Assessment of Atlin Ruffner Abandoned Mine, BC, Canada

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Introduction

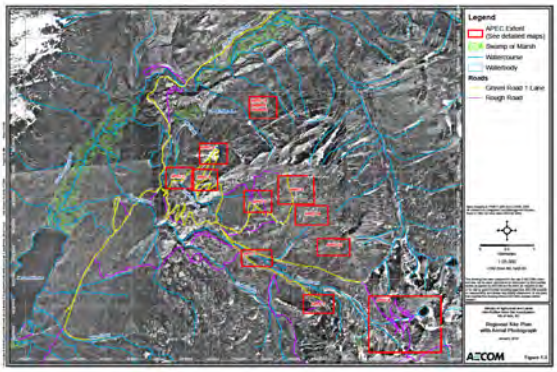
- The BC Ministry of Agriculture and Lands, Crown Land Reclamation and Opportunities Branch (CLORB) is responsible for managing human health and environmental risks from contamination associated with historical abandoned mines in BC - where no mine owner can be identified.
- This is a case history that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

Atlin Ruffner Mine Location

- Remote site 28km NE of Atlin
- Mine occupies 30 Crown lots – total of 5.1 km2
- Operated intermittently 1900 to 1981
- No former mine owners or operators exist

Risk –Based Mine Assessment Methods

- CLORB’s modified Preliminary Site Investigation (PSI) approach utilizes site inspections by experienced, multi-disciple 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, pyrrohtite, 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.

Atlin Ruffner Alpine Mining Areas

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 will surface soils, tailings, mine water
- Ecological
  - Terrestrial -Ingestion of mine water or surface soils
  - Aquatic Life

View of Mill building and surrounding area, with McDonald Lake in the background(ultimate receptor

Mill Area Contaminant Sources

- Mill building
- Residual ore and waste rock
- Surface Soil
- Adit
- Tailings Impoundment
- Sedimentation Ponds

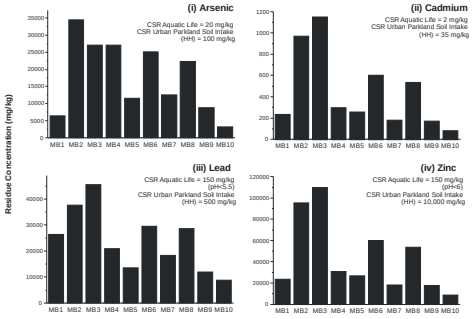
Scope of Detailed Site Investigation (DSI) of Mill Area

- 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

Summary of Metal/Metalloid Concentrations in Mill Complex Samples



Client logo
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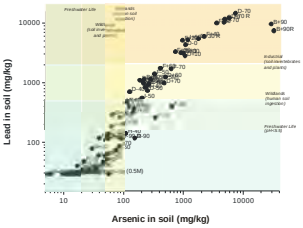
Arsenic and Lead Concentrations in Surface Soils



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Adit Mine Water Discharge

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Tailings Pond

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Upper and Lower Sedimentation Ponds

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Tailings and Mill Area Sediment Quality

	pH	Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Lead (Pb)	Mercury (Hg)	Zinc (Zn)
BC CSR Sensitive Standard		11	2.2	56	120	57	0.3	200
BC CSR Typical Standard		20	4.2	110	240	110	0.58	380
Mill Creek Drainage (EU1)								
SED02 - Adit	6.88	**167**	2.0	17.8	21.4	**155**	0.402	214
SED03 - Tailings Pond	6.95	**9490**	**63**	107	129	**1460**	0.0359	**5120**
SED04- Upper Sed Pond	7.37	**4520**	**50.8**	**123**	169	**1320**	0.198	**5050**
SED05- Lower Sed Pond	7.09	**4420**	**30.9**	93.7	112	**1120**	0.164	**2950**
SED06 (2008) – Pond Outlet	6.99	**366**	3.84	27.5	207	**169**	0.0156	**488**
SED06 – Pond Outlet	7.46	**2420**	**16.9**	76.6	91.8	**1160**	0.08	**1690**
SED105 – 50m downsteam	6.62	**128**	2.1	29.2	17.8	**68**	0.0122	105
SED106 – 150m downstream	7.04	**225**	3.02	57.5	47.7	54	0.0356	91.1
SED107 – 800 m downstream	6.87	**210**	1.75	55.1	28.4	<30	0.0437	80.4

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Aquatic Pathway

Aquatic Pathway

•Mine adit discharge - reported to be deep borehole discharge in mine formerly used for Mill water supply

•Flows through sedimentation ponds then infiltrates into the ground within 100m

•Groundwater flow down slope 800m then discharges into large wetland

•Wetland has no surface discharge

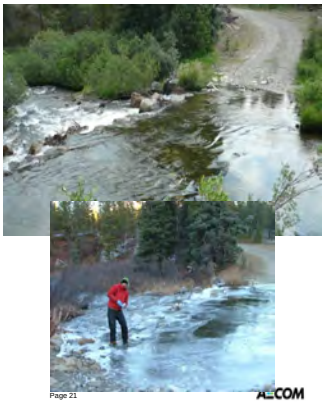
•Wetland discharge re-infiltrates into thick glaciofluvial kame and kettle gravel deposits.

Aquatic Pathway

•Groundwater flows 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 effectively as natural treatment system. Surface flow oxidizes metals and groundwater flow through gravel acts as a sand filter.

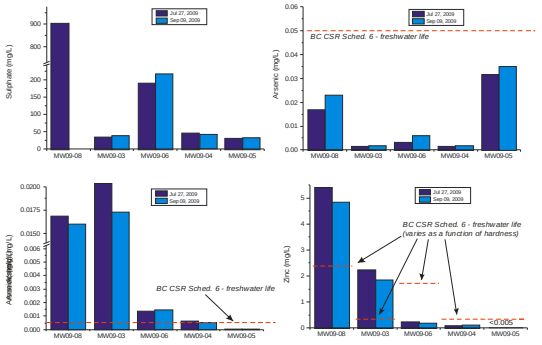
•Enormous potential for contaminant attenuation and dilution along flow path.



Mill Area Groundwater Quality, July 2009

Distance from Tailings Pond			40m	30m	80m	70m
Sample ID	CSR Standards (AW)		MW09-03	MW09-06	MW09-04	MW09-05
Conductivity	-		174	445	201	194
Hardness (as CaCO3)	-		77.2	226	97.8	96.7
pH	-		6.84	6.83	6.89	7.5
Alkalinity, Total (as CaCO3)	-		44.4	26.3	47.1	63.3
Fluoride (F)	3	Hz50	1.07	0.385	0.7	0.235
Sulfate (SO4)			36.2	191	47.8	32.5
Cyanide, Total	-		0.0047	0.001	0.0014	0.0059
Arsenic (As)-Dissolved	0.05		0.00168	0.00329	0.00141	0.0317
Cadmium (Cd)-Dissolved	0.0005	H = 90 - <150	**0.0204**	**0.00138**	**0.000616**	0.00006
Lead (Pb)-Dissolved	0.05	H =50 - <100	0.0005	0.0005	0.0005	0.0005
Silver (Ag)-Dissolved	0.0005	H ≤ 100	0.00002	0.00002	0.00002	0.00002
Zinc (Zn)-Dissolved	0.15	H =90- <100	**2.24**	**0.251**	0.086	0.005

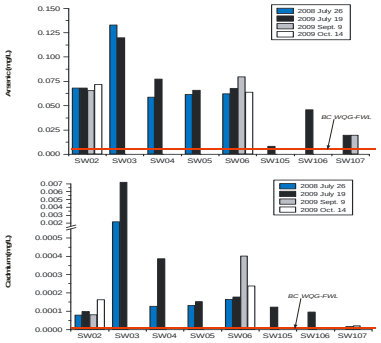
Groundwater Quality



Mill Area Surface Water Quality, July 2009

	Description	Adit A	Tailings Pd	Sed Pond Outlet	90 m From Sed Pond	150m from Sed Pond	Wetland 800m away	4th of July Creek
Parameter	Freshwater Aquatic Life (AW-F) Standard	SW02	SW03	SW06	SW105	SW106	SW107	SW 100
Physical Tests	BCAWQC[1] / BCWWQC[2] / CSR							
Conductivity (mS/cm)	-- / -- / --	177	217	177	171	214	181.00	80.3
Hardness (as $CaCO_3$)	-- / -- / --	86.6	104	86.5	83.7	109	81.60	35
pH (pH units)	-- / -- / --	7.56	7.14	7.84	7.58	7.68	7.57	7.67
Alkalinity, Total (as $CaCO_3$)	-- / -- / --	48.2	30.2	49.4	46.3	59	44.30	27.7
Fluoride (F)	0.2 / -- / 2	0.458	1.18	0.458	0.496	0.278	0.21	0.143
Sulfate (SO_4)	-- / -- / --	33.1	65.8	32.9	32.8	45.6	40.20	9.39
Arsenic (As)	0.005 / -- / 0.05	0.0051	0.12	0.0079	0.00824	0.0458	0.02	0.00335
Cadmium (Cd)	-- / 0.000005[3] / 0.0001	0.000099	0.00719	0.000178	0.000124	0.000096	0.000017	0.000098
Zinc (Zn)	0.033 / -- / 0.075	0.005	0.174	0.012	0.007	0.005	0.01	0.005

Arsenic and Cadmium Concentrations in Surface Water



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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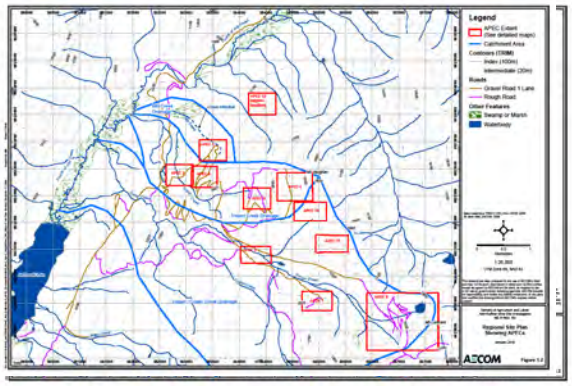
Surficial Geology and Aquatic Pathway

Mill Area Features

- Located on steep mountain slope in glaciofluvial gravel deposit s
- 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



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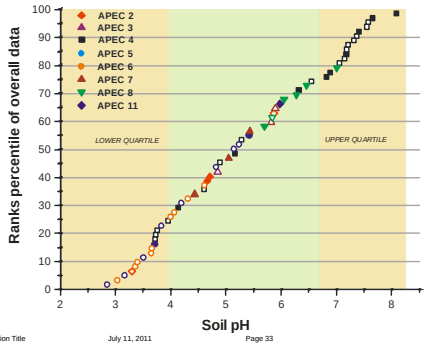
Contaminant Sources
Range of pH in July 2009 Waste Rock Samples



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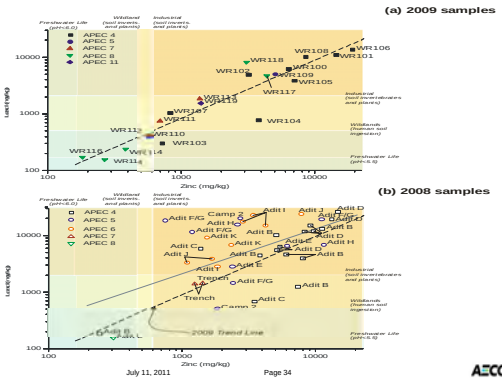
Contaminant Sources -Waste Rock Total Lead/Zinc



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