

Answers to Questions from the Virtual Audience			
Presenter	Question	From	Answer
Day 1			
Brian Ayres	Could the speaker provide an example of what he means by taking a risk based approach to closure vs. regulatory compliance model?	Anonymous Attendee	Great question. It is acknowledged that the majority of jurisdictions are moving to a risk-based as opposed to a prescriptive approach for closure / reclamation of mines sites. In some cases and jurisdictions, mine closure regulations are not stringent enough to force owners into a risk-based approach, supported by robust science and thorough technical assessments to select an optimized closure strategy. Every aspect of closure, such as end land use, surface / groundwater quality, biodiversity, and landform geometric configuration, needs to, at a minimum, consider legal regulatory requirements as well as industry best practices, however, even developing an end-state for a given closure aspect that adheres to local regulations and industry best practices may not be sufficient to adequately address the risk appetite of the owner and future users of the property. Furthermore, there needs to be some consideration of the future risk appetite as well as being informed about the latest research on emerging chemical species (e.g., PFAS). In summary, every site is different in terms of climatic conditions, hydrogeologic setting, receptors, soils, vegetation, waste material characteristics, etc.; site-specific closure strategies need to be developed for each site domain that considers not only regulatory compliance and industry best practices, but includes a sound, thorough risk assessment, with all pertinent groups / SMEs involved, to ensure risks have been adequately addressed from the perspectives of the owner as well as future users of the property.
Brian Ayres	Brian you mentioned climate change should be incorporated as base case, not sensitivity analysis. What guidance do you give your site practitioners on which climate warming scenario to apply in the base case, given that there are so many RCP/SSP scenarios to consider?	Chad Novotny	Great question. Every region and site is different, and selecting a climate change scenario should be based on the assessed risks of climate change affecting the predicted long-term performance of a selected site / domain closure strategy. The simplest approach would be to select the climate change scenario that results in the greatest change to climatic parameters that will have the greatest effect on long-term performance, however, this may be unrealistic or overly conservative in some cases. In summary, selecting an appropriate climate change scenario to evaluate long-term performance of a given site domain closure strategy should be based on a risk assessment involving all pertinent SMEs.
Darren Hennessy	What percentage quicklime was added and how was that determined?	Keith	If you are talking about the Boundary Pits, we monitor the lime input by maintaining a pH optimal for metal precipitation. We analyze the water on a daily basis in house via AA, therefore we can continue to optimize our lime consistency.
Darren Hennessy	How was the quicklime added/mixed?	Keith	The lime is mixed via the lime treatment plant (% determined by quality of water), it is transferred to a lime holding tank and then pumped to 15 m ³ contained water trucks for transport. The lime is then pumped under pressure to the pit surface water.
Darren Hennessy	Is there a dramatic drop in other minerals that could be harmful to wildlife like high levels of Selenium	Connor Fleming	No, we continue to monitor water on a daily basis and toxicology test are done monthly. Se is not in use for Duck Pond.
Darren Hennessy	Regarding the pit pumping, do you monitor the GW gradient to manage potential over pumping, is pulling non impacted groundwater into the pits excessively?	Graeme Donaldson	There are multiple GW wells located in the vicinity of the pits and are sampled for quality and elevations regularly. We will have inflow of GW to the pits due to the bedrock topography but not considered excessive and is monitored closely.
Darren Hennessy	pls expand on reasons why you do pore water extraction? Is it to pull pH 7 water through the material tailings and sulfur reaction?	Cory Graham	Yes, we will have a higher pH replacing a lower pH. The lower pH is then conveyed for treatment.
Darren Hennessy	How many years will treatment be required?	Henry Brahaat	Currently modeled at 2034.
Darren Hennessy	How is the sludge managed from the Water Treatment System?	Jacqueline Ho	There is little sludge produced from the treatment plant. We are only using 200-300 tonnes of lime / yr and is insignificant.
Darren Hennessy	Is there plans to manage the site 100% passively?	Jacqueline Ho	Not at this time but we continue to optimize for efficiencies
Darren Hennessy	Please want to ask the second presenter what percentage of the Duck Pond revenue was estimated for the closure and what percentage of the budget estimate has been spent to date?	Abiola	Duck Pond cannot disclose this financial information.
David Jones	While it is common knowledge among specialized firm, industry associations and research community that changing the standard waste dump approach is the best approach to limit future liabilities, it is not well known by mine engineers and operators. When it is presented as an option, it is frequently ridiculed due to high initial costs and misjudgement of future post closure cost. What can ICARD and other organizations can ICARD and the others in the industry do to spread that knowledge? Are their academics in the audience who can comment on inclusion of those principles in mine engineering curriculum?	Anonymous Attendee	ICARD (and the BC MEND Workshop) should continue to invite practitioners of integrated mine planning (and mine planning) to present at the conference. Typically this has been a very under-represented but critical category of technical professionals at such events. Even at Closure Conferences integrated mine planning from the start tends to take a back seat as the focus is the unfortunately too often on the "end game" rather than taking it back to the beginning. Another critical thing is to invite senior mining company personnel involved in such matters to present their perspectives. This is not easy to do - and getting any costing information in such presentations is even more difficult. Probably the most impact will be had by presenting on this topic at mining investment conferences where the "bean counters" and company executives are most likely to be present not only at technical fora such as ICARD where often we are "preaching to the converted". In my talk I raised the rise of ESG in this context and the increasing focus this is forcing on source control from the start. Given the huge increase in mining that has to occur over the next decade it will be essential for mining companies to address this matter as part of the pre-feasibility planning and approvals process so that both regulators and community stakeholders can be convinced as soon as possible that they will not be left holding a perpetual legacy at the end of mine life. Training of mining engineers is really important and do it all often the geo-environmental consequence of waste management are only included as a quick after-thought, rather than being a core part of the curriculum. The University of NSW in Australia is one exception that I know about.
David Jones	There is a lot of academic data from modeling or from deconstructing and instrumentation of existing dumps. Is there actual full scale examples of operations which have built their waste rock pile in this manner?	Anonymous Attendee	Examples of the application of better construction methods for WRDs from large to full scale are given in INAP's 2020 report "Rock Placement Strategies to Enhance Operational and Closure Performance of Mine Rock Stockpiles": https://www.inap.com.au/research/RockPlacementStrategies
Debra Stokes	How does Traditional Knowledge get incorporated into closure objectives and criteria?	Jacqueline Ho	Through meaningful engagement with representatives and the community on closure and end land use planning.
Amy Claever	What process was used to clean the filters?	Jonathan Lowe	We use the method developed in the paper, Gags et al. (2019) (reference included below). They tested a variety of different ways to clean the filters to remove trace metals and found that rinsing the PUF disk three times with fresh deionized (DI) water, followed by ultrasonication in 1% HNO ₃ for 1.5 h worked well. The disks were then rinsed several times with DI water to remove acid residues. Gags, E.O., Harner, T., Dabek-Zlotynska, E., Cator, C., Xue, G., Jeong, C., Matyjaszewski, S., Jariyasathien, N., and Su, Y. 2019. Polyurethane Foam (PUF) Disk Samplers for Measuring Trace Metals in Ambient Air. Environmental Science and Technology Letters. 6(9), 545-550. https://doi.org/10.1021/acs.estlett.9b00420 .
Rick Magliocco	Was chemical runoff evaluated from the products you used?	John Stokmans	live answered
Rick Magliocco	Any success with the application of effluents on tailings surface?	Anonymous Attendee	live answered
Rick Magliocco	How long is the foam amendment expected to last post-application?	Rob Purdon	Larger-scale testing of the foam products is required but based on the limited tests conducted to date we expect the product will remain effective for a minimum of 2-3 days after being applied. Of interest in the larger-scale trials was that the chemical properties of the foam product will be reactivated, after the initial 2-3 day wetting period, when the area is re-hydrated (e.g., when there is a rain event).
Johnny Zhan	Have you looked into how the seepage chemistry changes as a response to reduction in percolation?	Eduardo "Marques"	1. The project construction spanned two seasons from Mar 2021 - Oct 2022 due to weather conditions. Limer and earthwork were completed in the week of Oct 7, 2022, and seeding was completed in the week of Oct 24, just a few days before the presentation. 2. Seepage chemistry changes will be evaluated after a sufficient dataset is accumulated.
Johnny Zhan	Is there any field scale testing done to evaluate the performance of synthetic cover layers?	Kun Jia	Field Engineering and COA-Test Plot: Had to change the Test Specifications in order to allow use of oversized rocks in overliner. A Test Plot was constructed and evaluated to confirm that oversized rocks will not damage the liner system with the construction methods and equipment. Results are satisfactory and no indications of severe damage to the system were observed.
Day #2			
Sean Shaw	How does BC administer request to refund or reduce security?	Jacqueline Ho	A permittee would have to apply to the Chief Permitting Officer through an amendment application to change the reclamation security included in their permit. The information requirements for the application would be dependent on the scope of the change being requested.
Sean Shaw	Question RE adequacy of financial assurance. How many sites have required use of FA for reclamation by the Crown in BC and how have those actual costs compared to the amount of FA provided by proponents?	Rob Purdon	Information not available.
Sean Shaw	When/Where does BC involve the indigenous nations in the permitting process?	Jacqueline Ho	Indigenous Nations are included throughout the permitting process. The level of that involvement is dependent on the mine site and the affected Indigenous Nations.
Sean Shaw	Any thoughts about how to make funding easier to avoid paying twice (R&D and \$\$\$ for future)?	Stephen Day	When R&D of technologies is being done to replace existing, required, mitigations, proponents need to be prepared to take on the financial risk associated with the R&D process and the potential that the technology ultimately does meet their objectives.
Sean Shaw	On slide 9 you mentioned discounted vs. undiscounted rates. What is the discount rate that BC uses, and what is the rationale for that rate?	Anonymous Attendee	Discount rates are summarized in the Interim Reclamation Security Policy available online. They vary based on the size of the overall site liability.
Kevin Bossay	How is the Biocord reactor disposed of after treatment?	Jacqueline Ho	The BioCord Reactor consists of an aluminum frame and BioCord media. We would expect 15-20 years minimum given they are man made fibres. Once their useful life has passed, the BioCord reactor can be un assembled and the media should be disposed of in the landfill. The aluminum frame can be recycled or the media replaced.
Kevin Bossay	Question RE ammonia removal technology - what are the energy requirements for aeration and could this be achieved through small scale, on site solar and/or wind sources?	Rob Purdon	BioCord Reactors are equipped with an integrated aeration system containing Bubble Tubing™ - an energy-efficient, pressurized airflow system with high anti-fouling performance. Fine bubbles have a higher oxygen transfer efficiency and uptake rate by the bacteria compared to coarse bubbles. Compressors are used for BioCord aeration with our fine bubble aeration to create a high-pressure air delivery system. Note that air compressors decrease energy usage compared to blowers. The only energy required for BioCord Reactor system is the electrical power used to run the compressors. The energy can be achieved through small scale, on site solar and/or wind sources.
Kevin Bossay	Question RE ammonia removal - what was the ionized state of the ammonia and was the system more effective at removal of ionized or unionized ammonia?	Rob Purdon	The ionized state of ammonia is NH ₄ ⁺ . The system is more effective at the removal of ionized ammonia.
Kevin Bossay	Is this a passive treatment system or semi-passive treatment system?	Syed Hussain Attende	The BioCord System requires minimal operator oversight. Once installed, the system can run continuously. The biofilm that treats the water is naturally occurring within the existing waste stream. No chemical additives are required. No regular cleaning or replacement of the BioCord™ Reactors is required. There should be periodic/planned maintenance of the aeration system. For example, maintenance of compressors is required approximately every 40,000 to 50,000 hours (4.5 - 5 years) of continuous operation. Therefore, BioCord system is a semi-passive treatment system.
Kevin Bossay	Is the rope-type media really only needed in the winter time to get present value?	Anonymous Attendee	The BioCord system would be installed year round. It provides benefits in winter as you do not lose the colonies of nitrifiers in the same way that you would without a high surface area system.
Kevin Bossay	How do you recover valuable rear earth metal?	Syed Hussain Attende	Rare earth metal coagulants can be recovered from sludge using a similar method that ferric, ferrous, and aluminum based coagulants are recovered.
Kevin French	How do concentrations of iron change across PRBs using Zn? Is there the potential for iron concentrations to increase?	Katie Campbell	There will be some solubilization of (ferrous) iron leaving a ZnV PRB and so dissolved effluent concentrations will be higher than influent concentrations. This could potentially be a concern if there was a nearby receptor with a low iron limit. However, if this were to be the case it could potentially be addressed via risk assessment or an additional mild oxidative barrier to precipitate the reduced iron (as ferri) out of solution.
Kevin French	Have you had experience using PRBs in areas with acid rain?	Jacqueline Ho	No. However, since the treatment mechanisms for reducing heavy metals is primarily abiotic there should be no reason that a PRB wouldn't continue to work over repeating freeze-thaw cycles.
Kevin French	Have you experienced clogging of the media and blinding off of the installed PRB? How do you control short circuiting vertically and underneath the PRB?	Michael Choi	live answered
Kevin French	Monitoring appears to largely be associated with contaminants of interest (which makes great sense) but are there other items to monitor that directly provide information regarding PRB integrity. Are there leading indicators that are commonly used?	Anonymous Attendee	Monitoring of effluent quality leaving the PRB should include typical field readings, such as DO, pH and ORP, as well as sulphate, alkalinity and acidity. By comparing these results to influent results an assessment can be made as to the longer-term performance over time.
Kevin French	How long does a PRB last when we have permanent inflow of contaminants, and after how much time will it have to be replaced?	Anonymous Attendee	PRBs are typically designed to last on the order of approx. 20 years, but this can vary as it is site-specific and depends on such parameters as groundwater velocity, contaminant flux, etc. Routine monitoring of performance indicating parameters is important to identify when the PRB is beginning to lose effectiveness and can serve as an early warning for when replacement or regeneration may be needed.
Steve Pearce	What about the limitations on the spatial resolution (beam interaction volume) of the SEM and potential overlap of gypsum and Fe-hydroxide coatings in the analyses? Are you sure gypsum is "trapping" arsenic? In a transmission electron study, gypsum was separated from the Fe hydroxides, and gypsum was present, even when the SEM on the same (dressed Fe and other trace elements. Trace elements were associated with the Fe hydroxides or amorphous hydroxysulfates. (I could see a possible co-precipitated anomaly for the oxygen Arsenic, but not found necessarily on SEM analysis.)	Diana Loomer	Mineralogical analysis always requires confirmation by other non mineralogical based methods given limitations of methods, detection levels and user interpretation. Multiple lines of evidence are always better than reliance on one method. In this case upflow back testing was carried out to determine leaching dynamic and provides the strong empirical proof that the arsenic is retained in a consistent relationship as sulfate is released (as gypsum dissolves), therefore this is close as one can get to "confirm" that arsenic is "trapped" within the gypsum (which is suggested by SEM). Arsenic present in any iron phase would not be compatible with the release dynamic noted in the upflow studies. Further the previous work identifying that gold is trapped in gypsum demonstrates that "trapping" occurs during secondary mineral formation. So while one may not be convinced by any one result alone, with multiple lines of evidence more confidence can be given to any given theory. Note that the specific use of spot SEM technique also provides more certainty than general mineralogical techniques as the focus is on a very localized area, meaning there is less chance for "mixed" results. On a final note it should be recognised that commercial projects are not academic studies, whereas the actual sulfate containing the arsenic is gypsum or some other amorphous hydrated sulfate is not really relevant except to note that processing causes precipitation of this secondary phase and then results in long term release of contaminant species. It is the general mechanism of formation and release of secondary phases, and implications for ARDOM risks that is important to be identified and understood to the point that relevant risks can be identified and then addressed. It is for academic studies to determine the finer detail.
Thomas Lepine	How did climate warming predictions affect TSF freeze up?	Trevor Sims	live answered
Thomas Lepine	General comment: using a zamboni for dust management - only in Canada	Rob Purdon	live answered
Thomas Lepine	Question - have you considered climate change pieces, even when the SEM on the same (dressed Fe and other trace elements. Trace elements were associated with the Fe hydroxides or amorphous hydroxysulfates. (I could see a possible co-precipitated anomaly for the oxygen Arsenic, but not found necessarily on SEM analysis.)	Anonymous Attendee	Monitoring of effluent quality leaving the PRB should include typical field readings, such as DO, pH and ORP, as well as sulphate, alkalinity and acidity. By comparing these results to influent results an assessment can be made as to the longer-term performance over time.
Thomas Lepine	Does your thermal analysis account for global warming projection? How is it going to affect permafrost in 100 yrs?	Louis Bernier	live answered
Kelsey Norlund	If it's not just Engineers, now it's a number of OSG - biologists, agronomists, chemists, etc.	Guy Gilron	Thank you, this specific guidance would be for professionals working on MLARD prediction and prevention, who are typically regulated by EBC.
Kelsey Norlund	As part of guideline and policy development, are affected parties and their regulators invited to the working groups? Second question, does BC distribute draft guidelines/policy to affected parties and industry for comment and recommendation, and incorporate that information into the documents?	Jacqueline Ho	With respect to updating the MLARD Guidelines into professional practice guidelines, I would expect the working to comprise professionals working across the public and private sectors. BC often engages with affected parties and industry when developing guidelines and policies.
Kelsey Norlund	Do you see this type of geochemical characterization guidance for only major mines or all mines in BC? Thinking of aggregate mines where there are also characterization studies occurring?	Julie Sandusky	I see that question being answered when the scope of the guidance is established. As there are clear differences in geochemical risks associated with major mines and aggregate operations, different approaches are likely necessary.
Kelsey Norlund	It takes upwards of 12 months to hire a senior scientist in a govt position in Canada. (Speaking from personal experience with BC and federal hiring system.) It seems a stretch then to ask those of us now in industry to help craft policy when they've been ready to be involved all along. I hope you understand our frustration.	Anonymous Attendee	The request is for the people working in the profession to participate in developing professional practice guidelines. Hiring delays frustrate us all.