

An aerial photograph showing a large, turquoise-colored reservoir or dam. The water is a vibrant blue-green color. To the left of the reservoir, there is a dense forest of green trees. The surrounding landscape is a mix of greyish-brown earth and some sparse vegetation. The overall scene is a stark contrast between nature and industrial infrastructure.

# Untapped

Mining's opportunity to unlock value through strategic water management and innovative technology

# WEHR

Mining technology for a sustainable future

## Water in mining – an untapped opportunity



**Mining plays a critical role in enabling a low-carbon future through the metals and minerals it delivers. Effective water management is central to mining’s success, influencing productivity, environmental impact, and community relationships across the lifecycle of a mine. Yet miners today face the acute challenges of operating in increasingly water-stressed locations, driven by declining ore grades and rising demand for critical metals.**

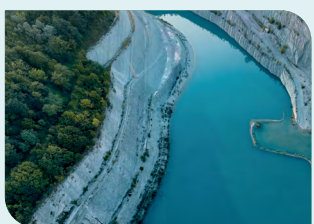
Too often, water management in mining relies on tactical fixes and traditional approaches, leaving significant room for improvement. This report highlights the untapped potential for the mining industry to rethink how it values and manages water. By treating water as a strategic resource and adopting innovative practices, mining can unlock substantial value, future-proof its operations and build trust and confidence with stakeholders.

Water management in mining is an increasing priority for companies, governments, and communities – driven by climate risk, regulatory change, and rising stakeholder expectations. But it’s clear that no single miner, innovator, community, financier, or government can solve the challenges or unlock this opportunity alone.

Progress depends on bringing together expertise from across the value chain, forging bold partnerships, and embracing new thinking. By working collectively, we can develop solutions that deliver lasting value for mining and the communities that depend on it.

This report spearheads that approach, inviting industry stakeholders to come together to elevate the discussion and take action to deliver better water management in mining and contribute to a more climate-resilient future.

**Jon Stanton**  
**CEO, Weir**  
 November 2025



**Cover image:** The Costa Masnaga quarry in northern Italy has been repurposed to help prevent flooding by acting as a retention basin.

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### Disclaimer

This report is intended to reflect Weir’s leading thinking on water in mining. Accordingly, certain statements, terminology, and conclusions presented herein are based on Weir’s interpretation of external data sources, expert interviews, internal datasets, proprietary assumptions, and the company’s extensive technical expertise and commercial insight. As such, not all content is accompanied by publicly available references, and some assertions represent informed perspectives rather than universally established facts. This report is provided for informational and discussion purposes only and does not constitute professional advice, nor should it be relied upon as a substitute for independent analysis or judgement.

## Foreword



**Scaling metals production to meet climate net zero goals has highlighted the mining sector’s escalating water challenges, placing water, and mining’s use of it, at the epicentre of debate.**

This debate has really highlighted the need to catapult water from a tactical site management issue to one of central, corporate importance. Lower grade ores, increased tailings production and water usage associated with critical metals demands exponentially accelerate the need for radical improvements in mine water use and stewardship. Increasing uncertainties around water supplies and inefficiencies in water management and treatment are weakening social licence and increasing investor reluctance. They underscore the business imperative to do better with water across the entire mining life cycle and mining sector.

This report sets out the challenges and opportunities, starting with valuing water appropriately. Elevating water to a strategic priority opens the door for mining to scale up sustainably, reduce risks, increase community, rights holder and investor confidence and drive the net zero transition. This report explores ways to seize this opportunity and start a new conversation about water in mining.

**Lesley Warren**  
 Director, Mining Futures Initiative, University of Toronto

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We would like to extend our thanks to everyone who contributed to this report, which would not exist without their knowledge, expertise and support. With particular thanks to Laurie Reemeyer for his role as advisor throughout the report’s production.

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## Executive summary

**Water is the basis for all life on Earth. It is also an essential component in many of today's industrial processes, including mining. Without it our sector would be unable to extract critical minerals that support modern life, and are at the heart of decarbonisation. But mining currently faces water challenges that are both chronic and acute and highly variable from place to place.**

### **Mining faces water challenges – but there is also opportunity**

While our sector represents a relatively small percentage of total water consumption, changes in water availability, driven by climate change and a growing population, have a direct, chronic effect on mining. Approximately 16% of the world's land-based critical mineral mines, deposits and districts are located in highly water-stressed areas.<sup>1</sup> The issue is particularly stark for copper. Around 40% of the world's copper supply is located in areas of high water stress, such as Australia, Chile and Peru<sup>2</sup> – and copper is a 'thirsty' mineral to process in terms of water consumption per tonne of metal produced.

Climate change adds to the urgency, intensifying the frequency and severity of both droughts and floods. An excess of water can cause flood damage, interrupt production and increase water treatment costs, while shortages can cause community tensions, increase costs and restrict production. Many mines now deal with the acute challenges of scarcity and excess at different times.

The geographical, geological and social context of where critical minerals are found makes managing water in mining an essential – and urgent – challenge. The increasingly unpredictable nature of water availability and threats to water quality, coupled with rising expectations from communities, investors and society, means it is more important than ever that our sector addresses water management as a strategic part of mining design.

We see this as an opportunity for the mining sector. Changing the way we think about water would enable mining to scale up to meet demand for critical minerals in more sustainable ways. It could also help miners manage risk, reduce costs, build greater operational resilience and, potentially, improve their access to sources of finance. All of which could help strengthen our sector's licence to operate and social performance. This report aims to explore potential ways to seize that opportunity – and deepen the conversation about one of mining's most pressing issues.

**c.16%**

**of the world's land-based critical mineral mines, deposits and districts are located in highly water-stressed areas**

### **Recognising complexity: every mine is different**

Every miner has to consider how to source the water they need, the way it interacts with their excavations, operations and tailings facilities, and how to release it back into the environment at an acceptable quality.

The challenge is that every mine is different. Geological factors affect the viability of choices in mining methods and process flowsheets. Geographical factors dictate precipitation and evaporation rates, and affect water flows. This combination has a profound impact on a site's water balances, influencing how water flows and risks are managed.

Faced with this complexity, miners tend to adopt tactical, site- and process-specific approaches to managing water, rather than the broader strategies they use to manage mining's other vital resource, energy.

This is a missed opportunity to tap the enormous potential of an integrated approach to water across the whole life of the mine, based on the marriage of data, end-to-end flowsheets and the best, most appropriate technology, leading to better outcomes for all stakeholders.

1. [More critical minerals mining could strain water supplies in stressed regions](#), World Resources Institute, 2024.

2. [The exposure of global base metal resources to water criticality, scarcity and climate change](#), Northey et al, 2017.

## Executive summary continued

### The potential of integrated thinking around geology, geography and metrics

Taking a more integrated approach would help our sector reduce complexity and make more informed strategic decisions. Finding ways to classify geology, geographic data and common water KPIs (for both quality and quantity) presents an opportunity to evaluate the best available technology at a strategic level, rather than at individual mine sites.

CEEC International's Global Water Initiative (GWI) has identified flowsheet 'archetypes' that represent the main processing alternatives for ores for four key commodities: copper, gold, iron ore and nickel. These archetypes provide a framework to help miners understand and assess the technology options available to them to balance recovery, processing costs, waste generation, and energy and water use. They also create ways to understand how water interacts with processing operations and mining wastes.<sup>3</sup>

Up to **80%**  
of a mine's total water balance can  
be accounted for in tailings

The archetypes can suggest measurable water-management benefits at every stage of the mining process. Their cumulative impact is often observed through a reduction in the overall quantity of water lost to tailings storage facilities, which can account for as much as 80% of a mine's total water balance.<sup>4</sup> This is a key gain: tailings are a major waste stream, with almost half produced from processing copper ores, and a further 21% from gold and 9% from iron ore.<sup>5</sup>

Further insights are possible through combining archetypes with context-specific research. Weir has been working with S&P Global to analyse large-scale mining data that rates specific climate- and nature-related risks and opportunities at an individual mine or for mines in the same archetype. This report argues that combining mine archetypes with greater insight into physical and nature risks points to ways that the mining sector could start to look at water use and management more holistically (see page 16).

In fact, according to the report *Reducing water and energy consumption through innovative mineral process flowsheet design*, adopting innovative flowsheets and an end-to-end approach could reduce water consumption per tonne of copper produced at a typical copper mine by as much as 78%, while lowering energy consumption by 48%.<sup>6</sup>

Adopting innovative flowsheets and an end-to-end approach could reduce water consumption per tonne of copper produced at a typical copper mine by as much as

**78%**

3. [Global Water Initiative campaign summary](#), CEEC, 2024.

4. Oyu Tolgoi project ESIA, 2012.

5. [Global tailings review, Chapter II - mine tailings facilities: overview and industry trends](#), Baker et al, 2020.

6. *Reducing water and energy consumption through innovative mineral process flowsheet design*, Klein et al, 2024.

## Executive summary continued

### Applying the archetypes and best available technologies across the mining process

We dedicate individual chapters in this report to discussing the specific challenges and opportunities around water management in each of the three critical mining stages. We also look at the potential of using the archetypes, data and best available technologies to create better outcomes:

- **Mine planning and ore extraction** (see pages 20–21).
  - How better classification and sorting during extraction reduces the need to process rock unnecessarily, thereby reducing water use per tonne of metal produced.
- **Comminution and mineral processing** (see pages 22–25).
  - How improving comminution and separation techniques can reduce water consumption.
  - How coarser processing improves water recovery from tailings.
  - Why incorporating digital technology and data analytics could improve efficiency.
- **Tailings processing** (see pages 26–30).
  - How technology can reduce water volumes in tailings, improve water recovery and reduce the scale and risk of tailings dams.

### Possible pathways to better water management

There is no single, simple solution for better water management in mining. But in the process of interviewing mining experts for this report, we have found some common themes.

Using archetypes in combination with physical risk- and nature-related data to help cut complexity can improve flowsheets and identify the best available technologies for a given context. But we also need common, agreed metrics that are used consistently across the sector to drive the right behaviours. The International Council on Mining & Metals' (ICMM) water accounting framework – *Water reporting: good practice guide* (August 2021)<sup>7</sup> – is driving industry alignment.

Innovative approaches, such as better digital systems and nature-based solutions, could help drive change. So may emerging financial approaches, in which miners demonstrating water-efficient technology use and long-term remediation planning could access preferential 'green' funding.

All of this must be underpinned by better collaboration across our sector. We need a bolder, more strategic conversation across all levels of mining about the way water is used, as well as closer working relationships between mining equipment, technology and services companies and miners.

### The economic and environmental prize for mining

We're grateful to all the experts who have contributed to this report. While the views in the following pages are our own, they are shaped by a series of conversations that have reinforced our belief that mining has a great opportunity to change water management at a systemic, strategic level.

The prize is potentially enormous. Miners can reduce costs and risks, strengthen community relations and social licence to operate, build climate resilience and attract more favourable investment. Meanwhile, the people and ecosystems with which we share water can enjoy a cleaner environment, fairer access to resources, and a continued supply of the critical minerals that underpin the transition to a low-carbon future. To make the most of this opportunity, we need to work together. We hope this report plays a part in that.

7. [Water reporting: good practice guide](#), ICMM, 2021.

# Water – a critical resource for critical minerals

Water is the basis for all life on our planet – whether for drinking, growing food and good sanitation, or for protecting unique ecosystems and the biodiversity they support. Water is also a key component in many of today's industrial processes, including mining. Here, we explore why we believe we all need to think more strategically about water and some of the tools already available that could help our sector take a more integrated, end-to-end approach to managing this precious natural resource.



## Water – a critical resource for critical minerals

**Water is used at every stage of the mining process; without it our sector would be unable to extract critical minerals that support modern life.**

### Why water matters

Water's importance is increasingly recognised by key mining, financial and environmental bodies, as reflected in the International Council on Mining & Metals' (ICMM) *Water in the mining sector*<sup>8</sup> report co-published with the International Finance Council in 2017, and the joint analysis on water risk in the mining sector from WWF and Water Risk Filter.<sup>9</sup> Both reports highlight the importance of a comprehensive response to water risk in mining.

Despite this, water remains undervalued. Unlike the industry's more mature approach to energy and greenhouse gas emissions, water is too often seen as a tactical constraint to be dealt with, rather than a key resource with strategic impacts, risks and opportunities.

We believe this needs to change, and that managing water as a strategic part of mining design is more important than ever. The combination of climate change and rising societal expectations means that water availability – and our industry's ability to carry out water-dependent activities – is increasingly variable and unpredictable.

But we have an opportunity to transform our sector's environmental impact, by strengthening the way we manage the risks associated with access to water sources, being more cost efficient, and working in partnership with stakeholders and rights holders on water issues. Doing so would help protect future mining operations, securing our sector's enduring licence to operate.

In short, changing the way we think about water would enable our sector to scale up to help meet demand for critical minerals in more sustainable ways.

### Growing pressure on water – and water use

We face a growing, chronic water challenge: the world's population is expected to increase by almost 20% by 2050, with declines in some regions offset by high growth in low-to-middle-income countries.<sup>11</sup> This means we will need more water to sustain life in all its forms.<sup>12</sup> And yet this precious natural resource is increasingly scarce in some parts of the world, and unpredictably abundant in others. As global pressure on freshwater supplies increases, so does competition for access to water and expectations on mining companies to improve water management practices or secure alternative supplies.

Mining isn't the only industry that needs water, of course. Agriculture relies on significant quantities, while the steel industry is a large user. In fact, our sector represents a relatively small percentage of global consumption, accounting for just 2–4.5% of national water demand, even in relatively dry, mining-intensive



**Water is the stuff of life – a tangible, shared resource that affects mining production, community wellbeing and financial stability. Our sector's licence to operate will only endure if we manage that resource well.**

Philip Bangerter  
Director, CEEC International Ltd

countries such as Australia, Chile and South Africa.<sup>13</sup> This compares with approximately 70% in agriculture.<sup>14</sup>

National consumption data can obscure the local picture, and there are exceptional cases where the mining sector's freshwater consumption far exceeds availability of naturally-occurring water.<sup>15</sup> And as demand for this shared, finite resource grows, so does the potential for conflict over how it is allocated; mining may not always be considered the highest priority.

# 1/3

of 250 mines assessed by Barclays in a recent report were found to be located in areas of high physical water risk<sup>10</sup>

8. *Water in the mining sector*, ICMM and IFC, 2017.

9. *An analysis of water risk in the mining sector*, WWF and Water Risk Filter, 2020. 10. *Navigating nature risk*, Barclays, 2025.

11. *World population prospects 2024*, United Nations Department of Economic and Social Affairs, 2024

12. *Focus on the future of the global population*, United Nations, 2025.

13. *The impact of metal mining on global water stress and regional carrying capacities*, Meissner, 2021.

14. *UN world water development report*, Unesco, 2024.

15. *The impact of metal mining on global water stress and regional carrying capacities*, Meissner, 2021.

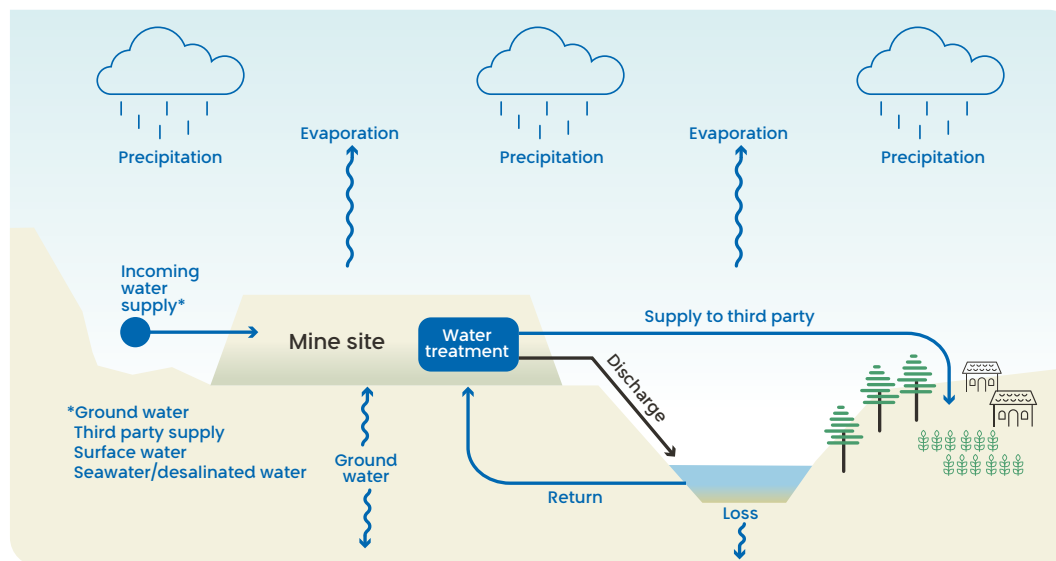
## Water – a critical resource for critical minerals continued

The issue is more acute for certain commodities, particularly those with more water-intensive needs during processing. Open pit copper and gold production, for example, are particularly ‘thirsty’ in terms of water consumption per tonne of metal produced. And yet, around 40% of the world’s copper is located in arid areas, in countries like Chile, Peru and Australia,<sup>16</sup> and places that increasingly face the risk of drought, such as the US and Mexico. South Africa<sup>17</sup> – another arid region – is a major source of platinum group metals, manganese and chromite – and, like Chile and Peru, is exposed to extreme weather patterns.



**The impact of climate change is being felt through water, and mining needs to think differently to adapt. With the right insight, we can turn this to an opportunity to unlock the value of water.**

Jonathan Horrell  
Group Head of Sustainability, Weir



**Miners must consider the different ways that water naturally occurs in any given location and the impact it has on a mining site, the environment and other stakeholders.**

Meanwhile, other locations in countries like Brazil, Canada and Indonesia can have the opposite problem: too much water, either from high rainfall or seasonal flooding, can disrupt operations if not carefully managed. In these instances, mining companies must also consider how to treat water before releasing it into the surrounding environment to minimise the risk of contamination.

In some cases, the climate emergency means that some mining companies now find themselves having to deal with both scarcity and excess, often in the same mine during different seasons or in years of flooding or major drought. And as the climate continues to change, pressure on water resources is likely to keep rising, with greater scarcity in some parts of the world and more frequent flooding in others.

The situation is further complicated by a broader trend in declining ore grades<sup>18</sup> – another particular issue for copper and gold. More ore has to be extracted to recover an equivalent quantity of valuable minerals, which means more water and more energy per tonne of metal produced.

The challenge we face is particularly urgent given the role that our sector has to play in the energy transition. More than 90% of the world’s GDP is now covered by a commitment to meet net zero.<sup>19</sup> But the transition from fossil fuels to a low-carbon economy needs a reliable supply of critical minerals and metals,<sup>20</sup> such as copper, nickel and lithium. This means developing new mines, expanding existing assets, and sourcing significant quantities of water. However, approximately 16% of the world’s land-based critical mineral mines,

16. The exposure of global base metal resources to water criticality, scarcity and climate change, Northey et al, 2017.

17. South Africa - African green minerals observatory, African Minerals Development Centre. 18. Decreasing ore grades in global metallic mining, a theoretical issue or a global reality?, Calvo et al, 2016.

19. The seventh carbon budget, advice for the UK government, Climate Change Committee, 2025. 20. The role of critical minerals in clean energy transitions, IEA, 2021.

## Water – a critical resource for critical minerals continued

deposits and districts are located in highly water-stressed areas.<sup>21</sup> Meanwhile, 7% of the world's copper supply in 2024 was at risk of disruption due to either drought or flooding – a figure set to rise by 30% according to the International Energy Agency's *Global critical minerals outlook 2025*.<sup>22</sup>

All these factors taken together mean that miners and their stakeholders are, rightly, increasing their focus on water. Investors are looking for clear indicators of sustainable water management in mining in order to allocate finance, while regulators are setting tougher standards. Local communities need secure access to clean water and protection from pollution, while consumers are increasingly interested in how water is used in the products they buy.

### How the mining industry views and manages water today

Generally mining companies have to consider the sources and quantities of water withdrawals required for their operations, as well as how water interacts with their mine excavations and waste management, and its release to the environment at an acceptable quality. Miners must consider water at each of the three key stages of the mining process:

- **Mine planning and ore extraction:** mine planners must identify viable water sources for the whole mining process, and consider how to remove and treat excess water in areas of abundance. During extraction, miners must manage water flow to avoid it entering mining areas, while water for dust control is needed to protect workers and the environment.
- **Comminution and mineral processing:** while initial rock crushing tends to be 'dry', most mineral processing operations use water. For example in wet grinding, as well as in physical separation

(for example, flotation), chemical processes help to extract the valuable minerals and move materials around a mine in the form of slurry. In many cases, process water can be recycled by removing water – known as dewatering – from certain product, intermediate and tailings waste streams.

- **Tailings processing:** tailings are a mixture of process water and particles of waste rock in slurry form, which can be pumped to a tailings storage facility. Tailings typically represent mining's largest water sink. Their water content must be carefully managed to prevent environmental damage or risk to life, for example due to catastrophic dam failures. Measures such as thickening and filtration can help reduce the water content, provide opportunities for water recovery and recycling, and improve the long-term stability of tailings storage facilities, the design of which also influences water management aspects during mine closure.

Despite these commonalities, every mine is different and context is important. Geography and geology play a fundamental role in determining where a mine is built, how the ore is extracted and processed and how tailings waste is managed. Regulatory frameworks vary widely, and permitting processes are typically long and inflexible. Different commodities require different processing and waste disposal methods, which influence water impacts.

Water, and its interaction with geology and geography, underlies everything. Geological factors affect the viability of choices in mining methods and process flowsheets, as well as the quantity and type of mining waste that is created. The end product formed is also a consideration as certain types of processes are more sensitive to water quality. Meanwhile, geographical factors, such as climate and topography, have an

impact on levels of precipitation and evaporation at a particular location, affecting the volume of and variation in water flows and their interaction with a mine. This combination plays a large role in a site's water balances, influencing how miners manage water flows and risks.

Geography also influences the viability and cost of water supply alternatives. Miners need to work out where their water will come from, which includes assessing quality, availability and reliability of any given water source. Some mines are close to sources of fresh surface water or groundwater. Some are near municipal water networks that supply neighbouring communities and businesses, although access may be restricted. For other sites, no readily available water supply currently exists. For all these reasons, some mines use alternatives, such as seawater, saline groundwater aquifers or third-party (municipal) wastewater. These sources can lead to trade-offs, such as the costs of modifying processes to use of lower-quality water or desalination.

As well as the impact that geography and hydrology can have on water quantity, quality issues often occur when water becomes 'contact' water, for example when rainfall or groundwater flows through a pit, waste rock dump or tailings facility. This water must be carefully managed before being reused or released to the environment, because it can carry contaminants.

All of this means miners need a deep understanding of hydrology, above and below ground, to assess water supply issues and interactions with mine and waste features.

**c.40%**  
of the world's copper is located in  
arid areas

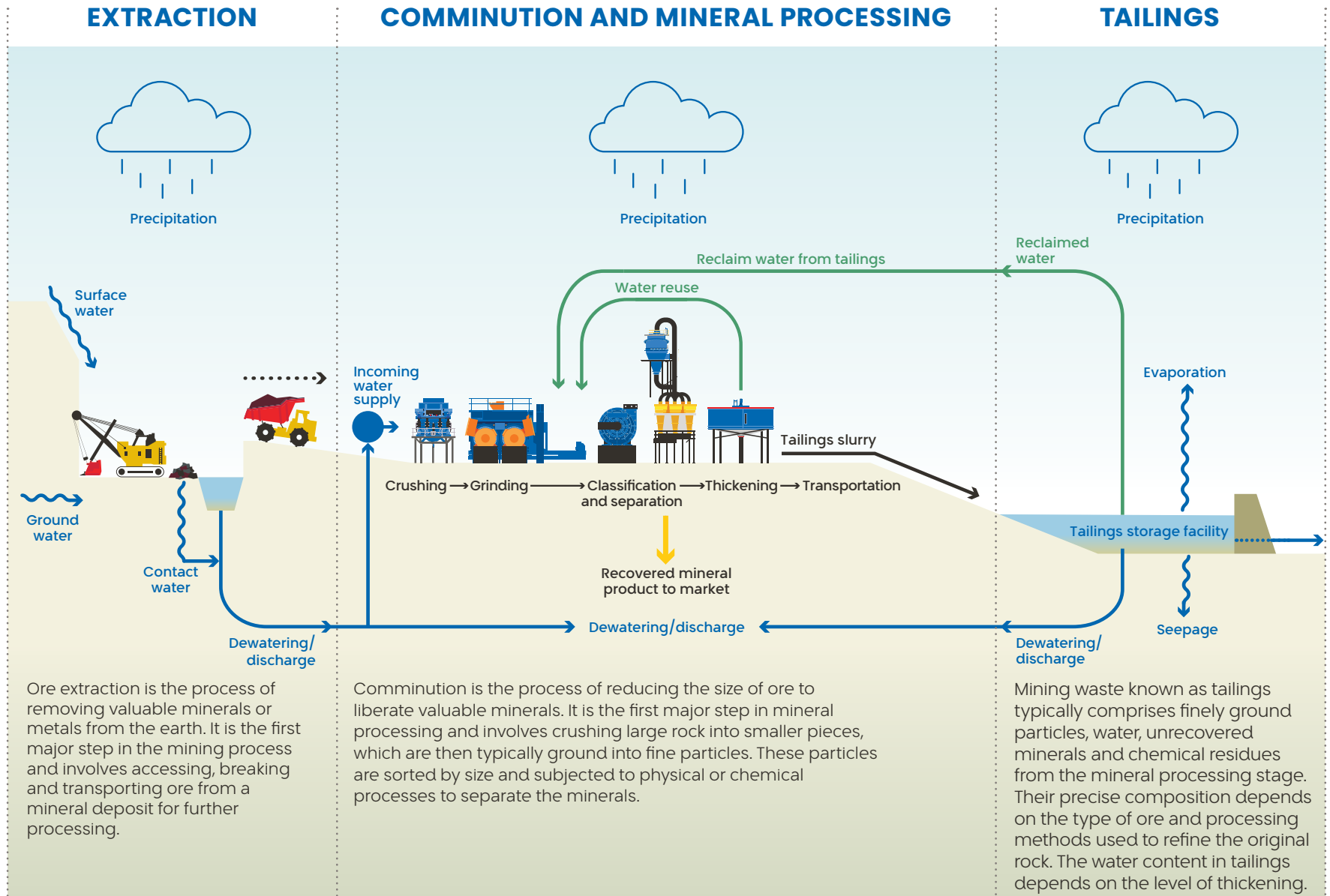
21. [More critical minerals mining could strain water supplies in stressed regions](#), World Resources Institute, 2024.

22. [Global critical minerals outlook 2025](#), IEA, page 10.

## Water – a critical resource for critical minerals continued

Water in the mining process – where and how it has an impact

Miners must consider water flows throughout the process of extracting valuable minerals. Water flows in and out of the mine need to be managed – while water also plays a crucial role in each of the three key stages of the mining process. Schematic shows example of high-level processing steps.



## Water – a critical resource for critical minerals continued

### Local issues require local solutions

A mine's geographic characteristics shape the technologies needed to run it successfully. For example, a mine located at altitude in an area of water scarcity will typically need infrastructure to transport water into the site, as well as a detailed water management plan to meet permitting regulations. A mine that sits below the water table, or is located in an area of high rainfall, needs a reliable plan to remove excess water, while ensuring a steady supply of process water remains available throughout the site.

Managing water excesses at a site can be just as complicated and costly as managing water scarcity. Climate change-related variations in water availability mean that a growing number of mines now have to plan for drought in one season and abundance in another. In all cases, water is a key component in remediation and risk management plans during a mine's operational lifetime and beyond, both due to the potential impacts on surface and groundwater flows and contact water quality effects.

### Tactical responses to mine-specific issues

A common theme in our conversations with experts contributing to this report is that unlike energy management – typically a more mature process in mining – water's complexity means miners tend to adopt tactical, site- and process-specific approaches to how they manage it. The interdependent nature of its availability, quality, cost and metallurgical performance, as well as climate, infrastructure, competition and regulation, also play their part.

As a result, decisions about water remain highly contextual, driven by practical problem-solving to address immediate need rather than considering the full life of a mine. Mining companies tend to devolve decisions to engineers, consultants and managers on the ground who are often incentivised to manage cost and risk and so tend to follow 'tried-and-tested' technologies to manage both. And while a growing number of miners are exploring alternatives, such as desalination to ease supply restrictions, or tailings filtration and stacking to improve water recovery, these tend to be heavily influenced by need, cost or environmental risk.

### Integrated approaches at mine and sector level – a missed opportunity?

Given the potential social, environmental and financial consequences of poor water management, risk aversion in miners' technology choices is understandable. But this has held mining back. By treating water as a siloed issue, our sector is missing out on the enormous potential offered by a more integrated, whole life-of-mine approach, based on the marriage of data, integrated water modelling, end-to-end flowsheets and the best, most appropriate technology.

And as society's expectations of our sector grow, so too does the gap between the strategic goals and decisions taken at the top of companies and the tactical choices around technology and flowsheets made at a local level. This is compounded by a lack of common language and shared metrics across the sector to drive the right behaviours and help our sector demonstrate what we are doing to address our impact on water. Improved coordination between miners, communities and governments could also identify new solutions such as shared water infrastructure.

Opportunities already exist to create greater industry alignment. A growing number of ICMM members – who represent around one-third of the global metals and mining industry<sup>23</sup> – are using the organisation's *Water reporting: good practice guide*<sup>24</sup> to measure and report on water use. The ICMM's water accounting framework is already aligned with external water reporting standards, in particular the Global Reporting Initiative (GRI).<sup>25</sup>

Together with other evolving mining standards frameworks, we believe this framework can help build a comprehensive approach to improve water practices and reporting. For example, it has been used as a foundation for water accounting in the Consolidated Mining Standards Initiative,<sup>26</sup> currently in consultation. And since a high proportion of water consumed by mining is linked to tailings, it is also highly relevant for the requirements of the Global Industry Standard for Tailings Management (GISTM),<sup>27</sup> which requires miners to develop and maintain a water balance model.

ICMM's framework considers overall water inflows and outflows at company or site level, as well as internal water flows. The table on page 12 summarises some of its key elements.

23. *Our members*, ICCM, 2025. 24. *Water reporting: good practice guide*, ICMM, 2021. 25. *The global leader for sustainability reporting*, GRI, 2025.

26. *Overview*, Consolidated Mining Standard Initiative, 2025. 27. *Global industry standard on tailings management*, Global Tailings Review, 2025.

## Water – a critical resource for critical minerals continued

### Metrics used in the ICMM’s water accounting framework

Metric	Description	Rationale
<b>Overall inflows and outflows</b>		
Operational water withdrawal	Water used to meet operational demand by source (e.g. surface water, groundwater, seawater, third party) and water quality.	Indicator of operational water dependency and transparency around water withdrawal to meet operational water demand.
Other managed water withdrawal (OMW)	Other water from any source that is actively managed (e.g. pumped, treated or consumed) by water quality.	Indicator of other water dependencies, especially where OMW volumes are high due to, for example, dewatering or community supply, or climate, such as wet weather events.
Total discharge	All water that is released by destination (e.g. surface water, groundwater, seawater, or third party) and water quality.	Indicator of water dependency and potential for associated downstream risks and opportunities.
Consumption	All water that is removed by evaporation, entrainment in product or waste, or other losses, and is not released back to the environment or a third party.	Indicator of water dependency and potential risks associated with water losses.
<b>Internal water flows</b>		
Reuse/recycle	Water that has been used in operations and is recovered and reused without treatment, or treated and recycled in operations.	Indicator of internal water management practices and ability to optimise systems.
Operational water use	The volume of water used in operational tasks.	Indicator of water dependency and internal water management practices.
Change in storage	The net change in the volume of water in storage (operational and OMW).	Allows transparency of all elements of the water balance.



The value of water is still not well understood within many mining companies, even though much of their climate-related financial risk is water driven. Companies often collect huge volumes of water data, but not always the kind that matters, and rarely connect it into a full picture. When they do, they often discover higher use and greater risk than expected. Establishing an accurate baseline is the essential first step towards understanding and managing the true value of water.

Raymond Philippe  
Head of Water, Skarn Associates

Newmont’s performance data tables provide an example of water accounting in practice.<sup>28</sup>

28. 2024 performance data tables, Newmont, 2025.

## Water – a critical resource for critical minerals continued

### Mine archetypes – supporting more holistic thinking and better water outcomes

How our sector thinks about water is changing. Given water's complexity, industry bodies are now looking at ways to help build shared understanding and greater cross-sector collaboration. CEEC International's Global Water Initiative (GWI) is particularly relevant here. CEEC has identified six flowsheet 'archetypes' that represent the main processing alternatives for ores for four key commodities: copper, gold, iron ore and nickel. These archetypes provide a useful framework to help miners better understand their water 'sources and sinks' and assess the technology options available to them to balance recovery, processing costs, waste generation, and energy and water use. They create ways to understand how water interacts with processing operations and mining wastes.<sup>29</sup> And they can support a more consistent, strategic conversation about water to encourage consensus around what constitutes the best available technology.

### The six geology-based mine archetypes and their link to water

The GWI's archetypes, shown in the table on page 14, are derived from three key factors driven by mine geology: mining method; commodity; and processing flowsheet.

The archetypes are arranged into the processing flowsheets that are most compatible with certain ore types, and can help identify which mining processes are most likely to have a high water impact. Which flowsheet a miner chooses to follow is typically driven by the deposit's geology. For example, the type of mineral and its grain size will determine how finely the ore needs to be broken down, as well as which separation or metal extraction technologies to apply. Flowsheets that require grinding will produce tailings, which may trap a significant volume of water.

This report largely focuses on archetypes 2 and 4 – fine physical separation and agitation leaching. Fine physical separation flowsheets incorporate grinding and may include a range of methods, especially flotation, gravity and magnetic separation. These methods apply to various sulphide ores, including copper, nickel and gold, as well as fine-grained iron ores such as magnetite, taconite and itabirite. Agitation leaching is predominantly used in cyanide leaching of gold ores.

In both archetypes, the site water balance is largely dominated by water losses to, or releases from, a tailings storage facility. This includes water entrapped in tailings, evaporation and uncaptured seepage. Tailings-related water losses are linked to the quantity of ore processed, the volume of tailings produced (which is closely related to quantity of ore processed), and the extent to which the tailings are dewatered. In contrast, heap leaching (archetype 3) treats crushed ores, which are drainable and trap little water.

From a water perspective, it is also useful to map different types of mining method – open pit, mass underground and selective underground – to the flowsheet archetypes.

Typically, open pit mines produce larger quantities of lower-grade ore and have more extensive surface footprints than underground mines. A larger footprint typically means more contact water, which may be used for processing or require treatment before being released to the environment. Heap leaching is invariably used in open pit mines, as suitable weathered ores are near the surface.

Mass underground mining methods, such as sub-level and block caving, are sometimes used for large, low-grade copper deposits. Mass underground methods do not create the large waste rock 'dumps' that are common in open pit mines.

By contrast, selective underground mining methods produce smaller quantities of higher-grade ore and lower volumes of waste rock and tailings. These mining methods are also compatible with backfilling dewatered tailings into the cavities created by extraction. This can reduce a tailings storage facility's overall footprint, and lower the volume of contact water and water trapped in tailings.

29. Global Water Initiative campaign summary, CEEC, 2024.

## Water – a critical resource for critical minerals continued

### CEEC International Global Water Initiative’s mine archetypes

Flowsheet archetype*	Grinding?	Tailings?	Copper	Gold	Iron ore	Nickel	Mining method
Archetype 1	No	Occasionally			Coarse grained		Open pit
Archetype 2	Yes	Yes	Primary and secondary sulphides	Sulphide (esp. refractory or polymetallic)	Fine grained (magnetite, taconite, itabirite)	Sulphide (esp. polymetallic - Cu, PGM)	Open pit Mass underground Selective underground
Archetype 3	No	No	Oxide, secondary sulphide	Low-grade non-refractory			Open pit
Archetype 4	Yes	Yes		Non-refractory			Open pit Selective underground
Archetype 5	Yes	Yes		Refractory		Ni laterite (limonite)	Open pit
Archetype 6	No	No				Ni laterite (sapolite)	Open pit

\*The six archetype flowsheets are:

- 1. Coarse physical separation:** coarse-grained iron ores.
- 2. Fine physical separation:** copper, nickel and gold sulphide ores treated by flotation; fine-grained iron ores, such as magnetite, taconite and itabirite, treated by magnetic separation and/or flotation.
- 3. Heap leaching:** copper oxide or secondary sulphide ores using solvent extraction and electrowinning (SXEW), cyanide leaching of low-grade gold ores.
- 4. Agitation leaching:** non-refractory gold ores, leaching dominated by cyanide.
- 5. Pressure leaching:** limonite nickel laterite ores, refractory gold ores.
- 6. Rotary kiln electric furnace:** saprolite nickel laterite ores.



Sustainable water management is one of our industry’s biggest and most urgent challenges, but it is not insurmountable. With the right technologies and flowsheets, and more collaboration, there is a huge opportunity to transform our sector’s environmental impact while driving greater efficiency.

Paula Cousins  
Chief Strategy and Sustainability Officer,  
Weir

## Water – a critical resource for critical minerals continued

### Using the archetypes to understand water impacts and support better technology choices

The archetypes provide a useful framework for thinking about technology choices that can improve water management for given ores within a particular flowsheet – for example, by reducing overall tailings production as well as enabling more intensive tailings dewatering.

Reducing the overall quantity of tailings can significantly reduce water withdrawals needed at a mine site, and there are two main ways to do that:

#### *More selective mining practices*

Including selective underground mining methods, smaller digging machines, more careful grade control during mining operations to minimise dilution into the ore stream, or incorporating sensor-based bulk sorting technology at the mine face. See pages 20-21 for more information on this process.

#### *Preconcentration techniques during mineral processing*

A range of wet and dry separation techniques can be used when removing coarse low-grade particles – known as ‘gangue’ – from the ore stream, including sensor-based particle ore sorting and magnetic separation (depending on the commodity). In wet processes, the coarse reject stream is free-draining and traps minimal water. Rejecting low-grade material before grinding produces fewer fine tailings. See page 25 for more information on this process.

Increasing the intensity of tailings dewatering is another important way to reduce water losses, if it can be done cost effectively. In many mines, tailings are partially dewatered through a process called thickening, where tailings are settled under gravity to recover a portion of water in the tailings slurry for recycling back as process water. The proportion that is recovered or reclaimed can be increased in several ways:

#### *Minimising overgrinding and preventing excessive quantities of fine tailings*

In general, tailings with a finer particle size – known as ‘fines’ – are more difficult to dewater and trap more water than coarser particle streams. By avoiding overgrinding, fewer fines end up in the tailings stream. One way to reduce overgrinding is by using enhanced classification technology at the grinding stage. See page 25 for more information on this process.

#### *Using coarser processing*

Technologies such as coarse particle flotation produce sands streams that are drainable or easier to dewater. These sands can then be used to construct tailings embankments, used in novel tailings storage designs, or sold for other beneficial uses. See page 25 for more information on this process.

#### *Enhanced tailings dewatering equipment*

Enhanced dewatering equipment, such as paste thickeners and filtration, can help recover additional water from tailings. Paste thickeners have a different design that enables them to produce denser tailings streams than conventional thickeners. Filtration, which produces a transportable cake with low moisture content, can further increase dewatering levels. See page 28 for more information on this process.

While this report doesn’t explore the heap leaching archetype (see table on page 14) in depth, its benefits are worth noting since it produces drainable residues that trap smaller volumes of water than tailings. This can reduce water consumption per tonne of ore processed by about 85% and per tonne of metal produced by more than 50%<sup>30</sup> compared with flotation processes that produce thickened tailings.

Major copper mining companies, such as BHP<sup>31</sup> and Rio Tinto,<sup>32</sup> have conducted long-term research into increasing the use of heap leaching to treat low-grade copper deposits. The findings suggest there may be opportunities to ‘switch’ certain ore types from the fine physical separation archetype to heap leaching, reducing water use per tonne of ore processed.

30. *Integrated mining and processing systems design for eco-efficiency*, Reemeyer, 2017.

31. *BHP completes heap leach technology trial for Olympic Dam*, BHP, 2019.

32. *Nuton: a better way to produce copper*, Rio Tinto, 2024.

## Water – a critical resource for critical minerals continued

### Enhancing the archetypes with data for long-term strategic planning and better decision making

The archetypes are an important step towards a common framework for improving the way our sector manages water. While mainly defined by a mine's geology, the archetypes can also be useful when considering geographical context, particularly when combined with context-specific research from individual mines.

Several 'tools' are already available that can help with this, such as the ICMM's new *Global Mining Dataset*,<sup>33</sup> which can be used to assess individual mines. The Natural History Museum in London, meanwhile, is working with Bloomberg to develop a new biodiversity tool that combines the museum's Biodiversity Intactness Index and Bloomberg's physical asset data for almost 50,000 global companies.<sup>34</sup> The tool will allow companies to understand their proximity to highly intact ecosystems, as well as the scale of their impact on those ecosystems over time.

Commercial datasets are also available that combine mine location with geographical context. Weir has been working with S&P Global, for example, to analyse mining data that rates specific climate- and nature-related risks and opportunities at individual mines or mines in the same archetype. While there are limitations in using global datasets when applied to individual locations, the conclusions are nonetheless striking when combined with the archetypes:

### *Around 90% of the 50 largest copper mines fall under archetype 2*

These are predominantly sulphide ores treated by flotation. Some have supplementary archetype 3 facilities for treating oxide and/or low-grade ores by heap leaching, although they represent a relatively minor contribution to copper production. Half these mines are in regions at chronic risk of extreme water stress, which often correlates with acute drought risk. Their focus is often on minimising water losses to tailings, enhanced by technologies such as coarse particle flotation, and using desalinated or raw seawater for processing to ensure continuity of operations. Some of these mines are in ecologically sensitive areas, typically tropical regions such as the African copper belt or glacial regions.

### *The top 50 gold mines are dominated by archetype 4*

These predominantly use agitation leaching. A smaller number have archetype 3 and 5 facilities. As leaching almost always uses cyanide, these mines typically incorporate cyanide detoxification to manage water quality risks. Around 25% of these mines are in areas of extreme water stress, with 25% also located in regions of ecological significance – typically wet climates.

### *Most iron ore mines are archetype 1*

These mines largely use coarse processing, which means they produce little or no tailings. Instead, water use is closely linked with other practices such as dust control. There are exceptions, with some significant iron ore operations that treat magnetite, itabirite and other fine-grained ores, which are increasingly being developed to produce iron ore feedstocks for lower emissions steelmaking processes. These mines fall into archetype 2 and require tailings storage facilities. Some are in areas of extreme water stress. For example, Karara and Iron Bridge are located in arid parts of Western Australia and have incorporated filtered tailings stacking and coarse gangue rejection respectively into their processing to limit tailings-related water losses. By contrast, operations in Brazil are located in wetter areas of high ecological significance, and it is notable that the Mariana and Brumadinho sites both experienced catastrophic tailings dam failures that caused significant environmental harm.

**ICMM's Global Mining Dataset identifies, by geocoordinates and facility name, around 8,500 mining or processing facilities producing 47 different primary commodities.**

33. Global mining dataset: understanding the global distribution of mining and metals facilities, ICMM, 2025.

34. The Natural History Museum and Bloomberg team up to make the museum's Biodiversity Intactness Index available to financial markets for the first time, Natural History Museum.

## Water – a critical resource for critical minerals continued

Insights like these can help inform a company's long-term water strategy, capital allocation and decision making for better financial, social and environmental outcomes. Miners clearly understand the impact of geography on their individual assets and are best placed to choose solutions based on their specific water balances. However, this type of data insight can help other stakeholders better understand the climate- and nature-related factors that affect mining. For example:

- Enabling more strategic discussions about appropriate capital allocation for water supply and treatment throughout a mine's operational lifetime and beyond. Upfront financing for more effective water management solutions could lower the provisions required for future liabilities once the mine has reached the end of its operational life. See 'Unlocking access to finance with holistic water management' on page 29.
- Informing flowsheet choices and helping to focus research and development into the next generation of water-efficient process technologies.
- Helping mines better manage water inventories and flows through short-term seasonal cycles as well as the long-term impact of climate change.
- Strengthening stakeholder engagement, with greater insight on the impact of a mine's water use and discharge on local communities and ecosystems. This could enable new forms of collaboration to identify and implement better water management and install mutually beneficial water infrastructure, and potentially reduce the time taken to receive environmental permits.

### Highlighting the benefits of a holistic approach

We believe the combination of these publicly available mining archetypes and data insights from physical risk analysis points to ways our sector could start to look at water use and management more holistically, and work together to address water challenges in different mining contexts. They can also inform technology discussions during mine planning to help redesign flowsheets and apply proven technologies that exist today to reduce water intensity, manage water quality and improve water efficiency over a mine's operational lifetime and beyond. This includes planning for a mine's eventual closure and remediation, which can be heavily influenced by upfront water management decisions, with studies showing clear potential benefits<sup>35</sup> (see page 30 for more information).

Building a collective understanding of the combined impact of geology and geography is essential if, as a sector, we are to be bolder and more strategic in our thinking, and swifter and more innovative in our action. That's not always easy in a business where cost efficiency is paramount and constructing and running a mine is a multi-decade operation. However, the cost of delaying action could make installing future solutions harder and less effective. This is particularly true if pressure to change increases as societal expectations harden at the same time that broader trends like managing declining ore grades put even greater stress on water demand and tailings management.



**Our research, combined with the archetypes, can help bridge the current gap between strategic capital allocation and investment decisions and tactical water use at a mine.**

Josef Fink  
Director, S&P Global Sustainable1

### Finding the right flowsheet

See page 30 for a detailed example of the impact that geography can have on flowsheet recommendations for mines in the same archetype.

35. Reducing water and energy consumption through innovative mineral process flowsheet design, Klein et al, 2024.

## Water – a critical resource for critical minerals continued

### Placing a value on water

A common framework is only a first step, though. We also need to place a value on water in the same way that industries increasingly value energy and its associated greenhouse gas emissions.

In many ways energy and water are deeply intertwined and should be thought of in similar ways – when it comes to getting a new mining project off the ground the two vital ingredients are power and water supply. While mines are very energy intensive, the benefits of reducing energy consumption are more easily quantified and many companies have mature energy reduction programmes in place. But while mines are also water intensive, there is often a perceived trade-off between water and energy, since better water management – such as recovery and recycling – as well as measures to increase supply, can increase energy consumption. So, the big prize for miners, particularly in water-scarce regions, is to reduce energy and water consumption together, while protecting water quality.

While reducing energy consumption is a more straightforward goal, establishing universal performance metrics for water is more complicated given its localised nature. Unlike the impact of climate change, which may be gradual and less perceptible locally, water scarcity can immediately halt mining operations. How much water is available and its quality has a direct, tangible impact on the communities living near a mine. And yet, measuring consumption hasn't always been a priority for miners.

However, water's local context is exactly why we need better metrics and more strategic thinking during the planning stages, since we have a responsibility to manage water well for stakeholders. We have all seen the cost to human life and local communities when water is not handled properly, as well as the financial and reputational implications for the mining companies in question.

### Tackling water's complexity and thinking more strategically

We don't see any of these challenges as insurmountable. Rather, they can – and should – be overcome. What's more, we see an opportunity to think about water more holistically, drawing on rigorous research, analysis and flowsheet design to take a more informed and nuanced approach to identifying the best available process and technology solutions. Doing so will naturally lead to greater operational efficiency and better social, environmental and commercial outcomes during the life of a mine.

This means making more informed strategic decisions about water in the earliest stages of mine planning, and treating water stewardship not as a compliance issue, but as a foundation for the way our industry manages risk and stakeholder trust. In doing so we believe it's possible to reduce miners' costs across the life of a mine, including its closure, while ensuring we continue to deliver the critical commodities society relies on.

We hope the rest of this report provides a catalyst for thinking differently about water across every stage of the mining process. Our aim is to start a more joined-up conversation about how we can work together to lower our collective environmental impact while reducing cost and risk and ensuring our licence to operate endures for decades to come.



**There's a growing rush to combine datasets and models to create water insights for mining. However, too often those producing them don't understand the limits of the data, and those using them treat the outputs as fact. That's not insight progress; it's false confidence. Water has to be understood in context, on the ground.**

Raymond Philippe  
Head of Water, Skarn Associates

# Water in the mining process

Water must be managed throughout the mining process. As well as considering sources and quantities required for their operations, miners must think about how it interacts with their excavation work, its use in processing and waste management, and its eventual safe release back into the environment. Over the following pages we look at the different ways that miners must consider water during each of the three key stages of the mining process and how the innovative use of archetypes, end-to-end flowsheets and best available technology could help our sector take a more strategic, informed approach to managing water.

In this section:

- **Mine planning and ore extraction**
- **Comminution and mineral processing**
- **Tailings processing**



## Water in the mining process

### Mine planning and ore extraction

Every mine starts by defining the available mineral resources and developing a plan to extract and process them. The interrelated mining, processing and waste management decisions made now will influence production and environmental impact for decades.

Traditional mine planning typically considers water as an input within the context of a mine's geography and the impact that its presence – or absence – has on the mine's ability to operate. In areas of water abundance mining engineers must determine what dewatering equipment a mine needs to safely remove, reuse or return water to the surrounding environment. Where scarcity is an issue, mining companies must consider where and how to source water, and the impact of any local regulations as well as environmental considerations. The costs to treat or source water can be substantial.



The choice of water supply is critical right up front in the planning. You have to take a life-of-mine perspective and predict your water supply over that time.

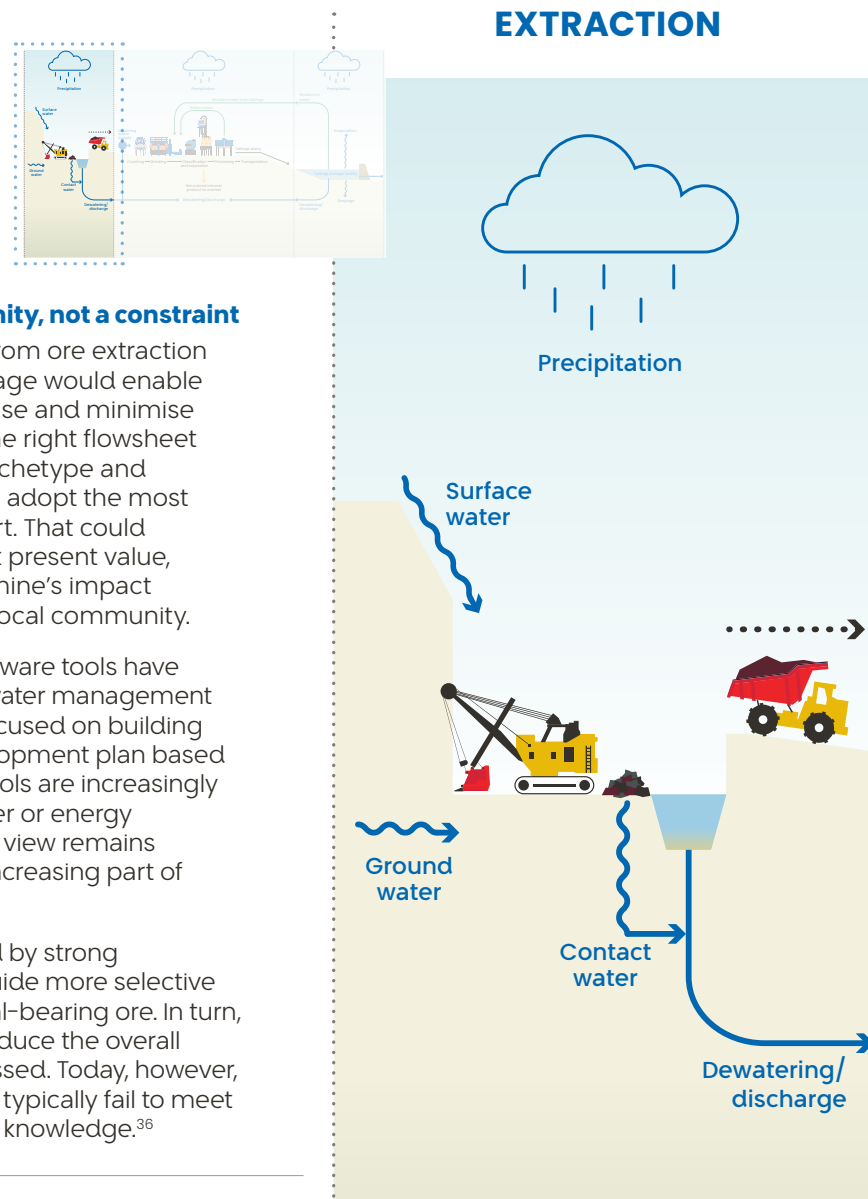
Stephen Marshall, Principal Advisor Mining, Weir

#### Planning around water – an opportunity, not a constraint

Taking a strategic life-of-mine view – from ore extraction to restoration – during the planning stage would enable mining companies to optimise water use and minimise impacts on water quality. Identifying the right flowsheet based on a combination of a mine's archetype and characteristics would enable miners to adopt the most appropriate technologies from the start. That could improve operational efficiency and net present value, reduce costs and risks, and lower the mine's impact on the surrounding environment and local community.

New generations of mine planning software tools have the potential to help miners consider water management at this early stage. While traditionally focused on building a safe and economically feasible development plan based on the geology of the deposit, these tools are increasingly able to account for factors such as water or energy consumption. While taking a joined-up view remains challenging, resource impacts are an increasing part of the mine planning discussion.

Effective mine planning is underpinned by strong knowledge of the ore body. This can guide more selective extraction with greater focus on mineral-bearing ore. In turn, this can help improve efficiency and reduce the overall volume of rock that needs to be processed. Today, however, around one-third of all mining projects typically fail to meet their targets because of poor ore body knowledge.<sup>36</sup>



36. The value of ore body knowledge, Bradshaw Research Institute for Minerals and Mining.

## Water in the mining process continued

### Smart extraction as the first step in end-to-end water management

Today, water is mainly used during ore extraction at open pit mines located in dry climates to manage dust control. This is essential for protecting the health and safety of everyone working at, and travelling around, the mine site. The volume of water required is highly seasonal, with far more needed on hot, windy summer days. That said, these volumes usually represent a small fraction of the total water used across the mining process on an annual basis.



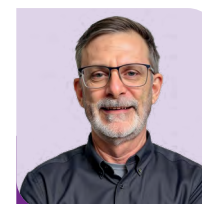
**Our sector needs to invest more in ore characterisation so that we can better understand what we are extracting – in real time – to help minimise processing waste and optimise water use.**

Chris Carpenter  
Vice President, Innovation and Technology, Weir

In mines located below the water table or in regions that experience periods of high rainfall, miners must also manage contact water, removing surplus water to minimise its impact on production and treating it to minimise the risk of contaminating the surrounding environment and affecting local communities. High-capacity pumps remove water from the mine and discharge it to a safe place, typically a holding pond, before it's transferred to the process water system, the tailings storage facility, or treated for compliant discharge.

Classification and separation technologies at the extraction stage have a key role to play in enhancing water management later in the mining process. Valuable minerals usually represent a small fraction of the total mined rock, yet traditional techniques require all ore to be processed and managed in order to unlock that value. The amount of water needed to process each tonne of ore is largely independent of valuable mineral content, therefore water per unit of mineral product increases as ore grades fall.

Introducing better processes and technologies to classify and separate material as either ore or waste can help miners be more selective about which rock to send into comminution and processing. Under certain archetypes this kind of ore sorting can generate multiple material streams, which can be combined with preconcentration processes, such as magnetic separation, and coarse gangue rejection, to increase the mineral content of processed ore and reject non-mineral bearing rock.<sup>37</sup> This can significantly improve the efficiency of water use per tonne of metal or mineral recovered and lead to more consistent ore quality and improved operating efficiency.



**Fully integrating water considerations into mine planning, and especially mine schedule optimisation, would go a long way to helping the mining sector optimise resource use and reduce the potential for conflict.**

Philip Bangerter  
Director, CEEC International Ltd

37. Reducing emissions and energy use in comminution, mine, 2025.

## Water in the mining process continued

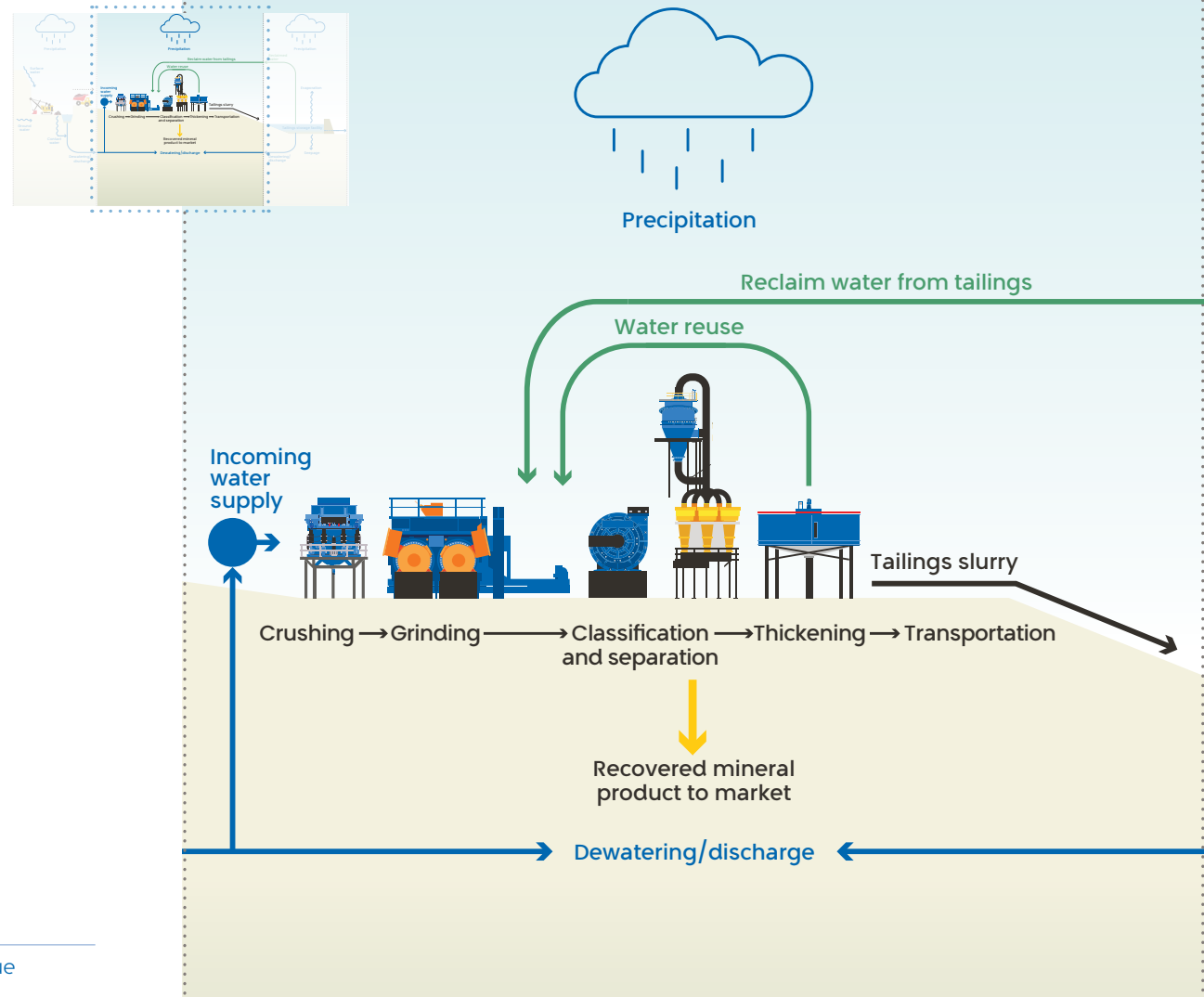
### Comminution and mineral processing

Comminution and mineral processing are key to producing the materials society needs and values from the mined ore. They are also central to the challenges associated with water use in mining since, without water, it would often be impossible to separate those materials. Further, the choices made during this stage can have a profound impact on how tailings – particularly the finely ground particles that can end up in the tailings stream – are managed and, therefore, the quantity of water needed across a mine’s operational life.

As mining companies expand existing operations and develop new projects to meet rising demand for critical minerals like copper, declining ore grades require ever larger volumes of water to extract equivalent quantities of valuable minerals.<sup>38</sup> While these broader trends make an already complex picture more challenging, operators have tended to make decisions about comminution and mineral processing equipment in isolation, often without considering what might be happening during other stages of the mining process.

High pressure grinding rolls are up to **40%** more energy efficient than conventional technologies when used in combination with vertical stirred mills and coarse particle flotation.

### COMMINUTION AND MINERAL PROCESSING



38. Decreasing ore grades in global metallic mining, a theoretical issue or a global reality?, Calvo et al, 2016.

## Water in the mining process continued

### How water is used today

Comminution is a multi-stage process that starts with crushing rock – typically a dry process using heavy duty equipment – followed by grinding, which is usually done wet. Grinding ore fragments into finer particles to free individual mineral grains is usually done in tumbling mills, which rely on significant quantities of water and energy. Processes such as flotation recover valuable minerals from these ground particle streams. The required fineness of grind depends on the characteristics of the ore; ores like copper porphyry have relatively coarse mineral grains and therefore do not need to be ground as finely as others, such as sedimentary lead-zinc. While reducing

grind sizes can help increase metal recovery, a portion of the ore will be over-ground to a smaller particle size than is needed for high mineral recovery. As well as consuming additional energy, this can result in tailings containing slime that are costly and more energy-intensive to dewater. This lowers overall water recovery rates and increases a mine's net water consumption. Finer tailings can also mean that waste is less readily drained, which can affect the stability of tailings storage facilities.

A lack of separation and classification during the extraction stage increases the challenge since gangue particles are ground alongside valuable minerals. This can increase energy consumption and result in tailings that trap larger than necessary quantities of water.

### Technology is available today that can help reduce water use

The good news is that there is already a range of technologies available that can help miners reduce the volume of water they need to carry out comminution and mineral processing. The benefits and impacts of current technologies are summarised in the table on page 24.



There is so much room to improve how we manage water, with better solutions available now. Taking a more holistic view would help us understand how to use those solutions to recover and reuse water when its value is highest.

Jeremy Hanhiniemi  
Director, Technology and Innovation, Weir



Driving down water and energy consumption are not mutually exclusive. By expanding the capabilities of technology that is available today and combining it with innovative flowsheet design, it's possible to significantly reduce both.

Professor Bern Klein  
University of British Columbia

## Water in the mining process continued

### Current technologies and their water management benefits and impacts

Technology	Description	Water management benefits and impacts
<b>Tumbling mills</b>	<p>A large rotating drum which may contain steel balls that break ore by the tumbling action of steel balls and/or rock inside the drum. This technology is used throughout the mining sector to grind crushed rock to the particle size required to liberate the minerals, often in two stages:</p> <ul style="list-style-type: none"> <li>– Semi-autogenous grinding (SAG) mills: larger diameter mills for primary grinding (or autogenous – AG – mills if steel balls not present).</li> <li>– Ball mills: typically lower diameter mills for finer, secondary grinding.</li> </ul>	<ul style="list-style-type: none"> <li>– Grinding generally done wet.</li> <li>– High energy consumption.</li> <li>– Embodied CO<sub>2</sub>e in steel media and liner wear.</li> <li>– Unselective and prone to overgrinding.</li> </ul>
<b>High pressure grinding rolls (HPGR)</b>	<p>Crushing material in a very controlled and selective way, between two opposing rolls, at high pressure. Can be used in combination with tumbling mills, for example with a ball mill for secondary grinding, or to replace them by deploying in series to achieve fine particle sizes.</p>	<ul style="list-style-type: none"> <li>– A dry process. For some ores, magnetic separation can be used on the product of HPGRs, further reducing water demand via dry waste rejection.</li> <li>– More energy efficient than tumbling mills.</li> <li>– Long roll lives and no media or liner wear.</li> </ul>
<b>Vertical stirred mills</b>	<p>In some designs, a bottom-fed ‘plug-flow’ device with a stack of rotating internal discs that grind and internally classify material.</p>	<ul style="list-style-type: none"> <li>– Plug-flow design and internal classification prevents overgrinding and slimes generation, with resulting water and energy efficiency benefits.</li> </ul>
<b>Flotation</b>	<p>Flotation selectively makes valuable minerals hydrophobic so they attach to air bubbles and float, separating the valuable minerals from the waste. The process starts with mixing ground ore and water in the form of slurry with chemicals to make the desired minerals hydrophobic. Air is then bubbled through the slurry in flotation cells, where the mineral-coated bubbles form a froth that is collected.</p>	<ul style="list-style-type: none"> <li>– Requires water, which needs to be managed and recycled and reclaimed from subsequent tailings.</li> </ul>
<b>Coarse particle flotation</b>	<p>Fluidised-bed device that separates valuables from waste at a coarser size, resulting in reduced slimes generation, cost, energy and emissions.</p>	<ul style="list-style-type: none"> <li>– A high proportion of the overall waste is removed as a coarser sand, which is self-draining for improved water recycling.</li> </ul>
<b>P29</b>	<p>An emerging process that uses engineered foam that replaces bubbles in conventional flotation. This has the potential to improve coarse particle recovery.</p>	<ul style="list-style-type: none"> <li>– A high proportion of the overall waste is removed as a coarser sand, which is self-draining for improved water recycling.</li> </ul>
<b>Hydrocyclones</b>	<p>A hydrodynamic device that classifies slurries based on size and density.</p>	<ul style="list-style-type: none"> <li>– With improved classification efficiency, fewer slimes are created in grinding, leading to water recovery and dewatering benefits.</li> <li>– Also used as a dewatering device to remove and recycle water from the waste stream.</li> </ul>
<b>Air classification</b>	<p>A dry alternative to wet classification that uses air to separate dry ores by size and density.</p>	<ul style="list-style-type: none"> <li>– Allows for dry classification without water use.</li> </ul>

## Water in the mining process continued

As already discussed on pages 20–21, better ore classification and separation during extraction can reduce the amount of ore that requires grinding. In addition, we see three key, interlinked ways that our sector could deploy technology during comminution and processing to significantly improve water management:

### 1. Improve comminution techniques to reduce water consumption and overgrinding

The basic comminution process used at many sites has not changed significantly for many decades. This means miners typically rely on technologies that they know and trust, like tumbling mills, which as already discussed, tend to be imprecise and energy and water intensive.

High pressure grinding rolls (HPGR), by contrast, is a dry-grinding technology that can reduce water use through opportunities for dry, early rejection of waste through preconcentration. The technology is also up to 40% more energy efficient than conventional methods, when used in combination with vertical stirred mills and coarse particle flotation.<sup>39</sup> While HPGRs have been available for more than 30 years, miners continue to rely on tumbling mills because they tend to be better understood by miners themselves, and replacing them requires significant upfront capital investment. However, the operating environment has changed significantly in the last three decades, with ore grades declining, meaning miners typically have to use more energy and water to release an equivalent amount of valuable minerals. At the same time, the cost of power and milling equipment has risen.

The [Iron Bridge project](#) in Western Australia exemplifies how innovative combinations of proven technologies can enhance both water and energy efficiency at the same time.

### 2. Coarser processing and improved classification to minimise fine grinding and improve water recovery from tailings

Crucially, the benefits of technologies like HPGR are amplified when combined with other proven technologies in innovative ways. For example, magnetic separation or coarse particle flotation can be employed after the initial grinding stage to remove non-mineral-bearing material and reduce the amount of ore sent for further grinding. Improved classification using enhanced hydrocyclones improves particle size distribution to reduce overgrinding. These techniques can lower water and energy consumption – as well as operating costs – because grinding power demand rises as the target grind size decreases.

In addition, coarser particles are free draining, making it easier to recover and recycle water into the mill circuit before it reaches the tailings stream. The remaining sand can then be repurposed, for example to construct tailings embankments.

The use of other technologies, such as hydrocyclone sands, is also growing. Hydrocyclones are used to separate fine and coarse material, which is then placed in separate parts of the tailings storage facility, including in novel designs like hydraulic dewatered stacking (HDS), to improve overall tailings outcomes (see pages 24–25).

### 3. Incorporate digital technology and data analytics to classify, grade and process ores more efficiently

Like many other industries, mining is beginning to embrace digital technology, alongside lithology and geochemical analysis, to help optimise overall performance, including water use. The use of sensor-based sorting technology and real-time data analytics can help miners to classify ore and remove uneconomic low-grade minerals, manage grades, and prevent dilution and loss. It also helps them respond quickly to changes in ore feed characteristics, supporting more informed comminution and mineral processing decisions to improve efficiency, minimise waste processing and optimise water use.

#### Taking a holistic view to improve water management

As well as having a direct impact on water consumption during comminution and mineral processing, the choices miners make at this stage can have a significant impact on the overall volume of water a mine consumes throughout its operational life. For example, decisions about technology, flowsheets and equipment can determine the volume of tailings produced, the amount of fines they contain, and, ultimately, how much water is lost to those tailings – which are discussed in more detail on pages 26–30.

In fact, adopting innovative flowsheets and an end-to-end approach could reduce water consumption per tonne of copper produced at a typical copper mine by as much as 78%, while lowering energy consumption by 48%.<sup>40</sup>

39. [New study by Weir highlights big energy saving opportunity in mining](#), Weir, 2023.

40. Reducing water and energy consumption through innovative mineral process flowsheet design, Klein et al, 2024.

## Water in the mining process continued

### Tailings processing

Tailings are a major waste stream, with almost half produced from processing copper ores, a further 21% from gold and 9% from iron ore.<sup>41</sup>

While tailings themselves do not add to water consumption, they are the point at which most of the water used earlier in the mining process ends up. Depending on the design and ore type, water retained in tailings can account for as much as 80% of a mine's total water balance.<sup>42</sup> This stage is critical, therefore, in determining how much water can be recovered and recycled, versus how much is lost to long-term storage, evaporation or seepage.

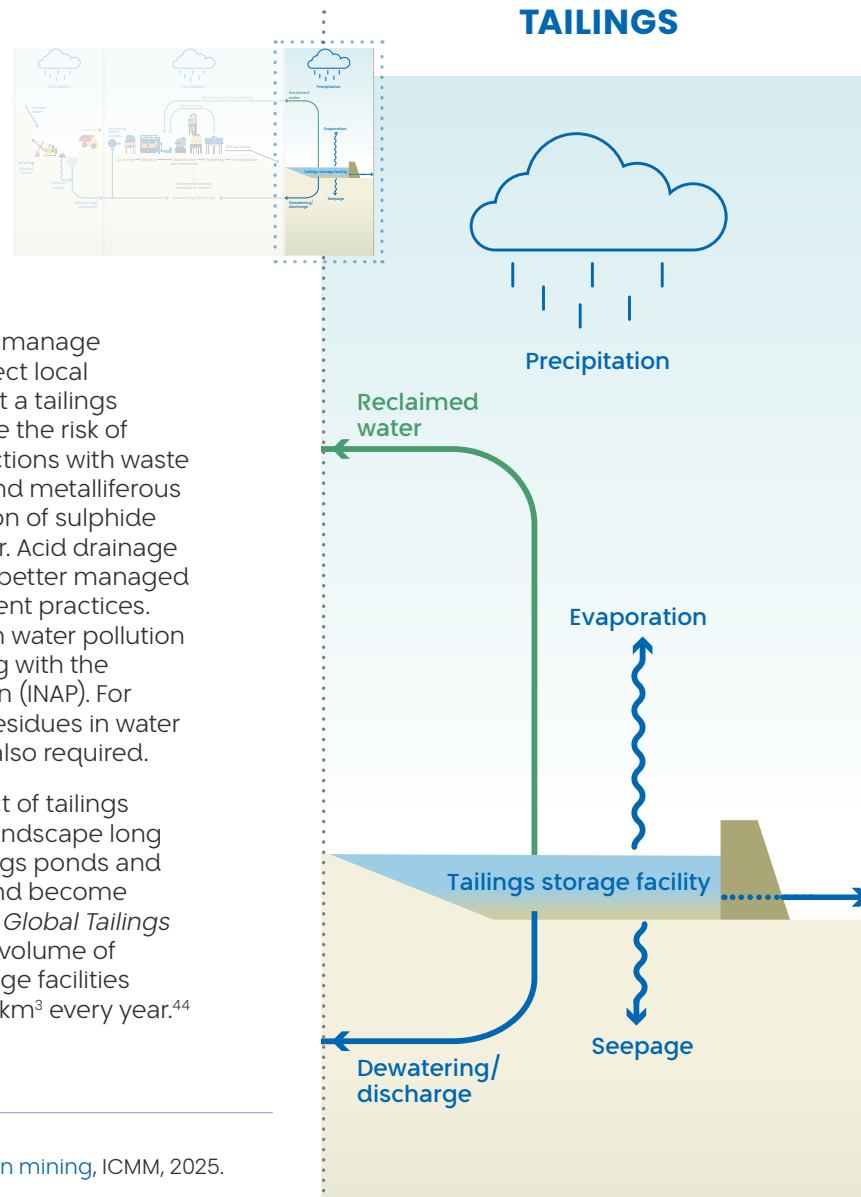


One of the biggest changes we could make as a sector is to stop seeing tailings purely as a waste stream to be contained, but a product in its own right to be managed.

Erik Vlot  
Global Tailings Director, Weir

Miners must carefully store tailings and manage the water associated with them to protect local communities from the risk of collapse at a tailings storage facility. They must also minimise the risk of environmental damage caused by reactions with waste minerals in tailings. For example, acid and metalliferous drainage formed by the natural oxidation of sulphide minerals when exposed to air and water. Acid drainage can often be prevented and its impact better managed with site-level planning and management practices. ICMM has launched a tool to strengthen water pollution management and prevention,<sup>43</sup> working with the International Network for Acid Prevention (INAP). For many gold mines, managing cyanide residues in water from mineral processing operations is also required.

Miners also need to consider the impact of tailings storage facilities on their surrounding landscape long after the original mine has closed. Tailings ponds and dams can be several kilometres long and become part of the landscape for centuries. The *Global Tailings Review* estimated that the current total volume of active, inactive and closed tailings storage facilities amounted to 217km<sup>3</sup>, increasing by 12.3km<sup>3</sup> every year.<sup>44</sup>



41. *Global tailings review, Chapter II - mine tailings facilities: overview and industry trends*, Baker et al, 2020.

42. Oyu Tolgoi project ESIA, 2012. 43. *ICMM and INAP launch new tool to strengthen water pollution prevention in mining*, ICMM, 2025.

44. *Transforming tailings solutions*, Weir, 2024.

## Water in the mining process continued

Some miners are now exploring ways to recover valuable byproducts such as construction sands from tailings, which presents an opportunity to increase water recovery from tailings, reduce tailings footprint and achieve better closure outcomes.

In short, tailings represent a long-term, ongoing risk and cost in terms of site restoration and management, both of which can be influenced by mineral processing and dewatering decisions made years before an impact is felt.

### How water is used today

Historically, the mining sector has viewed tailings as unavoidable waste to be contained at the lowest cost. This conventionally involves mixing finely ground particles with water for transportation to a separate storage facility where the water is left to settle naturally into a pond or dam. At this point, some of that water may be recycled back to the plant, while some of it will



**Companies need to balance the costs of tailings filtration with the potential benefits, such as water recovery and risk reduction, to build a financial case.**

Trevor Sparks  
Founder, Kipinat Ltd

naturally evaporate. The rest is essentially trapped with the tailings and stored long term in the facility. The sector has witnessed the catastrophic consequences for human life and the environment when tailings storage is not managed well.<sup>45</sup>

Given the scale of the risks associated with storage failure, miners are, understandably, exploring ways to dewater tailings more effectively. For example, filter processing is a two-stage method that thickens tailings to remove a proportion of the water before passing them through a filter to squeeze more out, leaving a solid 'cake'. These drier tailings are then transported using, for example, conveyor belts or trucks and stacked in a smaller storage facility. This minimises or eliminates the need for tailings dams and helps recover more water for recycling back into the processing plant. There are clear safety and environmental benefits to this process, with the additional advantage that it can be applied to both new projects and existing mines, making it a good option in areas of water scarcity or where community pressure is high.

However, filtration can be energy intensive and has high capital and operating costs. It is also more complex to transport and stack the filtered tailings rather than pumping them to a wet tailings facility. Therefore, miners and technology providers are devoting significant effort to developing energy- and cost-efficient methods to manage tailings in ways that best match the needs of each location. We are seeing gradual changes, particularly in regions like South America where factors such as water scarcity, the potential risk from seismic activity on the stability of tailings storage facilities, and community and regulatory pressures are driving greater adoption of more water-efficient and safer technologies.

<sup>45</sup>. [Global study of tailings dam failures by statistical and remote sensing methods](#), Rana, 2026.

## The potential for nature-based solutions

**Biogeochemical systems-level research is beginning to identify how endemic microbes, geochemistry and environmental conditions shape mine water quality outcomes, often explaining current management and modelling inefficiencies and failures.**

**This means it is increasingly possible to treat water using biological processes. While not likely to be a standalone solution, this approach has the potential to reduce the energy and chemical footprint associated with water treatment and help mines lower the impact of their discharge water on the surrounding environment.**

**“Innovative biologically based opportunities to de-risk, improve performance and resilience are myriad in the mining water space. Mine waters are typically highly bioreactive, with largely unexplored endemic microbes altering water and solids outcomes, especially from those predicted by abiotic models, through their metabolic activities. By identifying these underpinning microbial processes, controls and outcomes in mine water contexts, we open the door to developing nature-based and nature-positive solutions that achieve the outcomes you want.”**

Lesley Warren  
Director, Mining Futures Initiative, University of Toronto

### How proven technologies available now can help

There are no simple solutions when it comes to responsibly managing tailings, but there are proven technologies already on the market that we believe can help. The benefits and impacts of some available technologies are shown in the table on page 28.

## Water in the mining process continued

### Current technologies and their water management benefits and impacts

Technology	Description	Water management benefits and impacts
<b>Conventional</b>	Tailings pumped in slurry form and then stored in conventional tailings storage facilities.	No volume reduction of water in tailings; lowest cost solution in the short term, but complicates mine closure. Risk of dam failure, causing loss of life and pollution. The biggest contributor to failure is water-related operational issues.
<b>Thickeners</b>	Thickeners remove water from tailings, before being pumped to storage, creating a thickened slurry that can be more easily managed and stored.	Reduces the volume of water that needs managing by around 20-30%. Can improve a tailings storage facility's stability.
<b>Thickened paste</b>	Similar to thickeners, thickened paste tailings involve further dewatering to create a paste-like consistency similar to toothpaste.	Can reduce tailings volumes by 50-90% with up to 90% water recovery. This method allows the tailings to be stacked and reduces the risk of dam failures.
<b>Paste pumping</b>	Positive displacement (PD) pumps transport slurries at very high solids concentration to reduce water need.	Higher dewatering and nearly dry tailings transport and deposition.
<b>Filtered</b>	Filtering the tailings to remove most of the water and create a stackable material.	Filtered tailings can be transported and stored more safely, reducing the risk of environmental contamination.
<b>Mine backfill</b>	Tailings are used to backfill mined-out areas in underground mines.	This approach can help stabilise the ground and reduce the volume of tailings that need to be stored on the surface.
<b>Decant solutions</b>	Dewatering pumps are mounted on pontoons or barges to recover water from the tailings storage facility once solids have settled out.	Reduces the amount of water trapped in tailings and enables water to be recycled back into the processing plant.
<b>Terraflowing</b>	A dewatering solution developed by Weir that includes several flowsheets to help miners handle discrete tailings fractions in a way that produces an engineered paste. The process can change based on the site's requirements, using a range of other technologies, such as cycloning, screening, centrifuging, paste thickening, filtration and decanting. <sup>46</sup>	During extensive tests in Australia, we were able to recover 95% of the water in the tailings feed for reuse in the processing plant. <sup>47</sup>
<b>Hydrocyclones – coarse sand separation</b>	A conical container with no moving parts. Solids and water are pumped in under pressure, creating a swirling motion that separates solid particles in a liquid stream by size and density.	Separating coarser, drainable sands using hydrocyclones produces dam wall construction or mine backfill and can reduce the overall volume and water trapped in tailings.
<b>Hydraulic dewatered stacking</b>	Involves separating coarse and fine tailings and using the coarse tailings as hydraulic filtration layers for fine tailings stacked between.	Results in a drier, more stable material that can be stacked and stored more safely than conventionally thickened tailings. Also allows for recovery and reuse of water in the mining process. Lower cost than installing pressure filters.

Hydraulic dewatered stacking has been implemented by Anglo American at its El Soldado mine in Chile to improve safety, reduce water consumption and enable faster land reclamation at the end of the mine's life.<sup>48</sup>

46. Versatile tailings dewatering solution delivers high water recovery, Weir, 2024. 47. Ibid. 48. Progress on hydraulic dewatered stacking (HDS), Anglo American, 2025.

## Water in the mining process continued

### Taking an end-to-end view to reduce energy and water demand

Geography and climate all play a key role in the way that tailings must be managed. In areas of high precipitation, water will naturally collect in a tailings storage facility. So miners must consider how to maximise the facility's stability, while minimising the risk of pollution from run-off water. In areas of water scarcity, supplies of processing water tend to be more expensive and increasingly subject to tight regulation. Miners must, therefore, consider how to maximise water recovery rates from tailings for recycling back into the mineral processing plant.

As already discussed in this report, by applying an end-to-end view of water management, informed by the archetypes and using the best available technology throughout the mining process, we can start to change the way we think about tailings. Indeed, studies now show<sup>49</sup> that combining energy-efficient comminution techniques, coarser separation and improved tailings dewatering can create a sweet spot for miners where both water and energy consumption are reduced throughout the mining process. This is contrary to the common view that improved water recovery automatically leads to increased energy consumption.

And rather than seeing those facilities as a form of uncontrolled water storage, we believe the sector should be designing them in ways that keep tailings and clean water, including precipitation, separate, while recovering as much water as possible in the tailings themselves for reuse. This would enable miners to release water in a more controlled way, reducing the risk of instability in the tailings storage facility. It could also lower the cost of water treatment, since additional precipitation and run-off would not come into contact with reactive minerals and residual chemicals present in the tailings.

Codelco's projects in Chile provide an example of a water conservation approach in a water scarce region.

### Unlocking access to finance with holistic water management

Changing the way we think about tailings could help miners access preferential 'green' funding. Traditionally, the sector has treated technology choices as part of a mine's initial capital expenditure, rather than considering the potential legacy costs if those choices lead to significant or unexpected remediation and management further down the line. This can mean insufficient funds are set aside for future liabilities, making it more difficult to address any environmental impact and storing up significant problems for future generations.

However, some financial institutions are now looking at ways to offer mining companies cheaper funding earlier in the planning process. This funding can be used to invest in the best available water-efficient technologies, while ensuring that sufficient funds are available for remediation at the end of a mine's operational life. BNP Paribas' recent work to establish Decommissioning Reserve Funds is one example of

this approach,<sup>50</sup> and mining companies Gold Fields and South32, have secured sustainability-linked finance that relates to factors including water use.

Meanwhile, the finance sector is increasingly required to report its exposure to water-related impacts from climate change in its investments, under International Sustainability Standards Board requirements. This requires an understanding of water data for individual mines. Since many mines are owned in joint ventures, asset-level data will need to be attributed to different owners, which will require more detailed disclosure. There is emerging evidence that a financial premium is potentially already being attached to high climate risk exposure.<sup>51</sup>

A further challenge will be to attribute water data per tonne of metal produced, for traders and trade financing. Again, asset-level data will not always be sufficient, since many mines produce more than one metal.

49. Reducing water and energy consumption through innovative mineral process flowsheet design, Klein et al, 2024.

50. Decommissioning stranded energy assets, BNP Paribas Asset Management, 2025. 51. Does physical climate risk carry a financing premium? Insights, Bloomberg Professional Services.

## Water in the mining process continued

### Finding the right flowsheet

#### Viewing archetypes through a geography lens

Combining archetypes with physical risk- and nature-related data can help miners make more informed technology choices, as demonstrated below. The examples in the table look at the impact that geography has on tailings flowsheet recommendations for mines in the same archetype.

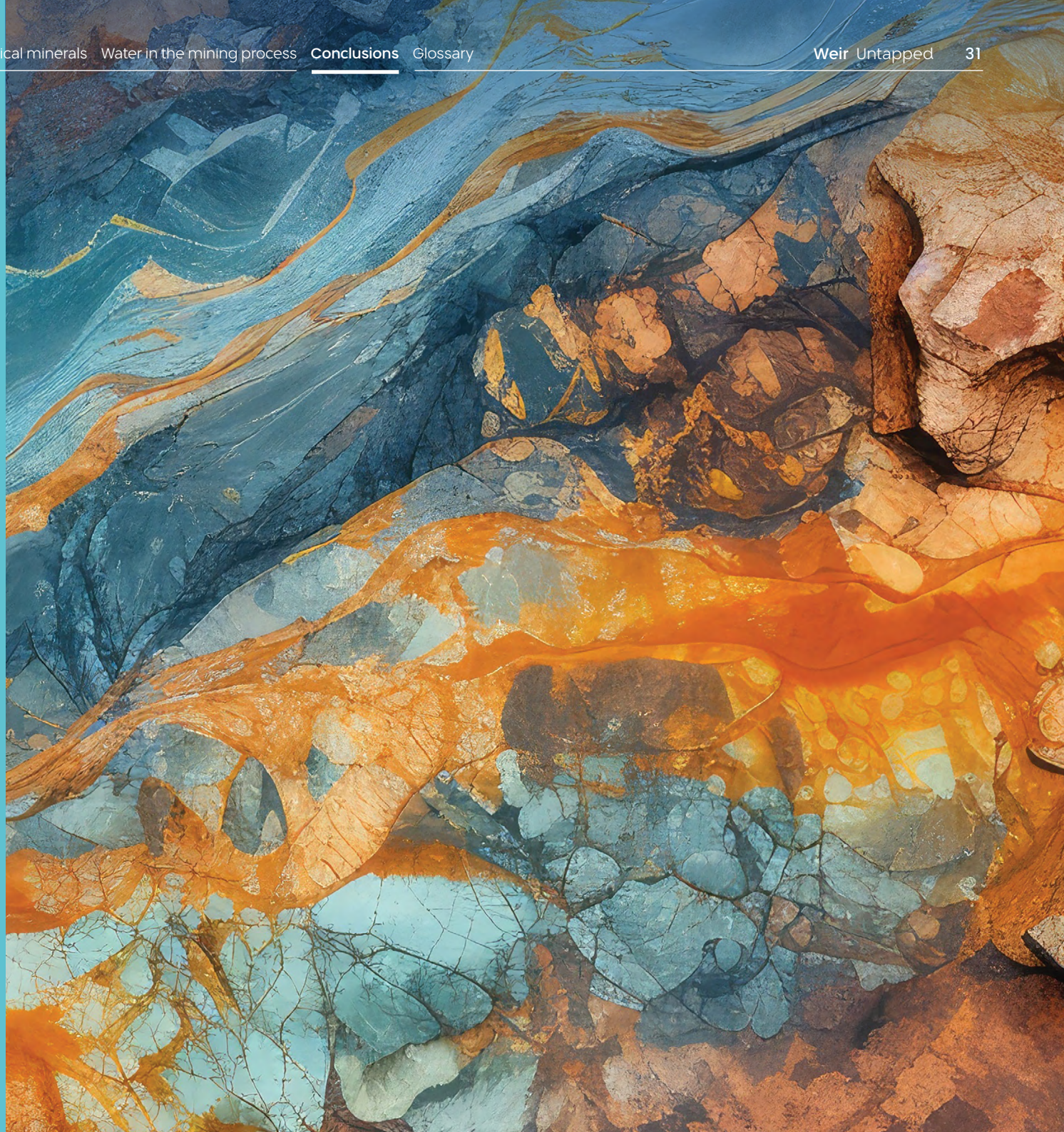
Commodity	Copper	Iron ore
Mine method	Open pit	Open pit
Archetype	#2 fine physical separation	#2 fine physical separation
Climate	Arid region	High-rainfall region
Constraints and risks	<p><b>Community:</b> risk of impact on fresh water availability for human consumption or use in agriculture.</p> <p><b>Regulatory:</b> extraction limits or permitting challenges.</p> <p><b>Water availability:</b> constrained at all times; vulnerable to periods of prolonged drought.</p> <p><b>Nature impact:</b> risk of impact due to reduction in water availability.</p>	<p><b>Community:</b> risk of pollution of water for human consumption or use in agriculture from tailings dam leakage or overflow. Risk to life and property from tailings dam failure.</p> <p><b>Regulatory:</b> penalties from pollution incidents. Permitting challenges.</p> <p><b>Water availability:</b> challenges of safely managing surplus and contact water and minimising pollution risks, especially during periods of acute high rainfall.</p> <p><b>Nature impact:</b> risk of pollution or destruction from tailings dam leakage, overflow or failure.</p>
Key technical priorities	<p>Minimise water withdrawals.</p> <p>Maximise water recovery from tailings.</p>	<p>Minimise pollution risks from water discharges.</p> <p>Maximise tailings stability, to minimise risk of dam failure.</p>
Tailings flowsheet recommendation	<p><b>Flowsheet A:</b> separates the tailings into coarse and fine streams. Coarse tailings are free draining and dewatered using vibrating screens. Fine tailings are dewatered using a filter press. In both cases, up to 90% of the water is recovered.</p> <p>The resulting unsaturated material is stackable and reduces – or may eliminate – the need for a tailings dam. A key advantage of this flowsheet is that it achieves water recovery with reduced investment and energy consumption compared with filter pressing alone, making it more likely to be financially viable.</p>	<p><b>Flowsheet B:</b> tailings failure risks mean that a conventional tailings facility is not preferred, and in some cases, will not be permissible. It may be possible to produce a stacked filtered tailings facility, although this may be complicated to manage because of high precipitation. An alternative flowsheet may be to produce a stable paste. Coarse material passes through a vacuum belt filter and fine tailings to a thickener. The streams are then combined to create a pumpable paste, with water recovery of around 80%, depending on the particle size distribution.</p> <p>Creating a stable paste material maximises water recovery, while maintaining tailings stability and reducing the risk of solids contaminating discharge water during heavy rain. Water should not be able to collect on top of the tailings and surface water should be prevented from entering the tailings dam.</p>

# Conclusions

Our conversations with experts have highlighted the enormous potential to reduce water and energy consumption, improve operational efficiency and reduce costs by taking a more strategic, whole life-of-mine approach. We explore those themes in the following pages and ask what can we do next to take collective action.

In this section:

- **What does successful water management look like?**
- **What next?**



## Conclusions

### What does successful water management look like?

Given mining's complexity, there is no single, simple solution for better water management. However, we believe there are steps we can take today to improve the way we think about and use water in the mining process.

#### **Better water management is difficult, but not impossible**

Demand for critical minerals is rising, ore grades are declining, and society's expectations of industry are growing and hardening. This is why action is essential, despite water's complexity.

In areas of water scarcity miners are already increasing the volume of water they recycle and reuse within mining operations, particularly through process changes that allow better tailings management. This should become the standard across our sector, rather than action born out of necessity. The combination of archetypes and insights from physical risk- and nature-related data can help cut through the complexity, helping miners lower costs and risks, and create more sustainable supply chains and better outcomes for communities and the environment.

Technology providers, meanwhile, have an opportunity to demonstrate that integrated solutions can simultaneously improve production, reduce energy, and lower water use, making change more attractive to miners.

#### **We must value water like we value energy**

As a sector, we need to shift the way we think about water. Rather than treating it as a constraint or risk to be managed, we need to value it in the same way that we value energy and carbon. That means understanding its long-term social and environmental value as well as its immediate economic value.

Placing a greater, context-sensitive value on water would help inform decisions about where and how best to recover and reuse it during the mining process at a point where that value is highest. It would help us all shift from tactical to strategic processes and procurement, recognising that current fragmented approaches to water management amount to a missed opportunity.

#### **We need to take an end-to-end approach to water management across the life of mine...**

As discussed throughout this report, how water is managed at different stages can have a profound impact on the total volume used throughout a mine's operational life and beyond.

Good water management starts with good planning, and includes setting clear objectives for water use, understanding competing demands and establishing appropriate metrics that consider the local context. Taking a strategic, end-to-end view of water requires strong collaboration between mining teams to help make more informed choices about best available technology and flowsheet design. It would also drive the right behaviours to support more sustainable mining outcomes that balance operational efficiency with community needs and environmental responsibilities.



There's an opportunity to collaborate with miners to design the 'concentrator of the future', offering comprehensive packages rather than isolated products to maximise impact.

Grant Caffery  
Director Australia, Clareo Partners

## Conclusions continued

### ...and adopt a common framework and metrics

We must find consistent ways to measure and report mining's impact on water balances and water quality. But this is only possible if everyone is speaking the same language and using the same metrics.

The Global Water Initiative's mining archetypes offer a good starting point, which, combined with physical risk- and nature-related data insights, create a platform to help our industry better quantify the costs, risks and benefits of improved water management.

A common language and agreed metrics can also improve visibility and transparency, supporting the way our sector engages with all our stakeholders, helping our licence to operate endure and improving social performance. The ICMM's water accounting framework – *Water reporting: good practice guide* (August 2021)<sup>52</sup> – presents an opportunity for industry alignment.



The biggest challenge is maintaining enthusiasm so that, as a sector, we make meaningful progress in the way water is managed.

Philip Bangerter  
Director, CEEC International Ltd

### Innovative use of technology and flowsheets can help our sector make change today

We can take action now – both in existing mines and new projects – to improve water management. The archetypes and data insights can help drive greater adoption of the best available technologies in innovative ways to create more efficient flowsheets that lower both water and energy use.

Deploying new digital technologies can also help. Water modelling in mine planning would help miners optimise resource use and reduce the potential for conflict. Sensors and geochemical analysis can improve real-time monitoring and better ore classification to drive greater efficiency, reduce waste and lower both energy and water consumption throughout the entire mining process.

As we apply those technologies, our sector must continue to invest in research and development to innovate the technologies of the future – looking at ways to introduce more automation into the mining process, for example.

### We must work collaboratively to make meaningful change

These themes are interlinked and require a bolder, more integrated, strategic conversation across all levels of mining. It requires greater openness to risk and innovation to help bridge gaps – between different mining stages, different parts of the value chain, and even different teams within a single organisation.

Greater openness relies on trust, which can only be built through collaboration. This starts with mining leaders championing water innovation and setting their teams ambitious goals, using achievable, common metrics, to foster cross-discipline collaboration, and reliably report on progress in ways that different stakeholders understand.

A key element of this change is highlighting the economic case for investing in water management by demonstrating how integrated solutions can boost production while reducing energy and water use, making change more attractive to miners.

We also need more collaboration between mining equipment, technology and services companies and miners to pool resources, share risk and accelerate new technologies and flowsheets. We need more academic partnerships to help tackle key challenges and develop the technologies of tomorrow. And we need greater cross-industry collaboration to help develop legislative frameworks that support meaningful water management improvements.



The ecosystem needs to be broader because none of us have the answer. We need different voices around the table whether they bring new technologies or different ways of thinking from researchers or community and First Nations voices, whether they're working with the industry right now or not.

Lesley Warren  
Director, Mining Futures Initiative, University of Toronto

52. *Water reporting: good practice guide*, ICMM, 2021.

## Conclusions continued

### What next?

**Our sector has a unique opportunity to work together to transform the way we manage water.**

As well as the right thing to do for our planet and local communities, a more collaborative, end-to-end approach would unlock greater operational efficiency – essential as demand for critical minerals rises and ore grades decline.

As a global leader in mining technology, Weir has more than 150 years' experience in working alongside customers, innovating new engineering and digital solutions that help them tackle their biggest challenges. We're already developing technologies and flowsheets that help customers address the water-related issues relevant to their commodity, mine site and across the end-to-end mining process.

We are proud of our role as a trusted partner and believe passionately in the power of collaboration. Indeed, this report would not exist without the support of the many specialists who care as much as we do about helping our sector adopt better, more holistic water management processes and solutions.

While we have important solutions to offer, we don't have all the answers and the challenges will not be solved by Weir technologies alone. Progress will require everyone in our sector working together. We believe that our sector has the collective expertise and innovation skills needed to create a win-win situation by setting a new standard for responsible water management in mining while reaping the economic benefits of higher productivity.

This report is intended to prompt a deeper, more integrated conversation at every level of our sector. We look forward to continuing that conversation with many of you in the coming months and years.



**We want to challenge our sector to come together and think differently about water. We're ready to play our part.**

Paula Cousins  
Chief Strategy and Sustainability Officer, Weir



### Get in touch

Real progress happens when people come together to share ideas and experiences. Open dialogue and collaboration are central to addressing the industry's toughest water challenges. If you'd like to continue the conversation, exchange perspectives or explore ways to work together on water in mining, please scan the QR code to connect with us.

## Glossary

### Acid and metalliferous drainage (AMD)

A process that occurs when oxygen and water interact with reactive ore or waste rock materials to dissolve certain constituents and release metal ions into solution. Typically occurs with materials containing pyrite and other sulphide minerals, resulting in discharges with low pH and high concentrations of heavy metals. AMD can be harmful to flora and aquatic fauna.

### Agitation leaching

The process of leaching ground ore slurries in stirred tanks. This process is commonly used for gold ores using a cyanide leach solution.

### Archetype (processing)

A typical configuration of processing unit operations that are suited to the physical or chemical separation of minerals and/or metals from ores. Archetypes are typically related to geological attributes of an ore, as these determine the separation processes that can be metallurgically and economically viable. Archetypes also have characteristic processing wastes associated with them, such as coarse residues, tailings or slags, depending on the archetype processing flowsheet.

### Backfill

The process of placing material back into a mined void. Typically this relates to selective underground mining, and often contains tailings and a binder, such as cement, to give the backfill strength.

### Ball mill

A type of tumbling grinding mill filled with steel balls used to grind material.

### Classification

In the context of mineral processing, classification refers to separating particles on the basis of size to produce different product streams suitable for downstream processing or, in some cases, to produce sand products for tailings dam construction.

### Comminution

The process of reducing the size of mined rock to break valuable mineral grains from gangue mineral grains (see: liberation). It is the first major step in mineral processing and typically involves crushing and grinding. The products from comminution circuits are generally sent to downstream separation circuits.

### Concentrate

A mineral product that has been upgraded from an original ore by mineral processing, typically grinding and physical separation. The form and grade of the concentrate depends on the minerals present in the ore, how finely the ore needs to be ground for effective separation and the quality requirements for downstream smelting and refining processes. Common concentrates include:

- base metals sulphide concentrates, e.g. for copper, zinc, lead and nickel, which are fed to sulphide smelters and subsequent refineries to produce high-purity metals;
- magnetite, taconite and hematite iron ore concentrates produced from fine-grained banded iron ore deposits, which become feedstock for pellet production for steelmaking.

### Contact water

Water, for example from precipitation or surface flows, that comes into contact with mining excavations, ore, waste rock or tailings, and, as a result, changes in characteristics due to suspended or dissolved constituents. A common environmental problem associated with contact water is acid and metalliferous drainage.

### Cyanide detoxification

A process to break down residual levels of cyanide – which may be present in tailings or leach residues from processing – into constituents that are no longer harmful to the environment. Cyanide detoxification can, therefore, help prevent death of birds, fish and other animals that might otherwise interact with affected water.

### Dewatering (mine)

The process of draining water that accumulates in mining excavations, which may be the result of precipitation and surface or groundwater inflows.

### Dewatering (slurry)

The process of removing a portion of water contained in a slurry. Commonly done by settling solid particles under gravitational forces in large tanks called thickeners.

### Entrainment (tailings)

Water that is carried and retained in tailings when deposited and settled in tailings storage facilities. This is often a major exit stream from an overall site water balance.

## Glossary continued

### Filtration

Separation of water from a slurry by passing water through a medium, such as a cloth or ceramic plate. The driving force for filtration may either be provided by a vacuum or by a high-pressure pump. The resulting solids form a relatively dry filter cake that is no longer pumpable, but can be trucked or conveyed and stacked into piles.

### Fines

A relative term relating to the particle size distribution of solids. In the fine physical separation flowsheet archetype, this refers to ores that require grinding, which may be the consistency of sand or silt (i.e. less than 2mm in diameter). Fine is, however, a relative term, as is coarse. For example, it is possible to describe some types of copper deposits as 'coarse-grained' because the mineral grains are up to several hundred microns in diameter, in contrast to a 'fine-grained' lead-zinc ore, where grain sizes might typically be less than 20µm in diameter. In both cases, grinding is required, but the required size distribution for lead-zinc ore is much finer than copper ore to achieve a satisfactory separation. 'Fines' can also refer to iron ore that has been screened to less than approximately 10mm.

### Flotation

A physical separation process where slurries of ground ore are treated with certain chemicals that make the surfaces of certain minerals attract air bubbles rather than water. The resulting mineral froth is then collected and separated. Commonly used in the treatment of sulphide ores and is the main process used to recover copper minerals.

### Gangue

The non-valuable minerals in an ore that need to be separated from valuable minerals and discarded.

### Grinding

The process of reducing the size of ore, typically to the consistency of sand or silt, depending on the ore's characteristics and the needs of the downstream separation process. Usually performed in tumbling mills that contain either steel or ceramic balls. In most mineral processing plants, grinding is a 'wet' process, i.e. grinding of slurries.

### Heap leaching

A process to treat low-grade ores that are crushed and stacked in heaps and irrigated by a leach solution to dissolve contained metal. Commonly practiced on oxide copper ores using sulphuric acid as the leach solution, or gold ores using cyanide solutions.

### High pressure grinding rolls (HPGR)

A breakage machine where crushed ore is fed between two rolls that rotate inwards towards each other. The rolls exert high compressive forces on the ore particles to break them and prepare them for downstream grinding and separation processes.

### Hydrophobic

Not wanting to attach to water. In flotation, where mineral surfaces are rendered hydrophobic by the addition of chemicals to a slurry, it makes it favourable for these mineral-bearing particles to attach to air bubbles and be recovered into a froth concentrate.

### Liberation

The freeing of different mineral grains from one another by breaking rocks into smaller sizes (see: comminution), the main precursor to physical separation.

### Mass underground mining

Underground mining methods done on a large scale and generally using caving methods such as block caving and sub-level caving, where a large rock mass breaks under its own weight. Such methods are generally larger tonnage, lower unit cost and less selective than selective underground mining methods that use stoping (see: stope).

### Mineral processing

The processing and recovery of valuable minerals into saleable products. There are two major steps in mineral processing – size reduction (see: comminution) to liberate valuable minerals from low-value gangue minerals, followed by the separation of those valuable minerals.

### Open pit mining

A mining method that removes rock from the surface. Typically, a significant amount of waste rock must be removed and dumped to uncover and extract the ore.

### Ore

A zone of mineralisation that contains concentrations of valuable minerals sufficient to support economic recovery.

### Ore extraction

The process of removing valuable minerals or metals in the form of ores from the earth. It is the first major step in the mining process and involves accessing, breaking and transporting ore from a mineral deposit for further processing. In many cases, waste rock may also need to be excavated to access the ore.

## Glossary continued

### Preconcentration

A process to separate low-grade particles from an ore stream at relatively coarse sizes (e.g. gravel size) to reduce the quantity of material that requires grinding. As a result, preconcentration can help reduce energy requirements for grinding and can reduce tailings production.

### Reclaim

Water recovered from tailings storage facilities when tailings solids settle and consolidate.

### Seepage

The slow migration of water from mining excavations, waste rock dumps and tailings storage facilities. Seepage may flow both into groundwater or surface water and can be captured or greatly reduced using liners or interception features.

### Selective underground mining

Underground mining methods that excavate ore in geometrically controlled shapes called stopes (see: stope). Will typically be higher cost and result in higher-grade ore streams than mass underground mining methods.

### Semi-autogenous grinding (SAG)

A form of grinding where crushed ore is broken in tumbling mills through the action of a combination of ore rock particles and steel balls impacting and tumbling on each other. In the case of autogenous (AG) milling, no steel balls are used and all grinding is from rock-on-rock interaction only.

### Slurry

A mixture of solids and water that is pumpable. For example, slurries are produced when crushed ore and water are mixed in a grinding mill and subsequently transported to separation processes, such as flotation. Tailings slurries consist of tailings solids and process water and are pumped to tailings storage facilities. The transport and settling characteristics of slurries can vary widely depending on the ratio of water to solids. This, in turn, can depend on the operational characteristics of different unit operations in a mineral processing flowsheet.

### Solvent extraction – electrowinning (SXEW)

A processing method commonly used to treat oxide copper ores in conjunction with heap leaching.

### Stope

An underground excavation to mine ore that creates a stable void. The shape and dimensions of a stope depend on geological attributes of the ore body and the chosen underground mining method. Often stopes are backfilled after ore has been mined out of them.

### Tailings

The ground residue that remains after valuable minerals are extracted from an ore. Almost always contains process water and may have some chemical residues from the mineral processing stage. Their precise composition and particle size distribution depends on the type of ore and processing methods used to refine the original rock.

### Thickening

A process of settling solids under gravitational forces in large, shallow tanks to allow production of water free from suspended solids, which can then be returned to the process for reuse.