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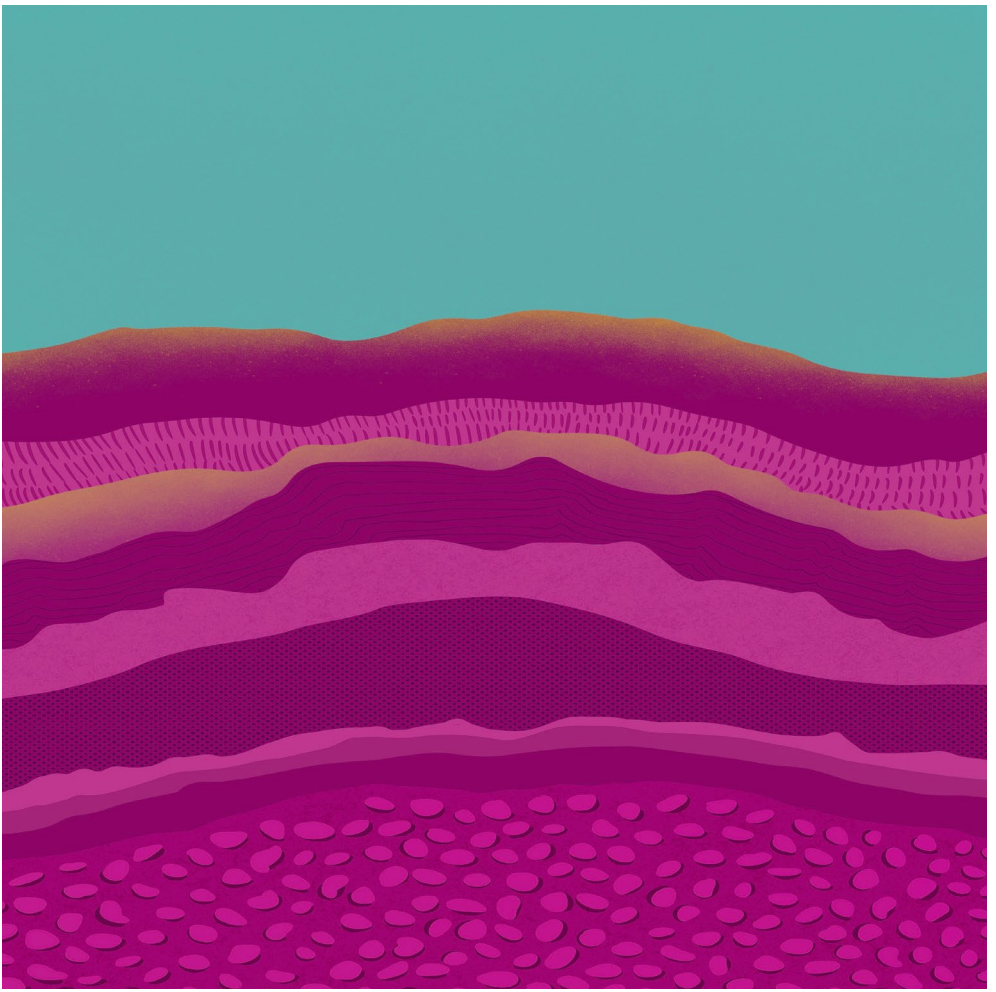
Waste Not

Unlocking critical and strategic mineral opportunities in Canada's tailings

JEFFREY COLLINS, ALEX COOL-FERGUS, ISABELLE GODIN, DAVIS LEVINE, LISA MAH, AND AARON PINTO



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Executive Summary

Canada is sitting on an untapped multibillion-dollar resource hidden in its mine tailings – critical and strategic minerals essential for the green economy, digital technologies and national defence.

With global demand for these minerals skyrocketing, re-mining tailings offers Canada a unique opportunity to boost its domestic supply chains, reduce environmental liabilities, and drive economic growth. This report examines the potential of re-mining active and abandoned mine tailings in Canada, identifies key barriers to mineral recovery, and proposes policy recommendations to unlock their value.

KEY FINDINGS:

» Canada's mine tailings are an underutilized resource for critical and strategic minerals, key for the green economy and national security.

» Regulatory hurdles, financial risks, economic feasibility, technological gaps, and the need for greater collaboration among stakeholders are barriers to enable re-mining.

» Re-mining could support remediation of Orphaned and Abandoned Mine (OAM) sites, reduce environmental risks, and generate economic benefits, including for Indigenous communities, through the recovery of valuable minerals.

RECOMMENDATIONS:

» **Advancing a National Tailings Inventory:** Build on efforts to create a centralized, publicly accessible database for tailings waste. Actions include enhancing data collection, standardizing methodologies, and integrating Indigenous knowledge.

» **Implementing Regulatory Reforms and a Re-Mining Policy Framework:** Create a purpose built regulatory framework for re-mining, streamline permitting, and introduce regulatory sandboxes for innovation. This includes harmonizing critical mineral definitions, developing taxation incentives, and ensuring Indigenous engagement.

» **Incentivizing Innovation and Collaboration:** Provide incentives for re-mining technologies, sustainable practices, and foster collaboration. Support R&D, pilot projects, and global best practices for tailings characterization.

"The sun provides raw energy, but electricity flows through copper...simply put, there is no energy transition without critical minerals."

2022 CANADIAN CRITICAL MINERALS STRATEGY

The Opportunity

To limit global warming to 1.5°C from pre-industrial levels, the world must undergo an unprecedented transformation of energy systems.

A billion machines[1], from vehicles to industrial equipment, will need to shift from fossil fuels to battery-powered technologies, requiring over 3 billion tonnes of minerals and metals.[2] The International Energy Agency (IEA) projects that demand for critical and strategic minerals will triple by 2030.[3]

Although sometimes used interchangeably, critical minerals and strategic minerals are separate terms. The former refers to minerals deemed essential for the functioning of key industries such as renewable energy systems, electric vehicle batteries and advanced electronics. Strategic minerals hold broader geopolitical or national security importance. They're deemed essential by governments because they are vital for economic stability, technological innovation, and defence capabilities.

A country's critical and strategic mineral list is thus shaped by differing economic priorities, technological needs and vulnerabilities.

Canada's key federal policy on this subject, the 2022 Canadian Critical Minerals Strategy,[4] lists minerals like silicon metal, nickel, lithium and rare earth elements (REEs) as both driving economic transition and securing this country's role as a key, sustainable player in global supply chains.

Those supply chains are fragile. With China as the dominant global supplier[5] of critical minerals, mounting geopolitical tensions and the risk of supply disruptions underscore the urgent need for secure, diversified and responsibly sourced critical and strategic minerals.

Canada is uniquely positioned to lead in this space. With some of the world's largest deposits of critical and strategic minerals[6] – like uranium, niobium, and aluminum – and a robust mining sector that supports over 625,000 jobs and contributes $100 billion annually to GDP,[7] Canada already plays a key role in global supply chains. As the energy transition accelerates, demand will only grow.

Yet, Canada's mining sector faces significant challenges. Establishing new mines is a slow and capital-intensive process

requiring, on average, 18 years,[8] and tens to hundreds of millions of dollars in investment to become operational. Fragmented jurisdictional powers, labour shortages and limited domestic capital further hinder new development. Mining's environmental and social risks, including land and water contamination, greenhouse gas emissions and conflicts with Indigenous treaty and constitutional rights cast a dark shadow on such an important industry.

And mining is an inherently inefficient process; certain types of ore mining yield less than 1 percent usable material.[9] For every tonne of metal extracted and produced, between 20 to 200 tonnes of solid waste[10] are deposited into tailings, the by-product of mineral extraction and ore processing. These tailings sit, mixed with water, ground rock and residual chemicals in giant tailings ponds, or in massive heaps, posing a major environmental liability. The federal government's[11] liability for these sites in 2024 was estimated at $10 billion.[12]

Canada's Critical Minerals List Identifies 34 Minerals and Metals

- Aluminum
- Antimony
- Bismuth
- Celsium
- Chromium
- Cobalt
- Copper
- Fluorspar
- Gallium
- Germanium
- Graphite
- Helium
- High-purity iron ore
- Indium
- Lithium
- Magnesium
- Magnesium
- Molybdenum
- Nickel
- Niobium
- Phosphorous
- Platinum group metals
- Potash
- Rare earth metals
- Scandium
- Silicon metal
- Tantalum
- Tellurium
- Tin
- Titanium
- Tungsten
- Uranium
- Vanadium
- Zinc

FROM LIABILITY TO ASSET

But mine waste is also a substantial untapped resource (see Appendix A). Sudbury's decades-old tailings alone could hold $8 to $10 billion worth of nickel,[13] with some entities suggesting an even larger economic windfall.[14] An additional $10 billion of metal value[15] is estimated to be in Canada's gold mine waste, with researchers conservatively estimating that 80 percent of this value could be recovered.[16] On a global scale, the Minerals Research Institute of Western Australia[17] puts the global value of precious, critical and strategic metals in tailings at over US$3.4 trillion.

Mining tailings produce a wide variety of mineral by-products, which vary significantly in composition, origin and management challenges. Different primary metal deposits and their tailings, for example, will produce different critical minerals as by-products. A critical mineral like copper typically comes in deposits containing several other critical minerals like tellurium (Te), rhenium (Re), tin (Sn), cobalt (Co), bismuth (Bi), uranium (U), indium (In), barite (Ba) and arsenic (As). Notably, Canada has 39 active copper operations[18] and a recorded 987 historical mine sites[19] where copper was a primary commodity.

Extracting these overlooked minerals from tailings, a process known as re-mining, involves recovering critical and strategic minerals from tailings at operating mines or orphaned and abandoned mines (OAMs). Re-mining alone cannot meet the world's growing demand for critical and strategic minerals, but it offers several key benefits:

- Alleviating supply pressures while new mines are in development;
- Reducing waste materials from active mines;
- Driving remediation and clean-up of legacy sites; and
- Lowering operational costs[20] compared to mining new ore.
- Re-mining also has the potential to drive technological innovation, create economic opportunities – particularly in partnership with Indigenous communities – and position Canada as a global leader in sustainable mineral sourcing.

Despite its promise, re-mining in Canada remains underdeveloped.[21] Domestic initiatives are limited, and the commercialization and adoption of innovative technologies are lagging. This report argues that re-mining could be a critical component of a diversified strategy to secure Canada's place in the global critical and strategic minerals supply chain, complementing traditional mining.

It could turn mine waste, currently a social and environmental liability, into an economic asset. It explores some key public policy solutions to catalyze re-mining practices in Canada. The report specifically addresses the following key questions:

» How can re-mining address some of the gaps in the current critical and strategic minerals supply chain?

» How can governments in Canada balance the economic benefits of re-mining with environmental impacts, social responsibilities and Indigenous rights?

» What innovations can drive re-mining advancements, and how can these be integrated into existing frameworks?

» What policies can federal, provincial and territorial governments introduce to advance re-mining practices?

TWO PATHWAYS FOR OPPORTUNITY

Tailings represent the largest waste stream by volume in mining operations and contain significant concentrations of unrecovered metals and minerals.

In Canada, tailings are ubiquitous across an estimated 10,000 abandoned[22] mines and 200 operational mines. Operating mine tailings and OAMs present different challenges and opportunities.

OPERATING MINE TAILINGS

Operating mine tailings are produced from active mining operations, including those extracting metals, uranium, oil sands and other minerals. These tailings are typically stored in tailings storage areas near mine sites and are managed by the mine operators under established operational, regulatory and remediation frameworks.

Tailings from active mining sites could provide an additional resource stream, leveraging existing infrastructure and improving operational efficiencies. By integrating modern technologies such as hydrometallurgical and biomining methods, mining companies can extract valuable minerals that were previously unrecoverable, thereby extending the life of their operations and diversifying revenue sources. Since active mines are already mandated to address tailings management under regulatory frameworks, re-mining

can be seamlessly integrated into existing remediation plans.

ORPHANED AND ABANDONED MINE TAILINGS

OAM tailings come from sites where mining activities have ceased, and no responsible owner can be found or compelled to remediate the site.[23] These tailings are common in legacy mining regions like Ontario, Quebec and British Columbia. Due to inadequate containment or insufficient remediation, OAM tailings often pose significant risks to ecosystems and nearby communities, often requiring government intervention for remediation and long-term environmental protection.

At OAM sites, re-mining offers even greater economic potential. These sites often house tailings with higher concentrations[24] of valuable minerals that were overlooked or deemed uneconomical to recover with previous technologies. Advances in extraction methods now enable the recovery of these resources, unlocking economic value while addressing the environmental and social liabilities. Re-mining tailings at OAM sites also reduces some of the need for new mining operations, aligning with sustainability goals.

OAM Case Study
Perpetua Resources' Stibnite Gold Project

Perpetua Resources' Stibnite Gold Project in Idaho demonstrates the potential for re-mining waste at a historic mine site to both recover critical minerals and clean up environmental damage. The project aims to create a domestic supply of antimony (Sb), a critical mineral that can be found in deposits of gold (Au).

In 1899, when mine operations first started in the region, critical minerals like antimony were not as valued as gold deposits. Over the years, antimony has come to be used in a variety of commercial applications like batteries and military equipment.

With the price of antimony surging 200 percent in 2024, and with additional gains expected in 2025, Canada's vast gold deposits, which account for 12 percent of tailings in Canada, could see opportunities in antimony recovery at historic mine sites similar to the Stibnite Gold project in Idaho.

REGULATORY LANDSCAPE FOR TAILINGS

The management of mine tailings in Canada is complex due to shared responsibilities between federal, provincial and territorial governments, and Indigenous rights-holders. Provinces and territories[25] are primarily responsible for exploration, development and extraction of mineral resources, as well as the construction, operations, reclamation and closure of mine sites within their jurisdictions.

Meanwhile, the federal government plays a key role in overseeing broader environmental impacts. Natural Resources Canada (NRCan)[26] promotes research on greener technologies and developed a Compendium of Tailings Management[27] to share knowledge and best practices. Agencies like Environment and Climate Change Canada (ECCC)[28] and the Canadian Nuclear Safety Commission (CNSC)[29] oversee tailings that may pose environmental or radioactive risks, while Fisheries and Oceans Canada (DFO)[30] regulates the release of tailings into water bodies.

While Canada has various regulations addressing mining activities and environmental management – such as the Metal and Diamond Mining Effluent Regulations (MDMER)[31] and provincial legislation – there is no specific, unified regulatory framework dedicated solely to the comprehensive management of mine waste. Existing federal, provincial and territorial regulations primarily focus on specific aspects like water quality, tailings discharge or environmental impacts, rather than a holistic approach.

The regulatory landscape also emphasizes the importance of Indigenous consultation and consent, ensuring that communities are engaged in decisions related to mining activities and tailings management. This evolving regulatory framework aims to balance environmental sustainability, Indigenous rights, and economic development.

DRIVING TOWARD RE-MINING IN CANADA

To enable the potential of re-mining, policy needs to shift from its emphasis on waste management and remediation to incentivizing mineral recovery from tailings. A number of such efforts are underway, with Ontario being the current leader in Canada in actively amending its legislation and regulation.

Other governments, programs and industry examples are working toward or acknowledging the potential value of re-mining.

Several companies are already actively engaged in re-mining efforts in Canada. Rio Tinto partnered[32] with RESOLVE[33] in launching Regeneration[34] to advance

tailings recovery, capitalizing on this process to create a branded product of responsibly sourced materials.[35] Technology companies like CVW Cleantech[36] are targeting oil sands tailings, seeking to recover critical minerals like titanium and zircon.

Nord Precious Metals is in the process of applying for a recovery permit in Ontario[37] to reprocess historic mine wastes of silver tailings. Additionally, 1911 Gold received support from the Manitoba Mineral Development Fund[38] to fund start-up costs related to tailings re-mining operations. These industry players are paving the way for re-mining in Canada, demonstrating that the sector is already moving toward more sustainable and responsible practices.

Despite these promising developments, a national strategy is needed to fully capitalize on this potential. A cohesive set of regulations and incentives at the federal level would help streamline the recovery process, ensuring that re-mining tailings is not just a possibility but a fully realized industry.

While federal action is critical, provinces and territories also play an essential role in advancing re-mining initiatives. Provincial and territorial governments, with their jurisdiction over natural resources, environmental management, and local economic development, must continue to implement and support targeted policies and incentive programs. By collaborating across federal, provincial and territorial levels, Canada can create a unified and supportive environment for re-mining.

PROVINCE / INSTITUTION	ACTIONS / PROGRAMS
Ontario	» New regulation under the Mining Act makes it easier to recover residual metals and minerals from mine waste » Building More Mines Act reduces rehabilitation requirements for re-mining
Saskatchewan	The Saskatchewan Research Council is investing in recovery of rare earth oxides from radioactive tailings
Quebec	Support Program financing includes recovery of critical and strategic minerals from tailings
Newfoundland and Labrador	Critical Mineral Plan acknowledges mining value from waste
CanmetMINING (NRCan)	CanmetMINING conducts research on critical minerals recovery from mine tailings and launched the Mining Value from Waste research program in 2017
MIRARCO (Mining Innovation, Rehabilitation, and Applied Research Corporation)	Focuses on innovative technologies for resource recovery and mine rehabilitation in Ontario
National Orphaned and Abandoned Mines Initiative (NOAMI)	Replaced by the Annual Orphaned and Abandoned Mines Workshop (2022) organized under the Canadian Minerals and Metals Plan (CMMP), NOAMI continues to improve the management, reclamation, and recovery of tailings

The Challenges

TECHNOLOGY HURDLES

Re-mining tailings presents significant technical hurdles due to the complex, heterogeneous nature of tailings. The mineralogical and geochemical composition varies widely across mine sites,[39] meaning there can be no single standardized recovery method. Each tailings site needs to be treated uniquely to determine the best technology and recovery method.

The technologies involved in re-mining are also varied, including physical separation techniques like flotation, chemical methods like leaching, and biological methods such as bioleaching. Each technique has its strengths and weaknesses, and selecting the right approach depends on the specific composition of the tailings (see Appendix B). For instance, flotation is commonly used to recover REEs, while hydrometallurgical techniques like bioleaching can extract metals like copper, zinc and nickel using bacteria. The development of these technologies, particularly in the context of low-grade sources like tailings, is still in its early stages, and further innovation will be key.

REGULATORY AND POLICY BARRIERS

In the absence of a fit-for-purpose regulatory framework for waste recovery, companies must adhere to the same permitting processes as new mining operations, including environmental assessments and new mining tenure issuance when working with OAM tailings

In fact, companies undertaking re-mining generally assume liability for past

Case Study
Mining Microbiome Analytics Platform (M-MAP)

The M-MAP initiative that demonstrates the potential of biomining, utilizing bacteria to transform waste tailings into valuable extractable metals. Microbes can be used to recover copper, uranium, gold and other potential minerals from tailings.

Developed through Canada's Digital Supercluster and other partners, M-MAP is an online sample analysis platform that accelerates the creation and deployment of microbial solutions for mining. It provides researchers and companies access to a sample library from various mining wastes, and a sample analysis service.

Data sharing platforms like these facilitate collaboration across industries, offering a valuable tool for mineral recovery.

environmental damage,[40] posing a significant deterrent. Larger companies may absorb these risks if the economic potential is compelling, but the barrier remains substantial.

Ontario has taken steps to address these challenges by amending its Mining Act,[41] reducing the rehabilitation burden for businesses involved in re-mining. For instance, companies engaging with existing sites are now required to ensure that the site is "comparable to or better than" its prior condition, rather than bearing the full responsibility for site rehabilitation or closure plans. While these changes provide some relief, there remains no specific, comprehensive regulatory framework dedicated solely to mine waste recovery in Canada.

ECONOMIC CHALLENGES AND COST CONSIDERATIONS

Compared to new mining extraction, re-mining tailings can reduce operational costs by up to 44 percent,[42] as it eliminates the need for mining, crushing and milling primary ores. However, these savings must be weighed against other economic factors. Experts we interviewed at the Mining Association of Canada[43] (MAC) listed factors such as the potential low concentration of minerals in some tailings, the need for advanced and often costly processing technologies, and the

high initial costs of rebuilding infrastructures at OAM sites.

Getting to an operational state also comes with high costs associated with tailings characterization, testing and investment in technology R&D. Because re-mining technology is in its early stages, high initial investments in research and development are needed, posing a barrier for smaller businesses. Since each site requires unique analysis and different technological approaches, investment in one tailing site does not guarantee a return on investment at other tailing sites.

Financial support, such as tax incentives or environmental credits, is crucial for re-mining projects. One existing incentive is Canada's Critical Minerals Tax Exploration Credit,[44] which provides tax relief for exploration activities targeting critical minerals. However, this tax credit, like many other critical mineral incentive programs, is limited in scope, as it does not target all critical minerals on the list, effectively excluding a portion of potential tailings where the characterized critical or strategic minerals are not eligible. Expanding this credit and other programs to cover a broader range of mineral compositions could enhance re-mining feasibility for businesses.

ENVIRONMENTAL IMPACT AND SUSTAINABILITY

Re-mining offers environmental benefits by reducing tailings volumes and simultaneously implementing remediation processes. However, environmental risks remain, particularly concerning water quality and ecosystem health when disturbing historic tailings. Analysis must be done to assess the full scope of these impacts before determining if re-mining poses a greater cost than leaving the tailings undisturbed.

IMPACTS ON INDIGENOUS TERRITORY AND COMMUNITIES

Areas of high mineral potential are often on Indigenous territory. Over 600 Indigenous communities are located within 100 kilometres of a significant mineral project.[45] While re-mining may present fewer risks compared to new mining activities, it still impacts Indigenous lands and the environment. Many Indigenous communities seek active participation in the resource development process, aiming for ownership or equity stakes in projects operating on their traditional territories. First Nations also expect to see tangible benefits in terms of employment, capacity development and economic participation.

The 2023 First Nations Major Projects Coalition (FNMPC) report[46] emphasizes the importance of meaningful partnerships,

where Indigenous communities are not merely consulted but are active participants in decision-making. For re-mining projects, such partnerships are essential for fostering trust and ensuring that communities benefit economically from resource extraction while also ensuring environmental stewardship. Respecting Indigenous free, prior and informed consent (FPIC) is vital as a means to determine whether the environmental or social risks associated with re-mining activities are too high.

Indigenous oversight of environmental monitoring is crucial, particularly for legacy mine sites. By integrating traditional knowledge with modern scientific practices, Indigenous communities can play a key role in managing environmental risks and ensuring the sustainability of re-mining projects.

TAILINGS CHARACTERIZATION

Tailings re-mining requires a detailed understanding of the composition of mine tailings, including any hazardous substances. This involves mineralogical, geochemical and physical analyses. The complex nature of tailings characterization processes can be costly and time-consuming for businesses. Some countries, like Australia and the United States, are actively investing in mine waste databases to address this gap.

For example, the U.S. Geological Survey[47] has conducted studies exploring mine waste as a source of critical minerals. Establishing a standardized inventory system and advancing tailings characterization technologies are crucial to lowering costs and enhancing the feasibility of re-mining initiatives.

Data resources of this kind are starting to be established in Canada as a critical first step. Geoscience BC[48] is developing a comprehensive, publicly available map of mining waste sites across the province.[49] Although limited to a single province, this type of mapping across Canada would be a valuable resource for future re-mining initiatives to reduce exploration costs and spur investment.

Re-mining technologies also depend heavily on accurate characterization of tailings composition. Many startups rely on data provided by mining companies, yet data restrictions limit innovation and scalability in the sector. The lack of publicly available data makes it difficult to develop comprehensive algorithms for efficient recovery, and pilot testing is often essential to evaluate the efficiency of new technologies.

Case Study

Australia's Approach to Tailings Data and Re-Mining Policies

Canada's Commonwealth cousin provides an ideal comparison for examining re-mining policies. A key player in global mining, Australia's tailings output is expected to double by 2035, driven by the growing demand for critical and strategic minerals in renewable energy. According to the Australian government's 2022 "National Waste Report," the country's mining waste increased from 502 megatonnes to 620 megatonnes over the previous three years, with 96 percent of this waste in tailings dams.

In 2023, Australia released its critical minerals strategy, shaped by geopolitical tensions, aligning its priorities with global trends such as the US's Inflation Reduction Act. The strategy aims to move Australia from an export-based model to one focused on processing critical minerals and securing stable supply chains.

Australia leads Canada in gathering comprehensive national data to understand the scope and scale of critical and strategic mineral re-mining opportunities. Notably, in 2023, a partnership between the Australian federal government and universities led to the creation of an online "Atlas of Australian Mine Waste," which maps at least 1,050 tailings sites (from current and former mines) as potential sources of critical and strategic minerals.

This data supports ongoing research by Geoscience Australia and the Queensland government, which have jointly invested in the University of Queensland's Sustainable Minerals Institute to identify secondary resources of critical and strategic metals in both operational and OAM sites. Additionally, Western Australia's state government established a publicly funded institute dedicated to researching alternative uses for tailings and exploring growth opportunities post mine closures. Data sharing platforms like these facilitate collaboration across industries, offering a valuable tool for mineral recovery.

Recommendations

The following policy recommendations outline the necessary actions that the governments in Canada could take to stimulate Canadian leadership in re-mining:

Recommendation #1

Advance the Creation of a National Tailings Inventory for Critical Minerals

A national database is essential to identify high-potential re-mining opportunities. By providing public data on tailings characterization, a database can spur private sector investment by reducing exploration, research, development and testing costs. A well-structured database can help prioritize projects with significant environmental and economic benefits.

KEY ACTIONS

Create a comprehensive publicly accessible, centralized tailings inventory

» NRCAN should continue to support CanmetMINING's efforts to develop a comprehensive Canadian Mine Tailings Inventory by standardizing classification and

tracking in collaboration with provincial and territorial governments.

» Develop standardized sampling protocols and testing methodologies to ensure consistency and reliability in data, aligning with National Instrument 43-101 standards for resource estimation.

» Building on the tailings inventory, establish a publicly accessible, centralized database that integrates historical mine site records and relevant metadata to provide detailed insights into tailings' quantity, quality and potential value, with a phased expansion to include active sites while balancing private sector considerations.

» Empower Indigenous communities to lead data collection for the database by providing targeted funding and resources.

» Explore the expansion of this inventory with a national monitoring system to track the progress and effectiveness of tailings recovery in supporting critical mineral production and liability mitigation.

» Model the national tailings inventory after global best practices, such as Australia's "Atlas of Australian Mine Waste."

Recommendation #2

Create a Purpose-Built Policy Framework for Re-Mining Waste

Regulatory reform and a new policy framework are needed to make re-mining a key component of Canada's Critical Minerals Strategy. This includes streamlining permitting processes, liability management, environmental and social safeguards, Indigenous engagement and strategic long-term planning.

KEY ACTIONS

Reduce liability and increase certainty

» Provinces and territories should establish re-mining policy frameworks to offer clearer guidelines and incentivize re-mining without assigning full liability for past environmental harm.

» Establish a Liability Transfer Program to reduce liability concerns for companies recovering metals from OAM, offering liability relief for pre-existing environmental damages when companies demonstrate active remediation efforts.

» Clarify the distinction between mining and restorative or recovery activities to reduce regulatory barriers and encourage more industry participation.

Foster Innovation through Regulatory Flexibility

» Provinces and territories should create regulatory sandboxes, which would allow companies to test new approaches to re-mining with regulatory flexibility and oversight in time-limited projects.

» Simplify and expedite the permitting process for re-mining projects.

Standardize Definitions and Taxation Incentives

» Align federal, provincial and territorial lists of critical minerals for tax and incentive harmonization across jurisdictions.

» Expand the list of eligible critical minerals for the Critical Mineral Exploration Tax credit to include critical minerals commonly found in tailings from primary deposits abundant in Canada, like gold mines or oil sands.

Develop a National Roadmap for Re-Mining

» Include a comprehensive National Roadmap for Re-Mining within the Canadian Critical Minerals Strategy that guides long-term recovery and remediation efforts. Use this roadmap to direct funding or fiscal levers for re-mining.

Recommendation #3

Incentivize Innovation and Partnerships

Canada must incentivize technological innovation for developing and scaling cutting-edge tailings recovery technologies. Additionally, public policy should encourage partnerships between industry, academia, Indigenous communities and technology firms to co-develop innovative re-mining solutions, including through pilot projects.

KEY ACTIONS

Drive Innovation and Investment through Targeted Incentives

» Implement government-backed financial incentives (e.g., tax credits, grants or low-interest loans) to offset the costs of tailings remediation and technology adoption. Encourage private sector investment by offering green financing mechanisms like sustainability bonds.

» Establish a “Liability-Linked Innovation Fund” that mandates companies responsible for mine tailings to contribute a percentage of their liability fees to fund innovative re-mining technologies and remediation efforts.

» Prioritize R&D investments in advancing re-mining technologies, such as biomining and hydrometallurgical methods,

as well as detoxification technologies, to improve re-mining efficiency and minimize environmental risks.

» Develop a taxation regime that rewards sustainable re-mining practices, through environmental credits or reduced rates for innovative recovery methods.

Facilitate Technology Testing through Pilot Projects

» Enable pilot projects that test new technologies in real-world scenarios, including remote site demonstrations.

» Connect these pilot projects with the regulatory sandboxes to ensure existing policy and regulation does not block innovation.

Promote Industry-Led Initiatives

» Encourage industry-led projects, including resource recovery innovation challenges, ensuring Indigenous participation in these opportunities.

» Building off the successes of the Annual Orphaned and Abandoned Mines Workshop, CanmetMINING should establish a national consortium to foster collaboration and knowledge-sharing between academia, government and industry on re-mining tailings.

Support Indigenous-Led Re-Mining Partnerships

» Enable partnerships with companies to advance re-mining initiatives and ensure community involvement in decision-making.

» Ensure that Indigenous communities are integral partners in re-mining initiatives, through beneficiary agreements, active engagement and opportunities for ownership, while incorporating Indigenous knowledge into re-mining practices for more holistic and sustainable outcomes.

Conclusion

The global demand for critical and strategic minerals in the coming decades is rising, and every possible source must be explored.

Re-mining critical and strategic minerals from tailings, both at operational and OAM sites, offers a secondary supply of essential resources, delivering both economic and environmental benefits. It won't replace the need for new mines, but it can be an important supplement. Re-mining presents an unparalleled opportunity for Canada to address its environmental legacy while supporting the surging demand for these essential resources.

The technological, regulatory and financial challenges to re-mining can be overcome through targeted policy measures and incentives that make it easier for the industry to adopt and implement re-mining practices. With concerted federal and provincial action in three key areas – advancing a National Tailings Inventory, implementing regulatory reforms and a re-mining policy framework, and incentivizing innovation and collaboration – Canada can begin to capitalize on the potential of re-mining and transform tailings from a long-standing liability to a strategic asset.

The time to act is now – billions of dollars remain untapped in operating and OAM tailings, waiting to be recovered. With the right strategies in place, Canada has the potential to lead the world in re-mining innovation, helping build a greener and more sustainable economy for future generations.

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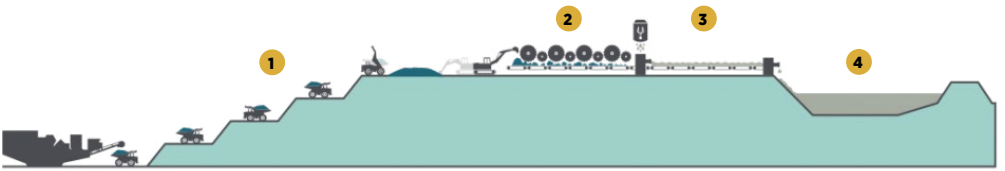
Appendix A
Visualizing the Tailings Development Process

Tailings are the by-products generated during the extraction of valuable minerals and metals from mined ore. Typically, they consist of a liquid slurry containing fine mineral particles. These tailings are produced as ore is crushed, ground and processed, leaving behind a mixture of water and waste materials. As such, tailings are often seen as both an environmental liability and an untapped resource.



1

Rock containing minerals and metals are mined from the earth and processed to separate the minerals and metals.

2

The mined rock is finely ground and mixed with water and sometiems checmicals to separate minerals and metals.

3

Once the desired minerals or metals are extracted from the finely ground rock, fines, the waste that remains is in the form of a slurry, known as tailings.

4

This slurry can be processed to a sand-like material and transported to a dry stack, or pumped in its wet state into a reservoir with a dam.

Source: Global Tailings Review[50]

Appendix B
Overview of Technology Methods for Re-Mining Critical and Strategic Minerals

TECHNOLOGY METHOD	DESCRIPTION	EXAMPLE
Physical Separation Techniques	Methods like flotation, gravity separation and magnetic separation that concentrate minerals from tailings. These are often used for REEs and base metals.	Flotation is used to recover REEs, as seen in the recovery of REEs from tailings at Mountain Pass, US.
Chemical and Hydrometallurgical Methods	A range of chemical processes that use solvents to extract metals from ores or waste materials. These methods are especially effective for low-grade or complex ores and tailings.	Hydrometallurgical extraction of gold and copper from tailings using cyanide or other chemical solutions. Examples include Barrick Gold's operation in Nevada and the use of thiourea in copper recovery.
Leaching	A process to extract metals by dissolving them in a liquid, typically an acid or base solution. Used for low-grade ore and tailings.	Rio Tinto is extracting battery-grade lithium through roasting and leaching waste rocks from the Boron mine site in California.
Bioleaching	A sustainable method using bacteria to extract metals like copper, zinc and nickel from tailings. It's particularly advantageous for low-grade ores and has less environmental impact.	BacTech Environmental is running a pilot in Sudbury pyrrhotite tailings (Vale), where there is an estimated US$22B worth of untapped nickel/cobalt. Other examples include the use of bioleaching at OZ Minerals' Prominent Hill in Australia.

TECHNOLOGY METHOD	DESCRIPTION	EXAMPLE
Ion Exchange and Solvent Extraction	Methods used to separate and purify metals from solutions by using selective absorbents or solvents. These methods are widely used for extracting REEs and other valuable metals from complex tailings.	Ion Exchange is used to recover lithium from brine, as seen in Livent's operations. Solvent Extraction is used in Arafura Resources' REE recovery process at their Nolans Project in Australia.
Pyrometallurgical Processes	High-temperature processes like smelting and refining that separate valuable metals from ores or waste. These are typically used for base metals and ores with high metal content.	Glencore's Sudbury Integrated Nickel Operations use pyrometallurgy to recover nickel from ore and tailings. Freeport-McMoRan's smelting plants in Arizona also use pyrometallurgy to process copper concentrates.
Electrochemical Recovery	Methods using electrochemical reactions to recover metals from solutions, where metals are deposited onto electrodes. This technique is often used in refining and recycling.	Electroplating is used to recover gold from e-waste and tailings. Companies like EnviroGold Global use electrochemical recovery for the extraction of gold and other precious metals from tailings.
Direct Lithium Extraction (DLE)	A set of advanced technologies designed to extract lithium from brines or clays with minimal environmental impact and higher efficiency compared to traditional evaporation methods.	Lilac Solutions is a leader in advanced lithium extraction technology, notably used in the Salton Sea Geothermal field in California. Other companies, like Standard Lithium, are using DLE for lithium extraction from Arkansas' brine sources.

Appendix C
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Note: We acknowledge that there may be some names missing from this list of consultations. We sincerely apologize for any oversight as we are truly grateful to all who have shared their knowledge and contributed to this report.

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