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Underwater tailings disposal and ARD mitigation at the Inmet - Samatosum Reclamation Site.

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Presentation Outline

The two sides to the Samatosum Reclamation Mine Site

- **Tailings water cover – success**
- **Waste dump layering – not so successful**

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Inmet's Operations

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Inmet Closed Properties Group

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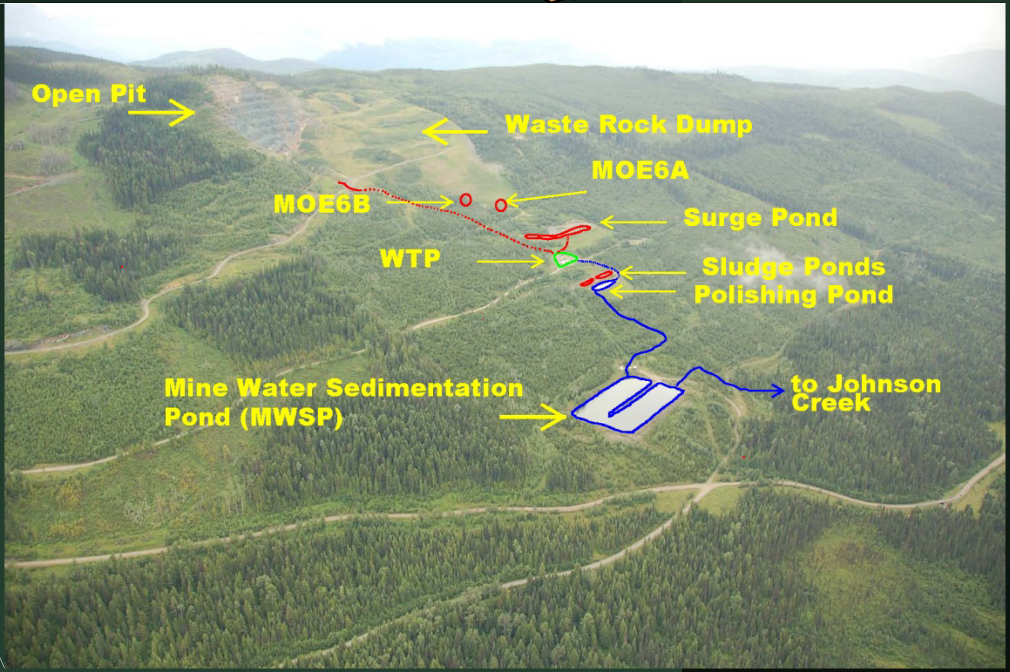

LOCATION

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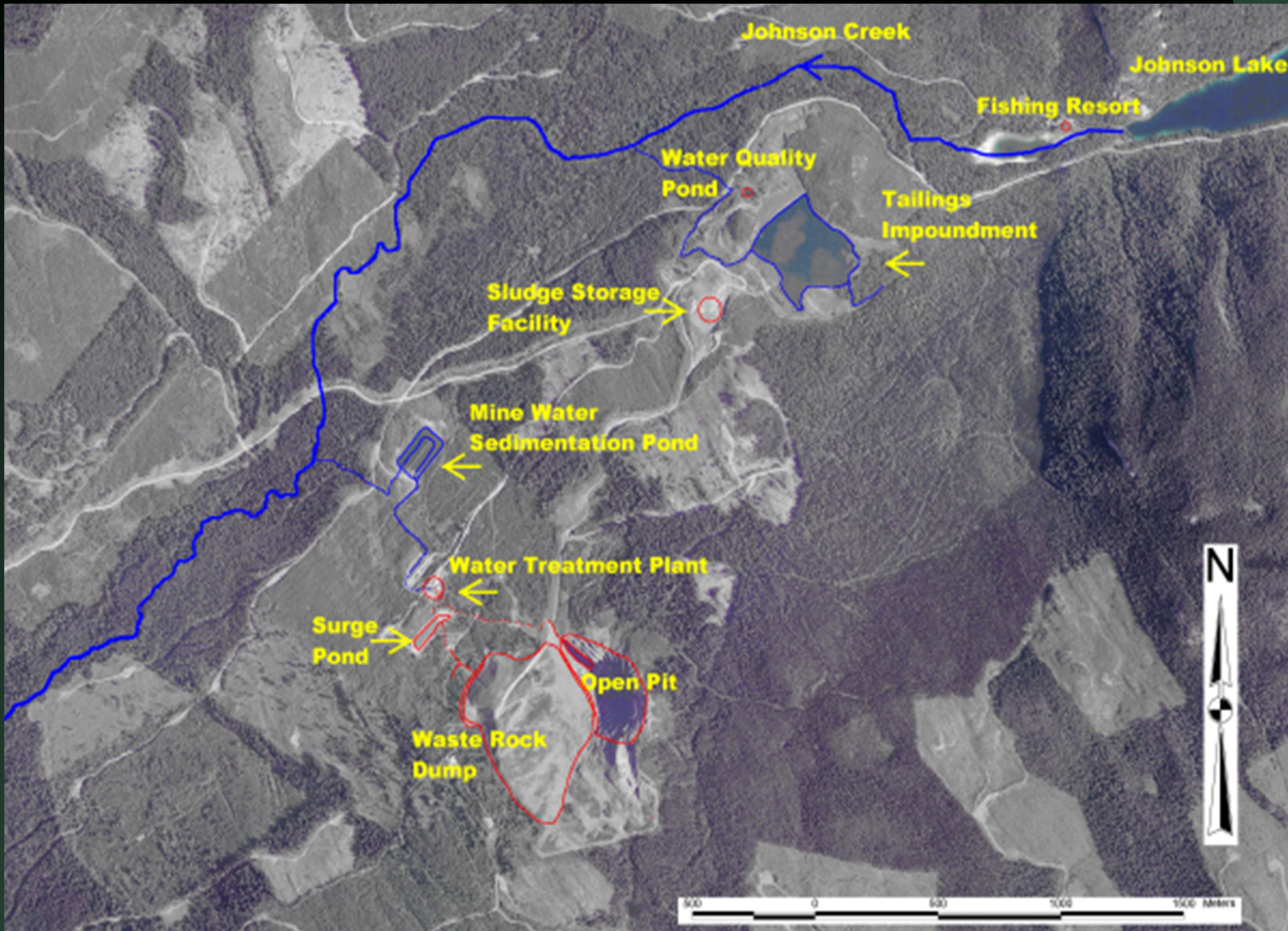

Samatosum Division:

Air Photo of Mine facilities and surrounding area.

~5 km x 4 km

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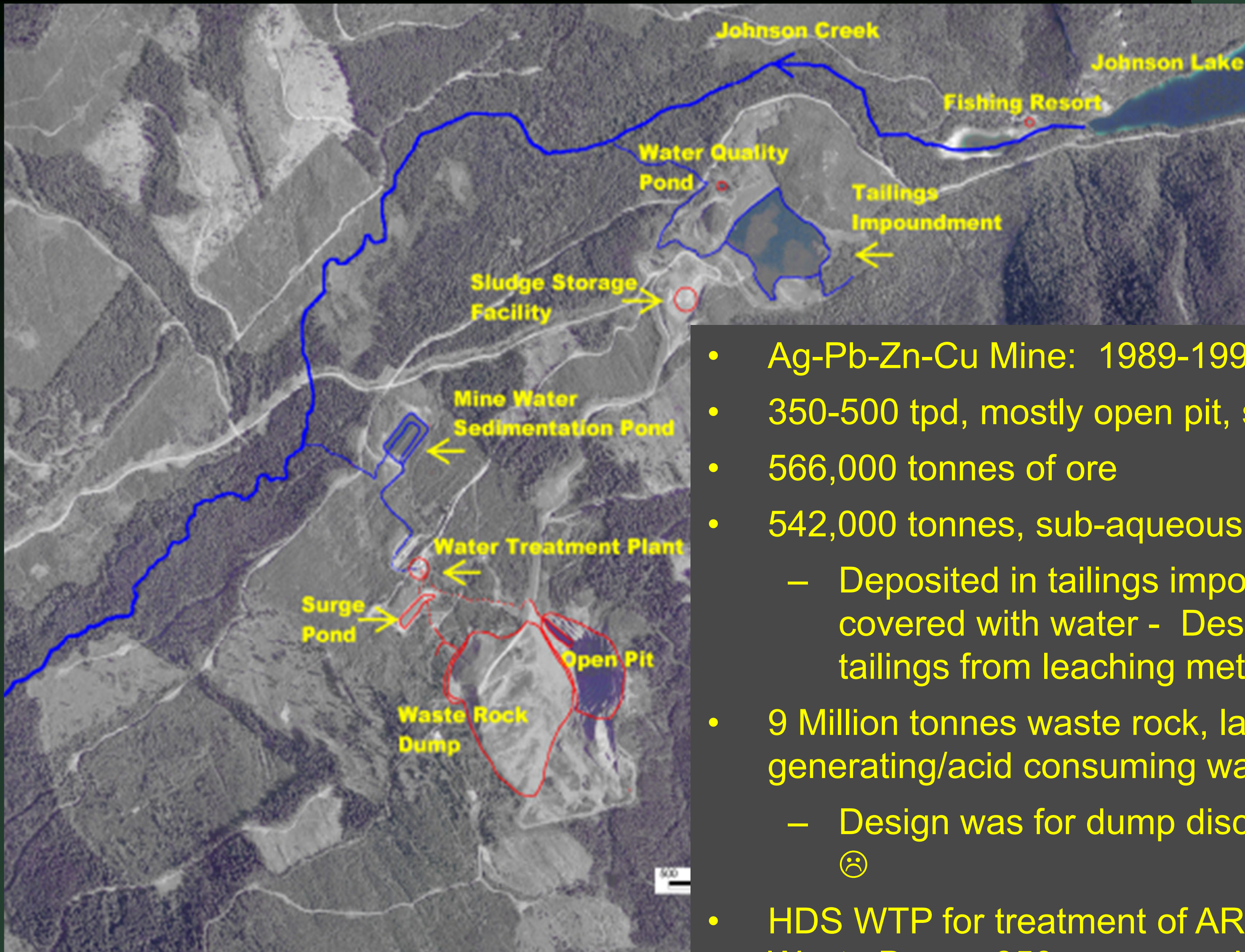

- Ag-Pb-Zn-Cu Mine: 1989-1992
- 350-500 tpd, mostly open pit, some ug
- 566,000 tonnes of ore
- 542,000 tonnes, sub-aqueous tailings
  - Deposited in tailings impoundment and covered with water - Design to prevent PAG tailings from leaching metals ☺
- 9 Million tonnes waste rock, layered acid generating/acid consuming waste dump
  - Design was for dump discharge to be neutral ☹
- HDS WTP for treatment of ARD runoff from Pit-Waste Dump, 850 mm annual precipitation

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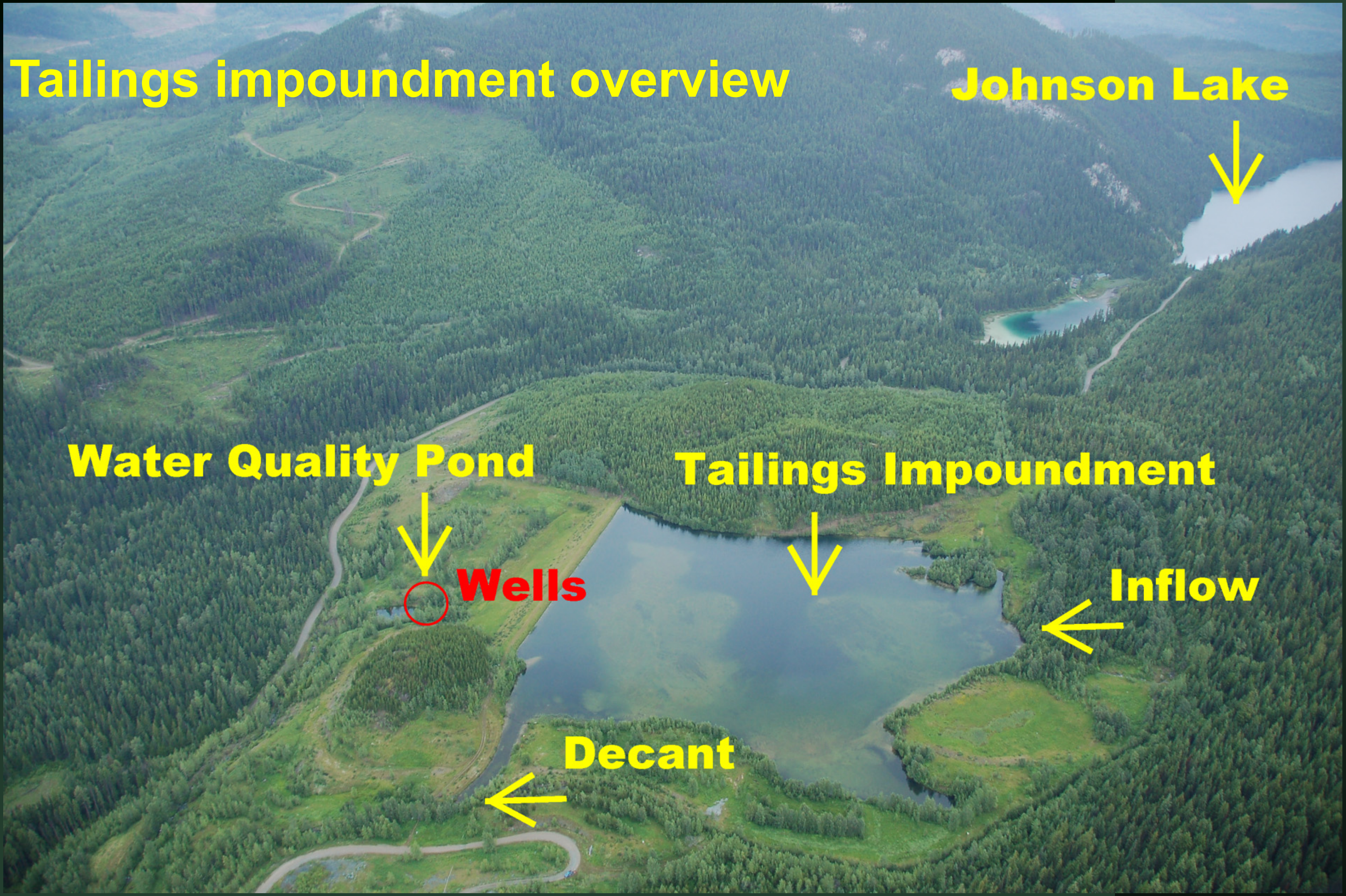
1994 Tailings water cover started - tributary diversion re-routed into impoundment;
1994-1996 Mine mill infrastructure being dismantled and removed.

Site History - Post-closure activities

1995	Tailings water cover installed, Waste rock drainage required treatment, unlike closure plan
1996	Control Order received from BC Ministry of Environment
	Low density lime treatment required and WTP constructed for treatment of pit and waste dump drainage
1998	High Density Sludge plant commissioned to treat mine drainage
2001	Surge pond (runoff) capacity increased
2002	Vegetation and stream investigations conclude rehabilitation is successful to date
2003	Discharge permit amended and control order rescinded
2004	Samatosum Dam Report done by SNC-Lavalin (Classification of Site Dams)
2005	Waste Dump Stability Evaluation by Piteau Engineering, WTP upgrades
2006	Waste dump Resloping Design Study Completed and project tendered
2008	Waste Rock Dump regrading completed; Awarded the Jack McDonald Mine Reclamation Award for 2007.
2009	Noxious weed guide reviewed and upgraded to Invasive Plant Management program (IPM).



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Tailings impoundment overview – construction and current view

1988 view across impoundment, dam foundation started

2011 view

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Tailings impoundment overview – construction and current view

Dam construction and borrow area

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Tailings impoundment overview – treatment before release

1994 Tailings water being treated before release

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Tailings impoundment overview – construction of spillway

Saddle dyke – decant construction and recent

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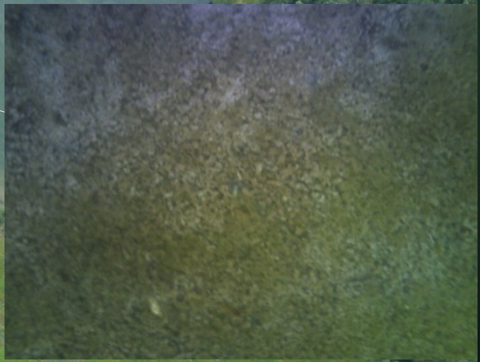
Tailings impoundment overview - Dam

25 m High x 250 m Long earthen dam, 1 L/s seepage

10 ha pond - 260 ha catchment, 2 m water cover typical (1 m minimum design)

Tailings impoundment overview - Tailings

- Potentially acid generating tailings at 1.46 AP/NP
- 10% pyrite, 4% Sulphur, 0.8% Zinc, 8.8 paste pH



Summary of mill ABA Quarterly composite data

Sample	Sulphur	Paste pH	AP	NP	NNP	AP/NP
	Percent (%)		kg/t	kg/t	kg/t	kg/t
Average	**3.96**	**8.8**	**121.02**	**87.99**	**-33.03**	**1.46**

Tailings impoundment overview
-Spillway, discharges into Johnson Creek

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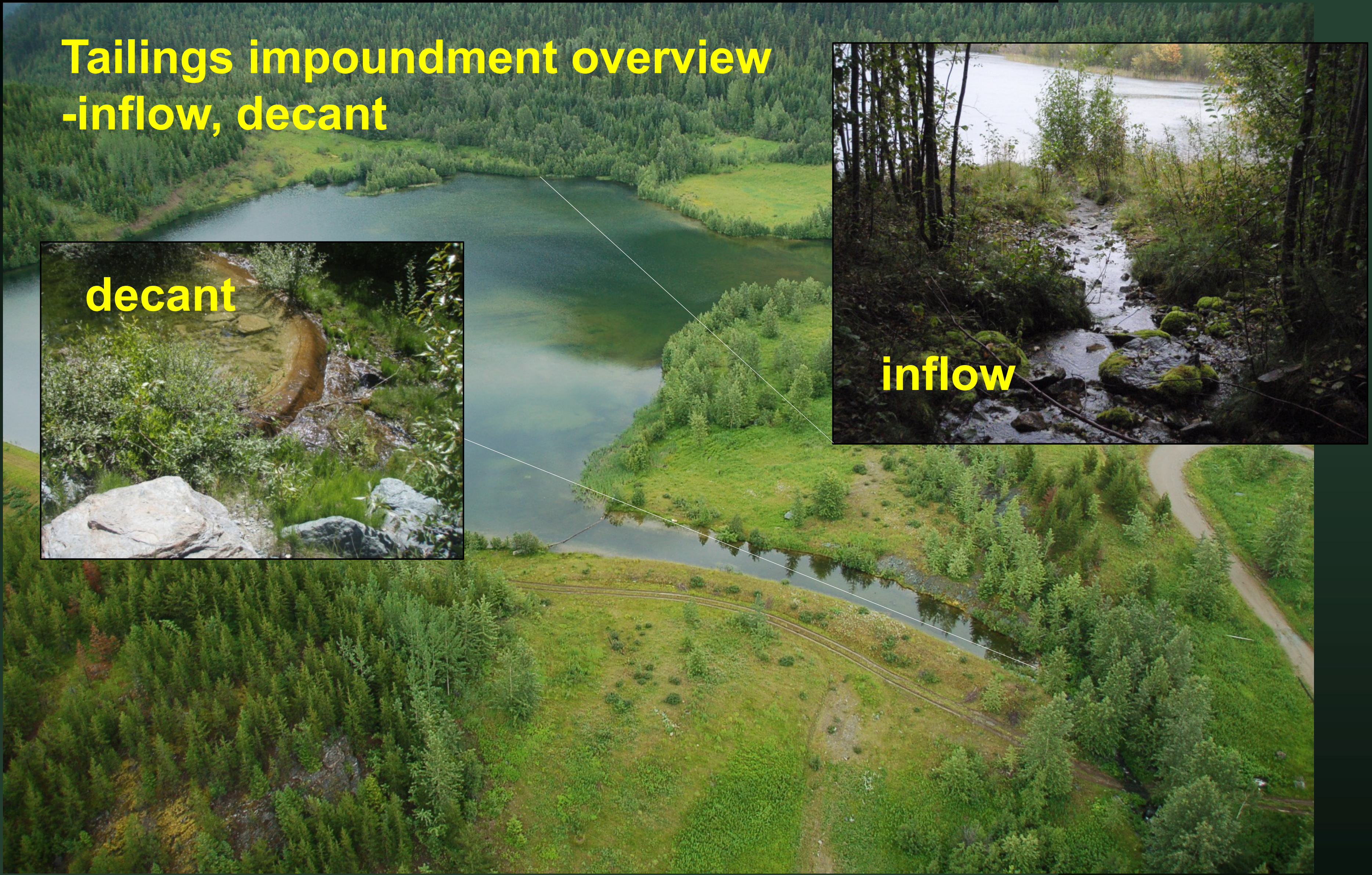
Tailings impoundment overview -inflow, decant



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Tailings impoundment overview - water quality review

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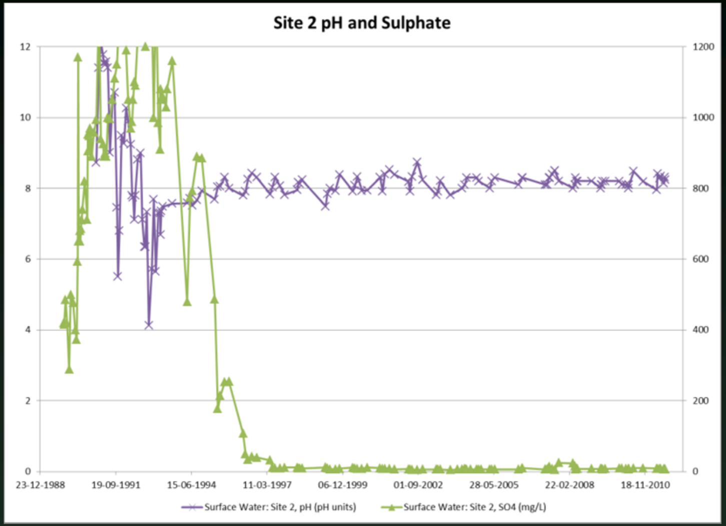

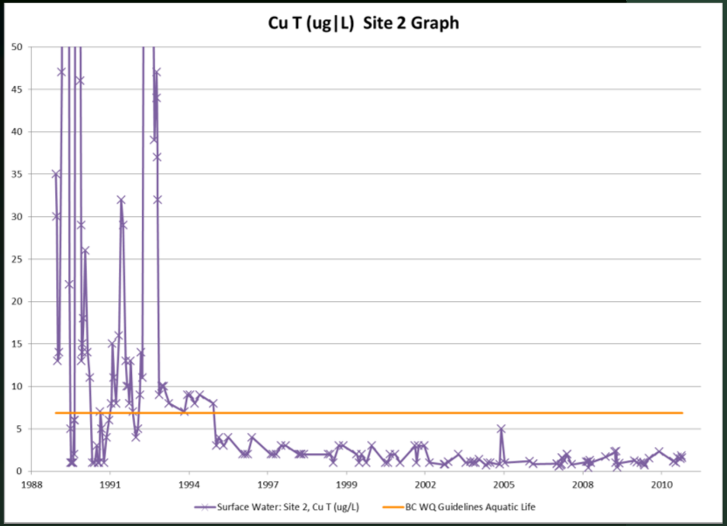

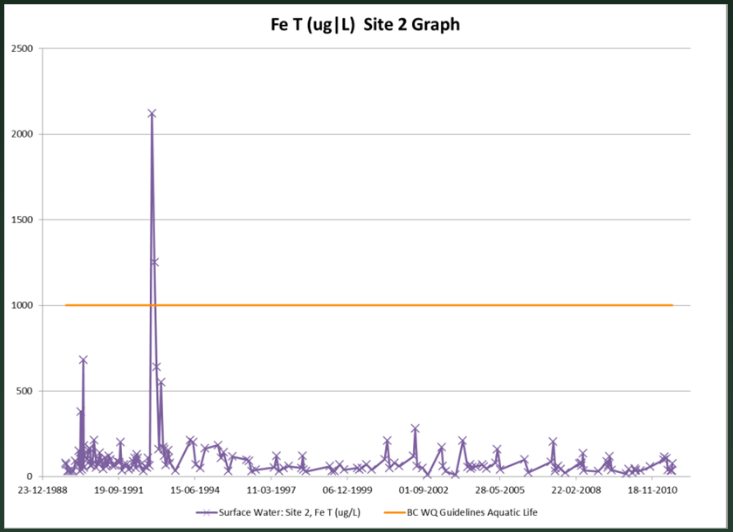

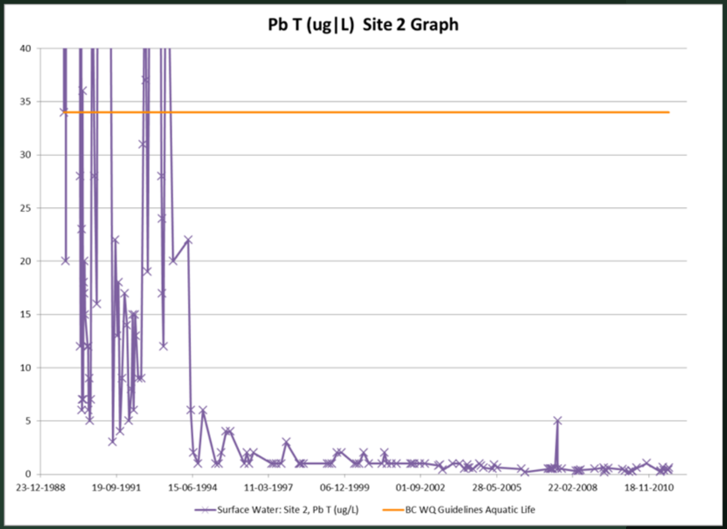

Site 2 - Tailings Decant water quality

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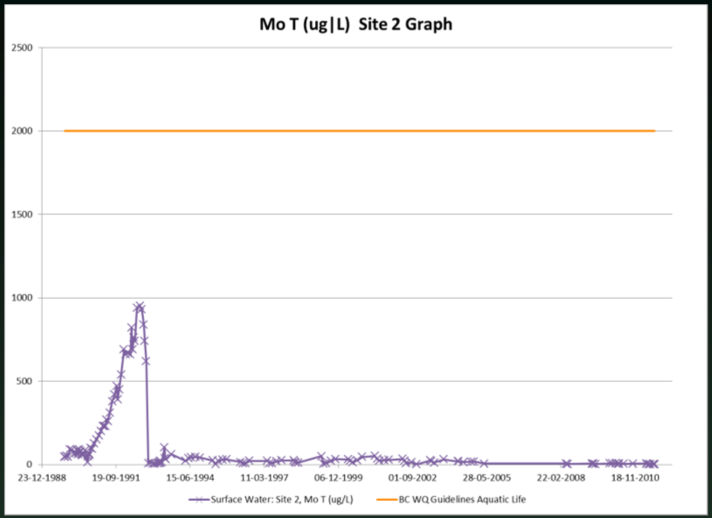

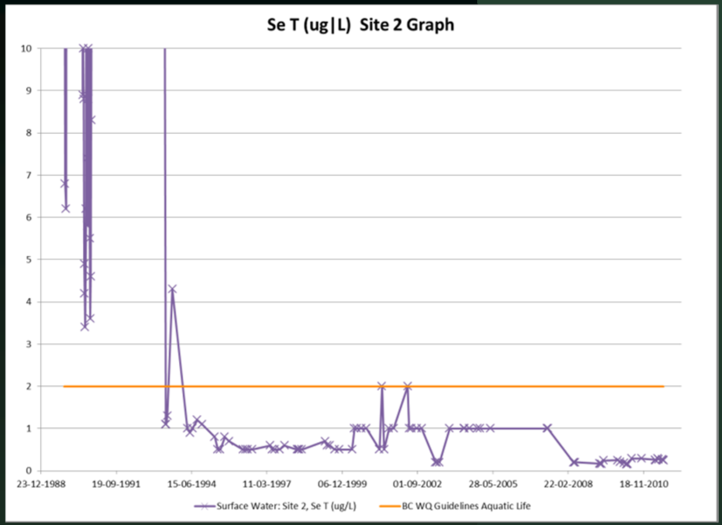

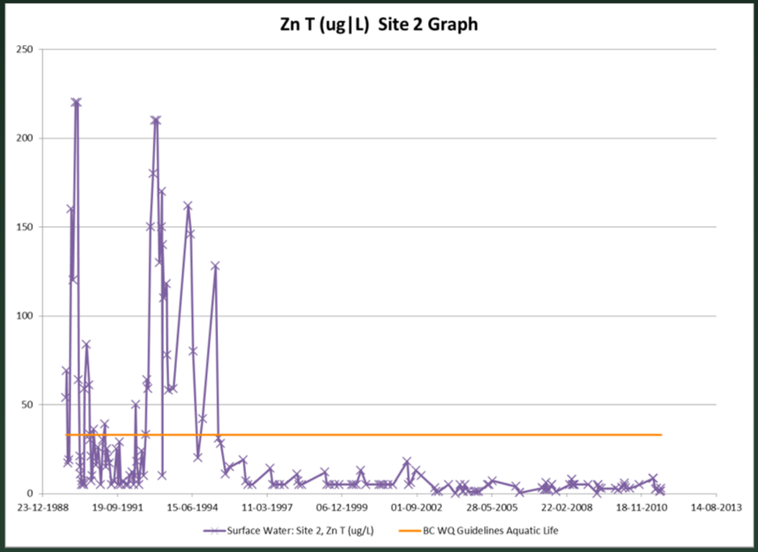

Site 2 - Tailings Decant water quality

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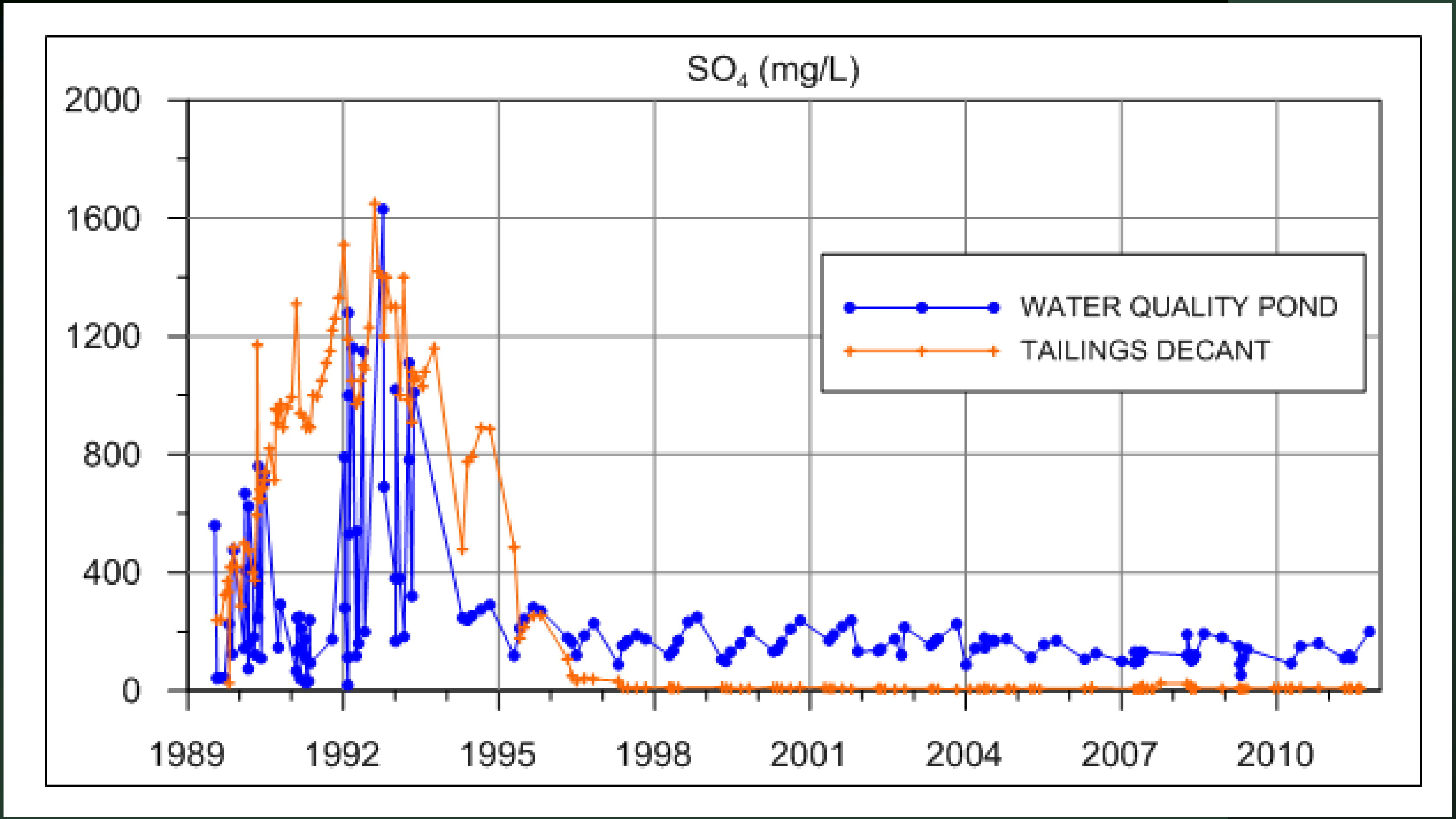

S04 at Site 2-Tailings Decant and WQP

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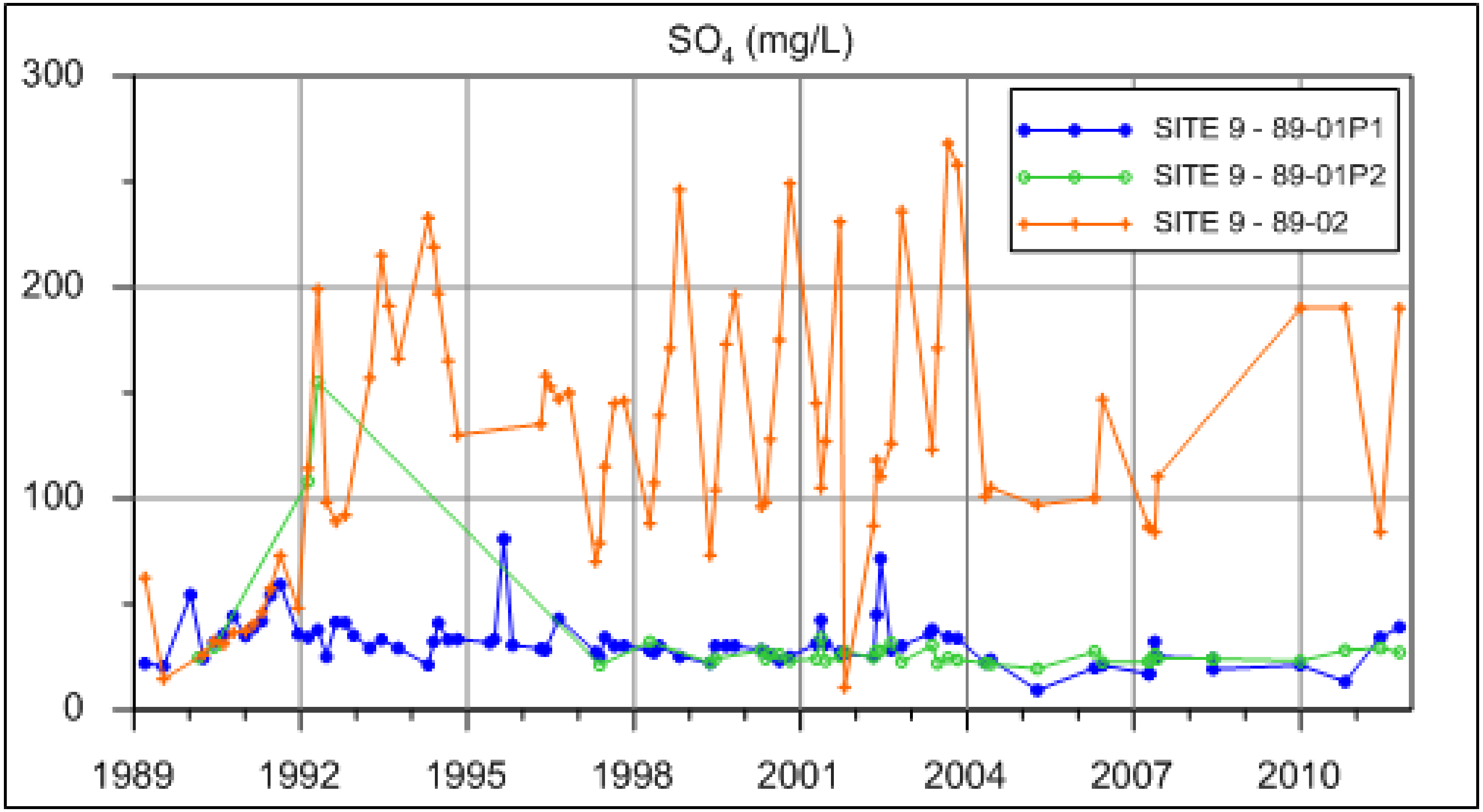

Groundwater wells below tailings impoundment

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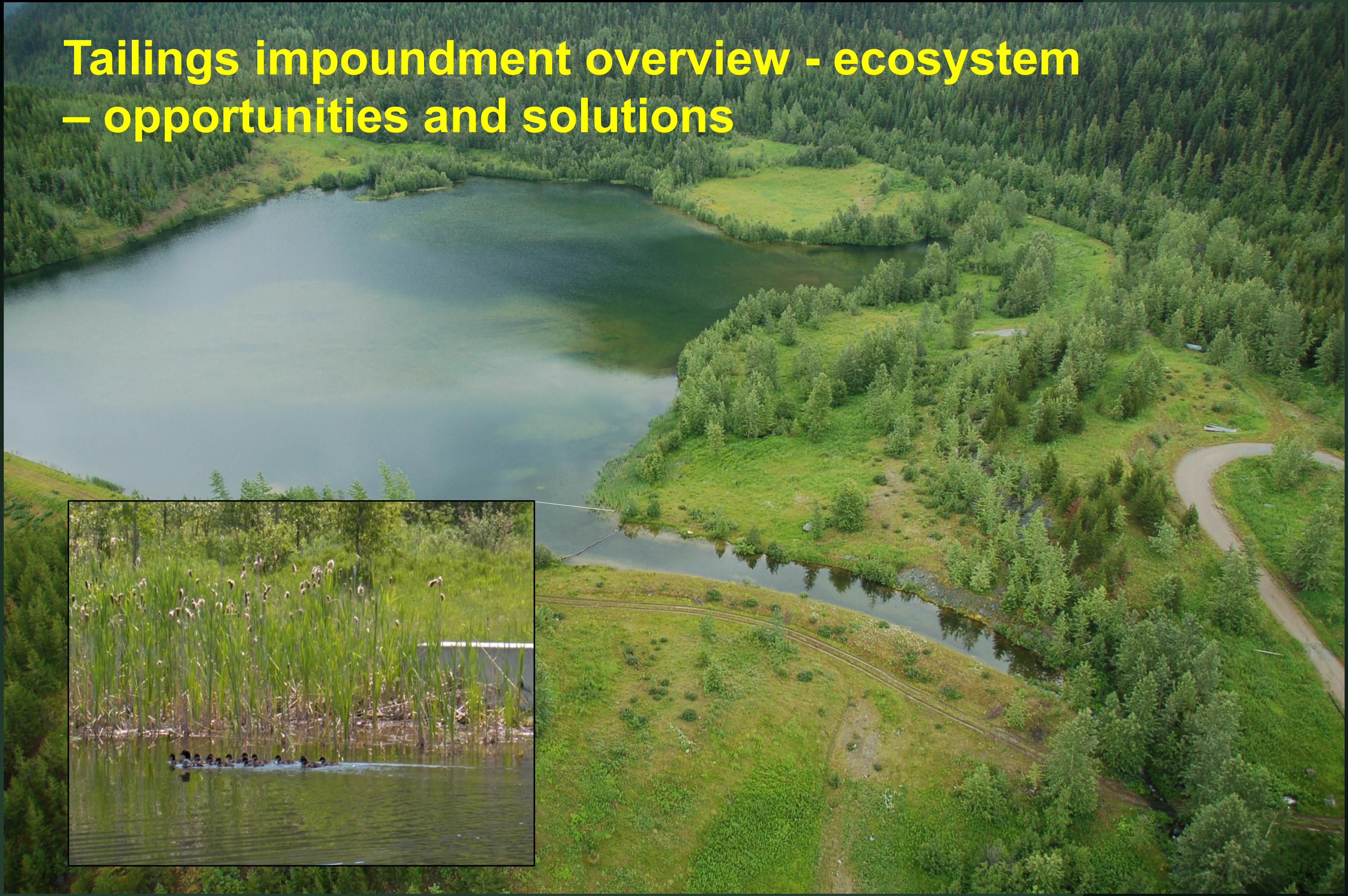
Tailings impoundment overview - ecosystem – opportunities and solutions



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Gophers

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Gophers - predators

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Gopher mesh – ¾ by ¾ galvanized grid mesh

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Cattails – transplant program to reduce erosion

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Before **After** **Roots/shoots**

Cattails – transplant program to reduce erosion

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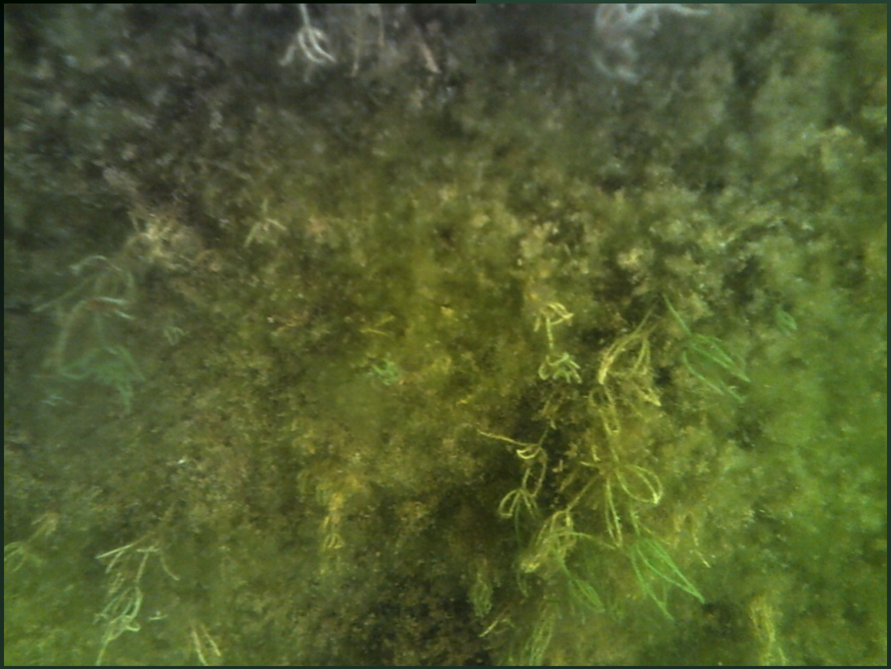
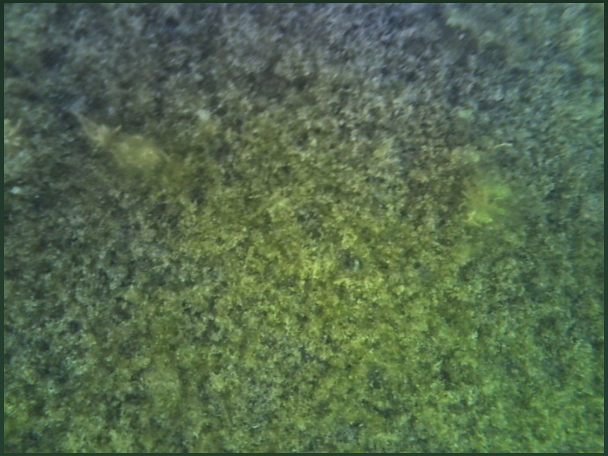
Amphibian hatch

boatmen

Underwater plants

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Considerations for Success

Site characteristics that affect the performance of a tailings water cover can be elements of:

- Design,
- Operations,
- Mitigation and Rehabilitation.

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Considerations for Success

- Impoundment characteristics
  - area, topography, climate (seasonal variation, wind)
  - watershed and flow-through, good annual rainfall
- Tailings characteristics
  - grain size, degree of oxidation
  - mineral content, pore water (process) chemistry
- Water cover characteristics
  - inflow chemistry, substrate (organic, carbonate, sediments), ecological systems

Where to next? Collaborative Investigations ?

- Characterize successes of tailings water cover relative to:
  - inflow chemistry, hydraulics and contaminant flux
  - substrate composition and thickness
  - substrate disruption (wave action, burrowers, plants)

Presentation Outline

The two sides to the Samatosum Reclamation Mine Site

- **Tailings water cover - success**
- **Waste dump – not so successful**

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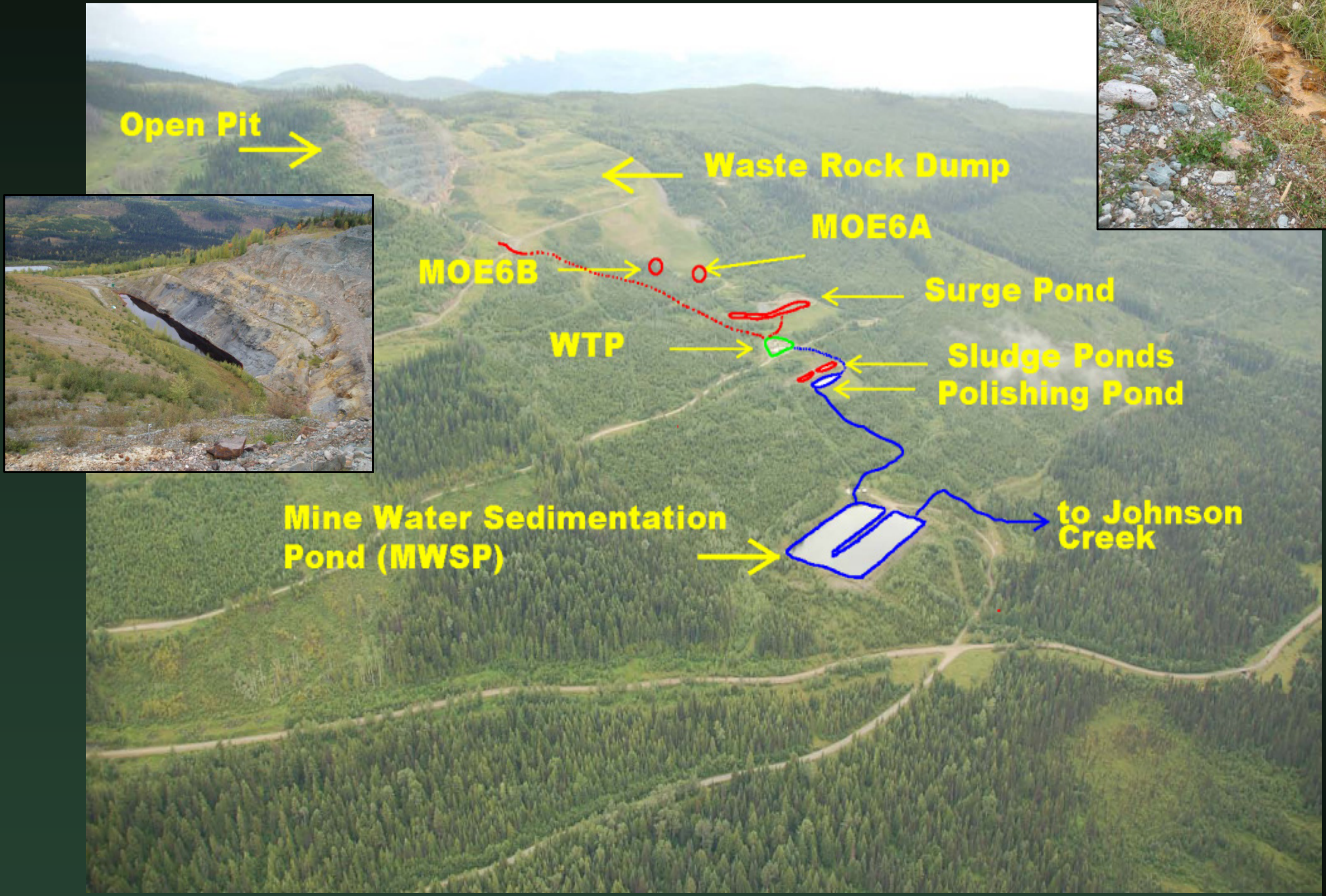
Part 2 ARD onset, mitigation – Pit, Waste Rock Dump, and Water treatment plant



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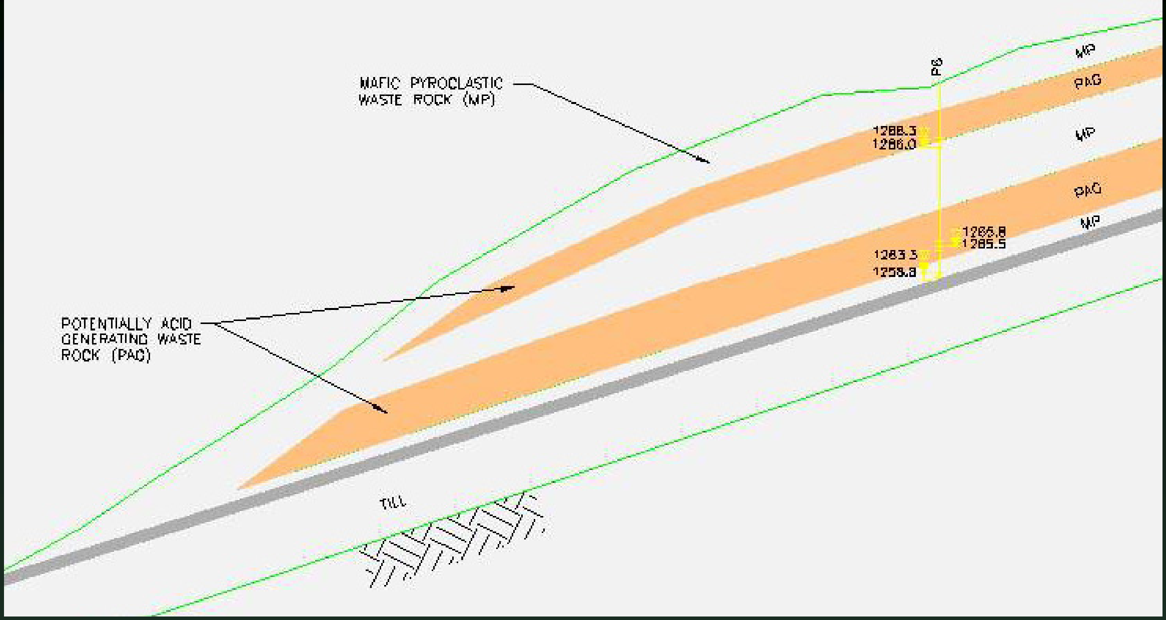

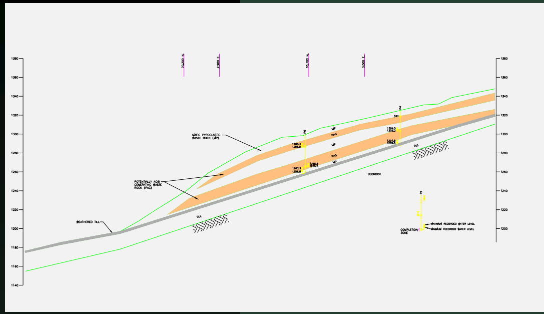

Design

- Layered with MP and PAG
- 5.7 million tonnes - mafic pyroclastic (MP) waste rock (NNP ~ 305kg/tonne)
- 3.9 million tonnes - potentially acid generating (PAG) waste rock (NNP) of -43 kg/tonne)
- Overall NNP for dump was 164 kg $CaCO_3$ equivalent per tonne

WTP's - 1996 LDS, 1998 HDS and expanded Surge pond (2001)

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WTP Process overview

- Water travels from the pit and surge pond through pipelines and enters the plant through the manifold house. (aka Doghouse)

- From the Doghouse the water enters the reactor where the treatment starts. A mix of oxygen, lime and recycled sludge is added and stirred with mixers.

- It is during this period that the pH (can be low if acidity is present) is raised to 9.60 Any metals are precipitated onto tiny recycled sludge nuclei. These little starter kernels (mostly iron) keep collecting metals and keep getting larger and heavier.

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WTP Process overview – WQ annual averages

Dissolved metals in µg/L	2009	2010	2011
Average Cu Inflow	1796	2781	914
Average Cu Outflow	1.9	2.2	1.8
Cu Inflow High	3880	4440	1820
Cu Inflow Low	9	24	7
Average Mn Inflow	6726	7293	3464
Average Mn Outflow	48	48	55
Mn Inflow High	11400	12500	9140
Mn Inflow Low	640	1790	305
Average Zn Inflow	34065	36427	12559
Average Zn Outflow	2.9	3.7	8
Zn Inflow High	64100	62300	35800
Zn Inflow Low	855	3080	518

Water treatment plant tanks

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WTP Process overview

- At the pipe entrance to the clarifier a polymer called flocculent is added (sticky elastic band).
- In the center well of the clarifier the stuck together sludge nuclei are separated from the water.

WTP Process overview

- The top of the tank is clean water and the bottom is settled out sludge. The Rakes continually pull the sludge into the center where some of it is pumped back into the reactor to start the process all over again.

- The Plant is a HIGH DENSITY SLUDGE operation. (20%-30% solids) We upgraded from a Low Density operation in 1998. (3%-5%)

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Sludge management

- The improved high density sludge now takes four to six years to fill one pond versus one years before plant optimization.

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Sludge management – test plots, sludge piles

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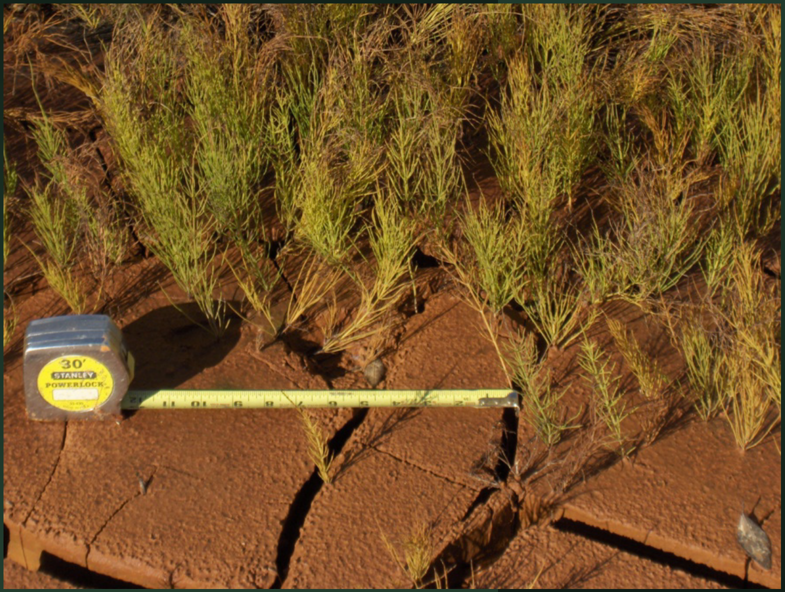
Vegetation growing in sludge



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- **Path Forward**
- We will continue to meet our regulatory commitments at Samatosum
- Continue to explore opportunities to meet and exceed our target and ultimate goal of **Zero Harm** to people and the environment.
- Continuously improve our Corporate Responsibility Management Systems - safety, environment, community dialogue, biodiversity, energy and resource conservation, sludge management, and a long-term solution to the pit and dump AD.
- Continue our Partnerships – Regulators (MEMPR, MOE), Consultants (Piteau Associates, Stantec/CEJones team), Contractors

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People

Special thanks to co-authors

Andrew Holmes and James Hogarth of Piteau Associates,

Craig Ford and Tracy Anderson of Inmet Mining

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THANK YOU!

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