GOVERNMENT OF BRAZIL
MINING SECTOR TECHNICAL SUPPORT AND COOPERATION

Report on Leading Practices for Mine Closures and the Use of Tailings

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Prepared by:
Deloitte & Touche LLP
1919 N. Lynn Street
Arlington, VA 22209

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Acronyms

AMD	Acidic Mine Drainage
ANM	Brazil's National Mining Agency
ARD	Acidic Rock Drainage
BPA	Blanket Purchase Agreement
CO2	Carbon dioxide
CONAMA	National Council for the Environment
CPRM	Geological Survey of Brazil
DOE	Department of Energy
DOS	Department of State
EMGP	Energy and Mineral Governance Program
ENR	Bureau of Energy Resources
EoR	Engineer of Record
ESG	Environment, Social, and Governance
EV	Electric Vehicles
FPIC	Free, prior, and informed consent
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Government Information System
GISTM	Global Industry Standard on Tailings Management
GTR	Global Tailings Review
HSE	Health, Safety, and Environment
IBAMA	Brazilian Institute of Environment and Renewable Resources
IBRAM	Brazilian Mining Association
ICMBio	Chico Mendes Institute of Conservation and Biodiversity
ICMM	Brazil's International Council on Mining and Metals
ICOLD	International Commission on Large Dams
IFC	International Finance Corporation
MMA	Brazil Ministry of Environment
MME	Brazil Ministry of Mines and Energy
NGO	Non-governmental Organization
OECD	The Organization for Economic Cooperation and Development
PRI	Principles for Responsible Investment
PNM	Mining and Development Plan 2050
SDG	Sustainable Development Goals
SFB	Brazilian Forestry Service
SGM	Secretariat of Geology, Mining and Mineral Transformation of the Ministry of Mines and Energy of Brazil

SME	Society for Mining, Metallurgy, and Exploration
TDF	Tailings Disposal Facility
TFC	Tailings Facility Closure
TSF	Tailings Storage Facility
UNEA	United Nations Environment Assembly
UNEP	United Nations Environment Programme
USGS	U.S. Geological Survey
WBG	World Bank Group
WHO	World Health Organization

EXECUTIVE SUMMARY

Deloitte is implementing the *Government of Brazil Mining Sector Technical Support and Cooperation* Task Order (the Project) under Deloitte's Blanket Purchase Agreement (BPA) with the U.S. Department of State (DOS) in support of the Bureau of Energy Resources' (ENR), Energy and Minerals Governance Program (EMGP). The Deloitte team is providing technical assistance to support the Government of Brazil's Ministry of Mines and Energy (MME) and the Geological Survey of Brazil (CPRM) as they seek to improve their ability to:

- Develop safe, sustainable, and effective mine closure procedures and use of tailings, including methods of tailings sampling and characterization, based on international leading practices, to protect and improve the legacy of ongoing and future projects, thereby realizing sustainable benefits from the extractives industry;
- Manage a growing mineral sector and compete effectively in the global market, given a growing market and accelerated demand for critical minerals that are essential to the development of innovative technologies to advance the global clean energy transition (electric vehicles [EVs], batteries, and battery storage systems, etc.); and
- Streamline the structure of Brazil's nickel-cobalt data inventory, so Brazil can improve its understanding and increase development of critical minerals.

Task 1: Report on Mine Closures and the Use of Tailings (this Report), outlines key findings and leading practice recommendations to support MME, CPRM, and the National Mining Agency (ANM) in the development of safe, sustainable, and effective procedures for mine closures and the use of tailings, including methods of tailings sampling and characterization. As part of Task 1, the Deloitte team conducted a review of Brazil's existing policies and regulations, comparing them with international leading practices for the sustainable management of mine closures and the use of tailings; analyzed leading practices for tailings management in other leading mining jurisdictions; and developed case studies for countries (*e.g.,* Peru, Chile, Portugal, Colombia) that have implemented initiatives to enable the beneficial use and reuse of tailings.

Key Findings

- Tailings dams store water and fine processing-related waste from the mineral extraction process. If tailings dams fail, they can release a downstream wave of waste and contaminated water that destroys communities and ecosystems. The Government of Brazil has taken steps to eliminate construction of "upstream" tailings dams[1] through its implementation of Resolution 13 (2019),[2] Resolution 68 (2021),[3] and other administrative actions (*e.g.,* ANM Ordinance[4] and the Minas Gerais 2017 policy).[5]

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[1] See Section 3 for an explanation of the construction methodology used in upstream tailing dams, and other tailing retention structures.

[2] Resolution 13 banned the construction of mining dams using the upstream construction method and provided a deadline for all existing upstream construction dams (September 15, 2021) to be removed from service and decommissioned.

[3] Resolution 68 requires all mines in Brazil to submit updated mine closure plans before June 1, 2022. The resolution includes specific requirements for the information required, and particularly focuses on mining dams and other facilities that may need to be decommissioned at mine closure. The resolution also addresses temporary closure and the need for regular updates to the closure plan.

[4] This ordinance outlines specific criteria for dam construction, evaluating the risks of mining dams, requirements for emergency action plans, schedules and contents of dam inspections, and related issues.

[5] This policy provides additional details to allow the industry to comply and the regulators to evaluate that compliance.

Upstream construction, while widely used in mining, has been associated with many tailings dam failures, and is now prohibited in several countries, including Brazil. The Government of Brazil has worked closely with the owners of existing upstream dams to develop plans to eliminate the dams and reduce residual risks. By 2035, the government plans to eliminate the existing tailings dams, which are designed to contain mining waste. Additionally, through Resolution 68, the Government of Brazil has strengthened requirements for mine closure plans, to enhance planning and design for tailings facility closure (TFC), post-closure monitoring, and remediation.

- The Government of Brazil has been working with industry and academia to develop specific projects in Brazil that incorporate leading practices related to tailings management, such as those outlined in the Global Industry Standard for Tailings Management (GISTM)[6]. These leading practices include guidelines to reduce the volume of tailings, and to beneficially reuse tailings. CPRM noted that there are a few tailings reuse and reprocessing projects under development in Brazil, primarily involving tailings from iron ore production. CPRM is working closely with industry, academic researchers, and other government entities, such as MME and ANM, to bring these projects to fruition. One of these projects, the Pico Block plant became operational in November of 2020, as Vale opened the Pico Blocks Factory at its Mina de Pico mining facility in Minas Gerais. The goal of the factory is to turn 30,000 tonnes of tailings annually into 3.8 million pre-molded construction products. Vale's sandy tailings at Mina de Pico have high silica content and very low iron content, making them particularly attractive for this type of use.[7]
- The Government of Brazil is taking steps to incorporate leading practices into its mine development and management regulatory framework. Following the severe impacts caused by accidents at two tailings dams (Mariana and Brumadinho) the government is requiring mining companies to accelerate their adoption of international Health, Safety, and Environment (HSE) and Environment, Social, and Governance (ESG) standards. For example, Sigma Lithium represents one of the largest and highest-grade hard rock lithium spodumene deposits in the Americas and has been at the forefront of promoting environmental and social sustainability in the EV battery materials supply chain. The Grota do Cirilo project developed by Sigma, includes a state-of-the-art green-tech processing plant that uses 100 percent renewable energy, 100 percent recycled water, and 100 percent dry-stack tailings. Sigma collaborated with the local Itinga and Araçuaí communities to design transformative new social initiatives, which allocates funding to build 2,000 rainwater collection systems and to empower 10,000 women through microcredit.[8] In addition, the Government of Brazil has participated in several partnerships and discussions to further advance mine closure procedures, use of tailings, and overall ESG standards.

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[6] Provides recommendations on the transparency of regulation of tailings storage facilities

[7] International Mining, "Vale opens Pico Block plant to produce civil construction products from iron ore tailings," November 22, 2020, https://im-mining.com/2020/11/22/vale-opens-pico-block-plant-produce-civil-construction-products-iron-ore-tailings/.

[8] Batteries News, "Sigma Lithium Successfully Initiates Commissioning of Greentech Plant on Schedule and Within Budget," December 23, 2022, https://batteriesnews.com/sigma-lithium-successfully-initiates-commissioning-greentech-plant-schedule-budget/.

Specific examples include: United Nations Environment Programme (UNEP) discussions on a new governance framework for the extractive sector known as the "*Sustainable Development License to Operate*" for mining, which includes consensus-based principles, policy options, and leading practices that are compatible with the Sustainable Development Goals (SDGs) and other international policy commitments on climate change.[9]

- Reducing tailings and mine closure-related risks requires a focused government effort[10]. Currently, Brazil has mining and environmental laws and regulations at the federal, state, and municipal level.

In addition, MME, through ANM, also implements specific requirements for licensing and environmental performance of mining operations. Although federal agencies, such as ANM, draft regulations and create overarching mining regulations for the country, Brazilian states have the authority to establish secondary regulations on certain aspects of mining activities including environmental standards, environmental impact assessments (EIA), safety, and labor requirements[11]. This localization of the mining regulation function results in overlapping roles and responsibilities between multiple different entities at the federal, state, and local level. This, in turn, creates administrative and enforcement complexity, and raises the costs of mining company compliance. Indeed, Brazil's lack of any formal procedures to coordinate between different mining sector entities can sometimes lead to lengthy licensing procedures, inconsistent data or compliance requirements, and increased investor risk perceptions.

Key Recommendations

To increase the safety, sustainability, and effectiveness of procedures for mine closures and the use of tailings, the Deloitte team recommends that the Government of Brazil considers the following:

- **Incorporate and enhance the inclusion of leading practices into the Government of Brazil's mine development and management regulatory framework.** The framework should include:
    - Risk assessments of Tailings Storage Facilities (TSFs) and waste rock storage that reduce the risk of Acid Rock Drainage (ARD), failure of TSF, and other geotechnical instabilities of mine operations;
    - GISTM recommendations on transparency for regulating tailings facilities and using these recommendations for industry as a template for future regulatory efforts. The Government of Brazil would also benefit from using GISTM as a benchmark for evaluating proposed, operational, or legacy TSFs and their risks to the public and the environment;

[9] The "*Mineral Resource Governance in the 21st Century Report*", published by UNEP in 2020, outlines a plan for creating a "*Sustainable Development License to Operate*" for mining. As part of this plan, the report encourages the public and private sector and local communities to work collaboratively to enhance the contributions of the extractive sector to sustainable development.

[10] OECD, "Regulatory Governance in the Mining Sector in Brazil," 2022, https://www.oecd-ilibrary.org/sites/89a72df8-en/index.html?itemId=/content/component/89a72df8-en.

[11] Sometimes state mining regulations may be more stringent than the federal regulations as it is the case of the regulations of mining activities in the state of Minas Gerais.

- Leading practices to expand opportunities for tailings reuse and tailings reduction developed by industry and academia to reduce the volume of materials that require long-term storage and management;
- Effective mine water management (both surface and groundwater) to make mine operations safe, ensure adequate water supply to local ecosystems and communities, and mitigate water quality impacts;
- Early and periodic review of biodiversity at mining operations;
- Continued attention to cultural heritage issues, with assessments, rescue, and/or avoidance of sites with significant archeological or cultural importance; and
- Additional investments in local communities so that they receive direct benefits from co-located mining projects, with particular attention to local livelihoods. The government should enhance outreach to, and the capabilities of, potentially impacted people and communities to understand and participate in the evaluation and decision-making processes related to Tailing Disposal Facilities (TDFs) for future, existing and closed tailings facilities.

- **Build the capacity of MME, CPRM, and ANM (e.g., appoint an "Engineer of Record" – EoR) to review and evaluate TSFs based on international standard requirements.** Applicable standards would include GISTM, and the life-cycle approach included in the Society for Mining, Metallurgy, and Exploration (SME) *Tailings Management Handbook* (SME, 2022) for design, construction, operation, monitoring, and closure of tailings facilities.
- **Implement formal coordination mechanisms between the mining functions of federal, state, and local government, and consider the benefits of intergovernmental coordination to help mitigate risks, lower costs, and improve investor confidence.** Formal processes to support intergovernmental coordination, working relationships, and regulatory decision-making would help to create a more open, transparent, and predictable environment for mining investment. Such processes would also harmonize work activities and instill greater investor confidence than the current pattern of many decisions being reached via (necessarily) informal arrangements. Through the Pro-Strategic Minerals policy (*Decree No. 10,657, of March 24, 2021, the Policy for Supporting the Environmental Licensing of Investment Projects for the Production of Strategic Minerals)*, the government is already focusing on easing the licensing process by facilitating, for example, a dialogue between the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA) – the environmental agency responsible for conducting the environmental licensing process, and authorities – such as the managing bodies of Conservation Units, the National Indian Foundation (FUNAI), the National Institute for Colonization and Agrarian Reform (INCRA), and the National Institute of Historic and Artistic Heritage (IPHAN). The government should move to formalize these arrangements, and develop a framework agreement between MME, ANM, CPRM, state, and municipal entities to integrate existing activities and standardize TDF, TFC, TSF and ESG requirements. The Government of Brazil should also consider how to streamline the manner in which the government's various mining-related entities: (i) convene regular coordination between different entities; (ii) establish/review/update formal policies to reduce risks associated with tailings; (iii) discuss leading practices and their application in Brazil, and the impact of climate change and extreme weather events on the prevention of accidental water pollution from tailings; and (iv) design action plans on how to best enhance safety at different types of sites, including legacy sites.

- **Evaluate the presence of valuable constituents in coal wastes.** The relatively acidic conditions of, and relatively high concentrations of some metals in coal wastes can be challenging from an environmental standpoint. However, over the past several decades, the U.S. Department of Energy (DOE) has funded significant research into the economic potential of coal tailings and revealed them to be a potential source of rare earth metals and other critical materials. The Government of Brazil should consider creating a program to assess ongoing and in-situ coal wastes for rare earths/critical mineral, thereby evaluating whether such in-waste minerals represent a potentially economic resource. While the chemical and geologic depositional environment of Brazilian coals may be different from the United States, there is an opportunity for further research into this potential possibility.

1. INTRODUCTION

1.1. Purpose of this Report

The purpose of this Report is to build Brazil's capacity for the development and execution of safe, sustainable, and effective procedures for mine closures and use of tailings, including methods of tailings sampling and characterization. In preparing this Report, the Deloitte team consulted with counterparts in the Government of Brazil, and reviewed Brazil's existing policies and regulations, comparing them with international leading practices for the sustainable management of mine closures and the use of tailings; analyzed leading practices for tailings management in other leading mining jurisdictions; and developed case studies for countries (*e.g.,* Peru, Chile, Portugal, Colombia) that have implemented initiatives to enable the beneficial use and reuse of tailings.

1.2. Organization of this Report

This Report is organized into nine main sections.

- **Section 1: Introduction** – Introduces the purpose, organization, and background of this Report.
- **Section 2: Brazil Legal, Regulatory, and Governance Overview** – Reviews the legal and governance structure for developing and managing mining operations in Brazil and summarizes issues related to tailings and mine closure, including an examination of efforts undertaken by the Government of Brazil, and the ongoing activities of the United Nations related to the governance of the minerals sector.
- **Section 3: Tailings Disposal Overview** – Reviews standard industry practices for tailings disposal and mine closure.
- **Section 3: Beneficial Use of Tailings** – Provides case studies and research related to the beneficial use and reuse of tailings, both in Brazil, and internationally.
- **Section 4: Technical Challenges for Tailing Disposal and Management** – Provides an in-depth discussion of technical issues related to tailings disposal and management, including international standards and guidelines.
- **Section 6: Environmental Protection Requirements** – Focuses on the requirements for environmental protection related to tailings and mine closure.
- **Section 7: Social Requirements** – Discusses social challenges and provides an overview of international leading practices and developing guidelines related to such issues.
- **Section 8: Conclusion and Immediate Next Steps** – Concludes this Report and summarizes recommendations and immediate next steps.
- **Appendix A: References** – Detailed bibliography of research and other references related to the topics of the nine sections (provided as a separate document).

1.3. Background and Context

Brazil has some of the largest and most diverse mineral deposits in the world, and its mining sector activities and revenues focus on core commodities such as iron ore, gold, copper, and bauxite.

According to UNEP (2019), the mining sector can significantly contribute to the achievement of all 17 United Nations Sustainable Development Goals, and particularly those relating to, "poverty eradication, decent work and economic growth, clean water and sanitation, life on land, sustainable and affordable energy, climate action, industry and infrastructure, as well as peace and justice."[12]

Mine tailings are the major solid waste stream created after the valuable components are removed from the mined materials by processing. The deposition/placement of these tailings into storage facilities has created significant risks and impacts to the local populations and to the environment. Among those impacts have been the high-profile collapses of eight unsuccessful Tailings Storage Facilities (TFS) since 2014[13] in Brazil, Canada, China, Israel, Mexico, and the United States. In several of these cases, the flow of saturated tailings downstream has resulted in loss of life, property, destruction of farmland and changes in stream flow and water chemistry. Three of the most notable have been in Brazil, which has put significant pressure on the government and its mining industry to take action to reduce the likelihood of more failures. These failures have resulted in nearly 300 deaths in Brazil, billions of dollars in damage to the environment, and long-lasting effects on lives and livelihoods.

In 2017, the UNEP and GRID Arendal (UNEP partner)[14] completed a rapid response assessment titled "*Mine Tailings Storage: Safety is No Accident*," to encourage technical and policy actions to reduce the threats from tailings.[15] The conclusions of the report, however, were not adopted into law and were not applied to previously constructed (legacy) facilities. Thus, without a mandate, "business as usual" did not mitigate legacy risks. Following the failure of the tailings facility at Vale's Corrego do Feijão mine in Brumadinho, Brazil, in January 2019, the International Council on Mining and Metals (ICMM),[16] the UNEP, and the Principles for Responsible Investment (PRI)[17] convened a Global Tailings Review (GTR) to examine the state of tailings management globally. These groups further committed to develop an industry standard for safer tailings management. Additional reports aimed at reducing the threats posed by mine tailings have been prepared in the last two decades by Australia, Canada, the U.S. Society on Dams, and the International Commission on Large Dams (ICOLD) among others.

Following the unsuccessful TSFs in Brazil, the government has introduced new regulations, laws, and efforts, including Resolution 13 and Resolution 68, to promote proper management of tailings at existing mines, proper closure of abandoned and discontinued mining operations, and appropriate planning for new operations. In this Report, the Deloitte team outlines key findings and leading practice recommendations to support MME, CPRM, and ANM in the development of safe, sustainable, and effective procedures for mine closures and the use of tailings, including methods of tailings sampling and characterization.

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[12] UNEP, 2019.

[13] WISE, 2017.

[14] A non-profit environmental communications center

[15] UNEP, 2017.

[16] The International Council on Mining and Metals (ICMM) is a global leadership organization for sustainable development that focuses on issues that deliver on enabling ambitious collective action to drive performance improvements at scale on key environmental, social and governance (ESG) issues.

[17] Principles for Responsible Investment (PRI) are six principles developed by investors that offer a menu of possible actions for incorporating ESG issues into investment practice.

2. BRAZIL LEGAL, REGULATORY, AND GOVERNANCE OVERVIEW FOR DEVELOPING AND MANAGING MINING OPERATIONS

2.1 Current Laws, Regulations, Rules, and Other Standards

Mining in Brazil is primarily governed by Article 176 of the Federal Constitution (1988), the mining code (Decree Law 227/1967), and the general mining regulations (Decree 9.406/2018). There are also laws that dictate how owners/operators develop mineral resources. Among those are Law 6.567 of 1978, which covers the development of minerals for use in civil construction, including calcium and magnesium carbonates used in various industries. Additionally, there is a separate framework for artisanal and small-scale mining under Law 7.805 of 1989.

The MME and ANM supervise mineral development among the requirements that are focused on environmentally sustainable mining. The Mining Code Regulation (Federal Decree 9.406/2018) covers exploration, mining, mine development, the use of tailings or waste, and mine closure. Mining activities require environmental licensing; the Brazilian system requires a prior license, an installation license, and an operating license to be issued sequentially as the project proceeds, though all can be applied for at once. There is also a separate environmental license required for waste piles and tailings dams.

In September 2020, MME published "*Mining and Development Program: Goals and Action Plan 2020/2023*" with the purpose of increasing development in the mining sector.[18] This plan includes 10 broad areas of focus:

1. Improving the economic knowledge on the mineral sector;
2. Socio-economic and environmental commitment in mining;
3. Increasing geological knowledge;
4. Expansion of mining to new areas;
5. Investment in the minerals sector;
6. Selectivity of actions for the sector;
7. Governance in mining;
8. Management and efficiency;
9. Combating illicit practices in minerals activities; and
10. Mining in society.

These areas include 110 specific goals, many of which are aimed at improving the government's role, encouraging the adoption of leading practices and new technologies, and enhancing sustainable practices in the industry. The aim of these efforts is to increase size of the mining sector in Brazil and to increase the understanding of the public and other key stakeholders. The government is in the process of finalizing Mining and Development Plan (PNM) 2050, which outlines long-term objectives for the mineral sector in Brazil

In March 2021, Brazil created an inter-Ministerial committee to analyze projects for strategic minerals. That committee published two resolutions – Resolution 13 and Resolution 68 — to define its work and to formally list those mineral commodities deemed strategic for Brazil.

[18] MME, 2020.

2.1.1 Resolution 13

Following the severe impacts caused by the accident at Brumadinho in January 2019, the ANM issued Resolution 13 on August 8, 2019. This resolution banned the construction of mining dams using the upstream construction method and provided a deadline (September 15, 2021) for all existing upstream construction dams to be removed from service and decommissioned. The Resolution also set out timeframes for all other mining dams to follow standards for operation, maintenance, and inspection, based on the size of the impoundment. This resolution was the government's decisive action to prevent tailings dam failures.

2.1.2 Resolution 68

On April 30, 2021, ANM published Resolution 68, which requires all mines in Brazil to submit updated mine closure plans before June 1, 2022. The resolution includes specific requirements for the information required, and particularly focuses on mining dams and other facilities that may need to be decommissioned at mine closure. The resolution also addresses temporary closure and the need for regular updates to the closure plan. There are also requirements that information is tied to a geographic information system (GIS) per Brazilian standards, and that the professionals responsible be appropriately qualified.

2.1.3 Other Legislative Changes

ANM issued Ordinance No. 70.389 on May 17, 2017, to address mining dams. This ordinance outlined in detail the requirements for permitting, construction, operation, and closure of mining dams. The ordinance was updated by ANM Resolution No. 32 of 2020. The standard includes specific criteria for dam construction, evaluating the risks of mining dams, requirements for emergency action plans, schedules and contents of dam inspections, and related issues.

The State of Minas Gerais also issued policy in 2017 for temporary closures and closure plans for mines within the state.[19] This policy is consistent with the ANM ordinance and provides additional details to allow the industry to comply and the regulators to evaluate that compliance.

2.2 Accountability

Many of the specific goals included in the "*Mining Development Plan 2020/2023*" described above are focused on providing sufficient information to stakeholders to fully participate in discussions regarding the mining sector. This builds on a principle that has been a part of Brazilian environmental law that provides for environmental education. The potential overlap of federal, state, and municipal legislation has been a cause of concern for investors. The disconnect between mining regulators and their environmental regulatory counterparts and the independent authority of agencies at all government levels have been cited as a major issue in protecting the interests of the public and the environment.

2.3 Adoption of Best Practices

Additionally, the "*Mining Development Plan 2020/2023*" contains specific goals aimed at improving the practices used within the mining sector, both by industry and within the government. The changes within the legal framework for mining in Brazil over the past five years also demonstrate a commitment to improvement of the governance and performance of the sector. The plan explicitly states the goal of importing international successes within the minerals sector into Brazil.

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[19] Minas Gerais, 2017.

2.4 Review of Governance Regime[20]

As a result of the long history of mining and its importance to the Brazilian economy, the Government of Brazil has many agencies with responsibilities related to mining. The following government entities in Colombia have the collective responsibility for developing policy and regulations, and the administration of the country's mining operations.

- **MME:** The ministry is responsible for the formulation and adoption of policies, plans, programs, projects, regulations and guidelines for the mining and energy sector, according to directives from the national government.
- **ANM:** The regulatory agency has the authority to manage mining activities, grant mining concession, and implement licensing rounds in the mining sector. ANM also performs consultation processes with local authorities at municipalities, as well as local communities before defining and approving projects MME has delegated ANM as the regulator of mineral resources owned by the State. ANM implements specific requirements for licensing and environmental performance of mining operations. Although federal agencies, such as ANM draft overarching mining regulations for the country, Brazilian states have the authority to establish secondary regulations related to environmental standards, environmental impact assessments, safety, and labor regulations. Sometimes the state mining regulations may be more stringent than the federal regulations, as it is the case of the regulations of mining activities in the state of Minas Gerais
- **Secretariat of Geology, Mining and Mineral Transformation of the MME (SGM):** SGM is the entity through which MME creates, co-ordinates, and implements the Brazilian mineral policy. Thus, the Ministry of Geology, Mining and Mineral Transformation evaluates the performance of the mining sector, of conducts sectoral planning studies, and of proposes actions to achieve the sustainable development of the sector.
- **CPRM:** CPRM is the Geological Survey of Brazil in charge of the country's geological mapping.
- **IBAMA:** It was created in 1989 by Law 7735, and it is an autonomous federal entity linked to the Ministry of the Environment. Its role is to enforce compliance with federal environmental legislation.
- **Ministry of Environment (MMA):** The ministry is responsible for the formulation of the national environmental and renewable natural resources policy for all sectors, including mining.
- **The Brazilian Mining Association (IBRAM):** This entity works closely with the government and provides leadership for statistics, promotion of the industry, and consistency of approaches.
- **National Council for the Environment (CONAMA**): This is an advisory and regulatory organization formed from representatives of various stakeholders.
- **Chico Mendes Institute of Conservation and Biodiversity (ICMBio)**: This entity implements requirements under the national system of protected areas.
- **Brazilian Forestry Service (SFB):** This entity promotes the sustainable use of forestry.

[20] OECD, 2022.

2.5 Intergovernmental Coordination

MME, ANM, and CPRM have direct roles in policy making, regulating, licensing, and supporting the mining industry. Although the states and municipalities have subordinate roles which are envisioned in the Brazilian Federal Constitution, there are other interested organizations within the various levels of government, often with separate, but inter-related authorities, for implementation of environmental laws or other issues related to mining, such as land use, water use, indigenous peoples, protected areas, and protected species

As a result, there are overlapping roles and responsibilities between different entities at the federal, state, and local level, which increases the complexity of enforcing standards. Moreover, there are no formal procedures in place for coordination between different entities involved in managing the sector. Potential implementation gaps include lengthy licensing procedures and widely varied institutional capacity among governmental organizations.

3. STANDARD TAILINGS DISPOSAL OVERVIEW

Tailings are created by many mining operations during the processing of the mined rock to produce or recover the product. The composition and physical characteristics of tailings varies by the geology and mineralogy of the deposit and by the type of product mined. Some standard practices are common among all types of mining while the scales and compositions of the tailings are the most relevant differences among mining projects. While some operations place the tailings using "dry" techniques (less than 20 percent moisture), most tailings are in the form of slurries and are placed hydraulically into the disposal locations, often behind earthen dams. Historically, these "tailings dams" have been standard industry practice.

Owing to these similarities, many countries and organizations have published guidelines for planning, design, construction, operation, and closure of tailings over the past two decades. For example, the Australian National Committee on Large Dams (ANCOLD) published its report in 2019,[21] the Mining Association of Canada (MCA) in March 2021,[22] and ICOLD will publish its revised Tailings Dam Safety Bulletin in December 2022.

These documents and other similar publications address key issues related to 1) planning and governance: 2) classification of dams based on size and risk of failure; 3) site and tailings classifications; 4) design criteria; 5) risk management strategies; 6) dam breach analysis; 7) emergency preparedness and response planning; 8) construction requirements; 9) operational planning and monitoring; and 10) closure and decommissioning techniques. Most of these guidance documents rely on the use of latest available techniques and engineering standards, rather than prescriptive approaches.

These guidelines serve as templates for operators and government regulators in evaluating and operating TDF or TSF. Each guideline recognizes the site-specific nature of design and implementation within a framework to prevent failures and minimize the harm of these facilities. The three primary types of dam construction techniques are downstream, centerline, and upstream construction (Figure 1).

- **Downstream construction** – The starter embankment is built on original ground (often excavated to bedrock) and the embankment is subsequently enlarged to provide additional storage volume by adding materials to the top and the downstream slope of the dam, also anchored on original ground. Relative to the other two common tailings dam construction methods noted below (centerline and upstream), downstream tailings dams are considered the most stable. However, this construction method requires larger areas and greater volumes of construction materials.
- **Centerline dams** – The starter embankment is the same as for the downstream method, but the enlargement of the impoundment and embankment is accomplished by adding materials to both sides of the center of the dam, resulting in increased height and thickness of the dam, while the centerline remains in the same location. This type of construction combines the principles of both downstream and upstream design concepts. Centerline tailings dams are generally considered more stable than upstream tailings dams and require less construction material than downstream tailings dams.

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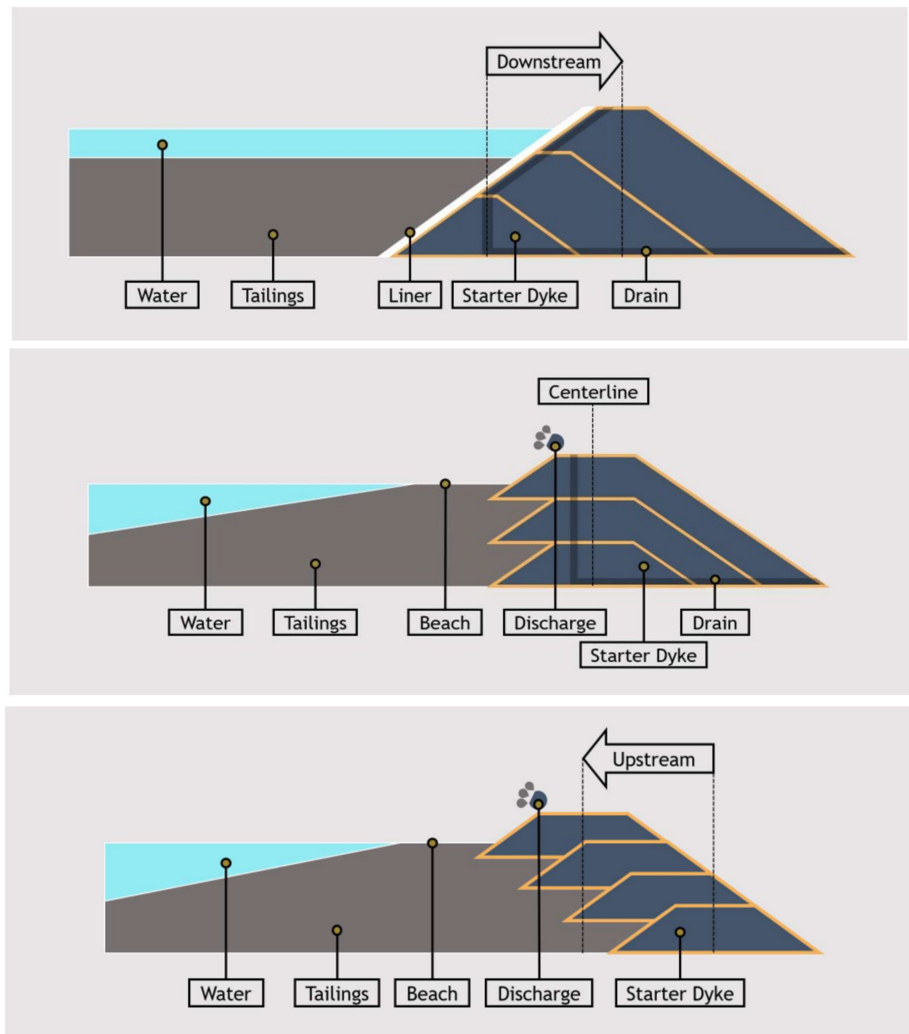
[21] Australian National Committee on Large Dams, "Guidelines on Tailings Dams," July 2019, Tailings-Guideline-Addendum-July-2019_v2.pdf (ancold.org.au).

[22] The Mining Association of Canada, "Annual Report 2021," June 2022, Annual Report 2021 - The Mining Association of Canada.

- **Upstream construction** – The starter embankment is like the other methods, but enlargement of the dam is achieved by adding materials to the top of the embankment and the upstream area, commonly through partial dewatering via cyclone classifiers and deposition of the coarse, heavy materials by gravity against the upstream face of the dam. Enlargement of the dam thus relies on foundations built on the tailings, which are expected to have dewatered and gained strength. Adequate water management is important in this design to create a beach area close to the embankment and keep water as far as possible from the embankment. The use of thickeners and other dewatering technologies is common. Relative to the other construction methods, upstream tailings dams generally require less construction materials. Upstream construction, while widely used in mining, has been associated with many tailings dam failures, and is now prohibited in several countries, including Brazil.

Figure 1: Typical Tailings Dam Construction Methods



There are also some specific considerations that relate to the type of tailings materials disposed (discussed below). These include chemistry, particle size, particle shape, and specific gravity.

3.1 Metals

Tailings related to the production of metals in Brazil comprise the largest volumes and highest risks relative to industrial minerals. Metals tailings, while distinct based on the specific metal being mined, have the potential to create the most risk to the public and the environment, due to the general reactivity of metals in the environment, their impact to organisms, and the volume of tailings and other wastes generated in metals mining.

3.1.1 Iron Ore

The volume of material is one of the major considerations for iron ore tailings. Much of the tailings will be of silt and clay size (less than 75 microns) and will thus be slow to settle out of slurry suspensions. The composition of the materials is primarily silicates, though different sites have distinct compositions of tailings. Additionally, some iron ore tailings contain other metals, such as manganese, and may contain radionuclides, as well as rare earth elements and other critical minerals. Iron ores usually have iron content of approximately 50 percent, usually in the form of oxides. In some instances, there is a presence of sulfide minerals (pyrite), which creates a potential for acidic rock drainage (ARD, sometimes called Acid Mine Drainage (AMD)). Depending on the local water chemistry and the specific mineralogy of an iron ore deposit, some metal acidity may result in the discharge if metal ions are dissolved at high enough concentrations.

As a result of the size distribution of the tailings, special considerations are necessary so that the fine materials are properly retained within the tailings disposal facility. Based on the size, the settling of the tailings is not rapid without intervention and the addition of external force, from either seismic events or local disturbances from blasting, etc., can cause liquefaction of the tailings, which may result in failure of the TDF. Discharge of fine materials results in significant downstream issues related to both the mass of the material and the impact that it has on downstream biota.

The chemical characteristics of the tailings also can create issues, such as dissolved heavy metals (selenium, mercury) and acid drainage (from oxidation of sulfide minerals), but the physical properties are of greatest concern, as they influence the moisture within the tailings mass, and thus the physical stability. The clay content of iron ore tailings may be similar to other types of tailings, so prevention of tailings flow is a common design consideration.

3.1.2 Precious Metals

Tailings for precious metals operations, particularly for gold, often contain significant amounts of residual metals value. Specifically, refractory gold mineralization (mineral that is difficult to process), gold associated with metallic sulfides, and fine-grained gold minerals may be found in most gold mine tailings. Additionally, processing chemicals, such as cyanide, may be present in relatively high concentrations, leading to concern about the decant water and the tailings themselves. While cyanide is used in processing in most modern operations, it is very unstable and decomposes in the presence of oxygen and sunlight.

Many precious metals deposits also contain base metals and may be a potential source of critical materials. As with iron ore tailings, the size distribution of precious metals tailings tends to be in the silt and clay size fractions, but other waste rock from the mine, including sub-ore grade materials, may be mixed into the tailings. In some cases, the tailings from precious metals operations may include more sand size particles, changing the strength and settling time necessary for dewatering (decreasing the entrained moisture in the material).

The age of the tailings is also a significant consideration, as older processes may have increased mercury contamination of the tailings (from recovery via amalgamation or from naturally occurring cinnabar in the ores)[23] and higher residual metals grades because of lower recoveries. The tailings are also apt to contain sulfide minerals that may lead to AMD/ARD and metals loading in discharges from the TDF.

3.1.3 Base Metals

Base metals tailings, such as those from copper, lead, and zinc operations, share many characteristics with those from precious metals mining. In fact, many base metals tailings have elevated concentrations of precious metals along with residual metals. Base metal mining often involves sulfide minerals, and thus the tailings from these operations have the highest likelihood of generating AMD/ARD. The tailings may also contain organic processing chemicals which have the potential to create other pollution in downstream watersheds.

Recent research in the United States, Spain, and Canada has shown that base metals tailings can have important concentrations of rare earth metals and other critical metals such as chromium, cobalt, and nickel. The natural process for creating AMD concentrates those important metals, and much of the research has focused on recovery from the enriched AMD-related materials.[24] This process offers opportunities for management of tailings and their impacts that may reduce the long-term risks and support significant recovery of new resources (discussed further in Section 4).

3.2 Nonmetals

For most nonmetals mining, the tailings are of concern primarily because of their physical properties, which can lead to suspended solids in water and sedimentation downstream, thus impacting biota and downstream residents. Waterways impacted by sand and gravel operations, for example, may see significant changes in stream characteristics that vastly alter the functions and uses of the stream.

3.2.1 Construction Materials

The residue from the mining and quarrying of construction materials are not generally considered tailings but are often managed in similar ways. One major concern for construction materials, such as sand, gravel, dimension stone, crushed rock, and cement ingredients, is that most wastes and reject materials are not large enough to be used as product. Thus, the potential to create issues of suspended solids and downstream sedimentation is very high. Fortunately, most of these materials are found in fluvial environments, so their chemistry makes up a part of the pre-mining watershed chemistry. For example, limestone operations may generally be expected to result in alkaline discharges. If the incoming ground or surface water is rich with metals, the reactions that may occur could result in sludges forming when metal carbonates and other salts precipitate because of pH changes. In general, most construction materials operations will not result in tailings that are of sufficient quantity or quality to create major concerns.

Another area of concern is created by silica and siliceous materials, which may exist in the rocks that are broken by a construction minerals operation. Silica dusts, particularly those in the respirable (less than 10 microns) range, pose a threat to both workers and nearby populations. Appropriate management of processing operations and tailings related to fugitive dust control is a necessary part of the proper management of construction materials operations and TSFs.

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[23] Cinnabar is a mercury mineral. Mercury is also a solvent for gold, thus the mercury can be within the rock mass or added during the recovery process

[24] Ziemkiewicz et al, 2021.

3.2.2 Fertilizer Materials

As with construction materials, the tailings from fertilizer materials production do not create significant hazards to downstream water based purely on the nature of the materials being mined. Phosphate rock operations, however, may create downstream eutrophication (or over fertilization of water, resulting in algae blooms and other impacts on water quality) if the phosphatic materials dissolve and create large concentrations of phosphate in downstream watersheds. Much of the phosphate rock is processed to produce phosphoric acid, resulting in a waste product known as phospho-gypsum. The phosphate rock deposits also contain naturally occurring radioactive materials and the radionuclides, radioactive minerals, often end up in the phospho-gypsum wastes (a calcium sulfate mineral byproduct), which may be placed into impoundments with clay slimes and other processing wastes. As a result, proper management of water related to the TSF is a primary concern.

The size of most fertilizer materials operations may be much larger than that of construction materials, as such, the size of TSFs associated may be much larger. Additionally, due to the depositional environment of phosphate rock and the other materials that are mined as fertilizers (such as potash salts from evaporite beds), the size distribution of tailings tends to be very fine, with most of the tailings being clay. Historically, flocculants, chemicals that cause particles in suspension to coagulate and settle, have been added to phosphate tailings to encourage more rapid dewatering, leading to concerns about the presence of the flocculants and other reagents as well as the physical properties of the tailings slurries stored in TSFs related to fertilizer materials.

3.2.3 Other Industrial Materials

Other than construction materials and fertilizer materials, there are some industrial minerals that Brazil produces, such as asbestos. The size of these operations is usually comparatively small, and the resulting TSFs are also not large. Based on the type of materials produced at the operation, special considerations should be made for materials handling related to the tailings. In the case of asbestos, because of worker and community health and safety concerns related to respirable dust containing fibrous minerals, great care is necessary so that the tailings are left submerged or otherwise encapsulated. The processing of asbestos-form minerals results in fine, respirable particles that can prove to be a long-term hazard.

For other industrial minerals that are not fibrous, there are also specific concerns on how the materials are handled and disposed of. In general, other industrial minerals tailings are very similar to construction materials and may be treated similarly. As noted above, silica is a concern in many of these deposits and tailings.

3.3 Coal

While usually much smaller than metals mining TSFs, failures of coal mine related TSFs have been a historical source of loss of life, property damage, and environmental catastrophes. For example, the Martin County Coal Company's coal slurry impoundment failure in 2000 in Kentucky, United States created environmental damages for nearly 100 miles downstream following the breakthrough into adjacent underground mine workings. The Buffalo Creek coal tailings dam failure in the United States in February 1972 resulted in the loss of 125 lives, 1,121 injured, over 4,000 homeless, and destroyed over 500 homes and businesses downstream. The environmental impacts were never properly quantified. The Buffalo Creek disaster did spur the creation of environmental laws in the United States that focus on coal mining operations and on the safety of coal impoundments.

This Report classifies “coal tailings” as coal slurry and other coarse refuse from coal mining and processing. Often, the coarse materials are used, sometimes along with other naturally occurring rocks and soil, to create dams, behind which the finer materials, often in the form of slurries, are placed. Due to the topography of the coalfields of Appalachia, United States, these impoundments are often very deep, and contain significant volumes of clay-sized particles, organic chemicals, and other byproducts of the coal extraction and beneficiation process. These tailings often include pyrite and other metal sulfides, making the water related to coal TSFs often acidic with high metallic concentrations. The chemistry of other coal residues is different in other coal basins, but there are often similar concerns.

The relatively acidic conditions of, and relatively high concentrations of some metals in coal wastes can be challenging from an environmental standpoint. However, over the past several decades, DOE has funded significant research into the economic potential of coal tailings and revealed them to be a potential source of rare earth metals and other critical materials. Several universities in the United States are actively involved in the research and both the University of Kentucky and West Virginia University have constructed pilot-scale recovery facilities. The Government of Brazil should consider creating a program to assess ongoing and in-situ coal wastes for rare earths/critical mineral, thereby evaluating whether such in-waste minerals represent a potentially economic resource. While the chemical and geologic depositional environment of Brazilian coals may be different from the United States, there is an opportunity for further into this potential possibility.

Additionally, advanced coal cleaning technologies have been developed to allow for the recovery of additional carbon from the coal tailings and wastes. This recovered material can be used as fuel, which has been demonstrated to serve as “carbon ore” for creation of high-tech materials such as carbon nanotubes and graphene.

4. BENEFICIAL USE OF TAILINGS

One way to reduce the risks posed by TSFs is through beneficial reuse of the tailings and other waste products (including water). There are multiple reasons for tailings reuse, depending on the physical and chemical properties of each tailings stream. These include:

- **Residuals of coal and mining tailings as an economic resource**. TSFs are an economically beneficial resource for alternative materials as research demonstrates that coal tailings and base metals tailings are economically and technically viable sources of rare earth metals and other critical materials. For example, diamond mines have tailings facilities that contain significant value as the demand for lower quality stones for industrial applications continue to rise.

  Tailings from some types of mining, such as iron ore facilities, may be a source of materials that can be used in making construction materials or as a source of aggregates, sands, and other materials that can be used directly in construction or other industries. These tailings and waste materials are used for reclamation of disturbed sites, such as abandoned mines, and for other civil works projects. Mine tailings have been used to foster reforestation, to improve drainage networks, and to create sites for future development. Through the recovery of materials from tailings, the minerals industry promotes a circular economy.

- **Environmental benefits in cases such as ARD, sediment loading, or metals contamination**. Removal of an existing TSF can permit restoration of natural drainages and reduction of the area of disturbance. Dusts from dry tailings can be more easily controlled, and sometimes eliminated, and the landscape and visual impact can be greatly improved. The reuse of tailings before they are placed in TSFs or TDFs minimizes the disruptions to the pre-mining landscape and watersheds.

  The reuse of tailings and the resulting smaller size of residual facilities reduces risks to the public and the environment. The risk reduction can result in lower liabilities for mining companies and government at all levels. The other associated improvements in the environment and the landscape may enhance the opportunities for future development bringing economic benefits beyond those realized from the reuse itself.

4.1 Current Projects in Brazil

During consultation for this Report, CPRM personnel advised the Deloitte team that there are a few tailings reuse and reprocessing projects under development in Brazil, primarily involving tailings from iron ore production. CPRM has been working with industry, academic researchers, and other government agencies to bring these projects to fruition.

One project became operational in November of 2020, as Vale opened the Pico Blocks Factory at its Mina de Pico mining facility in Minas Gerais. The goal of the factory is to turn 30,000 tonnes of tailings annually into 3.8 million pre-molded construction products. The factory is the result of studies conducted by Vale since 2014. Vale's sandy tailings at Mina de Pico have high silica content and very low iron content, making them particularly attractive for this use.

4.2 Special Considerations

Many of the special considerations for the storage and placement of tailings discussed above lead to opportunities for reuse and reprocessing.

4.2.1 Iron Ore

Studies in Australia have reviewed opportunities for processing of fine, low-grade iron tailings to create pellets or briquets for use in direct iron reduction furnaces or other steelmaking facilities.

Research has focused on magnetic processing technologies, but other opportunities to enhance quality for use have been investigated.

Researchers in China have demonstrated the usefulness of iron ore tailings in construction materials, ranging from cinder blocks and bricks to mortars and cements, to refractory sand and other uses. This research has identified key parameters that make a particular tailings composition useful for the various applications. Similar studies have also been done at universities in Australia, India, and Brazil.

4.2.2 Base Metals

Academic and industry researchers have investigated the chemical, mineralogical, and physical characteristics of base metals tailings to understand how to best to use the specific materials. Some tailings contain sufficient recoverable metals to make direct reprocessing feasible. Others contain metals that were not recovered at the time of original processing, and others contain precious metals that can efficiently be recovered by modern methods. Research is ongoing on the practicality of recovery of rare earth metals and other critical materials from base metals tailings and AMD. Depending on the specific composition and characteristics of the gangue materials in the tailings, these may also prove to be a source of construction materials or other products, such as pigments and fillers.

4.2.3 Precious Metals

Some tailings from precious metals operations may contain considerable residual value. This is particularly true of tailings from orebodies where some of the precious metals were in refractory ore or associated with complex mineral structures that made the recovery difficult using previous approaches. Modern extractive metallurgy can achieve efficient recovery at reasonable cost, particularly at current metals prices.

Additionally, precious metals tailings may contain other constituents that can be recovered economically, particularly given that mining, grinding, and processing has already been done. Some precious metals tailings are also targets of investigation for recovery of critical materials.

4.2.4 Construction Materials

Wastes from the mining of construction materials may not be suitable for the original uses they were mined for, but new markets have arisen for manufacturing of composite stone, such as for countertops, which may make these wastes valuable. In addition, certain fine materials from aggregate operations have become extremely desirable because of their shape and size profiles for various industrial uses.

4.2.5 Fertilizer Materials

Some phosphate rock operations result in the creation of phospho-gypsum that can be used for various purposes, depending on the presence of naturally occurring radioactive materials. The clays that are associated with the processing may also be suitable for use in the modern ceramics industry, and research is ongoing to determine the specific characteristics of useful feedstock for production of ceramics with specific characteristics, such as electrical conductivity.

4.2.6 Coal

The use of coarse coal refuse and coal tailings in waste burning power plants has long been conducted in Pennsylvania. Methods for recovery of fine and ultrafine coal particles using microbubble flotation and other techniques have been successfully implemented for decades. Concerns about greenhouse gases (GHGs) associated with burning low heat value fuels have limited the long-term viability of this reuse approach.

Research funded by the U.S. Department of Energy for the past decade has focused on recovery of rare earth metals and other critical materials from coal processing wastes and AMD associated with coal mining. Ongoing work in pilot-scale plants will determine the technical and economic viability of using these materials as feedstock.

Research is also ongoing into using the carbon in coal tailings as an ore to produce graphene, carbon nanotubes, and other high-tech materials. While this technology is not mature, the early results are promising and could prove to be another solution to address coal wastes and tailings.

4.3 International Examples

In September 2021, the Deloitte team provided an interim report, "*Tailings as a Resource,*" which outlined several international examples of tailings reuse. These are summarized below.

- *Cabeço do Pião, Portugal* — At this site, there were tailings of various types from over 100 years of mining. Mining primarily focused on the recovery of tungsten, but other commodities were also recovered through the years. Most of the tailings were waste from flotation and contained enough sulfide minerals to result in long-term acid mine drainage from the site. As the flotation processes changed over time, the recovery of metals improved, but older tailings contain significant tungsten and other metals. The reuse project is still in the study phase, with detailed technical and economic viability evaluations ongoing.
- *Morila Gold Project, Mali* — This project has been producing gold since 2000. After 2010, with reserves in the mine becoming depleted, the project began reprocessing the tailings. Since 2018, most of the gold production has come from the early tailings of the project. The efficiency of tailings reuse has allowed for a few satellite pits to be mined with the new ore being added to the tailings being reprocessed to increase grade and recovery.
- *Taltal, Chile* — In the area of Taltal, there were several government-owned and private TSFs near one another. Due to the potential for seismic activity and concerns about the construction of the TSFs, there was concern about the stability of the sites and the risks they posed to the environment and the public. Reuse of the tailings provided an opportunity to recover additional copper and other metals, such as gold. The reprocessing of the tailings was feasible, both technically and economically, and the project is currently in operation.
- *Unspecified site, Colombia* — The Government of Colombia, in association with the mining industry, began the project focused on dewatering the existing TSF and making the site suitable for revegetation and future development. The project is currently removing precious metals from the reprocessing of tailings and removing mercury, which was used during the previous mining at the site. The project is addressing an environmental issue as well as supporting future economic benefits.
- *Cerro de Pasco, Peru* — In this case, several mine waste piles and tailings impoundments were located near a former mining company town and the surrounding traditional villages. Acid discharge had affected the local water supply and heavy metals contamination threatened public health and the environment. A new operator saw an opportunity to recover copper, lead, zinc, and gold from the site by employing new reagents in the flotation circuit and by enhancing the ore sorting technology. The project is currently in operation.

There are many other operational tailings reuse and reprocessing projects around the world. Research is ongoing, including in Australia, Canada, and China, to evaluate how to address specific tailings sites of concern and how to get more value from the wastes of past and future mining and minerals processing.

5. TECHNICAL CHALLENGES FOR TAILINGS DISPOSAL AND MANAGEMENT AND RECENT LEADINE PRACTICE GUIDELINES

5.1 International Standards

The ICMM, UNEP, and PRI put forward a new Global Industry Standard on Tailings Management (GISTM) in August of 2020. While the GISTM focuses on standards for industry, it also provides an objective basis for the regulation and oversight of TSFs. Government agencies, non-governmental organizations (NGOs), and the public can benefit from using the GISTM as a benchmark for evaluating proposed, operational, or legacy TSFs and their risks to the public and the environment.

GISTM consists of 15 principles that create 77 requirements for tailings management; the 77 requirements provide specific information related to the principles. This Report highlights a few important aspects of the GISTM.

The 15 principles of the GISTM are:

- *Principle 1. Respect the rights of project-affected people and meaningfully engage them at all phases of the tailing facility life cycle, including closure.*
- *Principle 2. Develop and maintain an interdisciplinary knowledge base to support safe tailings management throughout the tailings facility life cycle, including closure.*
- *Principle 3. Use all elements of the knowledge base – social, environmental, local economic, and technical – to inform decisions throughout the tailings facility life cycle, including closure.*
- *Principle 4. Develop plans and design criteria for the tailing facility to minimize risk for all phases of the life cycle, including closure and post-closure.*
- *Principle 5. Develop a robust design that integrates the knowledge base and minimizes the risk of failure to people and the environment for all phases of the tailings facility life cycle, including closure and post-closure.*
- *Principle 6. Plan, build, and operate the tailings facility to manage risk at all phases of the tailings facility life cycle, including closure and post-closure.*
- *Principle 7. Design, implement, and operate monitoring systems to manage risk at all phases of the facility life cycle, including closure.*
- *Principle 8. Establish policies, systems, and accountabilities to support the safety and integrity of the tailings facility.*
- *Principle 9. Appoint and empower an Engineer of Record.*
- *Principle 10. Establish and implement levels of review as a part of a strong quality and risk management system for all phases of the tailings facility life cycle, including closure.*
- *Principle 11. Develop an organizational culture that promotes learning, communication, and early problem recognition.*
- *Principle 12. Establish a process for reporting and addressing concerns and implement whistleblower protections.*
- *Principle 13. Prepare for emergency response to tailings facility failures.*
- *Principle 14. Prepare for long-term recovery in case of catastrophic failure.*
- *Principle 15. Publicly disclose and provide access to information about the tailings facility to support public accountability.*

The overall goal of the requirements is to provide sufficient detail to suggest concrete actions that can be taken to adhere to the principle. Additionally, they provide a foundation for evaluation of the success or failure of adoption of the GISTM. While the mining operators address the principles and requirements, they also provide significant direction to governmental regulators and the public on how to evaluate the design, construction, operation, and decommissioning of TSFs.

Additionally, the group published a set of papers written from various disciplines that address issues, challenges, and developments within the broad area of tailings management, "*Towards Zero Harm*." Also, the GTR website provides a source for these documents in several languages and a report on the materials submitted during the public consultation process for the preparation of the industry standard.[25]

In May 2021, the ICMM released a tailings management good practice guide for governance and engineering practices for industry to use in adopting the standards. Further, ICMM also published Conformance Protocols for the GISTM, which provides specific metrics for evaluating the conformance of tailings facilities and tailings management programs to the standards. These protocols support self-assessment and for third-party review and auditing, which enhance the good practices guidance.

These standards and protocols were built upon the technical principles contained within those previously developed for Canada, Australia, and other countries based on the leading practices used by many companies within the mining sector. While not all mining companies are a part of the ICMM, their leadership has created a benchmark for the industry to use as a de facto standard. Given the site-specific conditions experienced by mining operations globally and the nature of social and environmental issues that exist in different jurisdictions, it is not prudent to adopt the standards without considering local concerns. Rather, the GISTM is a framework for specific requirements for each mining project where tailings are managed.

Another important facet of the GISTM and other similar standards is that operators should consider the full life cycle of the TSF before the project is started, and that regulatory agencies consider the life of mine and closure plan during the permitting process. Appropriate planning for all phases, including design, construction, operation, closure, and post-closure, as well as inspection and monitoring and emergency preparedness, need to be developed before any tailings are created or placed in the facility. It is crucial that all stakeholders fully understand the risks, opportunities, and eventual long-term use of the site, throughout the life of the project. The GISTM and similar standards and approaches seek transparency and public involvement.

5.2 Design Standards

The GISTM Principles 4, 5, and 6 (Section 5.1) provide the overarching framework for the goals of TSF design. The individual requirements specify how these principles should be implemented through the process of preliminary design, alternatives analysis, consequence of failure evaluation, and development of detailed plans for construction, operation, monitoring, inspection, emergency planning, risk management, and facility closure. The GISTM requirements are consistent with the previous publications for design standards from ICOLD and the United States, Canadian, Australian, and other dam safety and mining organizations. For example, ICOLD released a Technology Update for Tailings Dam Design at the end of 2021. The Canadian Mining Association "Guidelines for the Assessment of Alternatives for Mine Waste Disposal" published in October 2021, is another useful publication. *Appendix A* includes references to many of those standards.

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[25] www.globaltailingsreview.org

A key component of the GISTM and other approaches is public involvement in review of the preliminary plans and other key design documents. Since many of the details are highly technical, the information should be explained in a form that the public can understand and that the interested public, especially the potentially affected communities, are educated on how to understand and use the information that is shared with them.

Another key aspect of design standards is that the professionals involved in creating, approving, and reviewing the design standards have the suitable educational and technical expertise necessary for protection of the public and the environment. Section 5.7 provides more in-depth discussion of professional qualifications and certifications for those involved in tailings facilities.

5.3 Construction Standards

The six requirements under Principle 6 of the GISTM focus on promoting that the design that was created for the TSF is implemented properly during the construction of the facility, as well as the other phases of the life cycle. Requirements include creating "as built" reports, formal change management systems, and quality control/quality assurance. These requirements are founded on leading professional practice, the incorporation of "evolving knowledge," and the use of qualified personnel.

There are numerous other documents that detail what the leading design practices are for specific types of TSFs. Monitoring and oversight of construction by regulatory authorities, trained third parties (such as independent technical review boards), and other appropriate private and public groups is a critical aspect of ensuring that TSFs are constructed as designed and that there is transparency regarding the construction. These aspects are important to assess the potential risks posed by the TSF and that the facility can be operated as anticipated by the design. Further, changes during the construction process are memorialized to allow for ongoing evaluation of issues that may arise throughout the life cycle of the facility.

In addition to the general requirements in the GISTM, there are numerous national standards (for example Canada and Australia) that specify the most significant issues of concern that need to be addressed during the construction phase of the TSF. Operators need to develop testing and monitoring requirements based on the best engineering, geologic, hydrologic, seismic, and other practices for the specific location and type of TSF.

5.4 Monitoring and Inspection Standards

Principles 8 through 12 of the GISTM establish requirements for accountability within the operators and owners of TSFs. These are aimed at Boards of Directors and others who are to be designated as "Accountable Executives" for each TSF. The GISTM also requires designation of an Engineer of Record (EoR) and site-specific responsible engineers for each TSF to be accountable for the integrity of the facility. These roles and responsibilities should provide motivation for companies to monitor and inspect the TSF at all phases of its life cycle.

Similarly, the regulatory community, interested NGOs, and the potentially affected public have interests in making sure that operators appropriately monitor, manage, and inspect the TSF at all phases. During the construction of the TSF, the number of inspections and the scope of monitoring should be adequate so that the designs are adhered to, and if not, to structure a change management process to document any changes from the designs. Regulators should designate qualified and trained engineering professionals to oversee the work of the company's EoR and site-specific responsible engineers and to review the results of monitoring and inspections.

The need for proper government involvement related to mining operations and TSFs associated with mining operations, is reflected in the ongoing efforts of the UNEP and others to develop international leading practices for governance in the extractives sector (Section 6.1).

5.5 Closure Standards

The design for all phases of the life cycle of a TSF, including closure and post-closure, should be completed prior to the generation of tailings and their placement in the TSF. Moreover, with existing and abandoned TSFs, operators should make these designs and plans as soon as possible during the operation. The review of designs, construction details, operational information, the results of monitoring and inspection, and many other factors, such as the post-mining land and resource needs of the potentially affected communities surrounding the TSF, are critical input for preparing for closure.

Where possible, the operator and the regulatory community should investigate the opportunities for reuse of the tailings (Section 4). The operator should also consider the use of water associated with the TSF and incorporate these factors into the closure plan. The main purpose of the closure plan is to minimize the risk to people and the environment, during the closure and post-closure phases of the project.

The operator should regularly update the closure plans throughout the TSF life cycle to reflect the information gathered through operations, monitoring, and inspection. Generally, mines update mine production budgets on an annual basis, making this an opportunity to review how any changes in the life of mine plan might impact closure. Additionally, the operator should survey updated expectations of potentially affected communities as a part of the ongoing review of closure plans. As with all the other aspects of the GISTM and related approaches, transparency and public involvement are key aspects of the regular review and update of the closure plans. It is the responsibility of the regulator to check that the closure plans are reflective of the legal requirements for environmental protection, and the interests of potentially affected people.

5.6 Dam Rehabilitation and Removal Standards

The closure of TSFs may include the removal of dams associated with the TSF. While tailings dams are different in several ways from dams designed to hold only water, the engineering of both types of structures and the considerations for removal of the dams have many aspects in common. There are technical guidelines available regarding dam decommissioning, such as the 2015 publication by the U.S. Society on Dams.[26] In March 2021, the state of Minas Gerais published requirements for tailings dam decommissioning. These requirements note the removal of all dams constructed using the upstream method, which was the designed used in Brumadinho Samarco dams that collapsed in 2015. The law notes that those in breach of it could have their operating license suspended. Previously, the Province of Alberta's (Canada) Alberta Energy Regulator published requirements for dam operators to follow the Mining Association of Canada's guidelines, and to apply the guidance of the Canadian Dam Association (CDA) and the ICOLD related to tailings dams, which represent leading practices. The CDA guidance on tailings dam breach analysis published in 2021 and the Application of Dam Safety Guidelines to Mining Dams published in 2013 are two significant references for use.

[26] USSD, "Guidelines for Dam Decommissioning Projects," July 2015, https://www.ussdams.org/wp-content/uploads/2016/05/15Decommissioning.pdf.

ICOLD Bulletin 153: Sustainable Design and Post-Closure Performance of Tailings Dams[27] suggests that a facility is no longer a dam if "in the opinion of the authorities, it is considered to be physically, chemically, ecologically, and socially stable, and no longer poses a risk to life of the environment." Therefore, the dam and TSF are reclassified as no longer being in operation or capable of storing water or tailings.

Standard engineering practices for removal and decommissioning of tailings dams are only slightly different from those of other types of dams. One key commonality is that the removal prevents the TSF dam from risks to the environment. This requirement addresses not only the appropriate long-term removal, reuse, or permanent disposal of the tailings, but also the impact on the drainage and downstream water and ecosystems.

For some TSF dams that may be in operation for a significant period following review, rehabilitation of the dam may be necessary. Operators should consider previously referenced technical guidelines when making plans and creating designs for dam rehabilitation. The overall primary consideration is risk posed to people and the environment, by the dam and TSF, before, during, and after rehabilitation work. Rehabilitation will require oversight by an existing or newly appointed EoR.

5.7 Professional Qualifications and Certification

One of the more significant issues related to TSFs is ensuring that the EoR and the personnel who plan, design, operate, monitor, inspect, construct, and implement the other aspects throughout the life cycle of the facility have the appropriate qualifications to conduct the work. These qualifications are often based on education, experience, and specialized training related to tailings management. The failures of TSFs globally have created an impetus to introduce programs that provide third party validation of an individual's ability to perform these tasks to protect the public and the planet. To address the needs for certifications, many organizations have developed programs to provide specialized training and evaluation of qualifications. For example, in the United States, the University of Arizona, the Colorado School of Mines, and Colorado State University have formed the Tailings Center, which began teaching a series of courses and providing certification in 2020. Other such programs were created in Canada and Australia, to meet the international need.

In most jurisdictions, there are mechanisms for engineers to become recognized for their professional competence and qualifications. For example, the United States established standard requirements for registration or licensing of "Professional Engineers" through testing and evaluation of experience. Most other countries also have similar programs that certify or qualify engineers to take responsibility for their professional activities and to confine their practice to areas where they have adequate expertise. These registrations and licenses provide assurances that the engineering professionals are qualified to protect the interests of the public and the environment. The certification provides third-party endorsement of education and experience as insurance for the society that the engineering meets leading practice standards.

Tailings management, including the full life cycle of TSFs, is a topic that mining engineers, civil engineers, environmental engineers, and possibly other engineers may have the requisite knowledge and experience to take responsible charge of the activity. Nevertheless, tailings management is a field that crosses traditional disciplinary boundaries and not all engineers have the necessary skills to adequately evaluate that the risks from TSFs are understood and managed.

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[27] ICOLD, 2013.

Additionally, many engineers and other professionals in the mining industry and the regulatory community that enforce the standards do not have any specialized certifications, though they may have appropriate education and experience. To provide assurances to all stakeholders, particularly potentially affected communities, it is necessary that those organizations create opportunities for their personnel to become appropriately trained and certified. Using the programs that have been established as templates, additional certification programs can and should be established to meet the need of industry, government, NGOs, and other interested parties for professionals that have the appropriate knowledge, skills, and abilities to manage and regulate TSFs.

In February 2022, the Society for Mining, Metallurgy, and Exploration (SME), the largest professional mining society in the United States published its *Tailings Management Handbook: A Life-cycle Approach* to help build the capacity of engineers and other professionals tasked with the management of mine tailings throughout the extended timeline of a mining operation. Miners around the world have realized that TSFs are constructed, operated, closed, and remediated; and that full life-cycle planning is important.

6 ENVIRONMENTAL PROTECTION REQUIREMENTS

Generally, the environmental protection requirements related to activity within a country is subject to the national and local laws and regulations and local jurisdictions within that country. There are general environmental concerns that apply nearly universally to industrial activities on a global scale. This is particularly true for mining. In many cases, though the mined commodities, mining activities, equipment, processing and recovery, and waste management practices may differ, there are several impacts that are universal and are addressed in numerous laws, regulations, standards, and guidelines.

6.1 International Leading Practices

Most environmental impacts are local in extent, although some, particularly air pollution and water impacts, may cover a broad geographic area. Some environmental impacts are so universal that they are addressed in similar ways in many international standards. While the standards are often related to a specific set of activities, some are more general (discussed below).

6.1.1 International General Standards and Industry Voluntary Standards

World Bank Group (WBG) Environmental, Health, and Safety General Guidelines — The WBG guidelines and standards are enforceable upon projects that receive funding from the WBG. Due to the involvement of many countries in the activities of the WBG, and as other efforts use the standards as a template, the WBG standards have a more widespread influence.

This is true of the WBG Environmental, Health, and Safety Guidelines.[28] These guidelines are technical references for "good international industry practice" and are considered to include performance measures and levels that can reasonably be achieved by new projects using existing technology at acceptable costs. The guidelines include environmental topics including air emissions and ambient air quality; energy conservation; wastewater and ambient water quality; water conservation; hazardous materials management; waste management; noise; and contaminated land. They also address occupational safety and health, community health and safety, and issues related to construction and decommissioning of projects. Many of the guidelines are detailed and suggest specific requirements; others are vaguer and make general recommendations only.

Organization for Economic Cooperation and Development (OECD) — The OECD is active in more than 100 countries globally to provide standards, programs, and initiatives aimed at solving problems. While Brazil is not a member of OECD, it is one of the organization's "key partners," and OECD has been actively working to provide guidance there (as well as in China, India, Indonesia, and South Africa).

One area where the OECD has been active is in the environment. The OECD program on environment helps countries to develop and implement "effective policies to address environmental problems and sustainably manage natural resources."[29]

6.1.2 Water

While there are few absolute international standards for water quality, the overall approach is that mining and tailings management do not limit the previous uses of the water and does not adversely impact the quality and quantity of water available for other uses.

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[28] IFC, 2007.

[29] OECD, 2022.

Some tailings from various types of mining may create issues with sedimentation and changes to the chemical composition of surface and groundwater. Most of the international leading practices focus on the implementation of local requirements. Where there are parameters of concern they are generally, pH, total suspended solids, total dissolved solids, metals, other inorganics, organics, nutrients, color, temperature, pathogens, and toxicity. Other specific concerns may include radionuclides, dissolved oxygen, biological oxygen demand, and specific hydrocarbons. The overall goal of these discharge concerns is to protect or improve the ambient water quality that existed prior to the project.

Water conservation concerns are also a part of compliance, with the main goal being that other uses are not compromised by the project. Recommendations for onsite recycling and reuse of water are prevalent, as are suggestions for reductions in water use.

6.1.3 Air

Limiting the impacts of a project on ambient air quality is also the major focus of most internationally accepted air quality guidelines. The World Health Organization (WHO) has guidelines for sulfur dioxide, nitrogen dioxide, particulate matter less than 10 microns (PM10), particulate matter less than 2.5 microns (PM2.5), and ozone, because of the contributions these parameters can make to negative health effects. The WHO guidelines are intended to supplement national standards or serve in lieu of national standards if none exist. Other parameters of concern are volatile organic compounds and ozone depleting substances.

Of global concern over the past decades have been GHGs, carbon dioxide, and methane, related to global climate change. While tailings disposal is not generally associated with GHGs, coal tailings and other situations where significant organic matter and chemicals are involved may create GHGs concerns. Additionally, the removal of vegetation associated with the construction of TSFs may raise issues related to the control of carbon emissions into the atmosphere.

The most significant air quality issues related to TSFs are those related to fugitive dust emissions, particularly respirable dusts, PM10 and PM2.5, which may impact nearby communities. In situations where changes in tailings management may decrease the wet placement of tailings, these dust concerns may be increased. Encapsulation with evapo-transpirative soil and vegetation cover may mitigate concerns.

6.1.4 Solid Wastes

Solid waste management recommendations make a distinction between hazardous and non-hazardous wastes, since the appropriate protocols to deal with each are different. The international standards regarding solid wastes usually contain some guidance on how to decide whether a waste is hazardous and if so, what special handling requirements are necessary. One objective included in most solid waste management procedures is to encourage prevention, reduction, reuse, recovery, recycling, and removal of wastes as priorities over disposal. The overarching goal for disposal is to prevent the waste from posing any current or future risk to people or the environment.

In many national environmental programs, wastes from mining activities are considered separately from other types of wastes. This is because most waste materials associated with mining can be characterized as “high volume, low risk.” Special waste management programs for mining wastes usually contain requirements to prevent any contamination of surface or groundwater and to prevent people from having any contact with the wastes.

A common facet for hazardous waste management is ensuring that the waste is transported from the site where it is generated to a special facility where it can be treated or encapsulated to no longer pose a threat. This is a significant change from past practices that resulted in long-term land and water contamination. The key consideration is to minimize or cut contaminant risk factors, such as the hazardous nature of the contaminant, the receptors, and the exposure pathways.

6.1.5 Habitat and Endangered Species

As with most land-disturbing activities, mining and TSFs can result in the elimination or degradation of habitat for threatened and endangered species. Many international standards based on treaties and international conventions are focused on ensuring the continuation of species of concern, both plants and animals. Given the large geographic footprint of the Amazon Basin in Brazil and its unique place in the local and global ecosystem, many of the specific considerations for protection of habitat and species of concern are highly applicable in Brazil. In addition to the Amazon, there are other areas of critical concern for conservation of species and habitat within Brazil that draw international attention.

6.2 Brazilian Current Practices

6.2.1 Brazilian Law

The main environmental laws in Brazil are derived from Article 225 of the Brazilian Federal Constitution and other parts of the constitution that allocate responsibilities among the three levels of government (national, state, and local). In addition, there is a comprehensive framework of laws of importance:

- *Law 6.938 of August 31, 1981: National Environmental Policy Act*
- *Law 7.317 of July 24, 1985: Class Action Act*
- *Law 9.605 of February 12, 1998: Environmental criminal and administrative offenses*
- *Decree 6.514 of July 22, 2007: Implementation of Law 9.605*
- *Law 10.650 of April 16, 2003: Access to environmental information*
- *Law 9.433/9997: National Water Resources Policy Act*
- *Law 9.795/1999: National Environmental Education Policy Act*
- *Law 9.985/2000: National System of Conservation Units Act*
- *Law 11.445/2007: Basic Sanitation National Policy Act*
- *Law 14.026/2020: Amendments to Basic Sanitation National Policy Act*
- *Decree 6.040/2007: National Policy on Sustainable Development and Traditional People and Communities*
- *Law 12.197/2009: National Climate Change Policy Act*
- *Law 12.305/2010: National Solid Waste Policy Act*
- *Complementary Law 140/2011: Clarification of environmental competencies of each level of government*
- *Law 12.587/2012: National Urban Policy Act*
- *Law 12.651/2012: Forestry Law*

- *Decree 7.747/2012: Policy for Territorial and Environmental Protection of Indigenous Lands*
- *Law 13.123/2015: National Biodiversity Policy Act*

Four primary authorities implement these laws and decrees at the federal level:

1. National Council for the Environment (CONAMA) ─ Advisory and regulatory organization formed from representatives of various stakeholders;
2. Institute of Environment and Renewable Natural Resources (IBAMA) ─ Enforces compliance with federal environmental legislation;
3. Chico Mendes Institute of Conservation and Biodiversity (ICMBio) ─ Implements requirements under the national system of protected areas; and
4. Brazilian Forestry Service (SFB) ─ Promotes the sustainable use of forestry.

For mining, MME, through ANM, also implements specific requirements for licensing and environmental performance of mining operations.

All levels of Government in Brazil have responsibility for environmental protection. The federal regulations are often supplemented by state and municipal laws and regulations. This is particularly true in the states with significant mining activity. The federal, state, and local requirements for the environment form the National Environmental System (SISNAMA) under the responsibilities assigned by Federal Law 6.938/1981.

The regulatory enforcement process is generally conciliatory, focused on a clear administrative process with the goal of environmental protection. Generally, the regulations provide for corrective actions and/or compensation that can be used to offset or reduce any fines. The legal framework also gives standing to NGOs, citizens, and other stakeholders to participate in environmental matters, and environmental education is a priority under federal law.

6.2.2 OECD Review

In 2014, the OECD conducted, at the request of Brazil, an environmental performance review of Brazil's progress in achieving environmental protection and meeting international commitments.[30] As a part of that review, the OECD found that the country's environmental laws are stringent, but implementation gaps exist, saying:

Brazil has developed a comprehensive and advanced environmental legislation framework. The financial resources and institutional capacity of federal environmental institutions have grown markedly, and interagency collaboration has improved. Progress has been made in clarifying the boundaries of environmental responsibilities across levels of government and in streamlining environmental licensing. However, licensing procedures are still reported to be excessively cumbersome, delaying important infrastructure projects. Institutional capacity varies widely across regions and is often limited, which makes effective implementation and enforcement of environmental policies challenging.[31]

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[30] OECD, 2015.

[31] OECD, 2015.

In 2021, OECD published a second document focused on Brazil's environmental policies, "*Evaluating Brazil's progress in implementing Environmental Performance Review recommendations and promoting its alignment with OECD core acquis on the environment*".[32] In this subsequent review, OECD noted that "Brazil has developed sound legislation on environmental information, water and waste management, and biodiversity. However, further efforts are needed to translate legal provisions into effective practices promoting sustainability." The review covered a broad range of environmental topics that relate to tailings management and suggested that the multiple agencies at multiple levels of government involved in environmental regulation in Brazil need to improve coordination across levels of government to better implement policies at both the national and subnational level.

6.3 Governance and Interagency Cooperation

The legal and regulatory framework in Brazil is complicated by the independent roles of the federal, state, and municipal governments and the implementation of environmental laws by separate entities from those that implement the mining laws. Due to this, there exists a significant likelihood for conflict, lapses, and delays.

Currently there are no formal procedures for coordination between the environmental and mining regulators at the federal level, and even in mining rich states such as Minas Gerais, the coordination and cooperation is informal. Even within the agencies with responsibility for aspects of the Mining and Development Program, such as CPRM, ANM, and the various offices under MME, the coordination of efforts on the 110 specific goals will require a new approach to coordination. The government should consider providing one entity with lead responsibility to convene regular coordination and establish formal policies to reduce the risks by increasing coordination. This will also allow the industry, public, government entities at all levels, investors in the minerals sector, and other stakeholders to understand how the portfolio of laws, regulations, and other requirements interact and where to seek assistance and information.

[32] OECD, 2021.

7 SOCIAL REQUIREMENTS

7.1 Introduction and International Standards

Social performance for any industry, including mining, is rooted in the goals for sustainable development, outlined in part in "*Our Common Future*" published by the United Nations World Commission on Environment and Development in 1987.[33] One of the pillars of sustainable development is the society. As mining provides significant economic impacts, one of the major issues is whether the economic benefits are shared with the local communities and affected people. As related to tailings, however, the concern is more focused on whether the risks, both economic and safety, disproportionately impact local communities.

There exist many standards and approaches to ensuring that the social concerns related to mining and other endeavors are appropriately considered and that the rights of all are protected. Additionally, most of these include aspirational aspects aimed at improving the conditions for communities that are economically disadvantaged or that are excluded from participation in decisions that have impacted their well-being throughout history. Many of these standards are focused on performance by the industry, but as for other tailings management related issues, they can serve as templates for government regulatory bodies and the public to evaluate and monitor performance and establish best practices.

7.1.1 UN Framework Principles on Human Rights and the Environment

In 2012, the United Nations Human Rights Council established a mandate for an Independent Expert on human rights and the environment (Resolution 19/10). This mandate exists to, among other things, "examine the human rights obligations relating to the enjoyment of a safe, clean, healthy, and sustainable environment."[34] This resulted in the 2018 establishment of 16 "*Framework Principles*" on Human Rights and the Environment.[35] These framework principles are focused on what the role of the governments (called States in the principles) should be in relation to human rights and the environment.

The 16 Framework Principles:

1. *States should ensure a safe, clean, healthy, and sustainable environment in order to respect, protect and fulfil human rights.*
2. *States should respect, protect and fulfil human rights in order to ensure a safe, clean, healthy and sustainable environment.*
3. *States should prohibit discrimination and ensure equal and effective protection against discrimination in relation to the enjoyment of a safe, clean, healthy, and sustainable environment.*
4. *States should provide a safe and enabling environment in which individuals, groups and organs of society that work on human rights or environmental issues can operate free from threats, harassment, intimidation, and violence.*
5. *States should respect and protect the rights to freedom of expression, association, and peaceful assembly in relation to environmental matters.*

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[33] UN, 1987.

[34] UN, 2012.

[35] UN, 2018.

6. *States should provide for education and public awareness on environmental matters.*
7. *States should provide public access to environmental information by collecting and disseminating information and by providing affordable, effective, and timely access to information to any person upon request.*
8. *To avoid undertaking or authorizing actions with environmental impacts that interfere with the full enjoyment of human rights, States should require the prior assessment of the possible environmental impacts of proposed projects and policies, including their potential effects on the enjoyment of human rights.*
9. *States should provide for and facilitate public participation in decision-making related to the environment and take the views of the public into account in the decision-making process.*
10. *States should provide for access to effective remedies for violations of human rights and domestic laws relating to the environment.*
11. *States should establish and maintain substantive environmental standards that are non-discriminatory, non-retrogressive and otherwise respect, protect and fulfil human rights.*
12. *States should ensure the effective enforcement of their environmental standards against public and private actors.*
13. *States should cooperate with each other to establish, maintain, and enforce effective international legal frameworks in order to prevent, reduce and remedy transboundary and global environmental harm that interferes with the full enjoyment of human rights.*
14. *States should take additional measures to protect the rights of those who are most vulnerable to, or at particular risk from, environmental harm, taking into account their needs, risks and capacities.*
15. *States should ensure that they comply with their obligations to indigenous peoples and members of traditional communities*
16. *States should respect, protect and fulfil human rights in the actions they take to address environmental challenges and pursue sustainable development." (UN, 2018)*

The 16 Framework Principles are of pertinence to tailings management, and the principles serve as a platform for other internationally accepted standards and frameworks for social and environmental protection.

7.1.2 UN Sustainable Development Goals

In September 2015, the United Nations General Assembly adopted "Transforming Our World: The 2030 Agenda for Sustainable Development" as an update to the previously adopted 2020 Agenda.[36] This agenda was founded on the Universal Declaration of Human Rights and other key UN resolutions and declarations and established 17 goals to be implemented by 2030 (Figure 2). Subsequently, the UN Environment Programme and the UN Development Programme jointly produced a publication, "*Managing Mining for Sustainable Development: A Sourcebook,*" which provides a roadmap of the SDGs and the role that mining can play in achieving those goals.[37] Based on the analysis included in the Report, mining has both positive and negative implications for 11 of the 17 goals, which are circled in Figure 2 below.

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[36] UN, 2015.

[37] UNDP, 2018.

Figure 2: Mining and the UN Sustainable Development Goals

The ICMM's mining framework, discussed in more detail below, also incorporates the SDGs as the goals for action. Many of the other standards discussed below also use the SDGs to navigate towards desired outcomes.

7.1.3 IFC Performance Standards

The International Finance Corporation (IFC), a part of the WBG, implements the group's environmental, health, and safety guidelines referenced above through detailed performance standards. Although the IFC's Performance Standards on Environmental and Social Sustainability are mandated for projects that are funded by the WBG, they serve as the benchmark used by other lending institutions, investors, and governments for evaluation of all kinds of projects including mining. For example, Equator Principle financial institutions also use the IFC standards.

The eight performance standards are:[38]

1. Assessment and Management of Environmental and Social Risks and Impacts;
2. Labor and Working Conditions;
3. Resource Efficiency and Pollution Prevention;
4. Community Health, Safety, and Security;

[38] IFC, 2012.

5. Land Acquisition and Involuntary Resettlement;
6. Biodiversity Conservation and Sustainable Management of Living Natural Resources;
7. Indigenous Peoples; and
8. Cultural Heritage.

Performance Standard 1 establishes the need for prior assessment of impacts, the effective involvement of the communities potentially affected by a project, and the commitment of the project to manage its environmental and social performance. The remaining standards address the environmental and social risks that a project may pose. The IFC also provides specific objectives, scopes of application, and detailed requirements for each of the performance standards. These allow for those overseeing and monitoring a project to have a checklist to use to establish expectations and to evaluate performance. The IFC standards are particularly focused on social performance issues and are founded on the UN principles and SDGs.

7.1.4 Other General Standards

While the frameworks discussed above are critical for an understanding of the international principles for all types of projects, there are groups that primarily represent the mining industry who have also developed voluntary standards that focus on the social responsibilities incumbent upon mining operations. While these are not mandates for governments or regulators, they provide good templates for evaluation of the completeness of regulatory programs for addressing social concerns.

7.2 ICMM Sustainable Development Framework

First developed in 2003, and continually updated over time, the ICMM published the framework to provide on-the-ground guidance to mining companies on incorporating sustainable development into the design and operation of mineral projects. The current ICMM "Mining Principles" document[39] builds on the 10 principles by adding performance expectations, independent assurance, and validation of performance, and articulated "Position Statements" that define the challenges that the ICMM member companies must implement. While not all mining companies are members of ICMM, the organization's guidance is seen broadly by industry as a benchmark for performance.

Several of the 10 principles incorporate social responsibility, but Principle 9 is explicitly directed towards expectations for social performance. These expectations are:

> ***Principle 9: Pursue continual improvement in social performance and contribute to the social, economic, and institutional development of host countries and communities.***
>
> *Performance expectations:*
>
> - *9.1 Implement inclusive approaches with local communities to identify their development priorities and support activities that contribute to their lasting social and economic wellbeing, in partnership with government, civil society and development agencies, as appropriate.*
> - 9.2 Enable access by local enterprises to procurement and contracting opportunities *across the project life cycle, both directly and by encouraging larger*

[39] ICMM, 2020.

contractors and suppliers, and by supporting initiatives to enhance economic opportunities for local communities.

- *9.3 Conduct stakeholder engagement based upon an analysis of the local context and provide local stakeholders with access to effective mechanisms for seeking resolution of grievances related to the company and its activities.*
- *9.4 Collaborate with government, where appropriate, to support improvements in environmental and social practices of local Artisanal and Small-scale Mining (ASM).*

Principle 10 on "Stakeholder Engagement" also outlines the need to be transparent and to report achievements as well as to support independent evaluation and performance assurance.

7.3 Global Industry Standards for Tailings Management

While the GISTM reviews the technical and management concerns related to the management of tailings, several GISTM criteria also focus on social issues. Principle 1 (Respect the rights of project-affected people and meaningfully engage them…) and Principle 15 (Publicly disclose and provide access to information about the tailings facility to support public accountability) are focused on the responsibilities of tailings management towards society.

7.4 Public Involvement

The standards discussed above have a common theme of involvement of the potentially affected public and other stakeholders in all phases of a mining operation, with an emphasis on tailings management. Note that most also explicitly talk about governance issues and the need for education of stakeholders so that their involvement can be "meaningful." The role of regulators and other independent bodies in providing assurance and validation of the activities of the operator is also clearly outlined in most of these standards. The goal of public involvement, however, is much broader than one of providing information. The goal of the standards and the expectations is aimed at ensuring that those affected or potentially affected have an opportunity to provide real input into how a tailings management facility and other aspects of a mining operation are designed and operated, and that the long-term risks posed by the operation are understood and minimized. Meaningful public involvement provides mechanisms for guaranteeing that the public knows what may happen and what steps are going to be taken so that negative outcomes are avoided.

7.5 Transparency and Accountability

As mentioned above, one of the aspects of social issues in the standards is for providing reports and independent validation that the operation, including TSFs, are designed, built, operated, monitored, and closed in ways that minimize long-term risk. The requirements of these various approaches also require that specific individuals in the operating company organization are identified as being accountable for the application of best practices.

When TSFs have failed in the past, a repeated concern has been related to the lack of transparency and accountability of not only the operating entity but also the government regulators that supervise an operation. In addition to the previously mentioned standards and activities, the United Nations has begun the process of creating a standard approach for governance in the extractive industries.

In 2020, the UNEP published “Mineral Resource Governance in the 21st Century,” which outlines a plan for creating a “Sustainable Development License to Operate” for mining. It encourages the public sector, private sector, and a “third sector” – comprised of local communities, labor groups, consumers, concerned citizens, and NGOs – to work collaboratively to enhance the contributions of the extractive sector to sustainable development.[40] The report discusses current challenges and lays out a roadmap for future improvements in mineral sector governance. Among the many building blocks of a new governance framework, the report suggests that:

> *At the national level, host governments (of mining operations) have a critical role to play, including:*
>
> - *The award of exploration and ownership rights;*
> - *Devising concession agreements that ensure companies operate responsibly;*
> - *Mainstreaming strategic environmental assessments;*
> - *Domesticating natural capital accounting;*
> - *Adequately incorporating social and environmental assessments in national and local development plans;*
> - *Designing effective fiscal regimes;*
> - *Ensuring transparency and accountability; and,*
> - *Channeling extractive rents into national and local public investment.*

A separate document, “Mineral Resource Governance and the Global Goals,” provides an overview of the issues and challenges related to mineral resource governance and sustainable management of metal and mineral resources.[41] This document outlines the steps necessary to implement UNEP/EA Resolution 19 on Minerals Resource Governance that was adopted by the fourth session of the United Nations Environment Assembly (UNEA) held in Kenya in 2019. Tailings management was one of the key priorities identified in the consultation process addressed in the report. The next meeting of the UNEA to further focus on the needs for mineral sector governance will be held in Nairobi in early 2024

7.6 Indigenous Peoples Challenges

In addition to the general social issues discussed above, indigenous peoples are often afforded additional considerations. Among those considerations, based on the United Nations Declaration on the Rights of Indigenous Peoples specified that States obtain “free, prior, and informed consent” (FPIC) before adopting measures that may affect them. While that standard is based on the UN’s declaration of human rights, it is not universal.[42] In some countries, such as Canada, it is a guarantee. The ICMM and IRMA both provide guidance to mining companies on how to engage with indigenous communities to obtain such consent. Additionally, the World Bank Group requires that its clients conduct consultation for Free, Prior, and Informed Consent (FPIC) and obtain community support before initiating a project.

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[40] UNEP, 2020.

[41] UNEP, 2020.

[42] UN, 2007.

The concept of FPIC is that an indigenous community must freely give its consent for a project that may impact them (without coercion, manipulation, or bribery) prior to the commencement of a project and be fully informed (full disclosure of all aspects of a project, both positive and negative). Many have argued that such consent should be required for all communities, but at this point, the concept has only broadly been applied to dealings with indigenous and traditional communities. Other issues include whether the consent needs to be unanimous and whether it can be withdrawn during the operation. These last points are very sticky for miners and mining investors and may cause investment to avoid certain jurisdictions.

Many countries also have national laws, regulations, and other rules that apply to projects which may impact indigenous peoples. Most of those requirements are based on an acknowledgement of the traditional ownership or use of the lands and resources that indigenous communities had prior to colonization or modern times. Often, the national government exercises fiduciary responsibility on behalf of groups, which may fall short of the ideals of involvement of the indigenous peoples and the transparency of communication needed to maintain trust.

8 CONCLUSIONS AND SUMMARY OF NEXT STEPS

The mining industry in Brazil is a key component of the economy. The government has developed plans to further expand the sector, while enhancing the requirements that mining be environmentally and socially sustainable. Mine tailings, particularly those from iron ore mining, have posed a threat to the public and environment of Brazil, and failures of TSFs over the past two decades have highlighted the shortcomings of traditional approaches to tailings management in Brazil and globally. Led by efforts of the mining industry, the UNEP, and governments around the world, new voluntary standards for tailings management and governance of the mining sector have been developed, or are under development, which provide templates/examples for Brazil and other countries. Brazil has been an active part of the ongoing conversations and has taken steps to develop and enhance their legal, regulatory, and governance framework to be consistent with international leading practices.

8.1 Key Recommendations

To increase the safety, sustainability, and effectiveness of procedures for mine closures and the use of tailings, the Deloitte team recommends that the Government of Brazil consider the following:

- **Incorporate leading practices into the Government of Brazil's mine development and management regulatory framework.** The framework should include:
    - Risk assessments of TSFs and waste rock storage that reduce the risk of ARD, failure of TSF, and other geotechnical instabilities of mine operations;
    - GISTM recommendations on transparency for regulating tailings facilities and using these recommendations for industry as a template for future regulatory efforts. The Government of Brazil would also benefit from using GISTM as a benchmark for evaluating proposed, operational, or legacy TSFs and their risks to the public and the environment;
    - Leading practices to expand opportunities for tailings reuse and tailings reduction developed by industry and academia to reduce the volume of materials that require long-term storage and management;
    - Effective mine water management (both surface and groundwater) to make mine operations safe, ensure adequate water supply to local ecosystems and communities, and mitigate water quality impacts;
    - Early and periodic review of biodiversity at mining operations;
    - Continued attention to cultural heritage issues, with assessments, rescue, and/or avoidance of sites with significant archeological or cultural importance; and
    - Additional investments in local communities so that they receive direct benefits from co-located mining projects, with particular attention to local livelihoods. The government should enhance outreach to, and the capabilities of, potentially impacted people and communities to understand and participate in the evaluation and decision-making processes related to TDFs for future, existing and closed tailings facilities.
- **Build the capacity of MME, CPRM, and ANM (e.g., appoint an "Engineer of Record" – EoR) to review and evaluate TSFs based on international standard requirements.** Applicable standards would include GISTM, and the life-cycle approach included in the Society for Mining, Metallurgy, and Exploration (SME) *Tailings Management Handbook* (SME, 2022) for design, construction, operation, monitoring, and closure of tailings facilities.

- **Implement formal coordination mechanisms between the mining functions of federal, state, and local government, and consider the benefits of intergovernmental coordination to help mitigate risks, lower costs, and improve investor confidence.** Formal processes to support intergovernmental coordination, working relationships, and regulatory decision-making would help to create a more open, transparent, and predictable environment for mining investment. Such processes would also harmonize work activities and instill greater investor confidence than the current pattern of many decisions being reached via (necessarily) informal arrangements. Through the Pro-Strategic Minerals policy (*Decree No. 10,657, of March 24, 2021, the Policy for Supporting the Environmental Licensing of Investment Projects for the Production of Strategic Minerals)*, the government is already focusing on easing the licensing process by facilitating, for example, a dialogue between the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA) – the environmental agency responsible for conducting the environmental licensing process, and authorities – such as the managing bodies of Conservation Units, the National Indian Foundation (FUNAI), the National Institute for Colonization and Agrarian Reform (INCRA), and the National Institute of Historic and Artistic Heritage (IPHAN). The government should move to formalize these arrangements, and develop a framework agreement between MME, ANM, CPRM, state, and municipal entities to integrate existing activities and standardize TDF, TFC, TSF and ESG requirements. The Government of Brazil should also consider how to streamline the manner in which the government's various mining-related entities: (i) convene regular coordination between different entities; (ii) establish/review/update formal policies to reduce risks associated with tailings; (iii) discuss leading practices and their application in Brazil, the impact of climate change and extreme weather events on the prevention of accidental water pollution from tailings; and (iv) design action plans on how to best enhance safety at different types of sites, including legacy sites.

- **Evaluate the presence of valuable constituents in coal wastes.** The relatively acidic conditions of, and relatively high concentrations of some metals in coal wastes can be challenging from an environmental standpoint. However, over the past several decades, the U.S. Department of Energy (DOE) has funded significant research into the economic potential of coal tailings and revealed them to be a potential source of rare earth metals and other critical materials. The Government of Brazil should consider creating a program to assess ongoing and in-situ coal wastes for rare earths/critical mineral, thereby evaluating whether such in-waste minerals represent a potentially economic resource. While the chemical and geologic depositional environment of Brazilian coals may be different from the United States, there is an opportunity for further research into this potential possibility.

Deloitte & Touche LLP
1919 N. Lynn Street
Arlington, VA 22209
Phone: +1 571 882 5000
Fax: +1 571 882 5100