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Comments on the Global Tailings Standard: Draft for Public Consultation

GENERAL COMMENTS

I applaud this initiative by the United Nations Environment Program (UNEP), International Council on Metals and Mining (ICMM), and Principles for Responsible Investment (PRI) to create a Global Tailings Standard. This standard has the potential to be very influential among regulatory agencies, professional associations, and mining companies for many decades to come. I am grateful for the opportunity to provide my comments on the current draft.

Lack of Discussion of Specific Design Technologies

I was very disappointed to read Footnote 9 to Principle 2: "The Standard does not ban any specific design technology, such as upstream tailings facilities. Banning particular technologies was outside the Expert Panel's scope of work." The implication of the quote is that the obvious design technology that could have been banned is the construction of tailings dams using the upstream method. Upstream tailings dams have already been banned in Brazil, Chile, Peru and now Ecuador (announced on November 26, 2019). There is a growing Latin American consensus on the unacceptable danger of upstream tailings dams. I am strongly recommending that this Global Tailings Standard show more leadership in this area and discourage the continued construction of new upstream tailings dams, as well as the elevation and expansion of existing upstream tailings dams.

Because upstream dams are constructed on top of the uncompacted tailings and because of the difficulties in lowering the water table in upstream tailings facilities, upstream tailings dams are more vulnerable to all of the common causes of tailings dam failure, including floods, earthquakes, static liquefaction, internal erosion, and foundation failure. I am aware of the various studies that argue that upstream tailings dams are workable under ideal conditions (low seismicity, low precipitation, flat terrain) and if no mistakes are made. For example, Martin et al. (2002) have argued that "Of the 10 rules, a 'score' of 9/10 will not necessarily have a better outcome than 2/10, as any omission creates immediate candidacy for an upstream tailings dam to join the list of facilities that have failed due to ignoring some or all of the rules." However, the above caution is not a basis for the design of engineering structures, which should have a high degree of redundancy and a large margin of error. For example, no one would fly in an airplane if he or she were assured only that everything would be fine as long as conditions are ideal and no mistakes are made.

The other obvious recommendation for specific design technologies that could have been made is the recommendation to reduce the water content of tailings prior to storage, especially

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the recommendation to filter the tailings. Filtered tailings have a water content of 15-20% by mass and have physical properties much more similar to a moist soil than a slurry or a paste. The reduction of the water content in the tailings facility would reduce the probability of all of the common causes of tailings dam failure. In addition, reducing the water content would reduce the consequences of failure to the degree that released tailings would fail only by local slumping, as opposed to flows that can travel for hundreds of kilometers (Klohn Crippen Berger, 2017).

Although the Standard states that the consideration of specific design technologies is outside of its scope of work, some of the Requirements, in fact, depend upon a particular design technology. The best example is Requirement 4.1, which concludes, "This review should proceed until the facility has been safely closed and achieved a confirmed 'landform' status or similar permanent non-credible flow failure state." I have no idea how a tailings facility could be converted into anything resembling a natural landform unless the tailings had been converted into something resembling moist soil prior to storage. There are no natural landforms that resemble a dam holding back a paste or a thickened or unthickened slurry. It is quite confusing for the Standard to promote safe closure and the conversion of a tailings facility into a landform without saying anything about the type of tailings management that is required to make this possible. On this basis, I am recommending that the Standard promote the storage of filtered tailings, both as a safety precaution during the active life of the tailings facility and as a prelude to eventual safe closure. I will say more about the concept of "safe closure" under Specific Comments.

High vs. Very High vs. Extreme Consequences

The Standard includes a five-way Dam Failure Consequence Classification Matrix with the categories Low, Significant, High, Very High and Extreme. Among other factors, High-, Very High- and Extreme-consequence dams have potential loss of life of 1-10 persons, 10-100 persons, and more than 100 persons, respectively. I am very pleased with Principle 4: "Design, construct, operate and manage the tailings facility on the presumption that the consequence of failure classification is 'Extreme,' unless this presumption can be rebutted." However, I am concerned about who would be carrying out and approving the rebuttal. According to Requirement 4.2, "The decision to rebut the requirement to design for 'Extreme' Consequence Classification, shall be taken by the Accountable Executive or the Board of Directors (the 'Board'), with input from an independent senior technical reviewer or the ITRB. The Accountable Executive or Board shall give written reasons for their decision." This decision, that a tailings facility is not in the Extreme-consequence category, should be made by an appropriate governmental regulatory agency, not by the mining company.

I am concerned about the three higher-consequence dams (High, Very High, Extreme) that are classified according to how many people are likely to perish in the event of dam failure. Many governmental agencies have a three-way classification in which the potential loss of even

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one human life puts a dam into the highest consequence category. For example, the (U.S.) Federal Emergency Management Agency (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 (economic loss, environmental damage, or disruption of lifeline facilities may also be probable, but are not necessary for this classification)" (FEMA, 2013). FEMA (2013) also clarifies that "probable loss of life" means "one or more expected."

My recommendation is that, when there is a "potential" or "probable" loss of life, High-, Very High- and Extreme-consequence dams should be a single category. In other words, the loss of 100 lives should not be regarded as a matter of greater concern than the loss of one human life. This distinction, where the actions that are recommended by the Standard depend upon whether less than ten lives (High-consequence dam) or more than ten lives (Very High- or Extreme-consequence dams) could be lost, comes up in four places. According to Footnote 3 to Principle 1, "Updates [of the knowledge base] should be carried out whenever there is a material change to the tailings facility, the social or environmental context or conditions, or at a minimum every 3 years for 'Very High' and 'Extreme' Consequence Classifications, and every 5 years for others." According to Requirement 9.1, "For a proposed new facility where a potential credible failure could have 'Very High' or 'Extreme' consequences, the Board or senior management (as appropriate based on the Operator's organizational structure) shall be responsible for approving the proposal, after deciding what additional steps shall be taken to minimize the consequences." According to Requirement 9.2, "For an existing facility, where a potential credible failure could have 'Very High' or 'Extreme' consequences, the Board or senior management (as appropriate based on the Operator's organizational structure) shall mandate additional steps to minimize the consequences and publish reasons for its decision. This process is to be repeated at the time of every Dam Safety Review (DSR)." According to Requirement 11.5, "For tailings facilities with 'Very High' or 'Extreme' Consequence Classification, the ITRB, reporting to the Accountable Executive and/or the Board, shall provide ongoing senior independent review of the planning, siting, design, construction, operation, maintenance, monitoring, performance and risk management at appropriate intervals across all stages of the tailings facility lifecycle." My recommendation is that, for the four above cases, the same action should be recommended for High-, Very High- and Extreme-consequence dams when the classification is based upon the number of lives that could be lost.

In the final Table 2 (External loading criteria required by the Standard), High- and Very High-consequence dams as grouped as a single category in which the dams should be designed to withstand a 5000-year flood and a 5000-year earthquake. Extreme-consequence dams are a separate category that should be designed to withstand a 10,000-year flood or the Probable Maximum Flood (PMF), and a 10,000-year earthquake or the Maximum Credible Earthquake (MCE). My recommendation is that all dams for which the failure could result in the loss of human life (High-, Very High-, and Extreme-consequence dams) should be designed to withstand the PMF and the MCE. This recommendation would bring the Standard into alignment

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with the recommendations of the U.S. governmental agencies that regulate dams (Federal Emergency Management Agency, U.S. Army Corps of Engineers, and U.S. Bureau of Reclamation).

This recommendation of design for the Probable Maximum Flood and the Maximum Credible Earthquake is required to bring the Standard into alignment with the very first sentence of the Preamble: “This Standard strives towards the ultimate goal of zero harm to people and the environment and <u>zero tolerance for human fatality</u>” (emphasis added). “Zero tolerance” means that loss of human life is impossible. Zero tolerance requires design for the PMF and the MCE, which are the largest flood and the largest earthquake, respectively, that are even theoretically possible at a given location. By contrast, design for a 5000-year flood or 5000-year earthquake means accepting an annual probability of loss of human life due to dam failure of 0.02%. The PMF and the MCE have no defined return periods. However, for comparison with less extreme events, according to the U.S. Army Corps of Engineers, “the PMF does not incorporate a specific exceedance probability, but is generally thought to be well beyond the 10,000 year recurrence interval” (USACE-HCE, 2003). In the context of discussing criteria for determining the MCE at a particular location, FEMA (2005) states, “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.”

Use of the Word “Independent”

The word “independent” occurs 21 times throughout the Standard. The first Requirement to use the word is Requirement 2.2: “Engage an Independent Tailings Review Board (ITRB) or an independent senior technical reviewer with no conflicts of interest to assess and review the alternatives analysis for site and technology selection.” I would like to see more discussion as to what is meant by “independent” and perhaps this should be in the Glossary. An independent reviewer has no other business with the company under consideration, not in the past, not in the present, and not in the future. On this basis, I do appreciate this statement from Requirement 11.4, “The DSR [Dam Safety Review] contractor cannot conduct a subsequent DSR on the same facility.”

Use of the Word “Feasible”

The use of the word “feasible” also requires more attention. Requirement 2.3 states “Use the knowledge base to assess the social, economic and environmental impacts of the tailings facility and its potential failure. Develop impact mitigation and management plans, and meaningfully engage potentially affected communities in the process.” Footnote 11 to that requirement states “This Requirement applies the mitigation hierarchy to consequences or impacts and where avoidance is not feasible, to first minimize the impacts and then include

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measures to allow future compensation for remaining impacts to the extent they occur." Requirement 4.3 includes "Where the required upgrade is not feasible, the Board, or senior management (as appropriate based on the Operator's organizational structure), with input from the ITRB, shall approve the implementation of measures to reduce the risks of a potential failure to the greatest extent possible."

My concern is that "feasible" will be interpreted to mean only "economically feasible." Even economic feasibility could be interpreted only in terms of its potential for reduction of profit, as opposed to serious economic loss. My recommendation is that "feasible" should be clarified to mean "technologically possible." In other words, mining companies should be expected to fulfill the Requirements of this Standard unless they are technologically impossible.

SPECIFIC COMMENTS

REQUIREMENT 1.3: Where there is a potential for flow failure, conduct and regularly update an inundation study for the tailings facility using a methodology that considers credible hypothetical failure modes, site conditions, tailings facility conditions, hydraulic routing models of the slurry, and the amount of tailings and downstream materials entrained in the outflow. The results of the study should include estimates of the inundation area, flow arrival times, depth and velocities, duration of flooding, and depth of material deposition.

It should be clarified that inundation studies should consider worst-case scenarios, not most-likely scenarios. This concept is codified into legislation in many countries. For example, according to the Guide for the Preparation of Dam Emergency Plans in Spain, "*Si bien se admite la posibilidad de reducir o aumentar el número de escenarios, pero manteniendo siempre la obligatoriedad de tratar el correspondiente a la situación más desfavorable*" [Although the possibility of reducing or increasing the number of scenarios is admitted, it is always necessary to analyze the scenario corresponding to the most unfavorable situation] (Ministerio de Medio Ambiente, 2001). Therefore, I am very critical of inundation studies that are based on statistical models of past tailings dam failures, such as the statistical model of Larrauri and Lall (2018). According to this model, typically, the failure of a tailings dam releases about 35% of the stored tailings. However, this is the most-likely scenario, not the worst-case scenario. The worst-case scenario, which should be the objective of an inundation study, would be the release of all of the stored tailings, such as happened at the Brumadinho disaster.

REQUIREMENT 2.1: Undertake a formal, multi-criteria alternatives analysis of all feasible sites and technologies for tailings management with the goal of minimizing risk to people and the environment. Use the knowledge base to inform this analysis and to develop facility designs, inundation studies, a monitoring program, Emergency Preparedness and Response Plans (EPRP), and closure and post-closure plans.

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The most effective way to minimize risk to people would be to discourage the construction of new tailings dams and the raising or expansion of existing tailings dams where there is a population living close by and downstream from the dam. As an example, in response to the Brumadinho disaster, the Legislative Assembly of Minas Gerais (the principal mining state of Brazil in which the disaster occurred) passed a new Mining Legislation (Law 23291 of 02/25/2019), according to which "*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. 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. Para a delimitação da extensão da zona de autossalvamento, será considerada a maior entre as duas seguintes distâncias a partir da barragem: I – 10 km (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. A critério do órgão ou da entidade competente do Sisema [Sistema Estadual de Meio Ambiente e Recursos Hídricos], a distância a que se refere o inciso I poderá ser majorada para até 25 km (vinte e cinco quilômetros), observados a densidade e a localização das áreas habitadas e os dados sobre os patrimônios natural e cultural da região*" [The granting of an environmental license for the construction, installation, expansion or elevation of a dam for which studies of rupture scenarios identify communities within the self-rescue zone is prohibited. For the purposes of this law, a self-rescue zone shall mean that portion of the valley downstream of the dam where there is not sufficient time for intervention by the competent authority in an emergency situation. For the delimitation of the extension of the self-rescue zone, the greatest of the following two distances from the dam shall be considered: I - 10 km (ten kilometers) along the course of the valley; II - the portion of the valley likely to be hit by the flood wave within thirty minutes. At the discretion of the competent organ or entity of SISEMA [State System of Environment and Water Resources], the distance referred to in item I may be increased to up to 25 km (twenty-five kilometers), observing the density and the location of inhabited areas and data on the region's natural and cultural heritage] (Assembleia Legislativa de Minas Gerais, 2019). My recommendation is that this Standard should promote a similar policy.

REQUIREMENT 2.6: Taking into account actions to mitigate risks, the Operator will consider obtaining appropriate insurance to the extent commercially reasonable or providing other forms of financial assurance if appropriate to address risks relating to the construction, operation, maintenance, and/or closure of a tailings facility.

The entire phrase "the Operator will consider obtaining appropriate insurance to the extent commercially reasonable" seems very weak and likely to be overridden by economic considerations. I recommend rephrasing this as "the Operator will obtain appropriate insurance to the extent commercially possible."

REQUIREMENT 3.3: Where the risks of a potential tailings facility failure could result in loss of life or sudden physical and/or economic displacement of people, the Operator shall consider in good faith additional measures to minimize those risks or implement resettlement following international standards. The Operator shall communicate these decisions to those affected.

The phrase "the Operator shall consider in good faith additional measures to minimize those risks" seems very weak and likely to be overridden by economic considerations. I recommend rephrasing this as "the Operator shall undertake additional measures to minimize those risks." However, note that my recommendation, as stated above, is to not construct tailings dams in locations that would put a local population at risk.

REQUIREMENT 4.1: Presume the consequence of failure classification of all new tailings facilities as being 'Extreme' (see Annex 2, Table 1: Consequence Classification Matrix) and design, construct, operate and manage the facility accordingly. This presumption can be rebutted if the following three conditions are met:
a) The knowledge base demonstrates that a lower classification can be applied for the near future, including no potential for impactful flow failures; and
b) A design of the upgrade of the facility to meet the requirements of an 'Extreme' consequence of failure classification in the future, if required, is prepared and the upgrade is demonstrated to be feasible; and
c) The consequence of failure classification is reviewed every 3 years, or sooner if there is a material change in any of the categories in the Consequence Classification Matrix, and the tailings facility is upgraded to the new classification within 3 years. This review should proceed until the facility has been safely closed and achieved a confirmed 'landform' status or similar permanent non-credible flow failure state.

The concepts of "confirmed landform status" and "permanent non-credible flow failure state" require further clarification. In the first place, the fact that a tailings facility has been converted into something resembling a natural landform does not mean that it cannot fail by landsliding. I know that landsliding is a natural occurrence, but natural landsliding does not release hundreds of millions of tons of toxic materials. My recommendation is to remove the phrase "confirmed landform status" and focus on what is meant by a "permanent non-credible flow failure state."

Even if a tailings facility does not have the status of Extreme-consequence at the time of closure, it should be assumed that it will acquire that status sometime in the indefinite future. On

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this basis, I would define "permanent non-credible flow failure state" in the following way: A permanent non-credible flow failure state is a state in which a closed tailings facility can withstand the Probable Maximum Flood and the Maximum Credible Earthquake indefinitely, and can remain in that state indefinitely, with no further inspection, monitoring or maintenance. I would like to see this or a similar definition placed into Annex 1: Glossary and Notes.

REQUIREMENT 6.2: Apply factors of safety that consider the variability and uncertainty of geologic and construction materials and of the data on their properties, the parameters selection approach, the mobilized shear strength with time and loading conditions, the sensitivity of the failure modes and the strain compatibility issues, and the quality of the implementation of risk management systems.

Factor of safety is an antiquated concept that should not be promoted in this Standard. The only reason that any mining company or consultant is concerned about factors of safety is that they are still included in antiquated regulations. The reason that the concept is antiquated is that it is completely non-intuitive as to what should be an appropriate value for factor of safety. What everyone wants is for the probability of dam failure to be very small. On this basis, annual probability of failure is a much more modern and intuitive concept. Factors of safety cannot be converted into annual probabilities of failure without making further (usually unwarranted) statistical assumptions. In addition, many articles and books have shown that a dam with a higher factor of safety can have a higher annual probability of failure than a dam with a lower factor of safety. I would express the sense of Requirement 6.2 in the following way: All components of a Tailings Management System should have appropriate annual probabilities of failure so as to ensure that the entire system has an acceptable annual probability of failure.

REQUIREMENT 17.1: Publicly disclose relevant data and information about the tailings facility and its consequence classification in order to fairly inform interested stakeholders.

This Requirement should explicitly include dam safety audits and similar documents that are required by and filed with governmental agencies.

From Annex 2: Table 2 (below) sets the criteria for external loading, applied by floods and earthquakes. These criteria mean the tailings facility will be designed to withstand floods and earthquakes very much greater than any known previous flood or earthquake in the region where the tailings facility is or will be located, making the likelihood of failure due to floods and earthquakes negligible.

For context, this is Table 2:

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Table 2: External loading criteria required by the Standard

Dam Failure Consequence Classification	Design Flood Annual Exceedance Probability	Design Ground Motion Annual Exceedance Probability
Low	1/2500	1/2500
Significant		
High	1/5000	1/5000
Very High		
Extreme	1/10000 or PMF*	1/10000 or MCE**

* PMF Probable Maximum Flood
** MCE Maximum Credible Earthquake

The interpretation of Table 2 in the Standard is simply not correct. A design flood annual exceedance probability of 1/2500 means that the dam has been designed to withstand the flood for which the probability of exceedance in any given year is 0.04%. In the same way, a design ground motion annual exceedance probability of 1/2500 means that the dam has been designed to withstand the earthquake for which the probability of exceedance in any given year is 0.04%. This does not mean that "the tailings facility will be designed to withstand floods and earthquakes very much greater than any known previous flood or earthquake in the region where the tailings facility is or will be located." A tailings facility could be designed to withstand a 2500-year earthquake at a location where a 2500-year earthquake had occurred the previous year. This does not mean that "the likelihood of failure due to floods and earthquakes [is] negligible." Whether an annual probability of dam failure of 0.04% does or does not count as "negligible" (the word "acceptable" would be a better choice) must be made by society (or by governmental agencies).

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