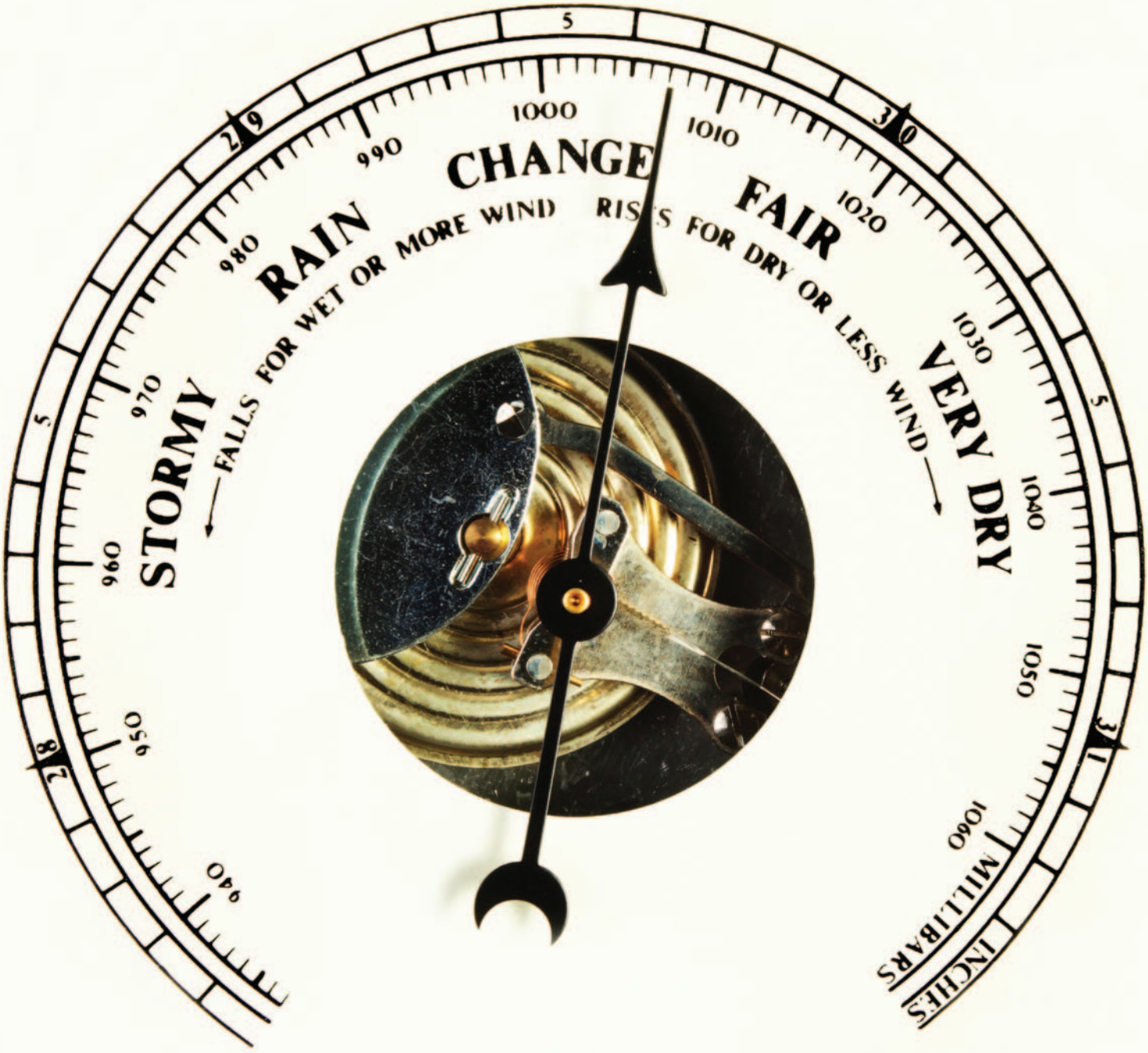

FUTURE-PROOFING AGAINST CLIMATE CHANGE

What does it take to develop a climate-resilient mine site? (Short answer: good climate data models and a willingness to accept them)

By Cecilia Keating

A summer storm that struck the northern Ontario town of Timmins in 1961 has served as the benchmark that Canadian tailings dams have been designed to withstand. The late-night downpour, which killed a family and ripped up roads, foundations and homes, breached the tailings dam of the Coniaurum gold operation, spewing waste into a local river. The 48-year-old gold mine closed soon after.

Despite the severity of the storm and its harrowing implications, the increased incidence of floods and storms across northern Ontario has rendered the decades-old environmental design storm benchmark obsolete. Over the last decade, there have been numerous examples where the so-called "one-in-100-year storm" event has been trumped.

"Everyone's favourite [regulatory storm], the Timmins storm event of 1961, is no longer appropriate to establish intensity-duration-frequency (IDF) curves for designing a dam," explained Marc Butler, director of regulatory affairs at Glencore.

To cater to this new and changing climate, a narrow dam being developed at Glencore's Strathcona operation just outside Sudbury is being designed "to a future standard," relying on IDF curves that account for multiple climate models, he said. IDF curves are graphical representations of the probability that a given average rainfall intensity will occur and are used to inform dam design. The dam will be constructed with these principles in mind, resulting in a larger structure.

The new design is just one way that Glencore is future-proofing its operations in an increasingly wet, hot and flood-prone Sudbury basin. Working closely with environmental consultancy Golder, the miner has overhauled its underground ventilation and water management systems to prepare them for future climate projections.

"People in mining need to accept the fact that the world is going through climate change, and that if we don't adjust our operations, we're putting our facilities at risk," explained Butler.

Temperatures in Canada have increased by 2.3 degrees Celsius in Canada since the mid-20th century, with the northern parts of the country warming at nearly double the global rate, according to Natural Resources Canada. Over the decades to come, precipitation is set to get heavier and more frequent, shifting from snow to rain. Droughts and heatwaves are expected to multiply and snow cover, sea ice and permafrost coverage to wane.

This has major repercussions for the Canadian mining sector. The seasons for ice roads and air strips needed for transport are becoming shorter and less reliable. Permafrost melt could cripple tailings retention structures, slope stability and other mine site infrastructure. Increased rainfall, snowmelt, floods and droughts will test water drainage and diversion structures. Warmer temperatures will strain underground ventilation systems and hasten evaporation and erosion from waste ponds.

Brendan Marshall, vice-president of economic and northern affairs at the Mining Association of Canada (MAC), is confident that the mining industry has the tools it needs to step up to the challenge.

"At the end of the day, risk management is a fundamentally ingrained reality of the mining industry. This is adding another lens on a core operational reality of the industry. It's hardly a revelation," he said. "Mining companies have always had to manage water, precipitation and weather variability. With climate change, we are now seeing accelerations and decelerations in the rate of those weather patterns and changes."

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– Charles Dumaresq, MAC vice-president of science and environmental management

MAC is completing a climate adaptation guidance document, with help from a number of industry stakeholders and a $325,000 NRCan grant. To be released later this year, the guidanceis designed to help mining companies understand climate change's potential impacts, advise on how to measure those impacts, identify how those impacts may affect site infrastructure and operations, and suggest how and when to apply adaptive management measures.

"It will help members prioritize actions and activities they are already undertaking to manage risk and, in some instances, bolster them further," Marshall said.

Charles Dumaresq, MAC vice-president of science and environmental management, said the readiness of the industry to acknowledge climate change as a problem and undertake adaptation work sits "on a spectrum." But for the most part, "people are increasingly recognizing that this absolutely needs to be done. The knowledge is there, and the determination is there to create the kind of resilient mine sites and resilient structures that we need, because the potential cost of not doing it is so substantial," he said.

With the industry facing increasing pressure, including from regulators, investors and insurers to demonstrate comprehensive and appropriate climate change adaptation and mitigation strategies, even the stragglers will need to adapt, Dumaresq added.

Courtesy of the International Council on Mining & Metals (ICMM) report Adapting to a Changing Climate

MAC is not the only group rallying the industry to shore mines and supply chains against climate change. In a report published in November, the International Council of Mining and Metals warned that "no company or geography is immune" to the impacts of extreme weather and climate change. It noted that climate change had already "led to reduction in or shut-down of production, increases in capital expenditure, health and safety impacts and made vulnerable communities more prone to social unrest."

Indeed, BHP admitted in a trading update in late January that smoke and dust from bushfires in Australia had affected production at its coal mines in December. Closer to home, mid-tier miner Centerra Gold's Mount Milligan copper and gold mine in British Columbia has been plagued by weather-related water issues, operating at reduced capacity in recent years. (When asked for comment, a Centerra representative said that "2017 and 2018 were very dry years, and the area where the mine is located was experiencing drought conditions, which reduced the amount of water provided by the spring melt and runoff.")

Potential logistics challenges

A slow response to the threat climate change poses to operations "could materially affect the survival of a lot of smaller mining companies," according to Ross Polis, Newmont's regional director of environmental planning. "As the world's largest gold miner, we have a lot of advantages. We have a lot of people and a lot of resources," he said. "But it could really be a project killer, or a company killer, for juniors out there who aren't as prepared."

Newmont has partnered with the National Center for Atmospheric Research (NCAR) in Boulder, Colorado, to produce climate models for the years 2040 and 2100 at each of its global operations. The results are expected in the spring, and site-specific risk assessments will follow, with a view to rolling-out site-specific climate adaptation approaches in 2021.

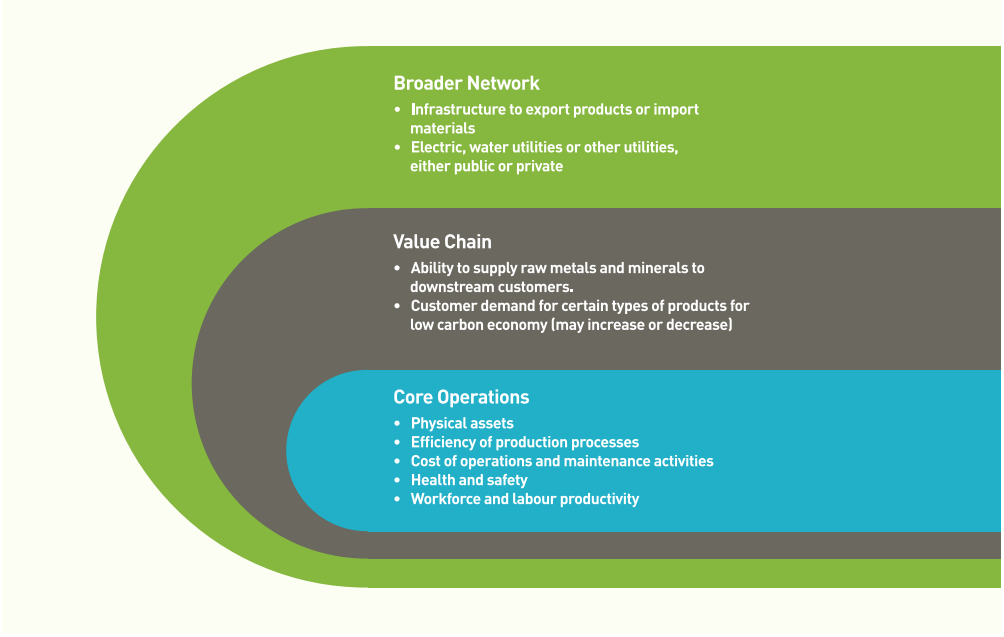
While hesitant to speculate on the specific climate impacts to operations ahead of the official risk assessments, Polis mused that increased incidence of storms and hurricanes could pose a threat to Newmont's transport networks. "A lot of our operations, specifically in the Americas, rely on sea transportation, whether that's to supply cyanide, explosives or just food and resources," Polis said. "To get in a place like Suriname, ships have to travel through the Caribbean or the Panama Canal. A changing climate that has more intense storms and hurricanes is recognized as a risk to the business."

In Canada, blizzards and inclement weather could disrupt flights that shuttle staff and goods between Toronto and remote

mines in northern Ontario and Quebec, he said. This could present a human resources challenge.

"If [a storm] passes in a day or two, that's not a critical issue, you can still get people in. It is, however, a cost issue and a disruption, and from an employment perspective, people may start looking for jobs elsewhere because they don't want to deal with that delay. From a family point of view, people may say: If I can't reliably get on this flight, I don't want to work at a place like that," Polis said.

Climate change might also force the company to redesign its water management systems or its social contracts with local Indigenous communities.



Courtesy of the International Council on Mining & Metals (ICMM) report Adapting to a Changing Climate

Categories of climate change impacts on businesses (based on Freed and Susmann, 2008, cited in ICMM, 2013).

"If the seasons become shorter – if the frozen season gets shorter – we will need to manage water more frequently. We may need to have more maintenance of pumps, pipes and infrastructure, and more infrastructure to handle volumes of melted water. We would need to increase our programs, for both water monitoring and surveillance of water facilities," he explained.

At its Musselwhite site in Ontario and its Éléonore site in Quebec, Newmont's social contract with local Indigenous communities might evolve to include providing assistance on how to navigate the impact new weather patterns will exact on local resources, wildlife and livelihoods, according to Polis. "It potentially has a social and community component. How are we a good neighbour helping communities through this?"

Rethinking tailings dams

The warming of Canada's North poses a major threat to the security of tailings dams, where miners have long relied on insulation covers (or "thermal covers" or "freeze back" covers) on waste ponds to prevent acid mine drainage.

"Leftover waste [in Canadian Shield mines] tends to react with oxygen and water and produce sulfuric acid, and the most cost-effective way to prevent that from happening is to cap them," said Vincent Le Borgne, research and development manager for Montreal-based GKM Consultants. "When [tailings dam covers] are frozen, it means that no water gets in and chemical reactions are very slow. But if the climate starts warming and there's rainfall, the chemical reactions happen faster, water gets in and generates sulfuric acid and that can leach into the environment. That's a major, major concern for a lot of Arctic mines right now."

The Research Institute on Mines and Environment (RIME), comprised of researchers from Polytechnique Montréal and the Université du Québec en Abitibi-Témiscamingue, has been testing alternative solutions to insulation covers at Agnico Eagle operations in Nunavut and at Glencore operations in northern Quebec at the Raglan Mine.

"Cover with capillary barrier effects, or CCBE, is a cover made of several materials, where fine-grained material is sandwiched between coarse-grained material layers," explained Thomas Pabst, scientific director of the RIME at Polytechnique. "It works even in the summer if the permafrost melts on surface, so it's a double security system. The more frost the better, of course."

All the materials for the CCBE method can be recycled from the mine site, he added, making the approach even more environmentally friendly. The method has been used in mines in southern Quebec in the past.

Whether or not RIME's industry partners will apply and scale its research – which also investigates how reclamation and water management practices will be affected by climate change – is up to them, said Pabst. "We're just trying to develop new approaches and new solutions. It's the job of consulting companies to take this into account in the design."

Pabst said he was encouraged by the enthusiasm for trialing climate adaptation approaches from operators at Quebec mine sites.

"As important as what executives are doing in head office, it's the people on site who are driving this change," he said. "It's the people on site, the people in communities who are actually there and who want their family and their neighbours to have a nice living environment ... There are so many examples where people on the mine site have found the money for these tests, even though they don't have the official budget."

RIME recently clinched $11.2 million of investment from industrial partners, Agnico Eagle Mines, Canadian Malartic Mine, Iamgold, Glencore's Raglan mine, Newmont Goldcorp's Éléonore mine and Rio Tinto Fer et Titane, to continue researching and developing new solutions to current environmental issues in the mining sector.

Realistic data models

While there is no one-size-fits-all approach to climate adaptation, Pabst noted that all mining operations stand to benefit

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– Marc Butler, director of regulatory affairs at Glencore

from using site-specific climate change models instead of "rough estimates."

When evaluating existing approaches to surface water management, RIME found that Quebec-based operations were relying on values that were "too conservative," in their estimates of how much the climate and weather patterns are changing Pabst said. "Climate change needs to be considered in a much more realistic way; working with climatologists is much more efficient than just multiplying the existing precipitation rates by 30, 40 or 50 per cent." RIME collaborated with Montreal-based climatology consortium Ouranos to develop climate scenarios for 2050 and 2100 at each of its research locations.

"The consequences of climate change will change from one place to another," Pabst explained. "There is no general conclusion what to do, apart from that it should be incorporated in a realistic way into design."

Sean Capstick, a principal with Golder, also said that accurate climate data was key to developing climate-resilient mines. For nearly a decade, the firm has worked to ensure Glencore's two nickel operations and its smelter in Sudbury are shored against climate change. Its starting point for the project all those years ago was climate datasets published by the United Nations Intergovernmental Panel on Climate Change (IPCC).

"It started as a water problem," Capstick said. "And now they're saying, we should be considering climate change anytime we make a capital decision or a long-term operational issue."

Golder's GoldSim climate software (which is freely licensed for anyone to use) has been incorporated into the company's broader Sudbury risk register and has materially impacted site design. Installed at the smelter, the water balance model now generates daily, monthly and annual records and considers global climate modelling for air and water and seasonal variations like rain-on-snow events. Glencore's Butler said that the GoldSim model has pushed the miner towards greenlighting a project that will increase groundwater flow to a surface water wastewater treatment system. It has also been applied to road and culvert maintenance, seasonal discharge scenarios and dam maintenance – "a whole multitude of plans from those less serious to critical," he said.

Glencore's Butler mused that climate adaptation is going to involve a radical mindset shift for the industry and will have multiple iterations. "Nothing about climate change adaptation is one-and-done. What we knew in 2011 is already being challenged in terms of most appropriate solutions for the longer term," he said. "We will be in adaptive management forever." CIM