LANDFORM DESIGN INSTITUTE

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Institute joins Swedish seminar on closure design

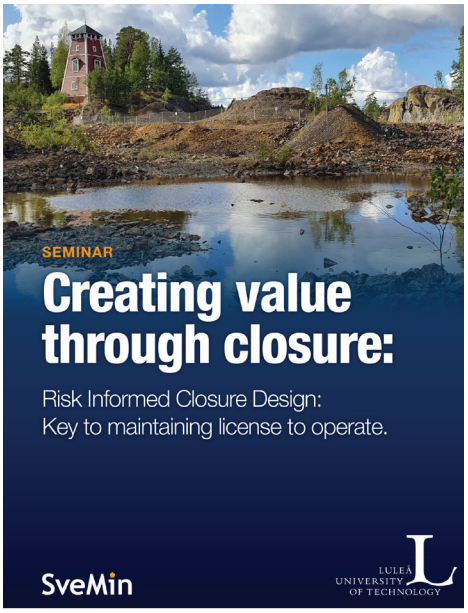
by James Hrynyshyn

Given the seminar's prevailing theme was the need to plan ahead of time, it should come as no surprise that members of the LDI figured prominently in a recent four-hour webinar hosted by the Swedish Mining Association.

Of the 10 presenters taking part in "Risk Informed Closure Design: Key to maintaining license to operate," four are members of the LDI. Founder Gord McKenna and Technical Advisory Panel Member Steven Pearce, along with LDI members Neeltje Slingerland and Matt Baida, led discussions as part of the third seminar in the Creating Value Through Closure series. The event was streamed live on October 27 through the association's YouTube channel.

McKenna's presentation introduced participants to the basic principles behind landform design — and the Institute's mission — by offering a how-to lesson on ensuring everyone at the mine-planning table has a shared understanding of the need to get the original users back on the land after closure.

Pearce, who is technical director of Mine Environment Management Ltd. in Wales,



explained why failure modes and effects analysis is not just a planning strategy — "it's also a communications tool." He and Seth Muller of the Swedish mining firm Boliden used materials supplied by Okane Consultants and the Mine Environment Neutral Drainage program (MEND) and experiences at the Kevitsa gold, silver, and platinum-group mine in northern Finland to explore how the tool applies to managing acid mine drainage.

Both Slingerland's and Baida's presentations dealt with the "geomorphic landscape design" approach to reclamation, which attempts to mimic stable reference landforms. Slingerland, a mine closure specialist with Golder Associates in Vancouver, focused on design element redundancy, while Baida, of the Stockholm-based architectural engineering firm VAST, emphasized the need to avoid "fighting against natural forces with engineered solutions" in favour of "working with nature."

Also presenting were environmental engineers from Sweden and Finland, and Jenny Wik Karlsson of the Sámi National Association, who discussed the impact of mining on reindeer herders in northern Scandinavia.

The seminar was moderated (In English) by Emma Härdmark, chair of Women in Mining – Sweden and director of communications for the Swedish Mining Association. The event was organized in collaboration with Luleå University of Technology to help industry propose new

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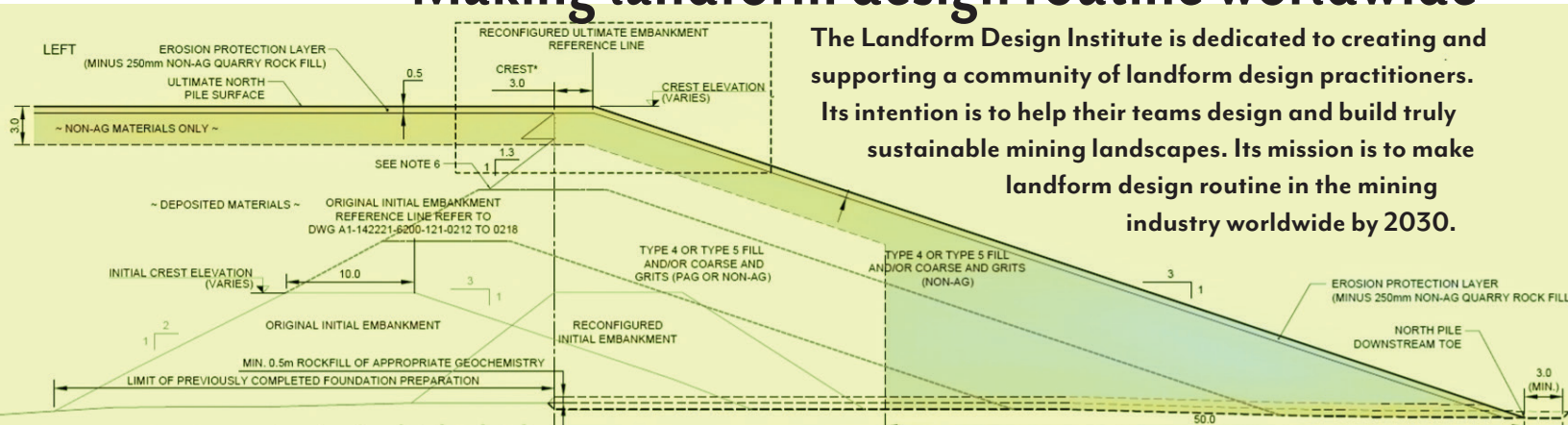
Making landform design routine worldwide



The Landform Design Institute is dedicated to creating and supporting a community of landform design practitioners. Its intention is to help their teams design and build truly sustainable mining landscapes. Its mission is to make landform design routine in the mining industry worldwide by 2030.

Women in mining tackle the changing face of mine closure

Knowledge, innovation, practice, and policy options in mine closure and reclamation have come a long way in the field's brief history, and advancements are expected to continue. Some describe this evolution as monumental. Miriam Clark, Christine Daly, M Anne Naeth, and Michelle Peters outlined these trends at a recent Women in Mining Calgary technical panel discussion. Their presentation is summarized here.

The end of operations is one of the most challenging phases of the mine lifecycle. Mine closure and reclamation involve multiple engineering and science disciplines, as well as collaboration with affected stakeholders, Indigenous peoples, and surrounding communities.

Closure of mine-affected lands must address complex technical and physical hurdles, including dramatic changes to topography and landforms, potentially contaminated soil and water, shortages of appropriate soil material, and, in most current scenarios, the need to establish sustainable ecosystems. Sophisticated and interrelated socio-economic factors must also be addressed, including the need to integrate traditional Indigenous knowledge and perspectives into landform designs and identify the highest-value post-mining use of the land and the potential impacts on local employment.

Someone just scratching the surface of mine closure could easily be intimidated by the depth and breadth of the challenge.

A brief history of mine closure and reclamation

Although the mining industry has been extracting natural resources from the Earth for thousands of years, mine closure and reclamation only became a widespread practice during the second half of the 20th century.

Partly driven by the inventory of legacy mines and growing awareness of the liabilities of unreclaimed lands, mine closure

A site visit to the Snap Lake mine in 2019

In October 2021, the Calgary chapter of Women in Mining Canada (WIM Calgary) hosted a technical panel to discuss some of the challenges and opportunities in mine closure and reclamation. "The Landscape of Closure," a virtual event, was well attended, with registrants from 10 countries. The Calgary chapter is one of the most recent to join WIM, a national not-for-profit organization that formed in 2009 and focuses on working with and supporting women in the minerals and mining industry. In 2020, a group of women working in the mining industry in Calgary decided it was time to launch a local chapter. WIM Calgary is dedicated to promoting inclusivity and diversity in the mining sector by working to enable and support a collaborative and accessible network to share career experiences, industry knowledge, professional development, and technical resources. Members of all genders are welcome.

Contact WIM Calgary by email at: wimyyc@gmail.com
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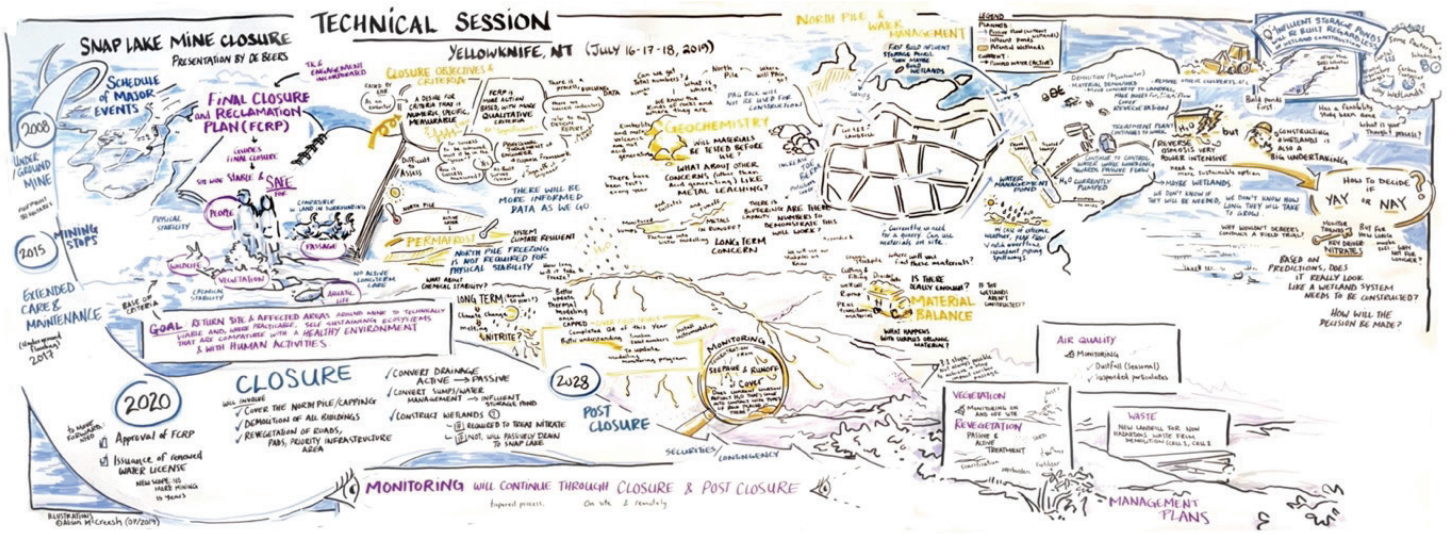

Graphic record from a Snap Lake technical mine closure workshop with regulators, stakeholders, and Indigenous peoples.

Women in mining, *continued from page 2*

and reclamation legislation and best-practice guidelines were implemented in Canada and other jurisdictions around the world. The global evolution of priorities for mine closure and reclamation can be described in three phases.[1,2,3]

Phase 1 (late 1960s to 1980s) focused on soil replacement and vegetative cover to prevent erosion and support post-mining agricultural or forestry. The growing environmental movement of this period contributed to heightened awareness of industrial impacts such as acid mine drainage, the legacy of abandoned mines, and passage of legislation and regulations governing mine closure and reclamation. In the latter part of this phase, the characterization and management of materials, including soil conservation, soil removal, and stockpiling protocols, acquired a new sense of importance, and the focus shifted from individual plants or crops to plant communities and ecosystems.

Phase 2 (1990s to 2005) saw an expansion of environmental planning efforts, both topically (e.g., geochemistry, ecology, wetlands, end pit lakes, sustainable development, social sciences, and the triple bottom line) and spatially (land uses, off-site impacts and communities beyond the mine).

Phase 3 (2005 to present) is dominated by increasing public scrutiny, demands for accountability from industry and government, and a greater diversity of stakeholder and Indigenous peoples' participation. Companies now strive for social license to operate and improve the quality of reclamation. Legislation requiring financial provisions that ensure reclamation is followed through to completion was developed to address the common practice of premature mine closure.

While mining companies once focused on reclamation planning, they are now beginning to embrace early and holistic approaches to closure, which includes broader and ecosystem-based environmental reclamation.

Social closure: Planning for sustainable communities and landscapes beyond closure

A critical and emerging aspect of closure is the integration of socio-economic and cultural values into environmental reclamation and progressive closure to help local communities make the transition to a sustainable post-mining future. Previously, mine closure was part of an environmental planning process that occurred throughout a project and culminated in the decommissioning and reclamation of a site.

In contrast, a social perspective sees mine closure as "an episode or moment in the ebb and flow of life in the surrounding communities — a moment that can stretch from several years to several generations as the memories of legacies of mining persist well past formal extractive activities" (Bainton and Holcombe 2018, p. 469). The physical and technical aspects of mine closure remain important, but mines around the world are increasingly anticipating the social demands upon mine closure to support positive legacies of mining, including sustainable social, economic, and cultural closure outcomes.

The International Council on Mining and Metals defines "social closure" as "the planning, considerations and activities undertaken throughout the Life of Asset to develop and implement the transition of a community, including its workforce, towards closure of an operation."

The social aspects of mine closure are often connected to the dependency of local communities on resource extraction, and include the social costs borne by land-based peoples, including Indigenous peoples, and those with experience with environmental change.

Examples of social considerations that must be taken into account when planning for the post-closure stages of a project include employment opportunities, the safe reuse of mine infrastructure and the reclaimed landscape, society-environment relationships; demographic changes,

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decline in local businesses, and decline in government taxes to fund local services.

The following mine projects were discussed at the "Landscape of Closure Event" as case studies that support planning for sustainable communities and landscapes beyond closure.

Latrobe Valley Regional Rehabilitation Strategy

A multistakeholder committee provided expert and strategic advice to support development of a rehabilitation strategy for three brown coal mines in Latrobe Valley, Australia. Members applied a local-first focus by inviting local groups with the most to gain or lose from mine closure to participate. The strategy included end land use ideas and feasibility reviews of closure options.

Sullivan Mine Public Liaison Committee

Local leadership and a collaborative attitude from the Teck Sullivan Mine created a constructive environment for the inclusion of local communities and Indigenous peoples in envisioning the future of the Kimberly, British Columbia, region.

A multistakeholder committee gave communities the opportunity to contribute to closure planning, and strategies were developed to mitigate the economic impact of closure of the zinc, lead, and iron mine.

Outcomes included career transition planning and training opportunities for employees, conversion of the local economic base from mining to tourism and recreation, and turning over mine-owned lands to the city for a community power plant, and expansion of a local ski hill and recreational resorts.

Thompson Economic Diversification Working Group

Closure of the Vale nickel mine, a major employer in Thompson, Manitoba, gave local Indigenous communities and other regional partners an incentive to plan for their socio-economic future.

They developed the Thompson Economic Diversification Plan to identify and pursue opportunities for the region to diversify its economy and strengthen its position as an economic contributor in northern Manitoba.

Snap Lake Mine Closure

The Snap Lake Mine is a modern example of the application of best practices to mine closure and reclamation. The mine is De Beers' first diamond mine outside of Africa, and the first in the Northwest Territories, to be entirely underground. In 2022, the company will be setting another precedent when it becomes the first of four diamond mines in the territories to begin closure activities, which follow 6 years of planning and engagement with local stakeholders and Indigenous peoples. The recent interim approval of the mine's Final Closure and Reclamation Plan, and approval in 2020 of a closure water licence for closure by the Mackenzie Land and Water Board, were key milestones in the closure journey.

At Snap Lake, the physical, biophysical, and infrastructure components of closure were considered, and social aspects received equal consideration. The plan's intended outcomes were designed to be mutually beneficial and sustainable over the long term.

From the beginning, the Snap Lake closure team ensured that closure was integrated

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The Snap Lake diamond mine in the NWT

into decision-making at the planning and operational levels, rather than being left until the last few years of production. The Northwest Territories Guidelines for Closure and Reclamation Cost Estimates for Mines, along with the Anglo American Corporate Mine Closure Standard and its associated Mine Closure Toolbox, provide detailed guidance on how to achieve increasingly higher standards of closure preparation.

Altogether, there are seven closure objectives at Snap Lake, each with associated closure criteria and underpinned by a vision "to return the site and affected areas around the Mine to where practicable, self-sustaining ecosystems that are compatible with a healthy environment and with human activities."

A site visit to the Snap Lake mine in 2019

The future of mine closure and reclamation

Integrated closure planning is a promising trend for the future of mine closure and reclamation. Historically, there has been a disconnect between the teams that develop the mine and tailings plans and schedules, and the teams that develop the closure and environmental monitoring plans. Integrated closure planning creates a single, fully integrated plan in which closure is as important as extraction or processing.

Integrated closure planning combines reclamation expertise with strategic mine planning to prevent poor and underfunded closure outcomes. Treating closure as an integral part of an operating site's lifecycle decreases environmental liability and preserves the social values of the land for future use. Socio-economic and cultural value creation must be united with the integrated mine, tailings, and/or extraction plan. This can help ensure the sustainability of communities, economies, and cultures long after a mine closes. Regional planning frameworks should integrate these dimensions by including the participation and local knowledge of stakeholders and Indigenous peoples in holistic closure planning.

Innovation and technology holds much promise for mine closure — as well as the full activity suite of exploration, permitting, construction, and operation of the mines. New mines will be designed to the smallest possible footprint, resulting in less disturbance and minimal generation of waste. This can be achieved with innovative solutions, such as smart power; hydrogen and green energy; microwave technology; hydraulic dry stacking; remote management and monitoring; nature-based designs, such as passive water treatment systems, wetlands, biomimicry, phytoremediation, and the circular economy; in situ bioremediation of soils; and agrivoltaics.

In addition, an examination of the trajectories of mine reclamation success can help determine whether the choices made as part of closure planning are actually working.

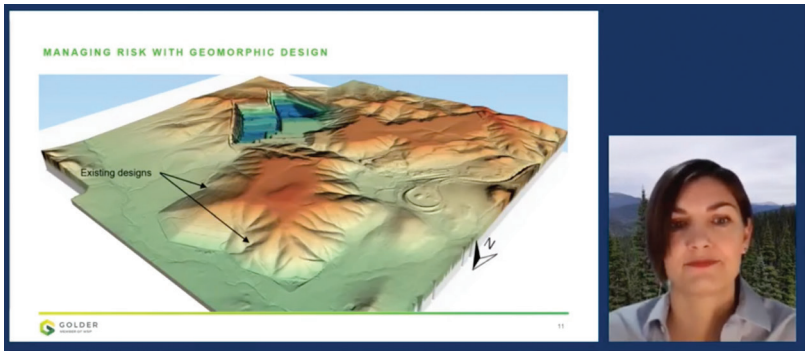
We expect the future landscape of mine closure to be characterized by even greater degrees of diversity and interdisciplinary understanding; integrated closure, mine, and tailings planning (which includes regeneration of socio-economic and environmental value post-closure); coordinated action from multiple stakeholders and Indigenous peoples; and integrated regional frameworks and/or regulatory processes.

We expect to see more diverse and multi-faceted closure outcomes as we consider all the users of reclaimed landscapes, and implement advances in land reclamation. More advanced approaches to monitoring and determination of reclamation success should follow.

1. Unger CJ, et al. 2020. "Transition or Transformation: Shifting Priorities and Stakeholders in Australian Mined Land Rehabilitation and Closure." Australasian Journal of Environmental Management. 27(1): 84–113.

2. Golder Associates Ltd. 2007. History of reclamation and reclamation research for the Suncor Oil Sands projects. Fort McMurray (AB): Golder. Report No.: 05-1344-021. Accessed April 16, 2021. https://open.alberta.ca/dataset/ea88e773-42b6-4d92-ba28-40aa636996c7/resource/bd596a25-3b30-434d-89e1-5285dd712385/download/History-of-Reclamation.pdf

3. Daly CA. 2011. History of wetland reclamation in the Alberta oil sands. In: Fourie AB and Tibbet M, Beersing A, editors. The Sixth International Conference on Mine Closure; 2006 Sept 18-21. Perth (WA): Australian Centre for Geomechanics. https://papers.acg.uwa.edu.au/p/1152_56_Daly/



LDI member Neeltje Slingerland delivers a webinar presentation focused on geomorphic design

Institute joins Swedish mining seminar, *continued from page 1*

government regulations that address the questions of "How long should mine plans last, who should be monitoring, and what state should land be when it returns to nature and what uses can it be put to?"

The entire seminar, including questions posed in real time by attendees from around the world, and answered by the presenters, is archived and available online at: youtube.com/watch?v=yS_-a0_IVfs.

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Technical Advisory Panel update

Aaron Sellick

June Pollard

The LDI Technical Advisory Panel is saying goodbye to **Aaron Sellick**, who is stepping down as he retires after 30 years as a mining engineer. Aaron began his career with Syncrude Canada and then spent almost a decade as manager of the Fort McMurray branch of the Alberta Energy and Utilities Board. In 2006, he joined the Norwest Corporation in Ontario, where he served as vice-president of mining and tailings, before moving to Stantec in 2018. He served on the TAP since its inception in 2019.

Aaron's departure does not leave the TAP short-handed. Original Board Member **June Pollard** moved over to the panel this fall to accommodate the increased workload associated with her new posititon as senior lead for applied research and development at Teck Resources in Fernie, B.C., and her added responsibilities at the LDI as director of corporate fundraising. A search is underway for a new board member.

Town hall on tap

The Landform Design Institute will be hosting a virtual town hall in late January as it works to set an agenda for 2022. The town hall will be open to all interested participants, and will also represent an opportunity for prospective individual, student, and corporate members to learn more about the Institute' mission. It will also act as a follow-up to the Annual General Meeting held in July.

Despite the COVID-19 pandemic forcing many events to be delayed or go online, the LDI — which celebrated its second anniversary a month ago — has continued to pursue its agenda by producing a range of products, including podcasts, the Quarterly, and a series of video-vignettes on landform design. In the interests of inclusivity, the Institute wants to hear from what those in the industry would like to see prioritized to advance the cause of successful reclamation.

At the December 2021 Board meeting, members expressed interest in hearing from current and prospective members as a major push to attract corporate members ramps up in early 2022. The Board concurred that the mandate to "mine with the end in mind" is as pertinent now as when the Institute was founded. With climate change and other environmental issue, communities, and First Nations increasingly taking centre stage, it becomes more relevant for industry to put landform design principles into practice.

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