Baseline data & initial impacts of the Mount Polley tailings pond breach on adjacent aquatic ecosystems

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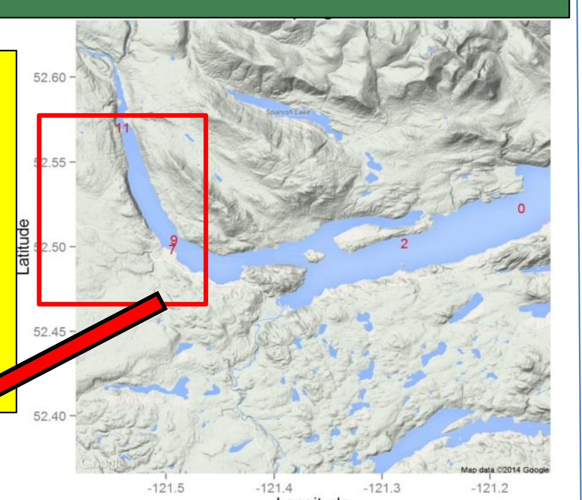
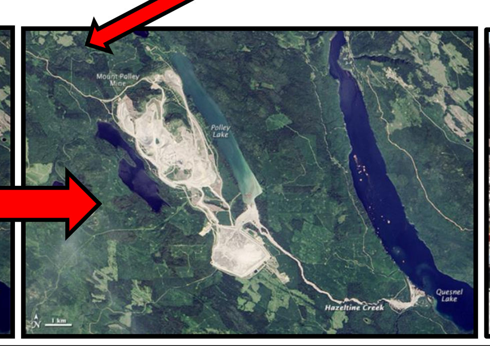
Introduction - the breach:

- August 4th: the Mount Polley tailings pond breaches.
- ~25 million m^3 of water & tailings were delivered into Polley Lake, Hazeltine Creek and the West Arm of Quesnel Lake (266 km^2).
- This pulse of material generated a seiche which rocked back and forth in the lake for 12 hrs with an amplitude of ~20 cm and a wave period of ~84 min.
- When seiching ceased the water level remained raised by 7.7 cm, suggesting an increased volume of ~20 million m^3.
- An extensive lake bottom deposit mixture of tailings, eroded soil and sediment was created in front of the mouth of Hazeltine Creek. This material now stretches across the entire width of Quesnel Lake at the breach site and exhibits a height of 1-3 m (pers. comm. Mt Polley Mining Corp, 6 Oct '14)

Environments impacted:

- Polley Lake, Hazeltine Creek, Quesnel Lake
- Down-lake river systems (Quesnel and Fraser Rivers)
- Up-lake river systems (east via potential sockeye salmon vector to Horsefly River, Mitchell River)





Following the breach:

- Imperial Metals received permission to pump water from Polley Lake, an end point for tailings and wastewater following the breach, into Hazeltine. Polley Lake was considered unstable and unsafe due to a plug of tailings elevating the lake outlet by 1.7 m.
- Pumping continued through October and were close to maximum annual flows. Pumped flows continued to erode and deliver sediment and tailings deposited/exposed by the event.
- Contents of tailings pond water and sediment are reported on the Mt Polley and BC Ministry of Environment (MoE) websites.

Tables: (1) water and (2) sediment quality of tailings prior to the breach (from Moe and/or Mt Polley Mining Corp websites).

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MOUNT POLLEY MINE

Tailings Impoundment Solids Analysis (2013)

		Average
Metals		
Aluminum (Al)	%	2.01
Antimony (Sb)	ppm	0.46
Arsenic (As)	ppm	10.63
Barium (Ba)	ppm	199.45
Beryllium (Be)	ppm	0.71
Bismuth (Bi)	ppm	<0.20
Cadmium (Cd)	ppm	0.13
Calcium (Ca)	%	2.67
Chromium (Cr)	ppm	20.63
Cobalt (Co)	ppm	17.55
Copper (Cu)	ppm	810.91
Iron (Fe)	%	5.14
Lead (Pb)	ppm	4.85
Lithium (Li)	ppm	16.05
Magnesium (Mg)	%	1.08
Manganese (Mn)	ppm	522.55
Mercury (Hg)	ppm	0.07
Molybdenum (Mo)	ppm	5.54
Nickel (Ni)	ppm	9.06
Phosphorus (P)	%	0.13
Potassium (K)	%	0.23
Selenium (Se)	ppm	1.14
Silver (Ag)	ppm	0.31
Sodium (Na)	%	0.16
Strontium (Sr)	ppm	247.82
Thallium (Tl)	ppm	<0.50
Tin (Sn)	ppm	2.25
Titanium (Ti)	%	0.17
Uranium (U)	ppm	1.03
Vanadium (V)	ppm	197.55
Zinc (Zn)	ppm	51.13

2

Date/Time	Mean	Maximum	Minimum	Drinking Water Quality Guidelines (BC/Canada)
Physical Parameters				
Conductivity (in situ) (µs/cm)	1352	2001	766	
pH (in situ) (pH)	8.54	9.94	7.30	
Temperature (in situ) (Degrees Celcius)	9.0	21.8	1.2	
Hardness (as CaCO3) (mg/L)	543	970	313	
Total Suspended Solids (mg/L)	9.5	54.9	1.5	
Total Dissolved Solids (mg/L)	1080	2450	730	500
Anions and Nutrients				
Chloride (Cl) (mg/L)	27.7	44.0	17.7	250
Sulphate (mg/L)	647	1100	397	500 (aesthetic)
Ammonia (as N) (mg/L)	0.284	0.719	0.0348	
Nitrate (as N) (mg/L)	5.68	8.15	3.42	10
Nitrate and Nitrite (as N) (mg/L)	6.29	8.33	4.44	
Nitrite (as N) (mg/L)	0.140	0.917	0.016	1
Total Nitrogen (mg/L)	7.05	10.50	3.62	
Phosphorus (P) Total (mg/L)	0.0236	0.0850	0.0035	
Dissolved Metals				
Aluminum (Al)-Dissolved (mg/L)	0.0191	0.0547	0.0082	0.2
Iron (Fe)-Dissolved (mg/L)	0.015	0.015	0.015	
Total Metals				
Antimony (SB) - Total (mg/L)	0.00222	0.00516	0.00087	0.006
Arsenic (As) - Total (mg/L)	0.00223	0.00377	0.00125	0.01
Barium (B) - Total (mg/L)	0.0780	0.108	0.0392	1
Cadmium (Cd)-Total (mg/L)	8.970E-05	0.0005	0.00001	0.005
Copper (Cu)-Total (mg/L)	0.0137	0.0641	0.0020	0.5
Chromium (Cr)-Total (mg/L)	0.0005386	0.00209	0.0003	0.05
Iron (Fe)-Total (mg/L)	0.266	1.69	0.033	3 (aesthetic)
Lead (Pb)-Total (mg/L)	0.00018	0.00115	0.000025	0.01
Mercury (Hg)-Total (mg/L)	1.7857E-05	0.000025	0.000005	0.001
Manganese (Mn)-Total (mg/L)	0.0350	0.1160	0.0063	0.05 (aesthetic)
Molybdenum (Mo)-Total (mg/L)	0.205	0.287	0.125	0.25
Nickel (Ni)-Total (mg/L)	0.00062	0.00165	0.00025	
Silver (Ag)-Total (mg/L)	0.0000126	0.000049	0.000005	
Selenium (Se)-Total (mg/L)	0.0241	0.0346	0.0158	0.01
Sodium (Na)-Total (mg/L)	89.8	119.0	55.9	200 (aesthetic)
Zinc (Zn)-Total (mg/L)	0.0024	0.0062	0.001	5 (aesthetic)
Organics				
Dissolved Organic Carbon (mg/L)	5.98	10.70	2.45	

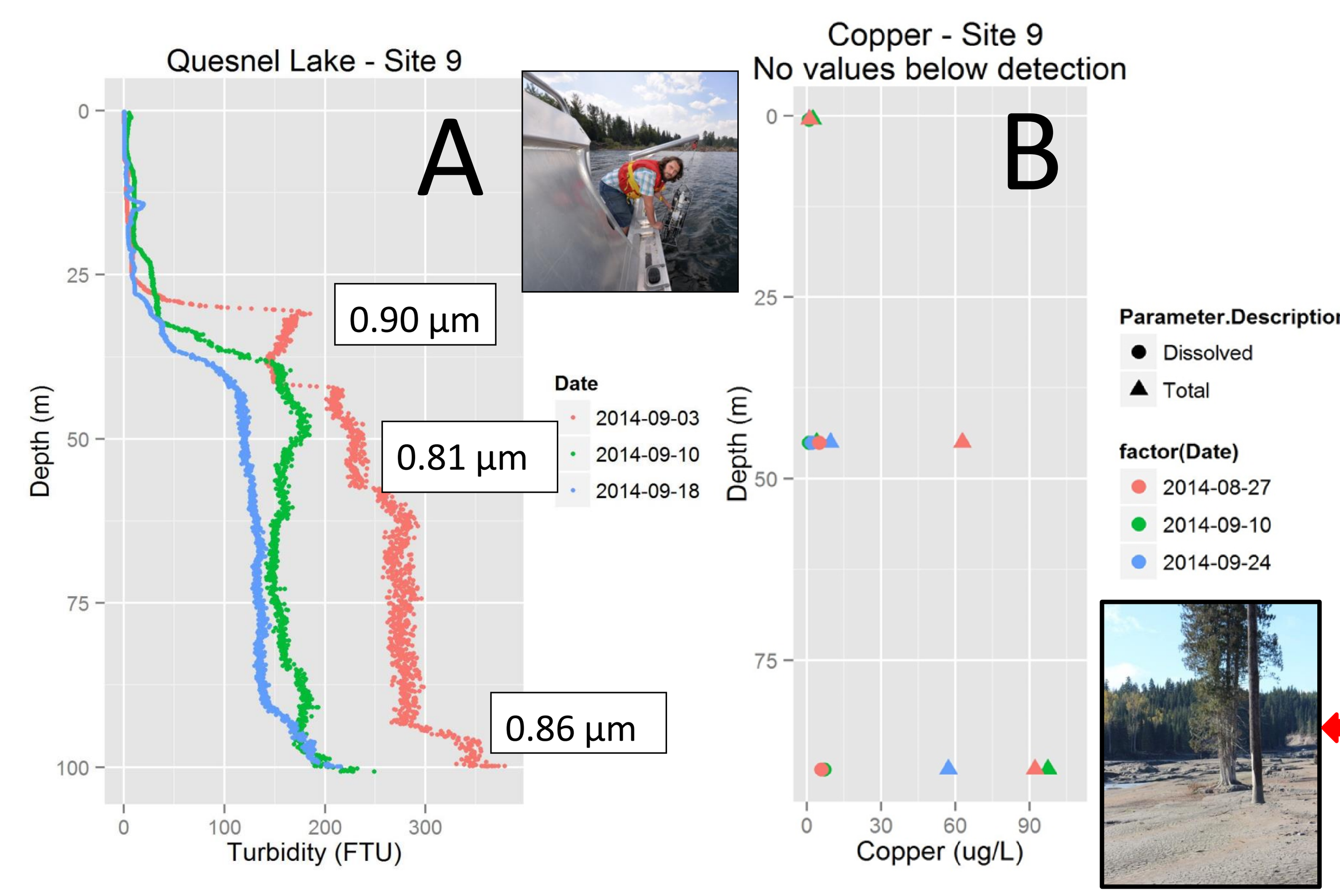

Figure 1: (A) Location of a plume of increased turbidity (i.e. fine sediment, with corresponding median particle size) below 30 m in the water column on 3, 10 and 18 Sept 2014 at Site 9. (B) [Cu] in water collected at several depths; other geochemical elements (e.g. Al, As, Mn and P) display a similar pattern. Higher values for total compared to dissolved fraction, and elevated concentrations in the sediment plume, suggest that the metal is associated with fine sediment.

Deposits along Hazeltine Creek and its 'delta'

Preliminary Results

- A plume of fine sediment is located at depth in the water column of Quesnel Lake that originates from where Hazeltine Creek enters the lake.
- The plume moves both down-lake (towards Likely) and up-lake (towards East and North Arms).
- Analyses of water samples collected from the plume show that it is composed of very fine particles (median size of ~1 micron).
- [Metal] in water from the plume are higher than in water above the plume. These metals are predominantly associated with fine sediment.

Preliminary Results con't:

- There are pulses of green, cold water in Quesnel River downstream of Quesnel Lake. These pulses of water and sediment originate from the lake plume due to vertical displacement of deeper, cold lake water.
- The pulses occur rapidly, with drops of water temperature of ~10°C in a few days, before returning to ambient conditions.
- These pulses are associated with increases in fine minerogenic sediment, and some geochemical properties.

Ongoing work

We are continuing to study the effects of the tailing pond breach temporally, spatially and trophically. Work includes:

- ✓ CTD casts at multiple sites to determine the movement of the sediment plume up to and after fall overturn.
- ✓ Assist DFO with installation of five mooring sites (winter conditions).
- ✓ Obtain suspended and channel bed fine sediment in Quesnel River.
- ✓ Sediment grabs and coring (geochemistry) Quesnel Lake sediments.
- ✓ Zooplankton collection at historical DFO sites for metal content.
- ✓ Analysis of fish tissue from Fraser and Quesnel Rivers.

Potential research directions

- Metals and other elements (e.g., P) that entered this watershed as a function of the breach are likely particle-bound and may thus be subject to transport over long distances, resulting in the potential for chronic exposures and thus toxicological effects in exposed biota.
- Metals (e.g., Hg, Se) undergo bioaccumulation and biomagnification, once incorporated into the food web. Thus, even small [metal] in water can lead to elevated [metal] in top predators.
- Over time, we thus predict that food web transfer will lead to an increase in [metal] from water to invertebrates to fishes.
- Pacific salmon travel great distances in this watershed and may be exposed to contaminated water during their migrations. Resident species in the study lakes will be exposed year round.
- Moreover, it is crucial to understand the food web transfer and potential long-term effects of the released metals on organisms.

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