Closure of a Legacy WRP: Transitioning to Passive Treatment

Greg Meiers
Cody Bradley
Mike O’Kane
Joe Shea

Public Works and Government Services Canada

O’Kane Consultants
Integrated Mine Waste Management and Closure Services
Specialists in Geochemistry and Unsaturated Zone Hydrology
Presentation Discussion Points

- Overarching Project Background
- Background for Focus of this Presentation
  - Reclaimed Victoria Junction Site
- Conceptual Model
  - Physical
  - Flow
  - Geochemical
- Summary Discussion Points
Background – Site Location

Site: Near Sydney, NS
Cape Breton Island

Atlantic Canada
Mean annual PPT is \(~ 1,500 \text{ mm}\) 
60% occurs in Winter (October to March) 
\(~50\%\) of winter PPT is rainfall 
Mean annual PE \(~700 \text{ mm}\) 
Energy deficit in most months

Meiers et al 2014
Background

- ECBC is a Federal Crown Corporation responsible for *environmental remediation* associated with coal mining activities in Cape Breton

- Mining operations began *in 1685 to the 1980s*

- *50 underground mines produced 500 million tonnes of coal*

*Meiers et al 2014*
Historical Mine Sites: Sydney, N.S.

**Remediation:** Enterprise Cape Breton Corporation

**Current Management:**

- Victoria Junction (VJ)
- Scotchtown Summit (Summit)
- Franklin
- Lingan
- Dominion No.4
- Gowrie
- Princess

Other Reclaimed WRPs
Monitored water balance component:
- AET
- PPT
- Runoff
- Interflow
- Water Storage
- Net Percolation (NP)

NP Estimated through:
- Water Balance
- Analytical Estimates
- Conservative Tracer

Internal WRP Monitoring System:
- Temperature
- Pressure
- GW Elevations
- Pore-Gas Concentrations
- Pore-Water Quality

Meiers et al 2014
**Landform:**
- Covers an area of 26 ha
- Height of 40m
- Plateau ~7%
- Side Slope 3:1
- Runoff ditch constructed around plateau which channels runoff to drop structures on side slope
VJ – Developing Conceptual Model

- Surface Hydrology
- Treatment and collection
- **Indicator / Receptor** to identify changes to loading to wetland and groundwater

*Allow for Testing of Geochemical Model*
VJ – Physical Model
VJ – Physical Model

**WRP: Waste Rock / Tailings**

- TSF No.1 and No.2 relocated to WRP
- TSF No.3 and No.4 covered in 1987
- TSF No.5 active until 1988
- Effect of tailings facilities on WRP drain-down

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**TSF No.1 and 2**
- 20 m thick

**TSF No.5**
- 18 m thick

**TSF No.3 and 4**
- 8 to 10 m thick
Surface and GW Flow Model

- Upward gradient in bedrock drives contaminant plume to surface
- Surface and groundwater contaminant load focused to Monitoring Point VJ ST-2016
Progressive changes to site operations:

- Lead to changes in loading and water quality

Acid Load Mass Balance to Test Three Conceptual Models:

1) Active treatment no cover system
2) Passive treatment with cover system
3) 100 yrs post reclaimed WRP
Acid Load Phase 1

Active Treatment Pre-Cover System

- Flow × Concentration = \textit{Load}
- NP ~400 mm/yr
- \textit{NP and mounding} provides the basal seepage
- Water treatment \textit{removes} ~788 t/yr

\textbf{Total: 934 t/yr}

\textbf{BS: 246 t/yr}

\textbf{RO: 70%}

\textbf{P/T: 40\% of basal seepage}

Total: 185 t/yr
Managing Load & Cover Systems

Two “Models”, or Approaches, used to Typically Evaluate Benefits of Managing Net Percolation and Oxygen to Sulphidic Waste

**Acid Load vs. Acidity**

**Acid Load:**
Concentration x Flow Rate

**Acidity:**
Concentration
Seasonal Changes in Acid load at VJ ST-2016 would support:

- Solubility Controlled – Constant Concentration
**Saturated drain-down** estimated at 75 mm/yr and will terminate in approximately **20 years**

- Numerical modelling completed to verify rates and inform on **unsaturated drain-down** which **terminate in ~100 years**
Post-Cover System Conceptual Model

- Reduction in deep groundwater loading
- Upward gradient in bedrock
**Acid Load Phase 2 - Cover & Passive**

**Post-Cover System with Passive Treatment**

- **Total acid** load generated *reduced from ~934 t/yr to ~38 t/yr*
- Approximately 26% of load collected in leachate collection system
- ** Decommissioned pump-and-treat wells**, reduction in treated load from 100 t/yr to 10 t/yr… Why

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**Diagram Description**

- **Till Growth Medium Cover Layer**
- **Granular Drainage layer**
- **HDPE Geomembrane**
- **Leachate Collection System**
- **Runoff From Site**
- **Net Percolation**
- **Oxygen Flux**
- **Groundwater Alkalinity**
- **Grand Lake Background**

- **~95% reduction in BS load**
- **~65% reduction at VJ ST-2016**
Acid Load Phase 3 – Prediction

100 Years Post-Cover System w/ Passive Treatment

- **Mounding** contributes largest load
- Total acid load reduced to ~38 t/yr
- **Understanding for long-term loading and outcomes without numerical simulations**

Grand Lake Background: 37 t/yr

Oxygen Flux: 0.4 m

Runoff From Site: 1.52 mm

Till Growth Medium Cover Layer: 0.4 m

Granular Drainage layer: 0.4 m

HDPE Geomembrane: 1.52 mm

Oxygen < 1%, Decreasing With Depth, Low Net Percolation ~1 mm/yr

PAF Waste Rock: 30-40 m

- Mounding: 13 t/yr
- Net Percolation: 0 t/yr
- Drain-down: 12 t/yr
- Groundwater Alkalinity: -2 t/yr

Leachate Collection System: 10 t/yr

Passive Treatment System: 38 t/yr

VJ ST-2016: 0 t/yr
Solute Transport (Sulphate)
Risk – Influence of Holes

- Very Good Lateral Drainage Capacity:
  - ... extend timeline
- Service Life of Geomembranes?
  - e.g. Benson et al 2011: 55-125 yrs

• Does a product in design carry the risk of failure, or a system?
## Costs, Loading, and Risk

<table>
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<th>Discount Rate (%)</th>
<th>Collection and Treatment NPV</th>
<th>Cover System NPV</th>
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<tr>
<td>1.0</td>
<td>$29.5M</td>
<td>$16.1M</td>
</tr>
<tr>
<td>2.5</td>
<td>$17.0M</td>
<td>$14.6M</td>
</tr>
<tr>
<td>4.0</td>
<td>$11.2M</td>
<td>$13.8M</td>
</tr>
</tbody>
</table>

*Groundwater Collection System Only Captured 40% of Basal Load*
Summary Discussion Points

- Going Back in Time: “Correct” Decision?
  - Depends on what *Discount Rate* you would use...
  - Value in receiving environment...

- More Importantly
  - Stop and think about the number of *Technical Assumptions* within the NPV calculation
    - For example: Flow Reduction = Load Reduction (i.e. constant)

- Is the Level of Information available for this Site Typical?
Getting Back to the Question…

- Can we Achieve Passive Treatment to Manage Residual Seepage in the Short Term?
  - Strong evidence for it at this site

- What About Other Sites?
  - Scale / Size of WRP
O'Kane Consultants
Rainbow of Hope for Children and,
Habitat for Humanity Initiative
- Cover system layering influences surface runoff
- Surface runoff and interflow ~65% for the geomembrane cover systems
- Interflow and NP offsets proportional runoff volume
- NP at Lingan ~30%
- High leakage at Summit
Geomembrane Defects

- Construction (wrinkles, tears, welds, punctures,…)
- Post Construction
  - Service Stress (differential settlement, ∆ temp)
  - Anthropogenic (e.g. artisanal mining)
  - Bioturbation
  - Vegetation (roots, blow down, etc.)

http://heapsolutions.com/applications/heap-liner-leak-detection/
O’Kane and Meiers 2014
Background – Cover System Profiles

Victoria Junction

D4m TILL
D4m GRDL
HDPE
D0.15m BEDDING SAND
WASTE ROCK

Franklin

D0.6m TILL
DRAINAGE-NET
HDPE
GED-FABRIC
WASTE ROCK

Scotchtown Summit

D0.5m TILL
GED-FABRIC
HDPE
D0.15m BEDDING SAND
WASTE ROCK

Lingan

D0.5m TILL
WASTE ROCK