Increasing risks: The unintended effect of our TSF Standards and Guidelines

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Recent and continual failures of tailings storage facilities (TSFs), often resulting in catastrophic consequences, has led to calls for action from the industry, stakeholders and the public at large. Several standards and guidelines are being prepared at the time of writing, most notably a Global Industry Standard on Tailings Management (GISTM), with the overall objective to reduce the rate of TSF failures globally. While better guidelines are certainly necessary, there are requirements that must be carefully followed in developing a document that has the ambition to become a standard. If such requirements are not fulfilled, the document can become ineffective or potentially have the opposite result to that which was intended. This paper discusses whether or not the GISTM meets the requirements of the standards and analyses the potentially negative impacts of its implementation on the industry and wider society. Based on this analysis, this paper provides several recommendations for improvements that should be considered by the GISTM panel and other working groups preparing standards and guidelines.

Keywords: Tailings, TSF, TSF Standards, TSF Guidelines.

The state of the tailings industry

Since the Brazilian Samarco tailings storage facility (TSF) failure in November 2015, there have been 21 reported TSF failures (as of June 2020), resulting in the deaths of 381 people and affecting upwards of 68,000 people either by impacts to property, infrastructure or the environment (WISE, 2020). The 21 failures equate to a failure rate of 5 failures per year, which is unchanged from the preceding decade despite the increased scrutiny from within the tailings community and external stakeholders.

This unchanged rate of failures is not indicative of the tailings industry (owners, regulators and designers) not taking action to lower the risk presented by TSFs. Many mining companies have produced, revised and reviewed implementation strategies for internal tailings management guidelines. Engineers involved in the design of tailings facilities have become more aware of the hazards, triggers and assessments to determine increased likelihoods of liquefaction and interest in alternate tailings processing technologies has become common place. National regulators are also producing or have revised national tailings design standards and design guidelines. Despite these actions, there lacked a standardised global approach to safe tailings management.

The Global Industry Standard on Tailings Management

It is understandable that stakeholders outside of the industry have decided to act, seeing that the activities implemented by the tailings industry so far have not been sufficient to limit the number of TSF failures. The tipping point for outside action came after the January 2019 Fundão TSF failure, which was responsible for the deaths of 270 people. In response to this tragedy, a Global Tailings Review (GTR) was initiated by three bodies being the International Council of Mining & Metals (ICMM), The United Nations Environment Programme (UNEP) and the Principles for Responsible Investment (PRI) (GTR, 2020a) group. The aim of the review was announced to be as follows:

> *...establish an international standard for the safe management of tailings storage facilities that can be applied to all tailings dams wherever they are located and whoever operates them."*
> *(GTR, 2020)*

The Global Industry Standard on Tailings Management (GISTM) was informed by carrying out a review and evaluation of the current global best practices in the mining industry and beyond.

The original motive for this paper was the original GISTM draft, which was issued in November 2019 for global consultation (GTR, 2019). The authors believed that the draft, as presented, may have had the unintended effect of increasing the risk that tailings management presents, perhaps not at the facility-level, but on a global-level. This was the result of GISTM not meeting the requirements of a Standard document, as well as the apparent underlying intent and reasonings for Standard's requirements. Indeed, the majority of the topics that were to be covered in this paper was originally communicated to the GTR in a letter containing suggestions from the authors sent as a result of the public consultation period held at the end of 2019.

The final revision of the GISTM was launched in August 2020. The authors of this paper support and applaud the overall intent and application of the final GISTM and commend the working group for undertaking a complex task and preparing a comprehensive and high-value document.

The amendments made to the final document addressed several of the perceived issues that were to be raised in this paper. Further, some of the issues that were identified by the authors of this paper in regards to implementation of the GISTM were confirmed by the GISTM working group to be issues that will be addressed by regulators, industry bodies, owners and other stakeholders going forward (GTR, 2020b).

However, the authors believe that many of the original concerns regarding the draft GISTM are still valid as the potential for the increase in risk on a global level as a result of the GITSM is still present due to the underlying intent of some of the GISTM requirements, or as a result of how the GISTM may be implemented by industry bodies and owners.

Further, as of September 2020, there were several bulletins, guidelines and other tailings related documentation being prepared, many of which aim to support implementation of the GISTM. These include the International Commission on Large Dams, International Council on Mining and Metals, United States Society on Dams, Canadian Mining Association, Brazilian Committee on Dams, South African Institution of Civil Engineers and others. The authors believe that many of the concerns that were originally identified with the draft GISTM and resulting suggestions can be used by the working groups of these guidelines and standards to produce robust and defensible documents that can be used to effectively guide our industry.

We as an industry have a vested interest in ensuring that the GISTM and any supporting documents from the industry bodies stated above are as sound and practicable as possible in regards to technical guidance, implementation and the ability to verify compliance.

While standards on their own are voluntary with no requirements for any parties to comply with them, it is often the case that federal and state governments and their regulators will refer to a standard in legislation, making adherence to that standard a regulatory requirement (SA, 2020b). Another instance when standards become mandatory is when a contract between two parties refer to standards to specify minimum requirements in fulfilling the contract (Phoon & Erian, 2014). As the GISTM will be a requirement for the 27 member parties of ICMM, including several of the largest mining companies in the world, it will likely be known and relied upon by the majority of tailings managers, engineers and stakeholders globally and used in contracts pertaining to work for tailings managements for the ICMM members.

Where guidelines or codes of practices refer to a standard (such as the GISTM) the requirements within the standard become part of the standard of care expected by a profession, even when the original standard is not part of regulatory requirements. As detailed in Singh et al. (2019), should knowledge of a standard and its requirements be accepted to be the standard of care of a professional, they will be legally evaluated against this expected knowledge. Thus, a professional would be legally obligated to, as much as practicable, adhere to the standard in carrying out their profession.

While acknowledging that any standard will be revised over time to address any deficiencies and to be updated with the current-practice of the industry, it is still imperative that the GISTM and any supporting industry documents be produced and implemented to truly reduce the risk of tailings storage both at a facility level and globally. Any regulation, standard or guidelines that is to be accepted by the industry should not be overly onerous or complicated.

This paper focuses on two areas: first, this paper reviews the conventions and requirements of a standard document that should be considered by working groups of standards and guidelines. While this may appear as semantics, the authors believe that it is important to consider what a standard should be, so that the final document be as clear and concise as possible for the end-users and regulators.

Secondly, and perhaps more importantly, this paper analyses the net benefit of any standard and guideline and how, if not written or implemented correctly, a standard or guideline could have a negative net benefit on the tailings industry.

As stated above, it is emphasised that the findings of this paper do not solely apply to the GISTM. The authors of this paper hope that the recommendations presented in this paper be considered by aforementioned working groups and other parties involved in regulatory standards, guidelines or bulletins at the international, national and internal owner levels, to increase the value of the documents as a useful tailings management resource.

What is the standard for standards?

The formal definition of a "standard" from the International Organization for Standardization (ISO, 2018) is:

> *"a document, established by consensus and approved by a recognised body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context."*

In addition, *SG-003: Standards and other publications* (Standards Australia, 2019) states that:

> *They establish a common language that defines quality and safety criteria. Standards are practical and set achievable goals.*

Standards Australia also states that standards, on their own, are voluntary to adhere to (SA, 2020b).

As outlined in *SG-003: Standards and other publications* (Standards Australia (SA), 2019), standards can be broadly, classified as either:

- Performance Based Standards – Standards which have their requirements expressed in terms of performance, that is, the outcomes to be achieved. Such standards allow the technical methods used to meet the requirements of the standard to be developed. In addition to the performance criteria, the standard includes testing or other approved forms of verification required to assess performance to ensure that the method or solution meets the requirements of the standard.
- Prescriptive Standards – Standards which express requirements in precise, often quantitative, terms. Due to their prescriptive nature, there is little chance that the technical method used to carry out the activity or produce the final product can deviate from what is prescribed in the standard.

An example to differentiate between the two types of standards can be illustrated by an example of installing wall hooks, as provided in SG-003. A Performance Based Standard would state that that a wall hook for a mirror "shall support a weight of 40 kg, when tested in accordance with the test method in Appendix A of the standard".

Conversely a Prescriptive Standard would provide the exact manufacturing requirements and installation requirements of the hook, such as "the hook shall consist of a 2 cm expansion case in accordance with Figure 1, together with a ¼ in. Whitworth mild steel zinc plated nut and matching 3 cm threaded hook in accordance with Figure 2".

It is likely that many users of Performance Based Standards may not have the time or resources to develop a unique solution, system or method to meet the minimum requirements and criteria required by the standard. Therefore, it is not unusual for Performance Based Standards (or parts of the standard), to be accompanied by a Prescriptive Standard. This can be thought of as a "fall-back" method or "deemed-to-satisfy" solution.

While the two types of standards differ in how they provide direction, they have a key common feature which all standards must contain: a way to verify that the standard has been met. In Performance Based Standards, this is done by the inclusion of performance criteria, testing or other approved forms of verification. In Prescriptive Standards, the verification is completed by the very nature of following the standard.

This feature of verification allows the user, or independent reviewer, to determine if the user, product, or method complies with the minimum requirements of a standard and, just as importantly, determine what deficiencies must be addressed to meet the minimum requirements of a standard.

For any document to meet the definition of a standard, it must meet the key requirements and parameters presented below.

- The language in the standard should be precise, consistent and unambiguous (SA, 2019) to assist users with understanding the requirements of the standard and how best to meet the minimum requirements. Identical wording must be used to express the same meaning or definition and use of the same terminology, with the use of synonyms being avoided (AS, 2020a).
- All requirements in a standard "shall be objectively verifiable" and should be able to verified in a reasonably short period of time (SA, 2020a) to allow users and independent verifiers to definitively determine if the requirements of a standard have been met. As a corollary to this, standard should limit the amount of additional or background information, but if required, it must be explicitly stated that statements are informative only (SA, 2019).

In addition, it is recommended by standard-setting bodies that standard be Performance-based where possible (ISO, 2020), (SA, 2020) & IEC, 2020). Aligning with the definition of Performance-based standards allows maximum freedom for technical development and reduces undesirable and unintentional market impacts.

By not limiting the method, design or process, the impact of regional or country-specific context is minimised as well. However, all standard-setting bodies do recognise that in reality, there may be cases where inclusion of design (or process) requirements for parts or whole standards is appropriate, but the effect of mandating that specificity must be determined for appropriateness and impact on the community.

How to improve our standards?

As stated in the section above, standards need to clearly define the requirements of an activity or product by either clearly and quantifiably stating how something should be done, or what the expected outcome is. This is important for users and independent verifiers to truly assess and confirm compliance for a significant proportion of the requirements stated in the GISTM.

If the requirements of a standard are not clear or quantifiable, it could have potential and devastating commercial and legal impacts for multiple stakeholders. For operation staff, it provides them no quantifiable way to address deficiencies to achieve compliance with certainty. For owners, it could result in non-conformances, resulting in increased premiums for insurance, higher interest rates for investment or potentially being unable to obtain either. For consultants, it could mean being unable to quantifiably prove that their design is robust and thus not fulfilling their commercial and legal obligation

to their clients. In the authors' experience reviewing and utilising various industry standards, guides and bulletins, and as seen several times in the GISTM, our industry documents are lacking in this regard.

Most notably the authors have come across the terms *risk*, *hazard*, and *consequence* used interchangeably although they have different definitions and meanings. As these terms are fundamental to safety management frameworks and are used in many existing tailings standards and guidelines across the world, they must be used clearly and precisely.

Similarly, working groups for standards and guidelines should avoid using unquantifiable or subjective terms and measures such as *appropriate*, *robust*, *conservative* and *best practices*.

These terms are used in the GISTM and although some of these terms are included in the glossary, the definitions are lacking clarity and compliance against these requirements cannot be objectively measured or verified. Where an owner or designer may believe that they have carried out their responsibility in accordance with *best practices*, an independent reviewer or regulator could just as easily say otherwise due to the lack of quantifiable measures.

While this may appear to be semantics, the lack of consistency and precision can have severe consequences in the application of the GISTM.

Of concern, is the use of the term *risk*, as it used throughout the GISTM both as a key consideration for the management of TSFs and in several requirements. An example is the following requirement from the GISTM:

> *Select, explicitly identify and document all design criteria that are appropriate to minimise risk for all credible failure modes for all phases of the tailings facility lifecycle.*
> *(Requirement 4.4)*

Without a clear definition of what the term *risk* in in the context of TSFs or this Standard, it is impossible to attempt to reduce it. This requirement also presents another ambiguous term in regards to *appropriate* levels of risk reduction, which has not been discussed or defined in the GISTM. The process of risk assessment and management in dams and tailings engineering is still in its infancy relative to other high-risk industries and is exposed to uncertainties in the tailings industry owning to the nature of TSFs (Singh & Herza, 2019). To discuss and include risk reduction in the requirements of the GISTM would require a significant amount of discussion and clarification in supporting documentation, with a fall-back position based on a Consequence-Based management framework (Herza et al, 2019).

It is recognised that the GISTM supporting documents being produced by various industry bodies may address this, however, it is then important that the working groups of these documents understand and produce their documents to align with the original intent of the GISTM working group, which may not be readily evident.

The need for a Global Tailings Standard

Net benefit

It is evident that the unchanged frequency of TSF failures and the increasing failure consequences necessitate better oversight of design, management and operational activities for TSFs. However, the industry must be certain that any new standards, regulations and practices does not result in a net loss for all stakeholders within the industry and society at large. In addition, a global standard must not infringe on the rights of national regulators or unintentionally negatively impact some regions of the world.

In producing and implementing a standard it is inherent that trade-offs between various factors, such as cost vs safety, must be carried out. This trade-off should provide a net benefit to all stakeholders and the community at large, otherwise the GISTM may lead to unintended negative consequences ranging from direct and indirect commercial, legal and social impacts to complete refusal of the GISTM. It is recognised that the aim of the GISTM authors was focussed on reducing the risk presented to downstream populations and environments and therefore it is understandable that a net benefit assessment may have only considered this group.

Standards Australia encourage a formal net-benefit assessment of a new standard be carried out prior to a standard being produced (SA, 2016). Standards Australia defines Net Benefit as:

> *Having an overall positive impact on relevant communities*

In the assessment, all benefits and costs of the GISTM to all relevant parties must be identified and quantified. Benefits and costs should be assessed against various criteria including, public health and safety, social and community impacts, environmental impact, competition and economic impact.

When identified and quantified, the benefits must be shown to exceed the costs likely to be imposed on suppliers, users of the GISTM and other parties in the community with the benefits outweighing the costs.

In reviewing the underlying intent and the consequences of implementing the requirements of GISTM across the globe, the authors of this paper believe a net benefit assessment may have shown a loss in the global context and even just for the downstream population stakeholders for the reasons detailed in the following sections.

The net benefit of the Global Tailings Standard

The net benefit of the GISTM has not been presented and the implementation processes and work to implement the GISTM has been somewhat divorced from the production of the GISTM itself (*Preamble*, page 4 of the GISTM). Without a clear understanding of how the GISTM would be implemented, the implementation effects, costs and risks cannot be accurately determined and the net benefit of the GISTM cannot be demonstrated.

The authors of this paper have hypothesised the impacts of the GISTM based on the requirements presented and the likely worldwide use of GISTM within and outside of the ICMM members as discussed earlier in this paper. It has been found that implementation of the GISTM may result in an unintended net loss for the industry and certain sectors of society, including the populations and environment downstream of TSFs which the GISTM aims to protect, with an overall increased risk presented by TSFs around the world. These unintended impacts all stem from the use of a consequence-based framework (Table 1 and Table 2 of the GISTM), without detailing levels of requirements and not considering the global impact of the GISTM implementation as discussed further below.

As stated previously, the authors believe that the effects hypothesised below are also potentially applicable to other standards or guidelines which may not fully consider the effects that their requirements will have when implemented.

Impact on resource allocation

The GISTM calls for multiple positions such as Engineer of Record, Designer of Record, Senior Technical Reviewer and members for an Independent Tailings Review Board to be fulfilled for the direct management, review or design of any TSF. Most of these roles are mutually exclusive and thus could not be fulfilled by the same individual. The requirement for several of these positions is also a minimum of 15 years of relevant experience, regardless of the consequences or risk posed by the TSF.

Due to the limited number of suitably qualified and experienced tailings practitioners, there are currently insufficient resources to meet the roles nominated in the GISTM for the design, review and management of the reported 1,930 TSFs around the world (UNEP, 2020).

Without the GISTM (and thus no requirements for the several roles it requires for the management and operation of a TSF), the supply and demand for tailings engineers will likely go on as it has pre-GISTM with the majority of services being for design, review and management. As per pre-GISTM, the supply of tailings engineers over time will meet the required demanded of services they provide, due to basic supply-and-demand theory, though with short-term peaks and troughs in both demand and supply as seen in our industry in recent history.

The introduction of the GISTM would lead to a significant and sudden undersupply of the required tailings engineers, which will not be resolved for many years due to the requirement for a minimum of 15 years of experience for some of the specified roles. To exacerbate this issue, it is very likely that all owners will seek to employ or engage the most skilled and experienced individuals for the nominated roles in an attempt to lower the risks presented by their portfolio of TSFs, regardless of the true consequences and risks presented by their TSFs.

Ultimately, the more resourced owners will have the capacity to attract the individuals in the industry who are truly suitably qualified and skilled to fulfil roles prescribed in the GISTM regardless of the true consequences or risks of the owner's TSFs. This will force the smaller owners and non-ICMM members to engage the less capable resources from the depleted resource pool for their TSFs, which will include TSFs with truly extreme consequences of failure. Therefore, the implementation of the GISTM may result in a greater number of true extreme consequence TSFs being in the hands of less capable and less experiences tailings practitioners, which will increase the likelihood of the true extreme consequence TSFs failures.

Regardless of whether the resources will be evenly spread and reallocated, the implementation of the GISTM will result in a net increase in overall likelihood of failure, and therefore risk, of TSF failures globally.

Lack of global context

Throughout the GISTM, reference is made to reducing consequences and risks presented by TSFs, which have objective meanings and can be verifiably quantified. To successfully use the consequence and/or risks of a TSF's potential failures as the fundamental measure to plan, design and operate TSFs, it is essential that the partitions and maximum tolerable limits of consequences and risks are clearly defined and explained. The GISTM uses the consequence-based principles and consequence categorisation, similar to what is recommended by ANCOLD (ANCOLD, 2012), as defined in Table 2 of GISTM.

The issue with using a singular framework for either consequence or risk across the world is that tolerability of either is highly variable and it depends on regional, cultural, societal and individual factors. Tolerability is ultimately derived from two fundamental principles (Bowles, 2011):

- Equity – the right of individuals and society to be protected, and the right that the interest of all are treated with fairness
- Efficiency – the need for society to distribute and use available resources so as to achieve the greatest benefit

In balancing these two, with respect to regional contexts such as life expectancy, quality of life and benefits derived from the source of the risk, tolerable consequences and risks for activities are produced and adopted. As such, it is impossible to define uniform tolerability levels across the world.

The tolerable risk exposure for a single life defined by ANCOLD (2003) as 1:10,000 AEP was based on the annual background risk of death in Australia. While this value may be suitable for an Australian context, enforcing it through a standard on a country with a very different context may not meet their definition of tolerable based on their view of equity and efficiency.

The logic in selecting tolerable risks also applies to a consequence-based system, which defines appropriate measures depending on the number of potential fatalities, population at risk and other consequences of the dam failure. Such a system is used in GISTM.

ANCOLD, through consideration of Australia's societal expectations has determined that a dam failure which could result in a single fatality should be classified as a High consequence category dam. For High consequence dams, ANCOLD recommends that the minimum magnitude of a flood that the facility has to withstand is the 1:10,000 AEP event. This threshold and recommended design requirements differs from country to country based on each societies or regions understanding of tolerability. Even where countries have similar tolerable risks levels, how that tolerability is legally defined and dealt with varies. For example, Netherlands has similar tolerable levels of risk to the UK but does not have the legal concept of ALARP (Ale, 2005)).

The GISTM recognises that the States (e.g. countries, states, provinces etc.) are best placed to enforce standards and regulate activities. Due to the different equity/efficiency balance in different countries and the countries' specific context, the States (with assistance and guidance from professional and industry bodies) are also best placed to determine tolerable limits for consequences and risks and thus develop their tailings related regulations and standards

Conclusions and recommendations

The continual failures of TSFs at a constant rate and their catastrophic consequences is a definitive indication that a better approach to the design, management and operational activities is needed. As a step to address this need, a Global Tailings Review was formed by interested parties to produce a Global Industry Standard on Tailings Management (GISTM).

Due to the backing of the interested parties, the commercial and legal implications of the GISTM on projects and the standard of care expected of tailings professionals, it is likely that the GISTM will become mandatory in the tailings industry. As such, it is imperative that the GISTM, as well as any supporting guides, be correct in regard to technical guidance, implementation and ability to verify compliance.

The authors of this paper outlined the requirements of a standard, which all working groups of standards and guides could consider when producing a new document so as to produce a standard that is clear, concise and quantifiable for the benefit of the standard's users and regulators. Further, this paper also identified that the GISTM could result in a net loss for society because the GISTM does not consider the very different societal expectations and tolerability to consequences and risks in different regions and countries. More importantly yet, the authors believe that the GISTM can result in a net increase in risk of TSF failures around the world because of the increased demand for tailings specialists and the reallocation of the limited resources in the tailings industry.

The following suggestions were produced to address the deficiencies identified in the draft GISTM. However, the authors believe that these suggestions can be used as lessons-learned for other working groups producing and updating other tailings management standards, guidelines and bulletins ANCOLD included.

- As recommended by ISO, Standards Australia and other standard-producing bodies, standards and guides should, as much as practicable, utilise performance-based requirements, which feature quantifiable measures of compliance. It is recognised in the GISTM that States are best placed to use the GISTM to build a regulatory framework that they can regulate. Therefore, the use of performance-based criteria has the added benefit of allowing the States to produce regulatory frameworks that both adhere to the requirements of the GISTM and any other standards and guides, while considering the local context in which it operates.
- The GISTM currently uses a consequence-based framework to scale the design loading requirements for TSFs. Any supporting guides should consider extending the consequence-based framework beyond the design loads to cover all aspects of TSF management, including TSF safety documentation requirements as suggested in Herza *et al.* (2019). Under the suggested system, all TSFs will still require the same responsible roles, processes and documentation, however, the conditions and necessities for all requirements could be scaled based on the TSF consequences
- The scaling of capability requirements for responsible personnel would help reduce the resourcing shortage that the tailings industry will face moving forward and which the GISTM will indirectly exacerbate. To truly align with a consequence-based framework, it is suggested that the fall-back of classifying TSFs as Extreme consequence facilities is limited to TSFs where the consequences of failure are unclear or for which the consequence classification has not been assessed and assigned.
- It is recommended that any standards or guides be produced with consideration to the details, logistics and realities of implementation. As recommended by Standards Australia, a net benefit analysis should be undertaken by the

working group to identify the potential losses and demonstrate the net benefit of applying the standard. With the details of implementation in mind, the requirements can be produced with consideration to how it will be achieved, verified and confirmed. Further, a defined roadmap for implementation will foster confidence from all stakeholders that the underlying intent and philosophy of the GISTM will not be diluted due to the practicalities of implementation which may not align to the GISTM that has been produced to date.

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