BRIEFING - November 2025

Driving best practice in mining waste management

A global benchmarking of mining waste rules

Summary

As the world races to secure the critical minerals needed for the energy transition, military technology, and more, and new mines open across the globe, we need to ensure that mining rules globally protect people and the environment. Mining waste in particular represents one of the most significant harms and risks of mining. Therefore, robust legislation governing mining waste is key to protecting people and the planet.

Research by T&E and Earthworks shows that whilst examples of best practice in mining waste legislation exist, such as in Brazil, legislation across the board remains weak. By benchmarking legislation governing mining waste in six countries, against the *Safety First: Guidelines for Responsible Mine Tailings Management*, we explore key gaps and areas for improvement.

Overall, the research finds significant weaknesses in mining waste legislation globally. No region mandates the use of best available technologies, and all regions fail to meet all the requirements set out in *Safety First* on safe closure of tailings facilities. Nevertheless, in certain areas, some countries are leading the way. For example, Brazil has in many respects the strongest legislative framework, being the only country or region to fully ban upstream dams. Legislation in Brazil also goes the furthest when it comes to monitoring requirements, whilst the US State of Montana has some strong requirements around independent monitoring. In addition, Brazil has clear rules limiting how close a tailings facility can be to an area where people live, and China also has restrictions in this regard. Finally, almost all of the legislation analyzed in this study found that governments require some sort of financial assurance.

Taking into account the results of the research, T&E and Earthworks call on:

- All governments to take significant steps to bring mining waste legislation in line with *Safety First;*
- The European Commission to commit to a revision of the EU Extractive Waste Directive, as part of the upcoming EU Circular Economy Act, in order to bring it in line with *Safety First;*
- US Congress to reform the archaic 1872 mining law to better protect taxpayers, communities, and the environment, and align regulation with *Safety First;*
- Indonesia to close the regulatory gaps in the laws related to mine waste such as Law 32/2009 on Protection and Management of the Environment, in accordance with the guidelines set out in *Safety First;* and
- South Africa to establish a legally binding national standard for tailings storage facility (TSF) design, with clear definitions and bans on upstream and hybrid construction methods in high-consequence areas.

EARTHWORKS

T&E

1. Introduction

As demand for raw materials essential for the advancement of clean energy technologies continues to rise, and new mines open across the globe, we need to ensure that mining rules protect people and the environment.

Mining waste in particular represents one of the most significant harms and risks of mining. Safe and sustainable management of mining waste, using the best technologies available, is therefore a key dimension of responsible sourcing, ensuring community rights are respected and eliminating future safety and environmental concerns. Building on the *Safety First: Guidelines for Responsible Mine Tailings Management* is critical for driving best practice in mining waste management.

T&E and Earthworks have benchmarked various national and regional mining waste legislative frameworks against the *Safety First* guidelines, exposing significant weaknesses in mining waste legislation globally and identifying key areas for improvement across the board.

The global benchmarking compares mining waste legislation across a range of geographies:

- European Union: EU Extractive Waste Directive;
- United States: 1872 General Mining Law and state-level legislation in Arizona and Montana;
- Brazil: Federal Mining Laws nº 12.334 and nº 14.066 and the state legislation nº 23.291/2019 (Lei Mar de Lama Nunca Mais) in Minas Gerais;
- South Africa: The National Environmental Management Waste Act;
- China: Regulations on Safety Supervision and Management of Tailings Dams[1]; and
- Indonesia: Regulations on Dam Safety, Mining and Environmental Protection[2].

What are the Safety First Guidelines for Responsible Mine Tailings Management?

The *Safety First* guidelines were written by global mining experts, civil society, and academics, and have been endorsed by over 150 organisations, mining impacted communities, and Tribal governments. The guidelines explain in detail how tailing sites should be designed, managed, and closed, and set out key financial and governance provisions that should be put in place.

[1] See China: Executive Summary for details
[2] See Indonesia: Executive Summary for details

2. Key findings

Overall, mining waste legislation globally is weak and risks causing significant harm to people and the environment. Without the right protections in place, we risk seeing future dam failures such as the 2019 tailings dam collapse in Brumadinho, Brazil which killed 272 people, or the 2022 failure in Jagersfontein, South Africa which destroyed over 160 homes and left five people dead.

From a lack of mandating of best available technologies to limited monitoring systems in place, the analysis demonstrates where rules are falling behind best practice across the globe. Nevertheless, there are some examples of specific regions leading the way in measures to address mining waste management, as well as the development of innovative technologies which can ensure safe and sustainable tailings management. For example, Brazil is the only country or region to fully ban upstream dams.

A comparison of mining waste legislation

✔ Yes ✘ No

Safety First Guideline	EU	US	Montana	Brazil	Indonesia	China	South Africa
Ban upstream dams at new mines	✘	✘	✘	✔	✘	Limited	✘
Mandate Best Available Technology	✘	✘	Some	✘	✘	✘	✘
Require Adaptive Management Plans (AMP) for monitoring tailings	✘	✘	Most	✔	✘	Some	✘
Require an Independent Tailings Review Board (ITRB)	✘	✘	✔	Most	Some	✘	✘
Make information publicly available	EIA only	✘	Some	Most	✘	EIA only	✘
Ban new tailings facilities where inhabited areas are in the path of a failure	✘	✘	Limited	✔	✘	✔	✘

Source: Consultant analysis of legislation governing mining waste

2.1 Banning upstream dams and limiting proximity to inhabited areas

Upstream dams are prone to failure because they are built on uncompacted tailings, making their structure more susceptible to collapse. However, they continue to be used in numerous mining waste facilities across the world, despite the fact that safer alternatives exist. According to *Safety First*, the structural zone of a filtered tailings stack must not be constructed on top of uncompacted or lightly-compacted filtered tailings. If it is, it would be an upstream dam and must be prohibited. As such, the guidelines recommend banning upstream dams at new mines and closing existing upstream facilities. Nevertheless, according to the study, **Brazil is the only country or region to fully ban such dams and mandate the decommissioning of existing upstream dams.** This shows that such an approach is feasible, despite not being widely mandated. In China, though upstream tailings dams are not banned outright, national legislation sets out certain requirements in terms of site selection, design, and ongoing risk management. Although not included in this review, Chile, Ecuador, and Peru have also banned the use of upstream dams.

In parallel, few regions include restrictions on tailings facilities being built where inhabited areas are in the path of a tailings dam failure. There are no such requirements in the EU, South Africa, or Indonesia. In China, it is strictly prohibited to build new "overhead ponds," the specific phrase for upstream dams, where inhabited areas are in the path of a tailings dam failure. It is also prohibited to build new residential areas, industrial and mining enterprises, trade markets, leisure and fitness entertainment plazas, and other types of infrastructure with crowds of people within 1 kilometer downstream of an existing tailings pond. In addition, federal and state-level mining legislation in Brazil requires studies and mapping to determine "self-rescue zones." The self-rescue zone is the zone in which no help can be expected from the outside in the event of a tailings dam failure. State-level regulation in Minas Gerais defines the self-rescue zone as the zone extending 10 kilometers downstream from the dam along the course of the valley, or the zone that can be reached by the tailings flood within 30 minutes, whichever is farther. The regulatory authorities can extend the zone up to 25 kilometers depending upon the population density and the area's natural and cultural heritage. It is illegal to construct or expand new tailings dams where there is a population residing within the self-rescue zone. However, existing upstream dams may be raised or increase in volume. In the US State of Montana, zones of influence are identified to a lesser extent. The permit application must identify residences, which would capture populations below the mine's operations. Safe and timely evacuation would inherently be considered, but is subject to regulatory discretion.

2.2 Mandating best available technologies

Alternate technologies are available to ensure safe and sustainable tailings management, though they are rarely mandated. Certain techniques and technologies for storing tailings, such as filtered tailings (sometimes referred to as "dry stack") and backfilling can help minimize risk and limit harm. According to the *Safety First* guidelines, all new mines that create tailings must

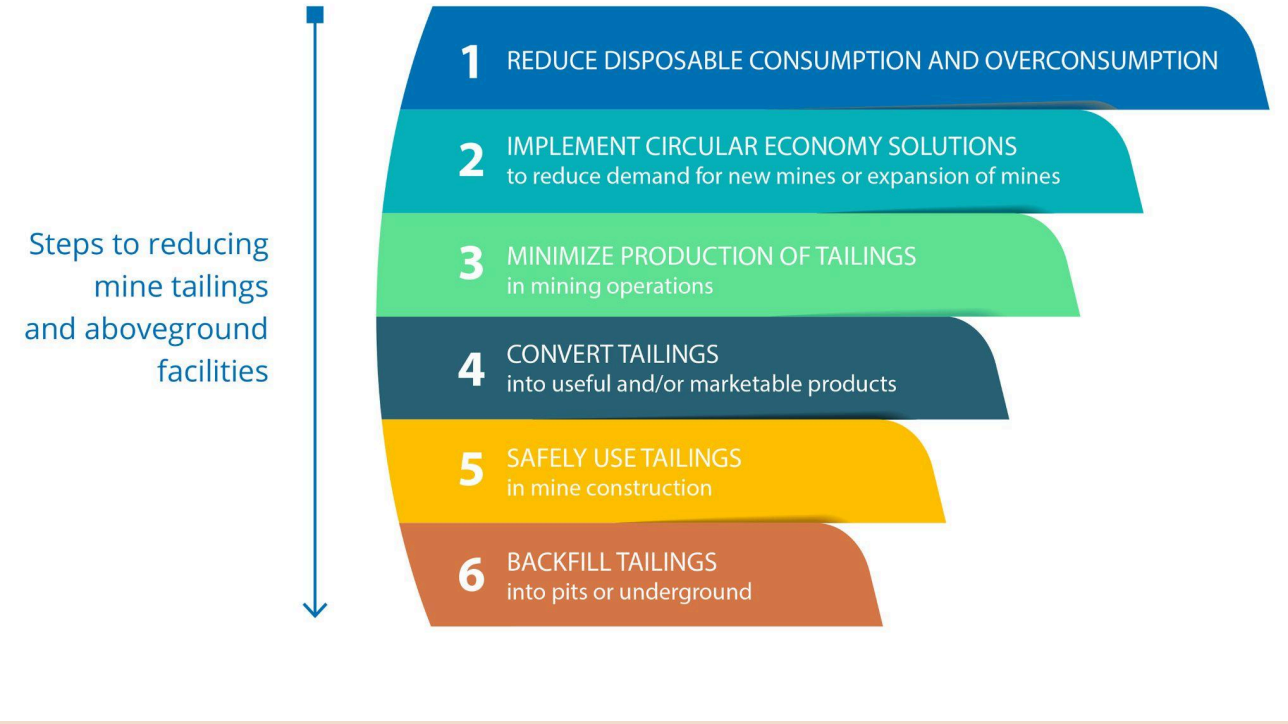
begin with an analysis of the best available technology (BAT) for tailings disposal. Whilst best available technology and practices in tailings management will continue to change, the goal of BAT for tailings management is to assure physical stability of the tailings deposit.

The analysis of the six regions found no instances where BATs are mandated. After the tailings dam failure at the Mount Polley Mine in British Columbia, Canada, an expert panel produced a report that outlined a number of Best Available Technologies for tailings management. The EU Best Available Techniques (BAT) Reference Document for the Management of Waste from Extractive Industries (MWEI BREF) does set out some recommendations on the use of BATs, though they are not mandated. In addition, filtered tailings and backfilling are only listed as options to be considered amongst others, and are in some cases incorrectly described. Montana has tailings impoundment requirements that could reasonably, or should reasonably, capture many important features in *Safety First* and/or the Mount Polley Investigation's BATs. However, specific BATs are not described in detail and the processes employed in Montana are subject to regulators' interpretation and application, which may be subjective. Arizona does not require best practices for tailings impoundment designs but it does include best practices as an element of permitting regulators' considerations. Finally, in China, whilst BATs are not mandated, companies are encouraged to apply advanced and applicable technologies such as online monitoring of tailings dams, tailings filling, dry tailings discharge, and comprehensive utilization of tailings. In all cases, the lack of specific requirements on the implementation of BAT leaves decisions on if and how to implement BAT at the discretion of regulators and mining companies, which can lead to significant discrepancies.

Spotlight on Best Available Techniques

Reducing the water content in a tailings facility increases safety because it reduces both the probability and consequences of a tailings dam failure. Filtered tailings refers to the process of dewatering the tailings such that they behave like moist soil, achieved by thickening followed by vacuum or pressure filtration. Filtered tailings can be compacted in the tailings facility, which reduces the likelihood of failure.

Additionally, best available technology includes reducing the amount of tailings stored above ground as much as possible. Backfilling refers to the process of depositing tailing into unused mining shafts or open pits, instead of storing them behind dams.



2.3 Appropriate monitoring systems and Independent Review

Appropriate monitoring systems at tailings facilities are key to identifying and mitigating risk. According to *Safety First*, tailings facilities must also have a clearly defined Adaptive Management Plan (AMP) linked to tailings monitoring results that encompasses a complete set of predictions and pre-planned actions. **Nevertheless, their enforcement in legislation is limited.** Indonesia and South Africa set out no requirements on independent monitoring of tailings facilities. At the federal level in the US, there are no requirements. However, in the State of Montana, the annual reviews and operational manuals could be interpreted as meeting much of the AMP criteria. Similarly, the EU Extractive Waste Directive is very limited in its requirements on monitoring. The accompanying MWEI BREF document does set out stronger recommendations, although they are not mandatory. In China, the Safety Regulation for Tailings Ponds gives fairly detailed stipulations on monitoring systems, although not all criteria for AMPs, as detailed in *Safety First*, are met. Legislation in Brazil goes the furthest in requiring AMPs. Although national legislation does not directly cite the term "Adaptive Management Plans," it clearly includes requirements for management and monitoring practices, and numeric and measurable performance criteria based on predictions of engineering behavior.

According to *Safety First*, monitoring and review of tailings dams should include the evaluation of all aspects of the design, construction, operation, and maintenance by a group of competent, objective, third-party reviewers (e.g., an Independent Tailings Review Board (ITRB)). This ensures aspects related to mine safety are adequately and independently verified. **This study**

found that half the jurisdictions analyzed do not require ITRB assessments. Indonesia requires an ITRB but only in cases where the height of the dam is over 75 meters with a storage capacity over 100 million cubic meters, or for dams that have “complex engineering problems” or are “implementing new technology.” However, because the latter lack specific definitions, there is considerable latitude for all but the largest tailings dams to forgo the advice of an independent expert review panel. Montana requires an Independent Review Panel consisting of a majority of licensed engineers who are tasked with certifying that dams are operating as designed. Depending on the risk category and potential damages caused by a dam failure, federal legislation in Brazil requires a multi-disciplinary team carry out inspections of some tailings dams during the construction, operation, and decommissioning phases, and produce a report with specific instructions for the mining company. Finally, the EU does not specifically require an ITRB, but independent review and oversight of waste facilities and their components are mentioned. For example, independent or "third-party" review and oversight is discussed, rather than mandated, in the MWEI BREF and usually by an implied single expert rather than a board.

2.4 Ensuring safe closure

It is key that the closure of tailings facilities is a factor in their initial design and siting. According to *Safety First*, a tailings facility is safely closed when deposition of tailings has ceased and all closure activities have been completed so that the facility requires only routine monitoring, inspection, and maintenance in perpetuity, or until there are no credible failure modes. This analysis explores how closure is addressed across the various regional, national, and local legislation. **Whilst legislation in all regions approaches the closure of tailings facilities in some form, across the board, the approaches fail to meet all the requirements set out in the *Safety First* guidelines.**

In China, Article 8 of the 2020 Safety Regulation for Tailings Ponds sets out reasonably detailed requirements for safe closure and post closure monitoring. However, closure plans are not linked specifically to the initial permitting, and it does not require operating companies to present transparent documentation on the estimated cost of mine site cleanup, including closure and reclamation. Indonesia and South Africa require closure plans be developed during siting and design (during the permitting process), though the requirements for such plans are very weak. Montana requires limited closure plans during the permitting process but detailed, full-scale closure plans are not required until later in the mine's life, while Arizona requires a reclamation plan but not a closure plan during permitting. Requirements on safe closure of tailings facilities are perhaps strongest in Brazil and the EU. Several elements of legislation in Brazil are aligned with *Safety First,* especially regarding the need for stability and post-closure monitoring. However, the legal framework is more conceptual than technical-operational, and does not explicitly mention “no credible failure mode” or “perpetual maintenance” as described in the guidelines. The EU requires closure plans to be developed during siting and design, and defines closure in a manner consistent with *Safety First*. However, there are no requirements on

assessments by regulatory agencies related to safe closure, and much is left at the discretion of the competent authority.

If a tailings dam is abandoned by a mining company, the responsibility for keeping communities and the environment safe falls to the government. The US Environmental Protection Agency (EPA) estimates $20—$54 billion is needed to clean up the over 500,000 abandoned mines in the Western US. Therefore, *Safety First* states companies must prove to regulators they have the financial capacity, through financial assurance, to safely close the mine, and regulators should not allow operating companies to declare bankruptcy or sell to junior companies to avoid closure monitoring and liability. **Almost all of the legislation analyzed in this study found that governments require some sort of financial assurance.** The exceptions were China and federal legislation in Brazil, although state-level legislation in Minas Gerais does require financial assurance. Indonesia imposes strong penalties for failure to carry out reclamation or to deposit reclamation funds, including the option of imprisonment. South Africa, Indonesia, and Arizona have no provisions to stop companies from declaring bankruptcy to avoid closure costs. At the EU level, bonding or other forms of financial assurance are required and must be in place before operations begin. However, whilst the European Commission (2021) Guidelines for Mine Closure Activities and Calculation and Periodic Adjustment of Financial Guarantees presents the pros and cons of possible financial instruments, it does not require that they be independently guaranteed or reliable.

2.5 Addressing climate risks

Climate change creates unpredictable weather patterns and increased severity of rainfall, which exacerbate the risk and consequences of tailings dam failures. Upstream dams are especially problematic in wet climate areas, particularly as weather events become increasingly severe with climate change. Tailings dams design and operation should account for expected and possible weather patterns in a given area, but climate change is bringing unexpected weather conditions across the globe. This creates added risk for tailings dams, especially those that may be decades old. *Safety First* says that all modeling and design for floods must take climate change into account, for both closed and operating facilities. **None of the legislation reviewed in this study required that mining companies take climate change into account for modeling and design of tailings dams.** However, the EU MWEI BREF does include consideration of the effects of climate change as a best practice in tailings dam siting, design, and management. Nevertheless, the MWEI BREF document is non-binding and only serves as guidance to competent authorities and so has limited impact.

2.6 Making information public

Resources are unequally distributed between mining companies, affected communities, and rights holders. To ensure meaningful engagement, rights holders and affected communities

must have access to credible, accurate, accessible information in a timely manner. *Safety First* states that governments and regulators must make all information relevant to the safety and stability of tailings facilities publicly available, at no charge, as soon as possible, in one or more languages as necessary, in an accessible format, and in plain language whenever possible to afford adequate access for all interested stakeholders. **None of the legislation reviewed requires making all documents related to safety and stability available**. Most jurisdictions require that environmental impact assessments either be published or made available upon request, with Indonesia as the exception. Brazil has the most extensive publicly available documentation, including a national registry of dams with hazard classifications and the publication of Emergency Action Plans and Dam Safety Reviews, as well as requiring information about tailings failures be made available to the public. However, Brazil does not meet the full scope of safety documents laid out in *Safety First*. At the EU level, under the Aarhus Convention, the public's right to to receive environmental information held by public authorities, including on policies or measures affecting the environment, is protected.

3. Recommendations

3.1 What is needed to drive safer management of mining waste?

What is clear is that legislation and regulations around the world have significant gaps when it comes to the protection of communities and the environment from dangerous tailings facilities.

Because there is no comprehensive global inventory of tailings facilities, governments should take responsibility for creating publicly-available registries that identify the locations, and potential risks and impacts, of all tailings facilities in their jurisdictions. Most jurisdictions have limited or no publicly available data that lays out the full scope of risks presented by tailings.

Governments must take significant steps to:

- Ensure the use of BAT, and phase out riskier practices like the use of upstream dams;
- Require companies to have internal monitoring systems that appropriately assess and respond to risk, as well as independent third-party review to verify the safety and stability of facilities;
- Establish mechanisms to make information regarding tailings safety publicly available;
- Have systems in place that ensure tailings dams are safely closed and that liabilities are not passed off to local governments or communities;
- Create buffer zones so that tailings failures do not endanger nearby communities; and
- Ensure companies are appropriately addressing the new risks and uncertainties posed by climate change.

What this analysis also makes clear is that in many jurisdictions, there is a breach between what is written on paper and what is done in practice. In some cases this is the result of giving

discretionary oversight to regulators instead of writing specific mandates into statute, as in many instances in Montana and Arizona or in the MWEI BREF for the EU. In other jurisdictions regulators are simply not enforcing the laws, as shown in the mining corruption scandal in Brazil (see Brazil Executive Summary for details). All tailings oversight must have specific, clear, actionable guidance for regulators, and legislation must include penalties and remedy when mining harms communities and ecosystems.

3.2 Policy recommendations for the European Union

- The European Commission must commit to a revision of the EU Extractive Waste Directive, as part of the upcoming EU Circular Economy Act, in order to bring it in line with global best practice, by:
    - Turning the directive into a new European Extractive Waste Regulation to ensure harmonised implementation across Member States;
    - Mandating the accompanying MWEI BREF document to ensure best available techniques are required, including dry stacking and backfilling, as well as banning upstream dams; and
    - Ensure objective harmonised principles throughout the legislation, including with regards to the proximity of a facility to an inhabited area and facility closure.
- The MWEI BREF should be updated to clearly establish dry stacking and backfilling as BATs, as well as including best practice on independent monitoring and closure.

3.3 Policy recommendations for the United States

- Congress must reform the archaic 1872 mining law to better protect taxpayers, communities, and the environment, and align regulation with *Safety First* guidelines. As noted in Annex I, the US was the only jurisdiction analyzed for this report where federal mining legislation failed to meet every single criteria established in *Safety First*.
- Congress needs to close the hazardous waste loophole for mine tailings. The Resource Conservation and Recovery Act (RCRA) Subtitle C (hazardous waste) categorically exempts mine tailings, instead calling them "solid wastes" under Subtitle D. Metals like arsenic, lead, cadmium, and others EPA considers toxic and characteristic of hazardous waste are present in tailings. Closing this RCRA C loophole would align the law with the science. Waste from the exploration and production of oil and natural gas contains a similar loophole.
- The EPA and Army Corps of Engineers need to close two Clean Water Act (CWA) loopholes that allow for tailings disposal into the waters of the US. The CWA should not label mine tailings as "fill material" (i.e. wood chips or construction materials) for disposal in "waste treatment systems" (rivers, lakes, and streams). If Congress decides mine waste is hazardous, operators should not dump it in water.

- The EPA should update their Toxics Release Inventory (TRI) to include identification of the waste sources (e.g., tailings, waste rock); total volume of waste and grade estimates; and basic metallurgical evaluation of wastes, especially mineral liberation and potential processing methods. The TRI metals list should conform to the US Department of Energy's critical material and US Geological Survey's critical minerals lists by adding lithium, Rare Earth Elements (REEs) aluminum, and zinc (for releases to land and water).

3.4 Policy recommendations for Indonesia

- Close the regulatory gaps in the laws related to mine waste such as Law 32/2009 on Protection and Management of the Environment, Law 24/2007 on Disaster Management, Mining Law 3/2020 and Amendments to Law Number 4 of 2009, Government Regulation (GR) 37/2010 on Dams, GR 27/2020 on the Utilization of Hazardous and Toxic Waste, GR 22/2021 on Implementation of Environmental Protection and Management in accordance with the guidelines set out in *Safety First*.
- Require mining and processing companies to publicly disclose the location of all tailings facilities and all information related to their safety and stability. In the case of tailings failures, require companies to immediately make the location, date, volume, and environmental and social impacts publicly available.
- Increase the capacity of environmental officials to conduct regular inspections to ensure the safe management of existing tailings facilities, and to assess social and environmental impacts and operational governance of the facilities.
    - Regularly publish the outcome of these inspections and assessments of facilities' social and environmental impacts.
    - Establish baseline water quality data during the permitting phase, before mining and processing begins, and regularly collect and publish water quality data as operations continue.
- Increase the capacity of relevant agencies to enforce fines and other penalties for non-compliance with regulations.

3.5 Policy recommendations for South Africa

- Establish a legally-binding national standard for tailings storage facility (TSF) design, with clear definitions and bans on upstream and hybrid construction methods in high-consequence areas. This standard should institute a prohibition of tailings dams built over shallow aquifers or near populated areas.
- Strengthen the public registry of all TSFs, with classification, ownership, design type, risk level, and hazard maps. The registry should be a tool to ensure greater compliance by mining companies.
- Establish a National Tailings Liability Fund backed by levies or bonding, managed independently, to guarantee funding for emergency response and long-term monitoring.
- Mandate independent oversight of tailings design, construction, and monitoring.

- Strengthen interagency coordination among the Department of Mineral and Petroleum Resources, the Department of Water and Sanitation, and local municipalities, with shared emergency response authority.
- Mandate community involvement in TSF oversight and disaster preparedness, including transparent information sharing and mandatory early warning systems.
- Establish a formal seat for civil society organizations on an advisory team that will monitor compliance through developing measures to improve transparency and accountability.

Further information

Emily Ritchey

Policy Manager, Supply Chains

Transport & Environment

emily.ritchey@transportenvironment.org

Jan Morrill

Tailings Campaign Manager

Earthworks

jmorrill@earthworksaction.org

Annex

I. A Note on Federal US Mining Law

In the US, the 1872 Mining Law, designed to encourage colonial expansion and development of the West, still governs hardrock mining on federal public lands: 350 million acres, mostly in the Rocky Mountain West and Alaska. This is more than 15% of all the land in the country. Its provisions focus on exploring and claiming mineral resources on US federal lands and lack any specifications on actual mining or reclamation methods, and do not mention mine waste or tailings at all and privatize public lands to dispose of mine waste. The law is out of touch and out of scale with modern industrial hardrock mining, and desperately needs to be updated. There are other US federal provisions, such as the Clean Air Act, Clean Water Act, Resource Conservation and Recovery Act, Endangered Species Act, and others that apply to all mines, on public or private lands, possibly taking up some of the deficiencies in the well-aged law, but the US was the only jurisdiction analyzed for this report where federal mining legislation failed to meet a single criteria established in *Safety First*.

II. Further information on research

EU: Ann Maest, PhD, Buka Environmental and Alejandra Torres, JD

China: Bambu Consulting, prepared by Beibei Yin and Colin Reobertson

Brazil: The Instituto Fórum Permanente São Francisco with the collaboration of Daniela Campolina, Letícia Camarano and Julio Grillo

Indonesia: Malach Consulting

United States, Montana, and Arizona: The Center for Science in Public Participation, prepared by Stu Levit

South Africa: Nathi Mjenxane