Introduction

- The BC Ministry of Agriculture and Lands, Crown Land Reclamation and Opportunities Branch (CLORB) is responsible for managing human health and environmental risks from contamination associated with historical abandoned mines in BC - where no mine owner can be identified.
- This is a case history that illustrates the risk-based assessment methods used to assess and prioritize reclamation activities for the Atlin Ruffner historical mining area.

Risk-Based Mine Assessment Methods

- CLORB’s modified Preliminary Site Investigation (PSI) approach utilizes site inspections by experienced, multi-discipline teams including risk assessors. They conduct site inspections and limited sampling of soil, mine wastes, sediment and water.
- Chemical analysis results for all investigated mines are statistically analyzed in a standardized manner. The methodology considers terrestrial and aquatic contaminant pathways to human and environmental receptors.
- The Atlin Ruffner mill area was previously ranked as the 3rd highest risk (abandoned mine) in BC, based on arsenic & lead concentrations in soil & mine wastes.

Background

- 13 adits but very small output: 138,000 kg lead, 13,540 kg zinc, 2,079 kg silver
- Mineralization - Sphalerite, galena, arsenopyrite, pyrite, pyrrohite, chalcopyrite, pyargyrite in granodiorite batholith country rock
- Mill, tailings and 1 adit at lower elevation – highest priority due to high concentration, larger area and accessibility to people
- 12 other adits in alpine area – less accessible therefore less risk and lower priority
- Waste rock 1% to 2.8% sulphide - with little neutralizing potential.
Mill Area Detailed Site Investigation Objectives

• The objectives of the DSI were to:
  – Confirm the previous high risk ranking based on further sampling and chemical analysis of soil, mine wastes, mine water, surface water, sediments and groundwater
  – Provide a more detailed assessment of contaminant sources, pathways and human and ecological receptors
  – Provide more data on the extent of contamination for reclamation planning

Human Health and Ecological Receptors

• Human health
  – Potential water supply at McDonald Lake
  – Direct human contact with surface soils, tailings, mine water

• Ecological
  – Terrestrial - Ingestion of mine water or surface soils
  – Aquatic Life

Scope of Detailed Site Investigation (DSI) of Mill Area

• Surface soil, waste rock, tailings sampling
• Mill inspection and soil/dust sampling
• Surface water and stream sediment sampling
• Adit mine water discharge sampling
• Groundwater monitor installation and flow assessment
• Groundwater quality assessment
• Environmental receptor observations
• Drainage mapping and contaminant pathway assessment

Mill Building and Surficial Soil Contamination

• Permeable sand and gravel soils, deep water table
• High levels of arsenic and other metals in surface soils – inside and outside of building
• Small areas of spilled concentrate
Aquatic Pathway

- Groundwater flow through thick permeable gravel deposits for an additional 1.5 km to discharge into 4th of July Creek – the ultimate aquatic receptor.
- Natural system acts as an ideal treatment system. Surface discharge due to groundwater flow through gravel acts as a sand filter.
- Enormous potential for contaminant attenuation and dilution along flow path.

Mill Area Groundwater Quality, July 2009

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sample ID</th>
<th>Distance from Tailings Pond 40m</th>
<th>Distance from Tailings Pond 30m</th>
<th>Distance from Tailings Pond 80m</th>
<th>Distance from Tailings Pond 70m</th>
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<td>Arsenic (mg/L)</td>
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<td>Chromium (Cr)</td>
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<td>Silver (Ag)</td>
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<td>Total Hardness (mg/L equivalent CaCO3)</td>
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<td>65.8</td>
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</table>

Groundwater Quality

- Mill Area Surface Water Quality, July 2009

- Mill discharge re-infiltrates into thick glaciofluvial kame and kettle gravel deposits.
Aquatic Risk Conclusions

- Negligible risk to human or ecological receptors in high value habitat in valley bottom because:
  - concentrations of all substances except cadmium and zinc were below BC CSR numerical groundwater standards for the protection of aquatic life very close major contaminant source areas
  - Substantial decrease in groundwater cadmium and zinc concentrations over distances of 100m.
  - Groundwater transport pathway between the major exposure area (Fourth of July Creek) and the Mill Site is largely inoperable.
  - Metal leaching from soils is occurring, but 800m groundwater flow followed by surface flow through wetlands and then another 1.5 km of groundwater flow path prior to entry into Fourth of July Creek allows attenuation of metal concentrations to near background levels
- No apparent need for risk management actions to protect aquatic life in Fourth of July Creek or lower areas that are ecologically productive.

Terrestrial Risk Conclusions

Direct exposure risks to humans, wildlife, plants or other ecological receptors associated with the very high concentrations of arsenic, cadmium and lead in Mill Site soils merits further consideration and some form of risk management because:

1. The site is visited in summer time by campers, hikers and site-seers, - observed a group of families with several children hiking at the mill site during the July 2009 field visit.
2. Evidence of a high degree of wildlife use of the site, including by woodland caribou, which interact with the tailings pond and settlement ponds.

Terrestrial Risk Management/ Reclamation

Managing the toxicological risks associated with arsenic, cadmium, lead or zinc exposures from contaminated soils at the mill site (including in the Mill building) may include one or more of:

- institutional controls such as fencing or other means of limiting site access by receptors in light of the highly contaminated surface soils across the entire mill site;
- completion of a detailed quantitative human health and/or ecological risk assessment;
- Mill building demolition and equipment removal
- capping of the contaminated soils with about one meter of uncontaminated material to curtail the surface exposure pathway.
- limited excavation of hotspots

Thank You

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Mill Area Features
• Located on steep mountain slope in glaciofluvial gravel deposit
• Mine Adit with continuous mine water discharge – upper bench
• Mill – middle bench
• Tailings impoundment and sedimentation ponds – lower bench
• Drainage re-infiltrates into ground within 150m downslope of sedimentation ponds

Contaminant Sources
Range of pH in July 2009 Waste Rock Samples

Contaminant Sources - Waste Rock Total Lead/Zinc
(a) 2009 samples