

Transforming Tailings Management Systems toward Alignment with the GISTM: A Case History

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The publication of the Global Industry Standard on Tailings Management (GISTM) in August 2020, and supporting documentation from the International Council on Mining & Metals (ICMM) in May 2021, have had a profound impact on the mining industry. Mine operators around the world are striving to improve their governance, engineering, and operational practices for tailings management to align with the aspirational goals of the GISTM.

Even with the benefit of the ICMM Tailings Management Good Practices Guide and Conformance Protocols, Mining Association of Canada (MAC) with Towards Sustainable Mining (TSM) Tailings and Operation, Maintenance, and Surveillance (OMS) guides, as well as existing Technical Guidelines from long-standing dam safety organizations such as the Canadian Dam Association (CDA), International Commission on Large Dams (ICOLD), and Australian National Committee on Large Dams (ANCOLD), the development of a robust Tailings Management System (TMS) to manage large portfolios of existing structures has presented some challenges for Operators. As the industry moves in the direction of risk-informed approaches to planning, designing, constructing, operating, and closing tailings facilities, Operators need to update their existing management systems and develop specific policies and practices to reflect the step-change presented by the GISTM and facilitate the completion of objectives at a facility level. However, a TMS that is too prescriptive in its implementation of the new guidance may impose artificial restrictions to the process of continual improvement, turning into a mere exercise of “checking boxes.”

Industrias Peñoles and Fresnillo PLC (from here on “The Group”) and their subsidiaries currently own forty (40) tailings storage facilities at their Mexico mining operations, most of which have been in operation for several decades. In 2019, The Group launched a corporate initiative focused on reviewing and improving their tailings governance, engineering, and operational practices, and associated with Knight Piésold in 2021 to develop their TMS. Although not a member of ICMM and MAC, The Group aspires to achieve the best practices and technologies that lead towards alignment with International Standards.

This paper presents the case history of The Group’s TMS first phase of development, which comprises establishing clear, achievable objectives; striving to align with best available/applicable practices and technologies, which will later lead to alignment with recognized International Standards; creating mechanisms to measure compliance with existing and developing Technical Guidelines; and setting a clear roadmap to address gaps that may be identified. The significance of this process cannot be understated in the context of a dynamic industry that is pushing for a culture of change towards zero harm, while also balancing the established technical aspects that govern tailings dam safety.

1 BACKGROUND

The Group and their subsidiaries have been operating and managing several facilities in the mining industry in Mexico across various climates, topographies, and geological conditions for over 135 years. Their purpose is to contribute to the wellbeing of the people and surrounding communities through the sustainable mining of silver, gold, copper, lead, and zinc. This purpose is not an empty corporate promise but a way of thinking and acting that guides everything they do and every decision they take, with the health and safety of their people always an overriding priority. Safe tailings management is a key consideration in the design, construction, operation, closure, and post-closure of their mining operations. Recent tailings accidents in the industry serve as a reminder of the complex nature of these structures.

The Group launched a corporate initiative in 2019 focused on reviewing and improving their tailings governance, engineering, and operational practices. They also started engaging international consulting firms like Knight Piésold for different sites, which supports their corporate commitment and effort. In 2021, The Group began working with Knight Piésold and other relevant consultants to develop their TMS and corporate governance. The Group continues to work towards their goal of zero harm by implementing best practices in engineering and governance of their Tailings Storage Facilities (TSFs). The Group has made significant progress in maturing governance and adopting best practices, specifically as they pertain to an overall TMS.

The Group's governance framework establishes the roles, responsibilities, and accountability of the groups involved in tailings management. This framework has been implemented since 2019 at all their operations, with the following key components:

- **Site Management** – Mine managers are the risk owners responsible for operating TSFs in accordance with internal guidelines. The Regional Tailings Manager (RTFE) and a qualified Engineer of Record (EoR) provide the technical expertise to confirm the facility is managed safely and complies with the appropriate governance and best practice. This group also includes the Operational Tailings Team who implement the TMS.
- **Corporate Tailings Team**– This group of subject matter experts develops and administers the corporate governance and appropriate controls, including implementation of verifications and external reviews. The CEO of Technical Services leads the team with support from the Assistant VP of Infrastructure, corporate tailings specialists, and managers.
- **External Reviews** – The governance framework is supported by independent experts, inspectors, reviewers, and auditors to confirm compliance with the governance and engineering best practice requirements. The third-party review process includes an Independent Tailings Review Panel (ITRP), Dam Safety Inspections (DSIs), and Dam Safety Reviews (DSRs).
- **Group-level Oversight** – Oversight of the overall governance and operations is provided by the TSF Review Executive Committee. The Committee, comprising Senior Executives, relies on independent expert advice and assessment for the continuous review of the management system. Peñoles and Fresnillo PLC's CEOs are the Accountable Executive Officers (AEOs) for Operations, and Baluarte Technical Services Co-CEO is the AEO for Governance matters.

The Group's focus has recently been on moving from initial implementation to documentation and institutionalization of their governance framework. This framework is instrumental in providing guidance for all their facilities to verify safety is prioritized and risk is controlled to acceptable levels.

2 GUIDELINE TO TAILINGS MANAGEMENT SYSTEM

Developed this year, The Group's Guideline for TMS outlines their comprehensive framework to integrate the people, resources, processes, and practices related to tailings management. The Guideline helps their facilities achieve their performance objectives, manage risk, and verify safe, responsible tailings management. The Guideline is based on several industry recognized guidance documents, including:

- MAC, “A Guide to the Management of Tailings Facilities,” Version 3.2, March 2021
- MAC, “Towards Sustainable Mining Tailings Protocol – Table of Conformance,” February 2019
- ICMM, “Tailings Management Good Practice Guide,” May 2021
- ICMM, “Conformance Protocols, Global Industry Standard on Tailings Management,” May 2021
- Global Tailings Review, “Global Industry Standard on Tailings Management,” August 2020

The Guideline presents The Group’s approach to protect and improve Human Health and Safety, the Environment, and Community Relations (HSECR). Additionally, their corporate TMS commits them toward an ultimate goal of zero harm to people and the environment. Their Guideline sets forth the parameters required to promote a safe tailings management culture and will continue to be updated as needed to incorporate future changes in industry approaches and practices and conform with global expectations of safe mine waste management.

2.1 TMS Core Principles

In conformance with International Standards, The Group TMS is based on a Plan-Do-Check-Act cycle and integrated with other relevant site-level management systems. Additionally, and consistent with ICMM, The Group’s TMS core principles are:

- I. **Accountability, Responsibility, and Competency** – Accountabilities, responsibilities, and associated competencies are defined to support appropriate identification and management of facility risks.
- II. **Planning and Resourcing** – The financial and human resources needed to support continued facility management and governance are maintained throughout a facility’s lifecycle.
- III. **Risk Management** – Risk management associated with facilities includes risk identification, an appropriate control regime, and the verification of performance objectives.
- IV. **Change Management** – Risks associated with potential changes are assessed, controlled, and communicated to avoid inadvertently compromising facilities’ integrity.
- V. **Emergency Preparedness and Response** – Processes are in place to recognize and respond to impending failure of facilities and mitigate the potential impacts arising from a potentially catastrophic failure.
- VI. **Review and Assurance** – Internal and external review and assurance processes are in place so that controls for facility risks can be comprehensively assessed and continually improved.

These principles are key to the TMS Framework for preventing and avoiding catastrophic TSF failures. The Group’s TMS Guideline is currently aligned with MAC TSM guidance, and each of the above core principles are reflected within the MAC TMS Framework elements.

2.2 TMS Accountability and Responsibility

The Group put significant effort into developing a TMS Organizational Chart and defining key positions and associated accountabilities and responsibilities. The key roles and responsibilities for the governance structure of their TMS include the:

- Tailings Review Committee (TRC) – this committee is focused on enhancing governance at all facilities, ensuring appropriate practices are being used and overseeing stewardship of the facilities.
- Operational AEO – as Chief Executive Officers of The Group, they are accountable for minimizing harm towards HSECR and avoiding catastrophic failures of the facilities.
- Governance AEO – as the Co-Chief Executive Officer of Servicios Técnicos, they are accountable for establishing the governance tools needed to drive the Company’s operations using best practices.
- Corporate Tailings Team (CTT) – this group (Assistant VP of Infrastructure, Corporate TSF Specialist, and Corporate Tailings Manager) is accountable for reviewing the TMS annually to confirm the Company is satisfied with the tailings management or

ganizational structures, and systems are effective and continue to meet the organization's needs.

- Dam Owner – Mine Manager accountable for several requirements, including implementing OMS Manual and Emergency Preparedness and Response Plan (EPRP), managing emergencies, training, completing design reviews, and working with internal/external audits.
- Regional Tailings Manager – individual facility RTFEs with sufficient experience, skills, and knowledge to manage the risk and technical aspects of the facility, with support from other technical experts.
- Operational Tailings Team – team accountable for implementing and supervising tailings management throughout the lifecycle of the facilities.
- ITRP – responsible for conducting at least one annual independent review of all operational facilities and conducting at least one review for closed facilities, according to their consequence classification and risk profile.
- EoR – supports all facility elements that require their input (e.g., tailings deposition, OMS Manual, EPRP, water management, closure plan, etc.), to confirm associated site characteristics and inputs to these elements continue to meet design specifications and applicable guidelines, standards, and legal requirements.

In 2019, and in line with their current governance, The Group recruited internationally renowned experts to form an ITRP who advise them on TSF design, construction, operation, and closure. Additionally, The Group signed long-term agreements with several internationally recognized engineering consultancies to implement Dam Safety Reviews (DSRs) and Dam Safety Inspections (DSIs), recommend required improvement actions, and provide qualified EoRs for their TSFs.

2.3 Auditing and Reviews

The Group's Internal Auditing Team is in the process of reviewing their facilities to see where they stand with respect to MAC. Although the Corporate Guideline to TMS does not initially require compliance with ICMM and GISTM standards, The Group aspires to audit their facilities to determine what is needed to align with these protocols in the future. The Group is familiar with these International Standards and is committed to developing plans to align with their requirements as practicable.

As part of The Group's Guideline to TMS, ITRP and DSI performance evaluations will be conducted, at least annually, to review facility consequence classifications, perform inspections, confirm operational and maintenance status with respect to the design intent, assess facilities' risk profiles, and develop prioritized recommendations to reduce risk. Additionally, DSRs will be executed at the beginning of the EoR engagement and every 5 years thereafter. Management reviews and audits will be performed annually to assess the effectiveness of the TMS, implementation of the Guideline, results of performance evaluations, and progress toward implementation of respective recommendations.

2.4 Change and Conformance Management

Aligned with MAC, The Group's Corporate Guideline to TMS includes requirements for evaluating, documenting, and managing changes that inevitably occur during design, construction, and operation of their facilities. The Group understands the importance of recognizing and assessing the impacts and consequences of changes to their processes and the need to adequately review and approve these changes to reduce negative impacts to the quality and integrity of their facilities. Additionally, The Group's TMS includes a review of their facilities' performance and identifying areas of non-conformance and opportunities for improvement.

2.5 OMS Manuals and Emergency Preparedness and Response

Per their Guideline, all facilities are required to develop and implement an OMS Manual and EPRP, in conformance with MAC guidelines. As required by the OMS Manual, inspections must be conducted on a routine and non-routine basis, instrumentation and monitoring systems

must be in place, and tracking systems must be developed so appropriate information can be collected to identify risk and develop associated critical controls. Per the EPRP, all facilities must assess potential emergency scenarios, develop response measures, and maintain adequate capacity (e.g., personnel, equipment, and supplies) to respond to emergencies. Additionally, facilities must conduct training and exercises/tests of the EPRP regularly, in connection with the OMS Manual.

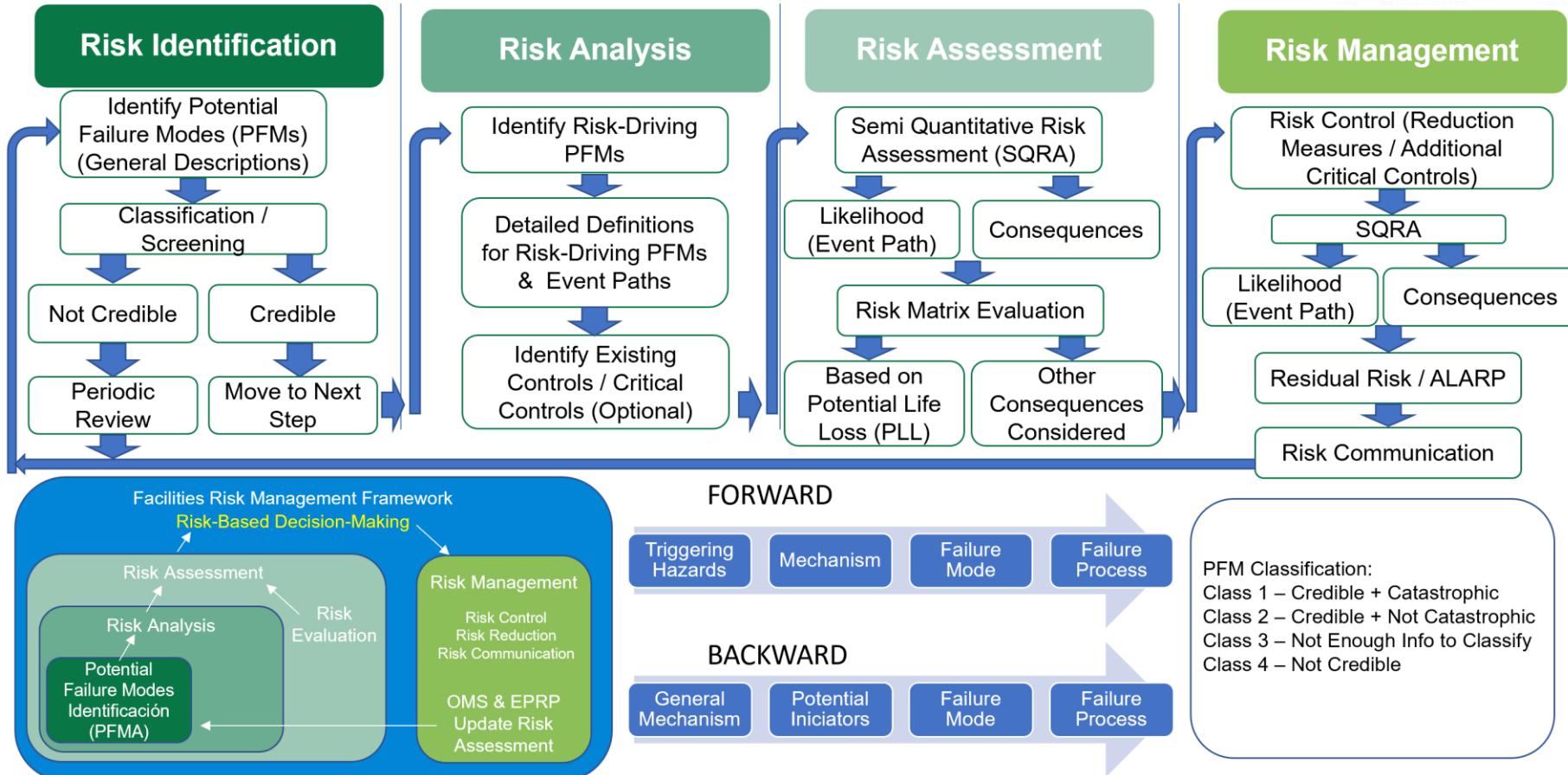
3 POTENTIAL FAILURE MODE ANALYSIS (PFMA) AND SEMI-QUANTITATIVE RISK ASSESSMENT (SQRA)

In mid-2022, Knight Piésold conducted a pilot PFMA/SQRA workshop at one of The Group's facilities, with the ultimate intent of establishing a corporate framework for conducting multiple assessments throughout The Group's portfolio of TSFs. The following bullets summarize the process conducted prior to and during the workshop.

- **Risk Identification and Analysis** – During the PFMA process, a robust evaluation was conducted to identify potential vulnerabilities of facility elements, components, or structures that could fail and result in adverse consequences. The general steps followed were:
 1. Collecting background information on the facility related to the ongoing safety of the TSF (e.g., studies performed to evaluate site-specific features or conditions).
 2. Performing a comprehensive review of background data on the TSF to gain a better understanding of available information with respect to potential failure conditions and actions that can be taken to reduce TSF failure likelihood or consequences.
 3. Developing a list of potential TSF failure modes (PFMs) associated with general failure mode mechanisms (e.g., overtopping, internal erosion, external erosion, instability/deformation, and environmental/operational).
 4. Performing a site visit to include key facility personnel interviews, an inspection focused on PFMs that consider geologic and structural conditions, and a review of project operations.
 5. Conducting a PFMA workshop with the people most familiar with facility design, analysis, performance, and operation (e.g., the RTFE, Mine Manager, Operations Superintendent, EoR team, and other key stakeholders).
 6. Documenting the process to include major findings such as PFM classifications and identified controls.
 7. Describing in further detail the sequence of events necessary for potential risk-driving PFMs to occur (i.e., failure mode event path).
- **Risk Assessment** – During the workshop, the participants performed risk estimations for each consequence category. The Group's existing risk matrix is a 5x5 matrix developed to support The Group's corporate enterprise risk management system. Based on Knight Piésold's experience, as well as the experiences of others, a typical corporate risk matrix is not likely sufficient for evaluating risks associated with TSFs, heap leach pads, or water retention dams, given that PFMs associated with these facilities are typically “low-likelihood / high-consequence” PFMs. For the purposes of The Group's pilot workshop, Knight Piésold used a 6x7 risk matrix to allow greater distribution of PFMs within the matrix.
- **Risk Management** – During the workshop, and as part of the risk management process, existing controls used at the TSF to manage risk were documented and assessed for criticality. Using the participants' collective knowledge and descriptions of the sequence of events necessary for a PFM to occur, workshop participants identified existing critical controls that either reduced the likelihood of failure, reduced the consequences of failure, or provided adequate warning time to implement emergency procedures. Additional critical controls will still need to be evaluated to identify the potential for additional risk reduction opportunities.

Several lessons were learned during this initial pilot workshop. The Group will be incorporating these findings into their PFMA/SQRA program to establish a corporate framework to consistently identify and characterize PFMs for each facility. Figure 1 below depicts the overall facilities risk management framework The Group is currently implementing.

Figure 1. Facilities Risk Management Framework.



4 FUTURE PLANS

Figure 2 provides a roadmap for how The Group is implementing their TMS through the life of their mines. Since 2019, The Group has implemented several of these elements and continues to work toward achieving these goals. In addition to establishing an ITRP and TRC, The Group has developed a TMS governance framework and organizational structure. They are also in the process of establishing EoRs for their operational facilities, developing OMS manuals and EPRPs for their facilities, and implementing best practices in the design and construction of new or expanded TSFs.

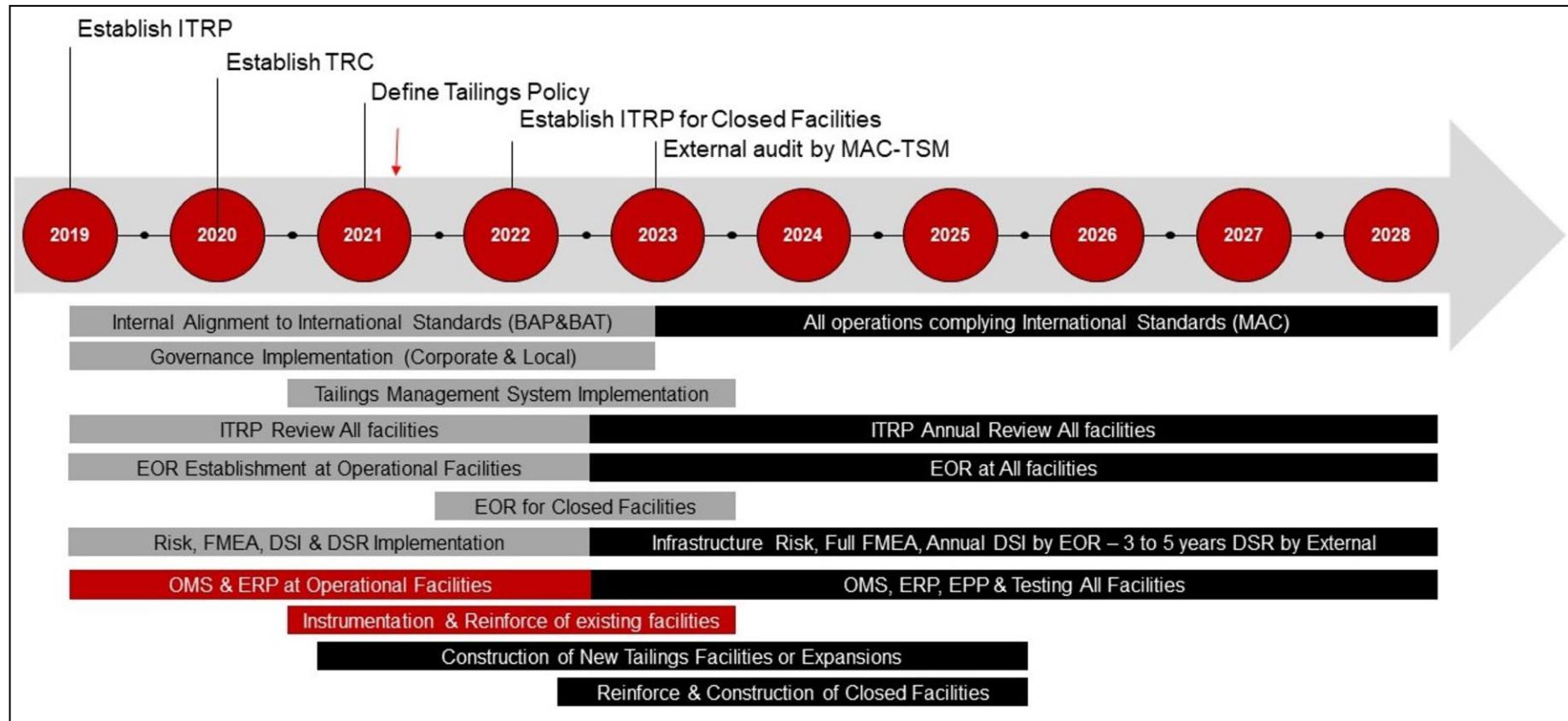
According to the roadmap, The Group will achieve the following goals:

- Establish formal EoRs for all facilities.
- Implement a formal TMS at all sites, achieving alignment with International Standards.
- Review and define The Group's position regarding the GISTM and, if applicable, establish a plan for alignment.
- Develop and implement a change management guideline.
- Construct new sites according to applicable International Standards.
- Develop succession plans for key positions associated with tailings structures.

Additionally, it remains a challenge for The Group to fill corporate regional tailings positions, as demand for qualified tailings related personnel is increasing. The Group is focusing on developing their existing internal staff and selecting talented, young engineers with exceptional personal and administrative skills to receive the additional technical training needed for regional positions. To date, The Group has filled 15 of the 18 available positions.

The Group's Internal audit team is also training their staff on tailings-specific matters so they can develop proper internal audits that consider both Mexican regulations and International best practices. Once a proper level of performance is achieved, external audit teams then will help the Company improve its TMS throughout the tailings facility lifecycle.

Figure 2. The Group Tailings Management System Roadmap.



5 CONCLUSIONS

The Group, one of the top mining companies in Mexico, continues to comply with national mining requirements and Mexican laws and has chosen to voluntarily adopt International Standards with respect to TMS. Implementing a comprehensive TMS that is aligned with International Standards is an ambitious undertaking that requires many years of dedicated effort. The Group has come a long way toward implementing a TMS based on industry best practices. Although The Group did not have any incidents related to their tailings management practices, they have significantly reduced the number of sites in need of immediate attention in line with recognized International Standards. In a short time, they have also attracted and developed a qualified team of tailings experts and implemented state-of-the-art monitoring instrumentation and technologies.

The Group's board and Senior Leadership have demonstrated unequivocal commitment, allowing them to move forward quickly and achieve remarkable success. A 2021 assessment by the ITRP, who reviewed The Group's overall tailings management corporate governance, noted the following significant achievements accomplished to date:

- Progress toward conducting dam safety inspections on all dams to identify key risks and develop a priorities plan for risk reduction.
- Appointing an ITRP to provide guidance on governance and technical matters.
- Appointing competent consultants to work on urgent matters for both safe operational continuity and risk reduction.
- Developing an internal tailings management team.
- Establishing a system for tracking recommendations related to tailings management.

The Group has proven their commitment to safe tailings management by being ready to stop operations rather than compromise the safety of the TSFs. Additionally, The Group is committed to conforming to the best technical industry standards for tailings management and in having a leadership role in Mexico for raising the country's tailings management standards. The Group is not implementing International Standards because they are required to; they want to do what is best to manage their TSFs safely and believe that aligning with these International Standards is the right thing to do. Additionally, The Group recognizes the importance and relevance of the GISTM and has followed its development and progress. The Group feels confident that compliance with the MAC guidelines is a strong baseline that will lead to alignment with the GISTM.

We would like to acknowledge Micaela Muro of SSR Mining Inc., without whom the abstract would never have been accepted.

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