



**LANDFORM
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Putting landform design principles into practice

by *David Wylynko*

The reclamation principles advocated by the Landform Design Institute (LDI) are already old hat for a mining company operating in southeastern British Columbia.

This spring, LDI board member Mike O’Kane took the Institute’s “Getting Closure” podcast to the field, recording an episode — and a video — with the president of North Coal, John Pumphrey, and the company’s first nations coordinator, Robert “Stubby” Williams, at the Michel Coal project in the Elk Valley area southwest of Calgary.

The field trip was greatly revealing in illustrating the ways North Coal has embraced LDI concepts.

While respecting the protocols demanded by the COVID-19 pandemic, the three toured the site to share expertise on how the project is already implementing many of the reclamation principles key to the Institute’s mandate, particularly the ideal of mining with the end in mind.

“The first thing we remember when we’re doing reclamation is that we’re bringing the land back for people in the future, for our future grandchildren and great-grandchildren, great-great-grandchildren,” said Stubby at the site, who is an active member of the Ktunaxa Nation. “So when we start a project, we’re always looking at the end. We want to know what this is going to be like when it’s finished.”



Mike O’Kane (left), Robert ‘Stubby’ Williams (centre), and John Pumphrey tour the Michel Coal site.

In demonstrating how the company prioritized collaboration, Indigenous and community concerns, and the environment, Pumphrey described the company’s decision not to develop one of the three areas it had originally expected to mine.

“In one of our mining areas, it became obvious early on in our work that it was a very special place for the Ktunaxa from a traditional-use perspective and had wildlife values. North Coal made the decision to remove that particular area from our mining plans,” said Pumphrey. “And we decided to leave that area undisturbed for the future and to make sure that area could be used for traditional uses and would remain an intact part of a migration corridor for grizzly bears and for other ungulates like wolves and cougars.”

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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.

Essay:

Geochemical risks at the landform scale The benefits of site-specific assessments for tailings storage facilities



Spigot discharge at a tailings dam in Scandinavia.

by Steven Pearce

Landform design for mine waste storage facilities typically includes consideration of long-term water quality as a key “metric” for environmental risk assessment. This metric has gained increasing prominence



in recent times as a result of the increasing visibility of environmental and social governance (ESG) issues.

As such, the relative importance of carrying out a robust geochemical risk assessment as part of the landform design planning has never been higher on the agenda. However, another trend that has been developing for decades is the standardization of geochemical testing and waste characterization, and “prescription” of engineering design solutions.

In heavily regulated jurisdictions like the European Union (EU), standardization is achieved via regulation/publications like the EU Waste Directive and best available

techniques for the management of waste form extractive industries. While standardized testing has some obvious benefits in that results can be compared on a “like for like” basis (which is required for generic pass/fail type risk assessment), there

are significant risks posed by utilizing standard methods to assess processes which are inherently site-specific like acid rock drainage and metalliferous leaching (ARDML).

Consideration of ARDML risks at circumneutral sites are a particular case in point. Experience in Scandinavia suggests that site-specific testing and assessment is critical to informing the basis of engineering design for tailings storage facilities. For example, the ubiquitous net acid generation test (NAG) test has been found to overestimate leachate pH in a number of the rock types in Scandinavian deposits, meaning that assessments based

Experience in Scandinavia suggests that site specific testing and assessment is critical to informing the basis of engineering design for tailings storage facilities.

on results of these tests likely significantly underestimate potential ARDML risks.

Many metals such as zinc, cobalt, and nickel are mobile in a circum-neutral pH environment, with order of magnitude differences in solute concentrations occurring over the range pH 6–8. As such, correct estimation of pore water pH is critical

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Optimizing geochemical risk assessment

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for ARDML assessment. Modification of the NAG testing method (for example removal of the boiling step) is therefore strongly recommended on a site-specific basis as a starting point for optimised geochemical risk assessment.

In Scandinavia, many significant tailings dams have been and are being built that require closure; based on publicly available information, much research and guidance for engineering design has focused on oxygen ingress as the key performance metric (e.g., $< 1 \text{ mol/m}^2/\text{year}$). However, many of these sites utilize existing processing technology (grinding and flotation) that produce significant secondary sulfates (gypsum) discharged with tailings.

In many cases, because of circumneutral drainage conditions, this technology results in near saturation of pore water with respect to gypsum post-placement, which may require a number of pore-water volume exchanges to remove. Because of the relatively low permeability of tailings, thickness of the tailings profile, and extended drain-down process, sulfate concentrations of $\sim 1,000\text{--}2,000\text{mg/L}$ can be expected to persist for many decades from these facilities.

This will be the case regardless of closure engineering performance with respect to any oxygen-ingress reduction for as long as gypsum solubility conditions are maintained. This means that in these cases closure designs focused only on specific oxygen-ingress targets may not be fully optimised, and net percolation (NP) rates may be a more relevant engineering criteria with respect to long term ARDML loading rates from seepage.

With regard to testing methods to assist with water quality predictions for tailings, standard kinetic tests such as humidity cells have very high flushing rates, and as such are not likely to capture the slow drain-down process occurring at low liquid



Customized upflow testing to evaluate carbonation of ultramafic tailings.

When considering geochemical risks at the landform scale, a further consideration is the significant effect that hydrodynamic separation has on geochemical risk.

solid ratios in these facilities. This can result in underestimation of flush-out times for residual sulfate loads from processing, inaccurate simulation of pore-water pH conditions, and overestimation of metal release rates.

More site-specific testing methods, such as modified upflow column tests, and customized kinetic column testing (using low liquid solid ratios and site-specific climate simulation such as NP control), are in comparison invaluable as aids to provide empirical data to assess site-specific processes such as tailings pore-water drain down, and also the likely effectiveness of closure engineering design solutions.

When considering geochemical risks at the landform scale, a further consideration is the significant effect that hydrodynamic separation has on geochemical risk. Based on Scandinavian experience, the outer perimeter of many facilities using the spigot technique have “beach” areas characterized by coarser texture tailings (higher sand content) and inner “pond” areas have finer texture (higher silt content) materials.

Beach area tailings typically have higher permeability, lower particle surface area, and different mineralogical composition (heavier minerals such as sulfides may be concentrated in these areas). As such, the geochemical property and thus ARDML risks of these materials are often significantly different. These risks can be typically “missed” unless site-specific testing is carried out.

These considerations can have significant implications for the landform design engineering basis for the facility as a whole. For example, adopting a uniform design basis for oxygen ingress or NP control for the entire facility may not be optimal if ARDML risks are significantly different in embankment and plateau areas. Moreover, if embankment areas can be recognized as having differing ARDML risks, the potential benefits of progressive rehabilitation strategies can be better realized earlier on in the landform design process.

Steven Pearce is the technical director of Mine Environment Management Ltd. in Wales, UK, and a member of the LDI Technical Advisory Panel.

Minding the 12 principles

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The project is intended to produce two million tonnes of clean, high-quality steelmaking coal per year over 25 years — to build renewable energy systems, hospitals, schools and bridges among other uses — while creating up to 500 construction jobs and 300 operational jobs.

As described on its website, North Coal is dedicated to being stewards of the land, always being mindful that actions in the present impact future generations' enjoyment of the land. This includes early and ongoing discussions with local communities and Indigenous peoples and building environmental protections into the mine design.

At the project's outset, North Coal brought water and mining experts with experience from around the globe together to propose designs that would protect the environment and generate strong economics.

During the video recording, O'Kane noted that to do closure and mine reclamation "better," the LDI is focused on helping practitioners learn not only what needs to



Aerial shot of Michel Coal site.

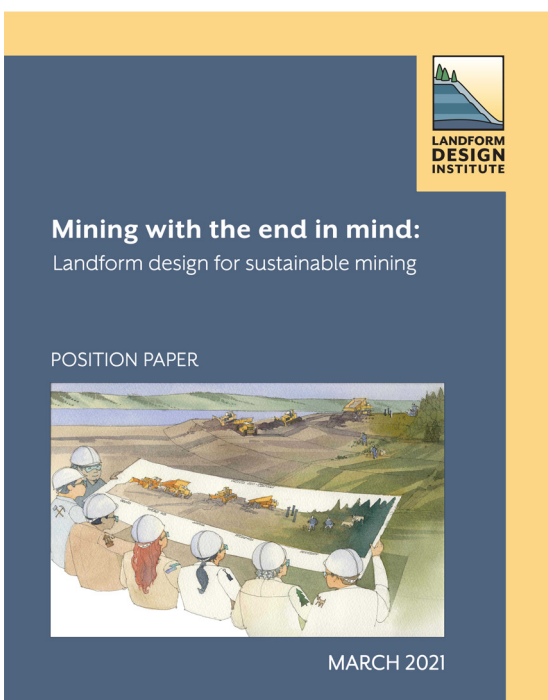
happen, but how to do it.

"I think North Coal is a great example of having that vision and developing the tools for doing the 'how,' and not just talking about doing the 'how,'" he explained.

O'Kane's discussion with Pumphrey and Williams is the fifth episode of the "Getting Closure" series, which began when O'Kane recorded the inaugural episode

with LDI founder Gord McKenna in February of 2020. Find the entire series at landformdesign.com/pod.html. The video will be posted on the LDI and North Coal websites.

David Wylynko is the LDI Director of Communications and principal of the national communications firm West Hawk Associates



The LDI position paper was published on March 30, 2021.

Mining with the end in mind

The LDI position paper Mining with the end in mind sets out the rationale for landform design, the emerging global practice of reconstructing mine landscapes responsibly and successfully. Below is abridged excerpt of the paper's summary.

Conceived 25 years ago, landform design is a discipline that has grown out of the concept of mine reclamation, which started in earnest in the 1960s and evolved under the rubric of progressive reclamation. Landform design has helped mines, regulators, Indigenous peoples, and local communities collaborate on creating mining landforms and landscapes that reliably and economically meet agreed-upon goals and objectives.

But while much direction exists on what needs to be done and why, little practical guidance is available on how to implement landform design. Landform design practitioners require the tools to transform the mining industry into a genuinely responsible steward of post-mining landscapes. A central source is needed to generate and distribute useful and educational resources.

At its most basic level, landform design is mining with the end in mind.

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Mining with the end in mind

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The process begins even before mining starts. This is the first of the 12 principles of landform design espoused by the Landform Design Institute (LDI). While the need to turn waste rock and tailings facilities into something resembling natural landforms is widely acknowledged, truly sustainable mine closure requires incorporating and implementing these measures into mine operations even before breaking ground.

This will result in better long-term landscape performance and lower costs, reduced liability, and less risk. Mines will more effectively meet their commitments to successful reclamation. The Institute will provide the tools practitioners need to make landform design a common

practice. It will advocate for the integrated, multidisciplinary and collaborative approach that is integral to this transformation.

For each mine, critical to this undertaking is the formation of a dedicated team of experts working together over the life of the mine and beyond: development, operations and progressive reclamation, final reclamation, and aftercare.

Currently, many see the “mining cycle” as a linear process of discrete phases. In fact, these activities are concurrent during every phase of mining. That’s effective landform design. Despite billions of dollars invested in mine reclamation and the expertise and hard work of thousands of people, conventional reclamation continues to fall short of achieving signoff and returning access to local communities.

In developing its work plan, the Institute

initiated a gap analysis to investigate how the current international state of practice in landform design and mine reclamation compares to the commitments made by mines and the expectations of regulators and Indigenous and local communities. The gap analysis has included consultations with experts and an overview of the available literature.

The need is urgent. Instituting landform design is required to ensure the industry will be equipped to handle the resource demands of the 21st century, while respecting the evergrowing expectation that mining become a fully collaborative and responsible undertaking and ensuring mine landscapes are being reconstructed sustainably. This document attempts to set out a common framework and definitions for the Institute’s future offerings.



A landform design team working together.

Webinar series explores varied reclamation topics (ASRS)



From February to May 2021, the **American Society of Reclamation Sciences** has been running a webinar series on innovative reclamation practices and other topics of interest to reclamation specialists. The series included a March 4 session on mine rock stockpiles by LDI board member and TAP chair Mike O’Kane.

Other webinars in the series have focused on passive treatment to address acid rock drainage (ARD), predicting and limiting regional total dissolved solids (TDS) releases at Appalachian coal surface mines, the use of drones in reclamation monitoring, the teaching of reclamation sciences, and paths to careers in reclamation. Once they’ve been recorded, ASRS members can watch the webinars at their leisure.

The ASRS was founded in 1973 as a small West Virginia advisory council concerned with reclamation of lands that had been disturbed by coal extraction. It evolved into a professional society of international prominence, with interests that now include all aspects of land reclamation and the protection and enhancement of soil and water resources.

LDI corporate membership drive underway

The LDI is actively building its corporate membership, complementing its ever-increasing contingent of individual and student memberships. The Institute is seeking to add 20 more corporate members in May, and another 20 by the end of 2021. A strong corporate membership presence not only allows the Institute to pursue its ambitious agenda but provides corporate members with a wealth of resources and contacts as they pursue landform design objectives in concert with their own clients. The LDI board has produced a corporate membership invitation package and registration form that are available by contacting info@landformdesign.com.

Expanding technical advisory panel

In February 2021, the LDI welcomed **Aaron Sellick** as the 15th member of the Institute’s international Technical Advisory Panel. Aaron is a mining engineer with 29 years of



experience in mine operations, regulation, and consulting, with a focus on the oil sands. He is manager of mining and tailings with Stantec’s Calgary Mining Group. Aaron is a generalist whose role varies according to the project, crossing traditional engineering and organizational discipline boundaries for high-level mining and tailings management, and reverting to long-range planning, project integration, and optimization as studies advance to more detailed evaluations with greater involvement by specialists. He often collaborates with geotechnical landform designers and closure specialists to incorporate their required specifications into executable mine and tailings plans. Aaron holds a bachelor’s degree in mining engineering from the Technical University of Nova Scotia.



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