ARD Seepage Gradient Control and Collection System at Island Copper Mine - South Waste Rock Dump, British Columbia

Project Background

• Mine site owned by BHP Billiton
  *ICM is managed by the BHP Billiton Base Metals group out of Tucson, Az. Ben Wichers is the Manager.*

• Mine closed in 1995

• Rescan Environmental doing ongoing monitoring and reclamation project management since 1995

• EBA retained to complete engineering design for South Dump seepage collection system

• BHP Billiton committed to reclaiming the site and protection of the environment
Temporary sump and pump system to collect seepage installed in 2001
Seepage Monitoring carried out along foreshore of lagoon. Metals of concern were identified as:

- Cadmium
- Zinc
- Copper
1. Site pre-mining
Anthropogenic Evolution of Site

2. Construction of emergency tailings impoundment
Anthropogenic Evolution of Site

3. Tailings deposition
Anthropogenic Evolution of Site

4. Waste Dump Deposition
Anthropogenic Evolution of Site

5. End of Mining, Flooding of Open Pit
Emergency Tailings Pond and Today's Flood Channel

Open Pit

South Dump

Tailings

Rupert Inlet

Narrow Island

Pit Lake

South Dump

Lagoon and Channel

Rupert Inlet
Problem Definition – Seepage Pathways

- South Dump
  - Waste Rock Pile
- Tailings Dam
- Tailings Deposit
- Lagoon
- Bedrock
- Natural Marine Sediments
- Narrow Island
- Rupert Inlet
Seepage Collection System - Concept

\[ Q = K_iA \]

Flow = Permeability \times Gradient \times Flow Area
Pre-Construction Investigations
Pre-Construction Investigations

Tailings

Marine Sediments
Site Investigation Findings

- Mixed tailings and waste rock are PAG
- Soil and Groundwater samples slightly alkaline (pH 7.1 – 8.2) due to high buffering potential
- Tailing have low shear strength.

<table>
<thead>
<tr>
<th>Depth</th>
<th>Stratigraphy</th>
<th>Hydraulic Conductivity (m/s)</th>
<th>% of Total Flow</th>
<th>Water Quality</th>
<th>Metals Flux</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shallow (intertidal)</td>
<td>Mixed waste rock and tailings</td>
<td>$1 \times 10^{-4}$</td>
<td>80%</td>
<td>Poor</td>
<td>~95%</td>
</tr>
<tr>
<td>Moderate (sub-tidal)</td>
<td>Tailings</td>
<td>$1 \times 10^{-6}$</td>
<td>10%</td>
<td>Moderate</td>
<td>≤ 5%</td>
</tr>
<tr>
<td>Deep</td>
<td>Underlying marine sediments</td>
<td>$1 \times 10^{-5}$</td>
<td>10%</td>
<td>Good</td>
<td>≤ 5%</td>
</tr>
</tbody>
</table>
**Location:** (As close to high tide line as possible)
- Maximize containment of PAG.
- Minimize excavation volume.
- Minimize geotechnical risk associated with deep excavation at the toe of the South Dump.

**Depth:** (Cut-off Wall up to 10 m below grade)
- Minimum 1 m into low permeability tailings (up to 6 m below MSL)
- Minimum depth of 2.5 m below MSL (low tide elevation).

**Length:** (470 m +/-)
- Tie into bedrock at both ends.
# Cut Off Wall Alternatives

<table>
<thead>
<tr>
<th>Issues</th>
<th>Plastic Concrete Slurry Wall</th>
<th>Steel Sheet Pile</th>
<th>Plastic Sheet Pile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost (est.)</td>
<td>$ 3.0 M ![important]</td>
<td>$ 1.6 M</td>
<td>$ 1.2 M</td>
</tr>
<tr>
<td>Permeability</td>
<td>Low</td>
<td>Moderate (Low if joints are sealed)</td>
<td>Moderate (Low if joints are sealed)</td>
</tr>
<tr>
<td>Construction Risks</td>
<td>• Dump stability ![important]</td>
<td>• Refusal on boulders (moderate risk).</td>
<td>• Refusal on boulders (high risk). ![important]</td>
</tr>
<tr>
<td></td>
<td>• Release of bentonite/cement to environment. ![important]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Excavation of boulders.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Durability</td>
<td>High.</td>
<td>Poor (potential corrosion). ![important]</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

Further Investigation
Construction Team

- Port Hardy Bulldozing – Prime Contractors/Site Safety
- Wolf CWC Distributors (Wayne Wolf - now Wolf Remediation) - Vinyl Cut Off Wall
- Stabcat Inc. - Mandrel Supply and Operation
- Ruskin Pile Driving - Crane and Vibratory Hammer
- BHP Billiton – Project Management
- EBA - Construction site inspection/engineering
- Rescan – Environmental monitoring during construction and long term
Construction Phase Components

- Access road upgrades
- Environmental Protection Measures
- Vinyl Cut Off Wall Installation
- Seepage Collection Ditch
- Temporary Pump system to direct flow to Pit Lake
- Monitoring
- Design of Permanent Pump System
“C” with Adeka String Driven over “T” (already in place).
Cut off Wall Construction - Starter Trench
Ditch and Cut Off Wall Performance at High Tide
South Dump Site - After
Construction Statistics

Start Date: July 25, 2005
Functional Completion: October 21, 2005
Total number of piles: 822
Sheet Pile Area: 3,500 m²
Average # of piles installed per day: 23
Excavation Volume for ditch: ~10,000 m³
Monitoring completed by Rescan Environmental.

Water Samples:

• Daily August 17\textsuperscript{th} to September 5\textsuperscript{th} 2006.
• Weekly Sept 11\textsuperscript{th}, 2006 to June 2007.
• Bi-weekly since June 2007.

Flow Rates:

• Daily (cumulative flow meter).
Seepage Collection System - Pumping

2006

- Average Annual Inflow = 740 litres/minute
- January Average Inflow = 2,200 litres/minute
- Salinity: 1.0 to 1.5 psu (vs. 35 psu for typical seawater)
Metal Loads Diverted to Pit Lake

- **Zinc**
- **Copper**
- **Cadmium**

Graphs showing the cumulative loads of Zinc, Copper, and Cadmium from January to December 2006.
Seepage Collection System Monitoring

- System inspected three times per week.
- Telemetry monitoring for power failure
- Telemetry monitoring for high ditch water levels
- Telemetry system failure alarm
- Dual telemetry data monitoring by Port Hardy Bulldozing and Rescan Environmental
Permanent Pumping System Design – In Progress

• Design being finalized based on monitoring results
• Power Supply – Grid Power
• Standby genset can be mobilized to site within 20 minutes
Advancements and Future Applications

• A pump applied sealant bead (field or factory applied)
• Mandrel system (patented) now used frequently for vinyl sheet pile installations in Canada
• Improved groove cleaning shoe (“Widget”)

Vinyl sheet piles with these advancements have since been used at CVRD Inco Sudbury storm water retention pond, Ontario
CREATING AND DELIVERING BETTER SOLUTIONS