Source Control and Suboxic Zones in the Elk Valley – New Learnings from Cedar North and Swift North Mine Rock Stockpiles.

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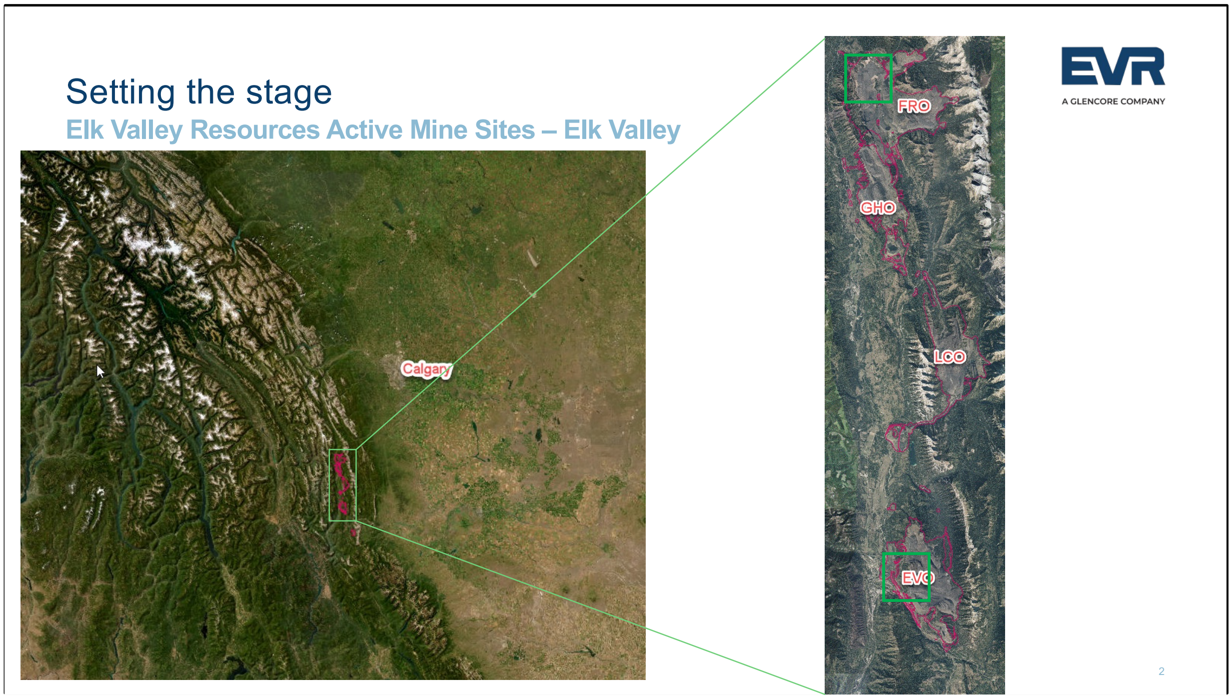
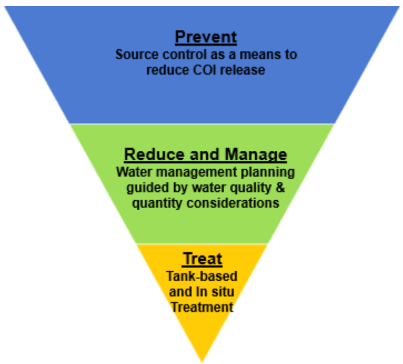


Set stage, note two projects, FRO and EVO

Defining the Problem

Consider the hierarchy of controls when considering source control options

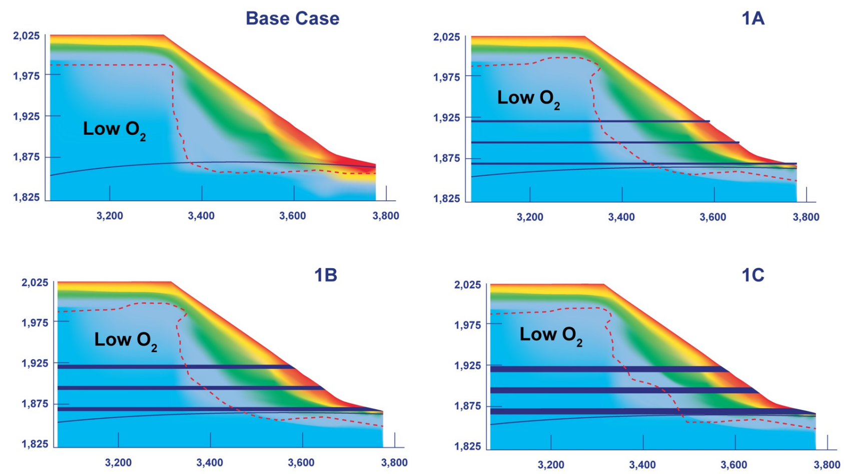


Key Questions to Consider:

- What is the current plan for managing mine impacted water reporting to the receiving environment?
- Does your plan include water treatment in perpetuity, and at what cost?
- What alternatives could you consider in mine planning to integrate source control?

Performance Modelling

Determine what the trends in leading indicators might be



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Considerations for performance predictions of detailed design options:

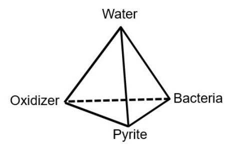
- Engineered structures – how is predicted performance influenced by design elements like thickness or material placement methods and construction specifications?
- What content do you include in permit applications?
- What are the limitations to modelling methods being applied?
- What uncertainties will be carried through the performance monitoring phase and how will you assess them?
- What is the expectation for COPC reduction internally, externally, and with company leadership?
- How will you communicate real vs. predicted performance results, and to whom?

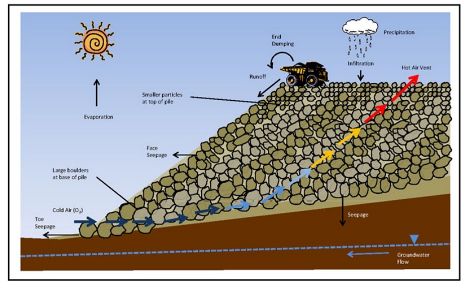
Objective Setting

Why SOZs for Source Control?

The objectives of the SOZ trials were to construct a trial of sufficiently large scale to:

- assess how suboxic conditions develop with time at the field scale,
- assess how well fine-grained engineered structures limit oxygen ingress and what the longevity of these structures is
- estimate the potential efficacy of in-dump attenuation zones to reduce mobilization of species like selenium and nitrate





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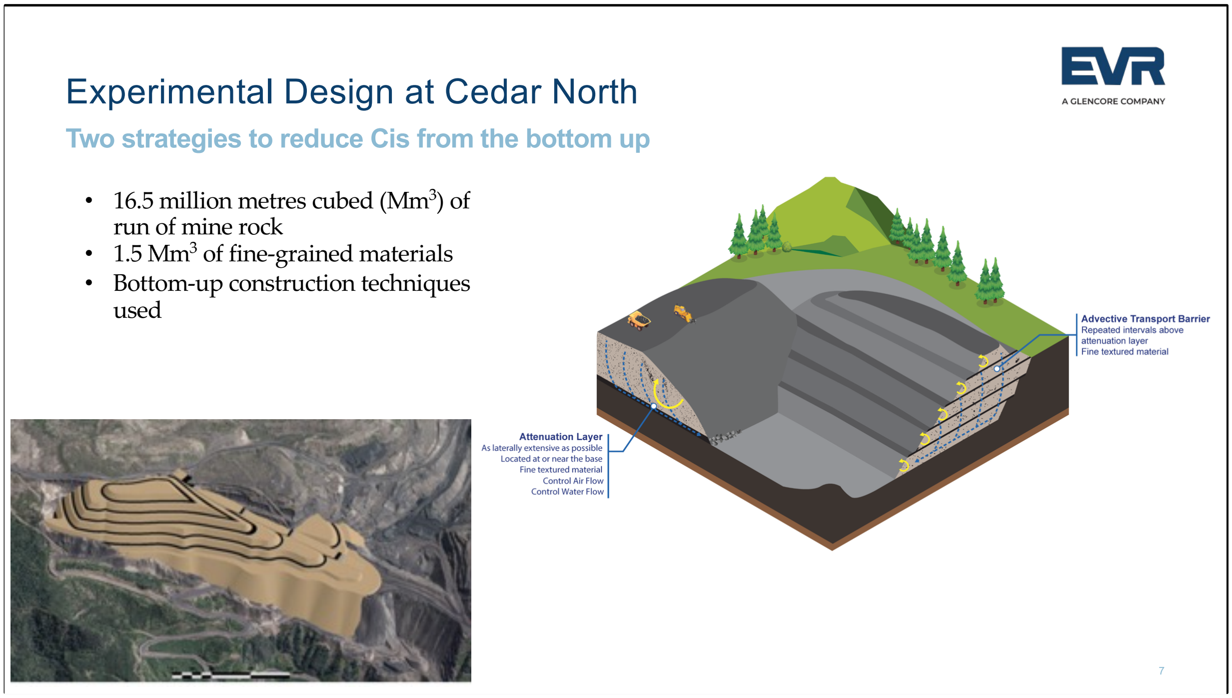
Cedar North SOZ



- Specific design criteria such as layer thickness & spacing were selected based on what was deemed achievable - and least disruptive to the operation,

Our Specific Design Criteria:

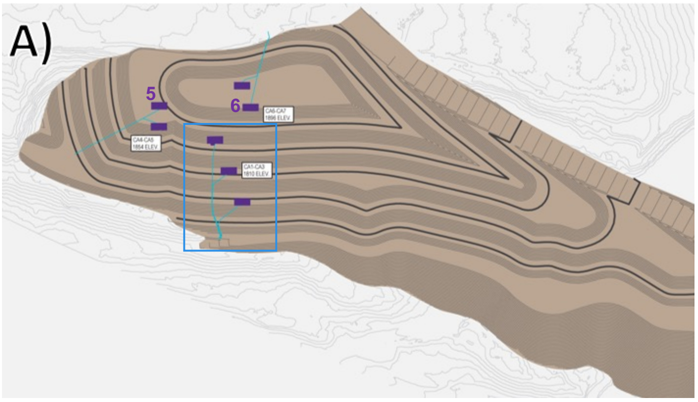
- 5 compacted finer texture SOZ Layers, every 20 m in spoil
- Attenuation Layer 3 m thick
  - -1.5 m engineered crush, overlayed by
  - -1.5 m Coarse Coal Refuse (CCR)
- Advection Layers 1m thick
  - -Engineered crush

- Tolerances +/- 10 cm
- Compaction 95%+ (summertime)

Cedar North SOZ

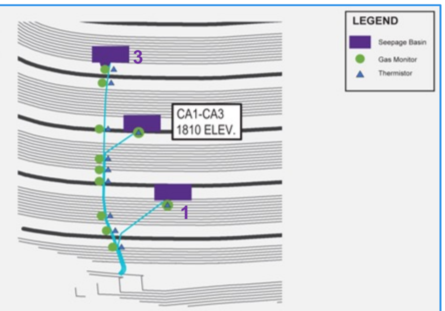
Monitoring Design Layout – Basins/Trenches

A)



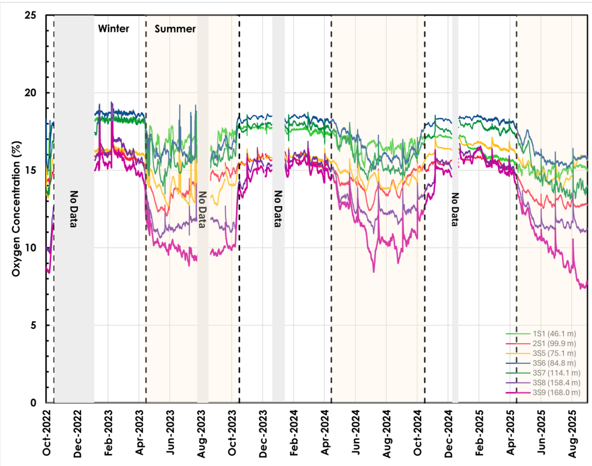
Key Challenge – how do you compare performance without a true “control”?

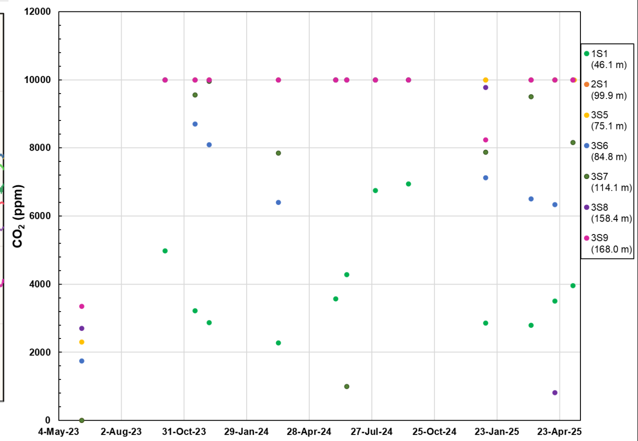
B)



Gas profiles

Oxygen and CO_2 – 1810 Lift





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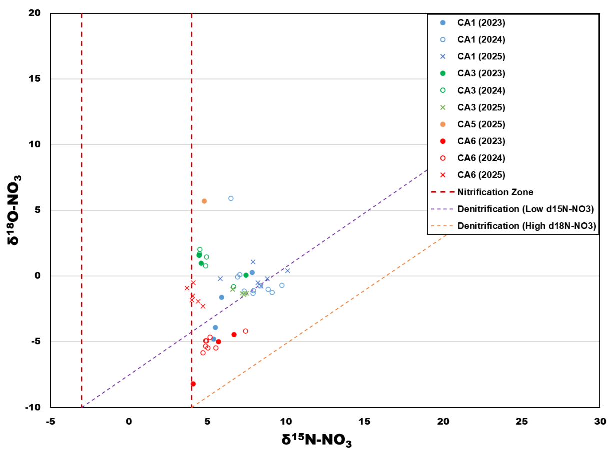
Key points – trends improve with vertical depth in spoil – not the

Nitrate Isotopes

Notable seasonal variation in deeper placed basins



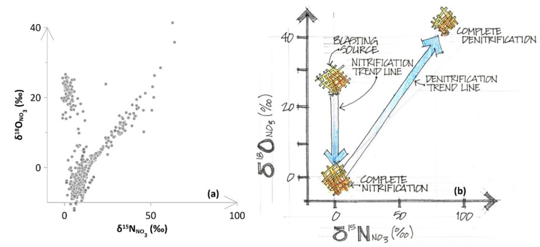
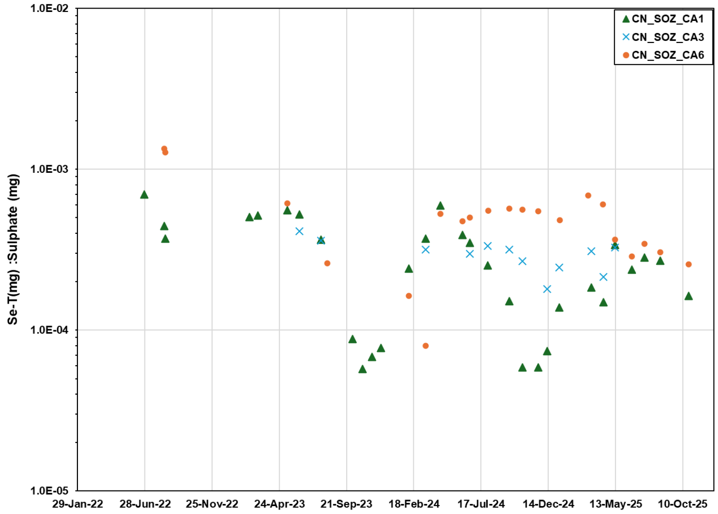


Figure 1. Cross plot of $\delta^{15}N\text{-}NO_3^-$ vs. $\delta^{18}O\text{-}NO_3^-$ values of samples collected from rock drains, groundwaters, saturated rock fills, backfilled pits, fresh blast rock, parent rock, aged waste rock, and blast products in the Elk Valley (a) and a schematic representation of the nitrification and denitrification trends for waste rock (after Hendry et al., 2018)(b).

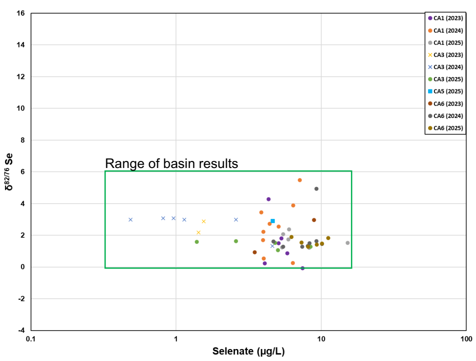
Se:Sulphate Trend

Notable seasonal variation in deeper placed basins



Selenium Isotopes

How does the data compare to other valley sites?



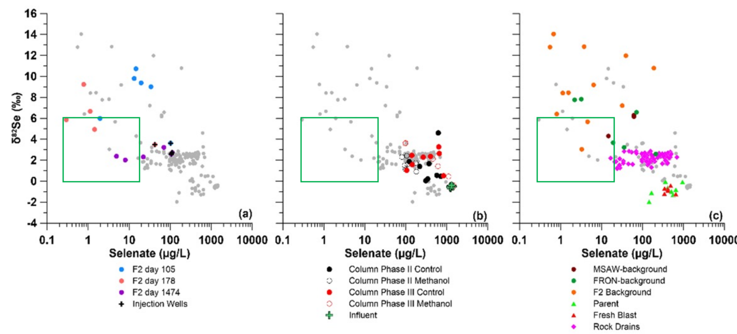


Figure 3. δ^{82}Se values vs. selenate concentrations for the (a) active *in situ* bioremediation experiment, (b) bioremediation column experiments, and (c) passive saturated rock fills, rock drains, and parent and freshly blasted rock. The grey data points in each plot represent data from all other classes of samples, for comparison.

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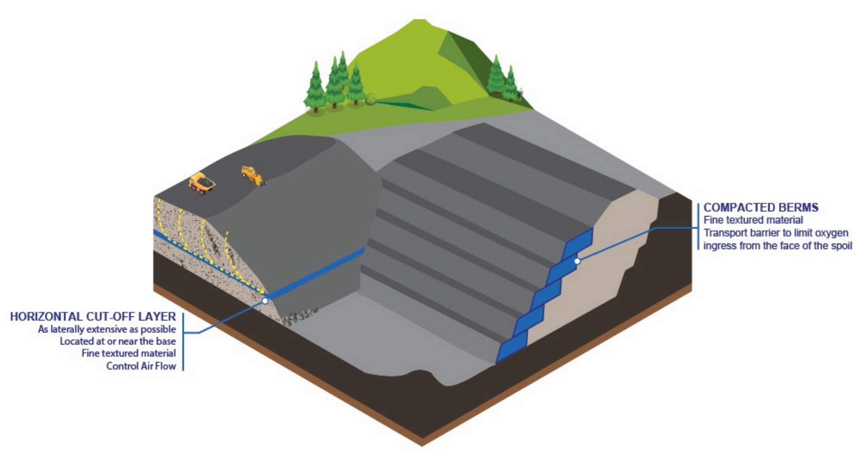
Swift North Design Strategy



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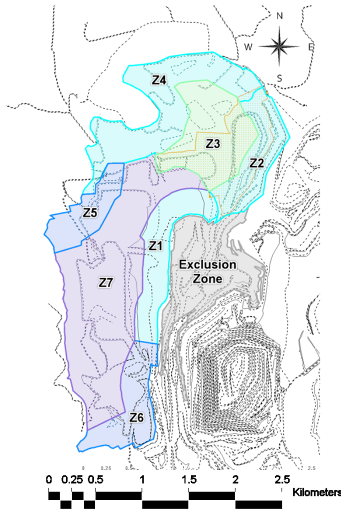
SOZ design is based on the CMF design. Exclusion zone is a geotechnical constraint that does not allow placement of any legacy waste

Zone 7 ties in against original ground providing a natural oxygen transport barrier

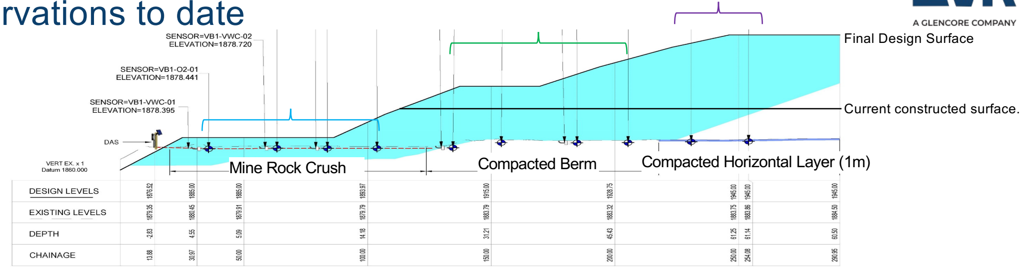
Zones 1,3 and 4 are under active horizontal cut-off layer construction right now with compacted berm construction ongoing in zone 2

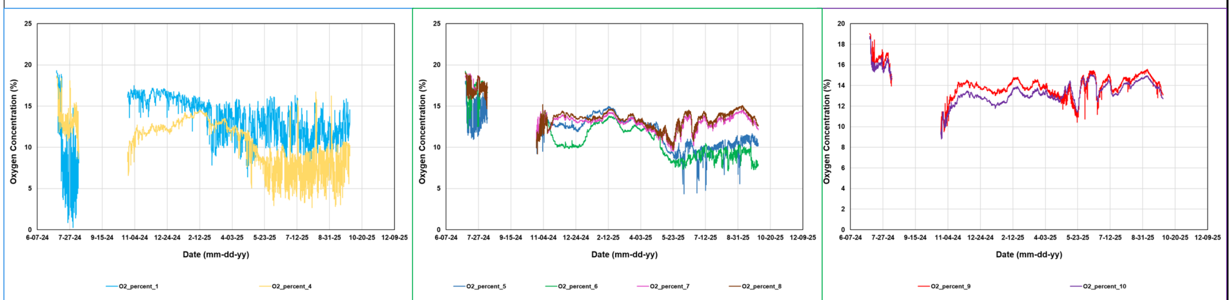
Design & Progress

Zone	Summary
1, 2, 4	Horizontal Cut-Off Layer & Compacted Berms
3	Horizontal Cut-Off Layer
5, 6	Compacted Berms
7	No designated construction needed



Observations to date





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Conclusions and Path Forward

Observations to date

Different scales, different challenges

Challenges	Opportunities
Challenges with construction sequencing when spoil footprint is large (Swift North vs Cedar North)	Larger footprints may mean slower vertical progression, more time to observe constructed surfaces
	Chance to early phase of construction, understand options for design changes if needed
Integrating different design features (CN) may mean confounding results	Increased chance you'll positive trends overall
Models are only as good as the assumptions and parameters they're based on	Collect early data, and keep revisiting the conceptual model

(speaking note, slower lift progression, construction area exposed for longer – challenges for mine sequencing)

Conclusions and Next Steps

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- Leading indicators may only be clear in hindsight
  - Conceptual models need to change as the dataset grows
- Heterogeneity adds complexity (and confusion)
  - Additional instrumentation needed to understand range of conditions in additional “typical” facilities

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Questions?