA-94, 38 p.

Stakeholders

Persons or groups who are directly or indirectly affected by a project, such as rights holders, as well as those who may have interests in a project and/or the ability to influence its outcome, either positively or negatively.

Source: Initiative for Responsible Mining Assurance, 2018. IRMA Standard for Responsible Mining IRMA-STD-001, Glossary of Terms Adapted from IFC, 2007. Stakeholder Engagement: A Good Practice Handbook for Companies Doing Business in Emerging Markets.

Tailings

Tailings are the materials left after the extraction of metals or minerals of interest from ore.

Source: Dougherty and Schissler, 2020. SME Mining Reference Handbook, 2nd Edition, p. 513

Tailings Dam

A structure or embankment that is built to retain tailings and/or to manage water associated with the storage of tailings, and includes the content of the structure. The structural zone of a filtered tailings facility is a type of tailings dam.

Sources: Adapted from Guidelines on Tailings Dams, Planning, Design, Construction, Operation and Closure, Australian National Committee on Large Dams, ISBN: 978-0-9808192-4-3, May 2012; and Klohn Crippen Berger, 2017. Study of tailings management technologies: Report to Mining Association of Canada and Mine Environment Neutral Drainage (MEND) Program, MEND Report 2.50.1, 164 p.

Tailings Facility

The Global Tailings Standard definition is: "A facility that is designed and managed to contain the tailings produced by the mine. Tailings can be placed in mined-out underground mines, in open pit mines and on external surface facilities. Tailings can be produced and managed as slurry-based (a mixture of solids and water) at various moisture contents ranging in appearance from a watery mixture to a less watery mixture to paste and to a drier material that has been filtered. Tailings slurry in a surface facility is contained by dams constructed of borrow materials including soil and rock as well as tailings. Drier materials, like filtered tailings, can be contained by rock piles." This document agrees with the GTS definition, but emphasizes that "rock piles" or whatever structures prevent the motion of filtered tailings are also a type of tailings dam.

Source: Adapted from Global Tailings Review, 2019. Global Tailings Standard Draft.

Voluntary Resettlement

Voluntary land transactions (i.e., market transactions in which the seller is not obliged to sell and the buyer cannot resort to expropriation or other compulsory procedures sanctioned by the legal system of the host country if negotiations fail) that lead to the relocation of willing sellers.

Source: Initiative for Responsible Mining Assurance, 2018. IRMA Standard for Responsible Mining IRMA-STD-001, Glossary of Terms.

Upstream Construction

A method of dam construction in which the centerline is translated upstream, over the tailings beach, with subsequent raises. This method requires that material placed in the upstream direction is well-drained and compacted or that it settles naturally to an adequate density.

Source: Klohn Crippen Berger, 2017. Study of tailings management technologies: Report to Mining Association of Canada and Mine Environment Neutral Drainage (MEND) Program, MEND Report 2.50.1, 164 p.

Worker

All non-management personnel including outsourced workers and contractors.

Source: Adapted from Initiative for Responsible Mining Assurance, 2018. IRMA Standard for Responsible Mining IRMA-STD-001, Glossary of Terms.

Endnotes

[1] Darlington, S. et al., 2019. *Tidal Wave of Mud,* New York Times.

[2] Robertson, P. et al., 2019. *Report of the Expert Panel on the Technical Causes of the Failure of Feijão Dam I*. 12 p.

[3] Robson, Paul. 2017. "The River is Dead: The Impact of the Catastrophic Failure of the Fundão Tailings Dam." London Mining Network. 5 p.

[4] Bowker, L.N. and Chambers, D.M., 2015. *The Risk, Public Liability, and Economics of Tailings Storage Facility Failures*.

[5] Global Tailings Review. https://globaltailingsreview.org/

[6] Mudd, G., 2019. *Mining & Its Growing Environmental Impacts*.

[7] Hund,K, La Porta, D., Fabregas, T.P., Laing, T., Drexhage, J., 2020. *Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition.*

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[10] Independent Expert Engineering Investigation and Review Panel, 2015. *Report on Mount Polley Tailings Storage Facility Breach*.

[11] 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. 11 p.

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[20] Brazil, 2019. *Resolution Nº 13*, August 8, 2019.

[21] Chile, 2007 Decreto Supremo *Nº 248*: *Reglamento Para La Aprobación De Proyectos De Diseño, Construcción, Operación Y Cierre De Los Depósitos De Relaves*.

[22] Perú, 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.

[23] Ecuador, 2019. Valencia, 2019. Ecuador alista reglas más estrictas para relaves con el fin de evitar desastres ambientales, Infobae.

[24] Upstream dams have been effectively banned in the Province of Ontario, Canada. Source: Macdonald, A.l. et al., 2019 "Sense of Dread: How a Mining Disaster in Brazil Raised Alarms in Minnesota" *Wall Street Journal.*

[25] The Riotinto Mine in Spain, operated by Atalaya Mining, can provide an example of this type of construction.

[26] Federal Emergency Management Agency (FEMA), 2013. *Selecting and Accommodating Inflow Design Floods for Dams.*

[27] USACE (U.S. Army Corps of Engineers), 1991. Inflow design floods for dams and reservoirs: Engineer Regulation ER 1110-8-2(FR), 10 p.

[28] FEMA, 2005. *Federal Guidelines for Dam Safety Earthquake Analyses and Design of Dams*.

[29] USACE, 2016. *Earthquake design and evaluation for civil works projects*: Engineer Regulation ER 1110-2-1806, 28 p.

[30] FEMA, 2013. *Selecting and Accommodating Inflow Design Floods for Dams*.

[31] FEMA's Federal Guidelines for Dam Safety Earthquake Analyses and Design of Dams from 2015 states "the MDE may be determined based on faults active in Holocene time." Since the Holocene Epoch has lasted nominally for the past 10,000 years, the FEMA regulation is equivalent to requiring design for a 10,000-year earthquake.

[32] U.S. Army Corps of Engineers' Safety of Dams-Policy and Protocol from 2014 states, "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."

[33] British Columbia Ministry of Energy and Mines, 2016. Guidance Document Health,Safety and Reclamation Code for Mines in British Columbia v1.0. 12 p.

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[41] This annual probability of failure derives from the statement from the USACE Hydrologic Engineering Center's 2003 *Application of paleohydrology to Corps flood frequency analysis*: RD 47 on page 34 that says "the PMF [Probable Maximum Flood] does not incorporate a specific exceedance probability, but is generally thought to be well beyond the 10,000 year recurrence interval." In other words, the PMF has an annual probability of exceedance significantly less than 0.01%. It also derives from the statement by FEMA's 2005 Federal guidelines for dam safety—Earthquake analyses and design of dams: FEMA-65 on page 75 that says "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." In other words, the MCE (Maximum Credible Earthquake) could be as rare as a 100,000-year earthquake (annual probability of exceedance of 0.001%).

[42] USACE (U.S. Army Corps of Engineers), 2000. Design and construction of levees: Manual No. 1110-2-1913, 164 p.

[43] The International Network for Acid Prevention (INAP), 2009. Global Acid Rock Drainage Guide (GARD Guide). Chapters 4 and 5.

[44] Robertson, P.K., de Melo, L., Williams, D.J., Wilson, G.W., 2019. *Report of the Expert Panel on the Technical Causes of the Failure of Feijão Dam I.*

[45] National Research Council, 2006. Geological and Geotechnical Engineering in the New Millennium: *Opportunities for Research and Technological Innovation*. Washington, DC: The National Academies Press.

[46] 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 (see Jefferies, M and K. Been. 2016. "Soil Liquefaction: A Critical State Approach"(2nd ed.). CRC Press. 690 p.). For the avoidance of liquefaction, all appropriate preventive actions must be carried out from the outset of the project.

[47] Initiative for Responsible Mining Assurance, 2018. IRMA Standard for Responsible Mining IRMA-STD-001, Glossary of Terms.

[48] Independent Expert Engineering Investigation and Review Panel, 2015. Report on Mount Polley Tailings Storage Facility Breach. 130 p.

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[50] This Guideline applies to both affected and potentially affected communities.

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[62] Initiative for Responsible Mining Assurance, 2018. IRMA Standard for Responsible Mining IRMA-STD-001, 67 p.

[63] Bowker. L.N. and Chambers, D.M., 2015. *The Risk Public Liability & Economics of Tailings Facility Failures*.

[64] Initiative for Responsible Mining Assurance, 2018. IRMA Standard for Responsible Mining IRMA-STD-001, 72 p.

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[66] For further details on financial risk criteria, see the last section of MiningWatch Canada's submission to the Global Tailings Review, December 2019

[67] Mining Association of Canada, 2019. *A Guide to the Management of Tailings Facilities* VERSION 3.1' 20 p.

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[69] World Tailings Failure Database. https://worldminetailingsfailures.org/