Performance of Denison Mine Tailings Management Areas (TMAs) Fifteen Years Following Decommissioning

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BC-MEND ML/ARD Workshop, Nov./Dec. 2011

Presentation Overview

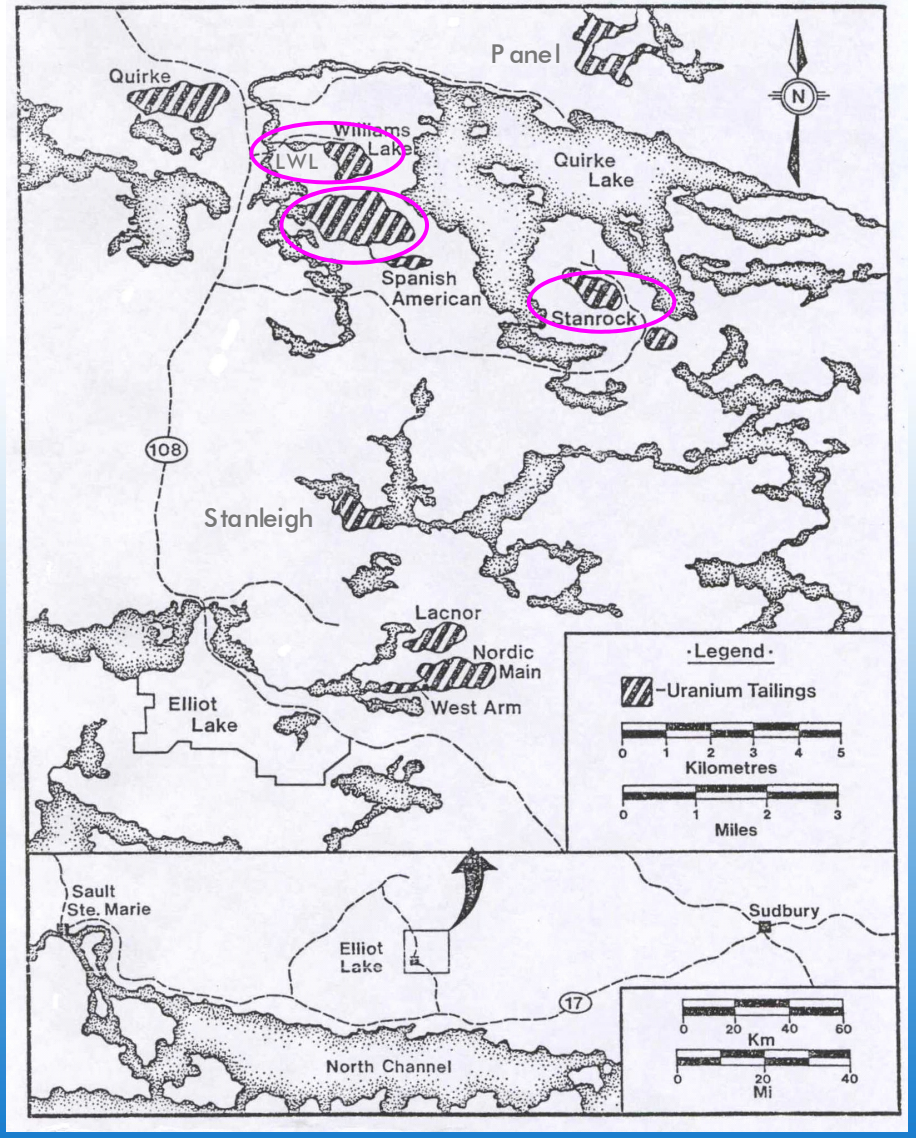
Performance Evaluation of Three Tailings Management Areas (TMAs)

- Denison TMA-1 and 2 – In-situ Water Cover
- Stanrock TMA – Elevated Water Table
- Lower Williams Lake TMA – Partial Water Cover/Wet Barrier

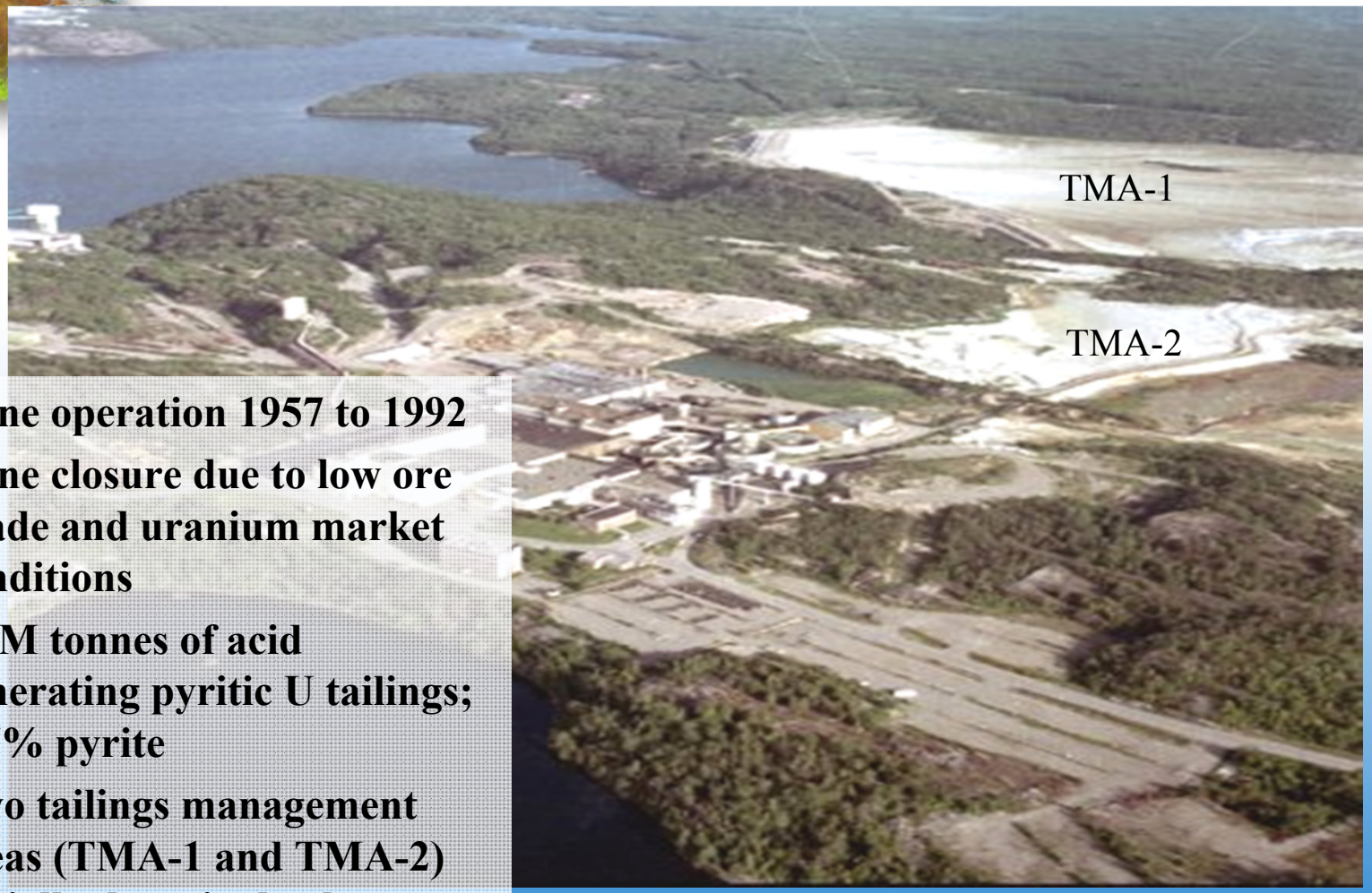
Acknowledgement

Denison Environmental Services, Elliot Lake, Ontario for making available the latest site monitoring data and management details

Elliot Lake Uranium Mining District TMAs



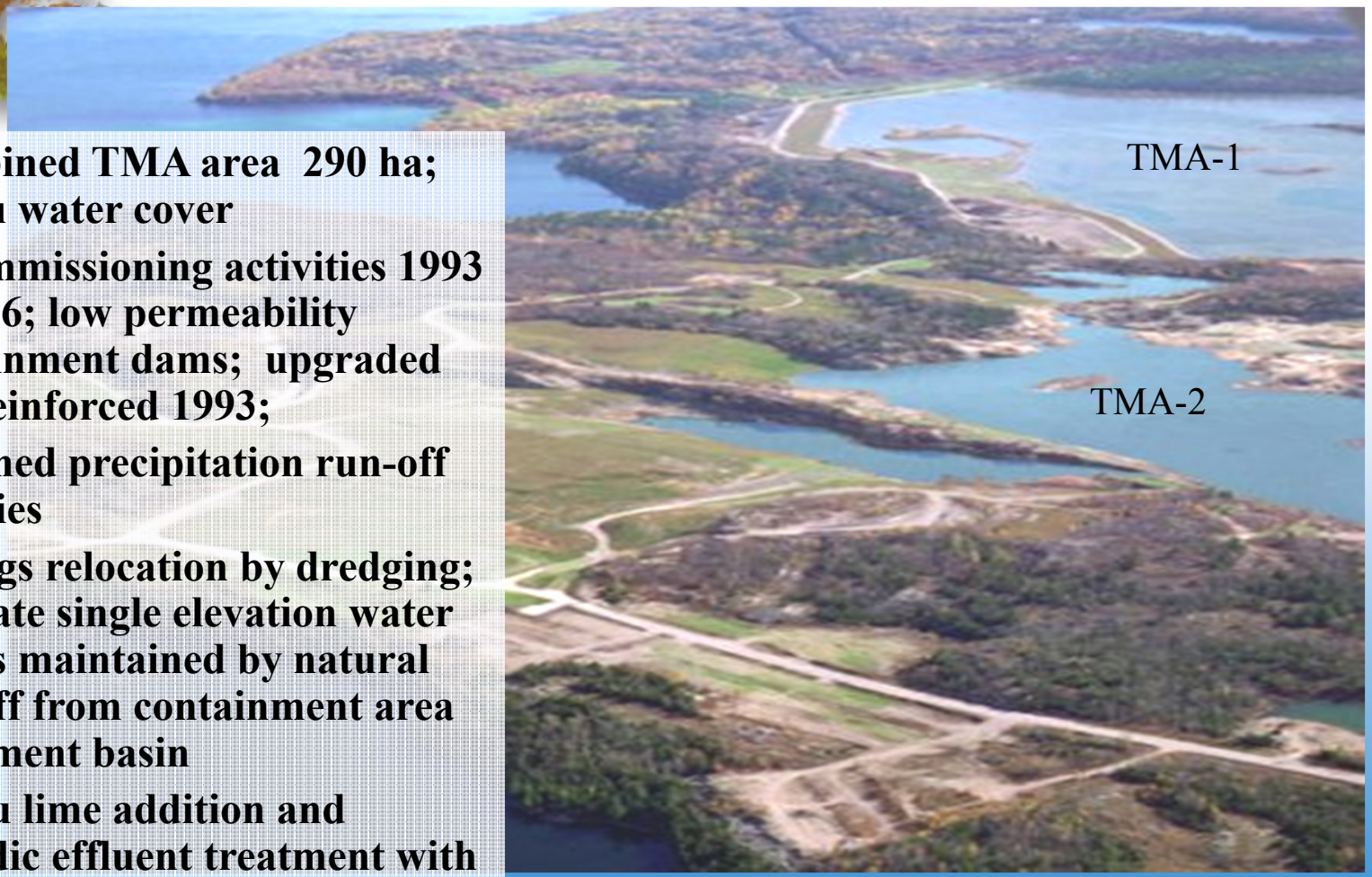
Denison TMA - Before Decommissioning



- **Mine operation 1957 to 1992**
- **Mine closure due to low ore grade and uranium market conditions**
- **63 M tonnes of acid generating pyritic U tailings; 5-7% pyrite**
- **Two tailings management areas (TMA-1 and TMA-2) initially deposited sub-aerially**

Denison TMA - After Decommissioning

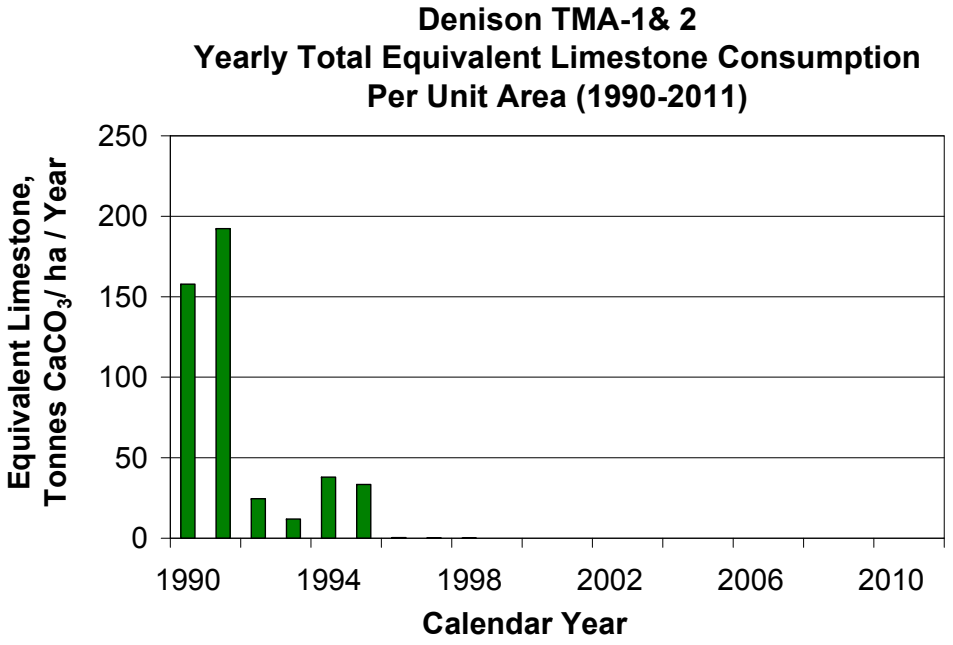
- **Combined TMA area 290 ha; in-situ water cover**
- **Decommissioning activities 1993 to 1996; low permeability containment dams; upgraded and reinforced 1993;**
- **Designed precipitation run-off facilities**
- **Tailings relocation by dredging; separate single elevation water covers maintained by natural run-off from containment area catchment basin**
- **In-situ lime addition and periodic effluent treatment with NaOH**
- **Radium removal with $BaCl_2$**



Denison TMA - After Decommissioning

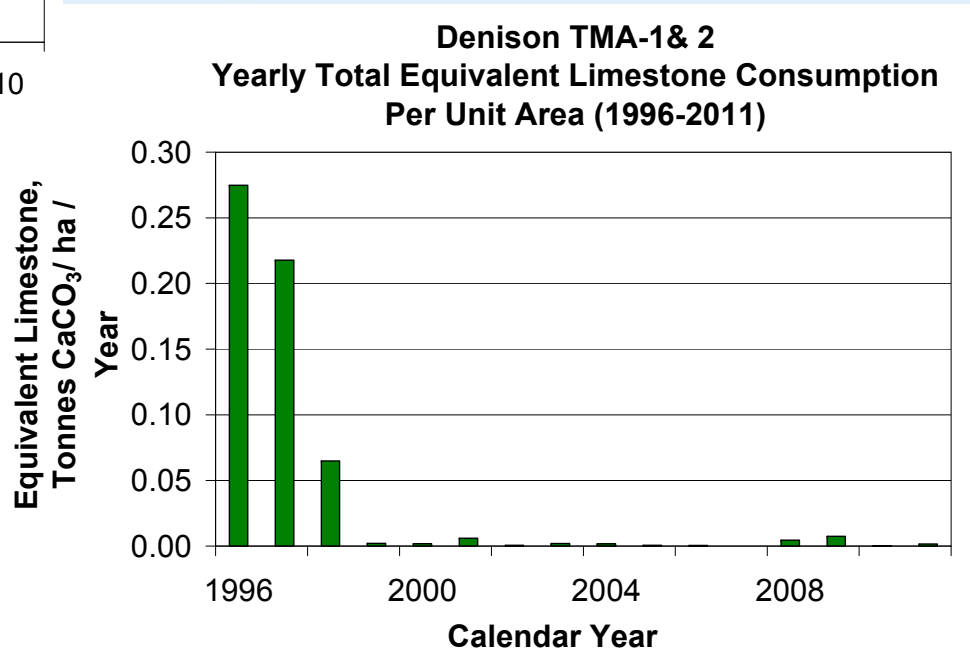
Denison TMA - After Decommissioning

Denison TMA Performance

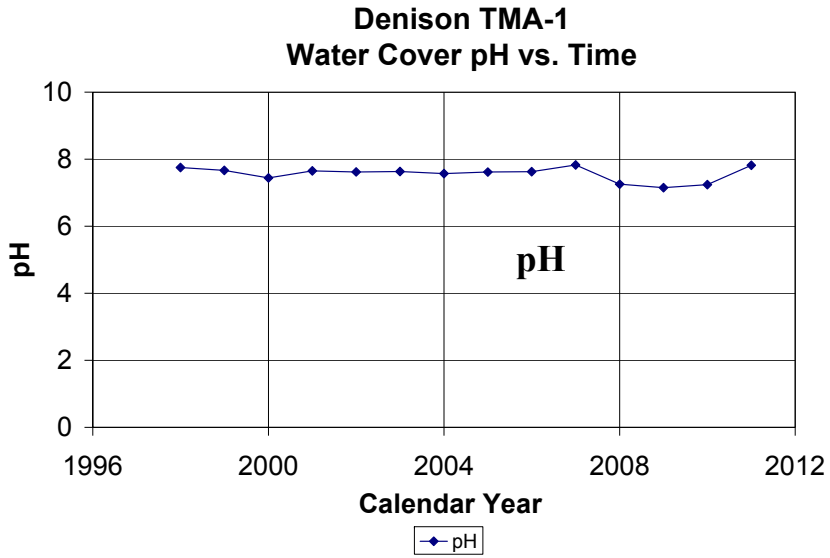


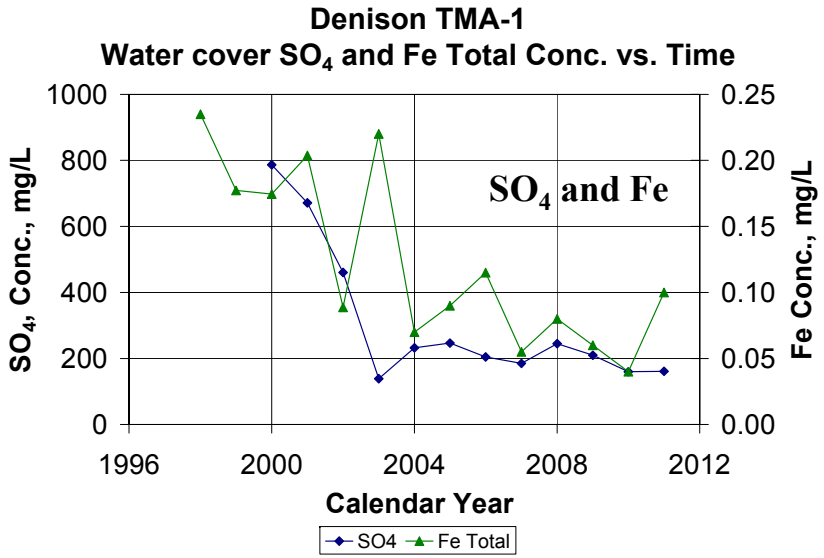
Acid generation reduced to less than 0.01% of operating phase

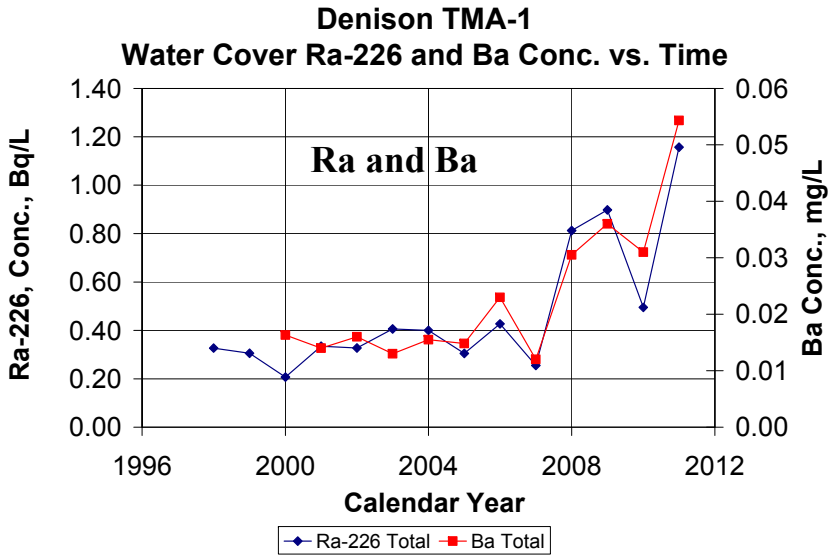
Acid generation reduced to less than 0.5% following decommissioning

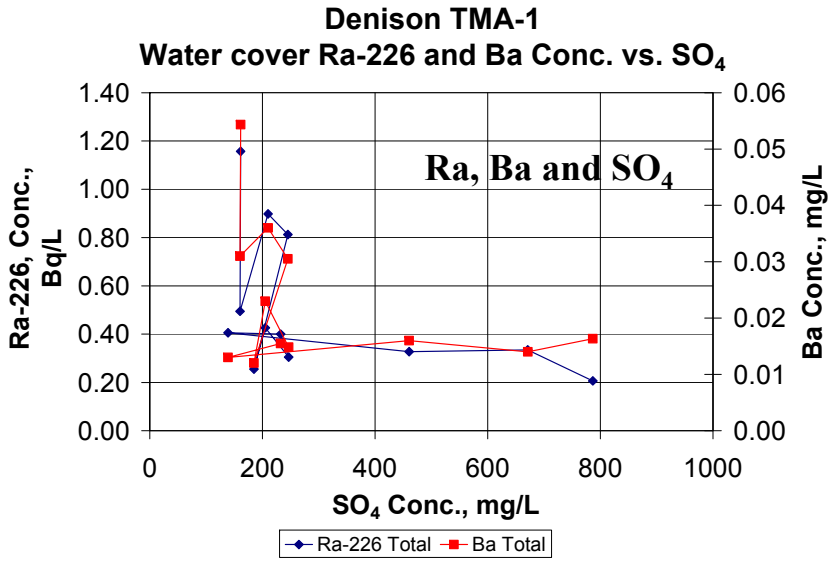


Denison TMA - Performance









Denison TMA – Performance Summary

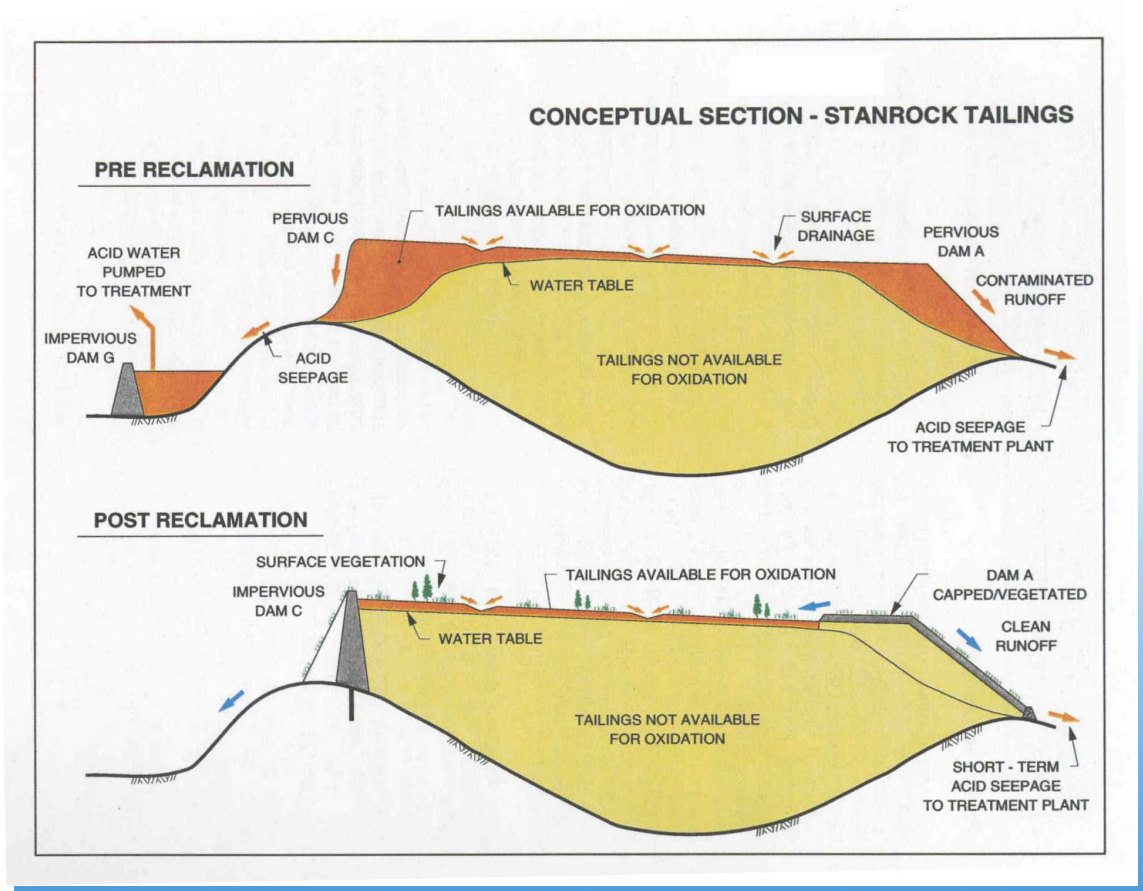
- Sites performing well as per design specifications
- Acid generation rate decreased to less than 0.01% of pre-water cover operating and 0.5% following rehabilitation and decommissioning
- Water cover at near neutral pH conditions with decreasing SO_4 and Fe total concentrations with time
- Gradually increasing dissolved Ra-226 and Ba concentrations with decreasing SO_4 concentrations in the water cover
- Long-term effluent treatment and control required for management of Ra-226

Stanrock TMA – Before Decommissioning

- Tailings deposited from Stanrock and Canmet mines, 1957 to 1964
- Strongly acid generating pyritic uranium tailings, 5-7% pyrite
- Stanrock TMA: ~ 56 ha surface area; ~ 8 million tonnes sub-aerially deposited tailings
- State of inactivity for more than 30 years, mostly well weathered and exposed tailings on the surface
- Cycloned-coarse tailings dams
- Sparse vegetation cover

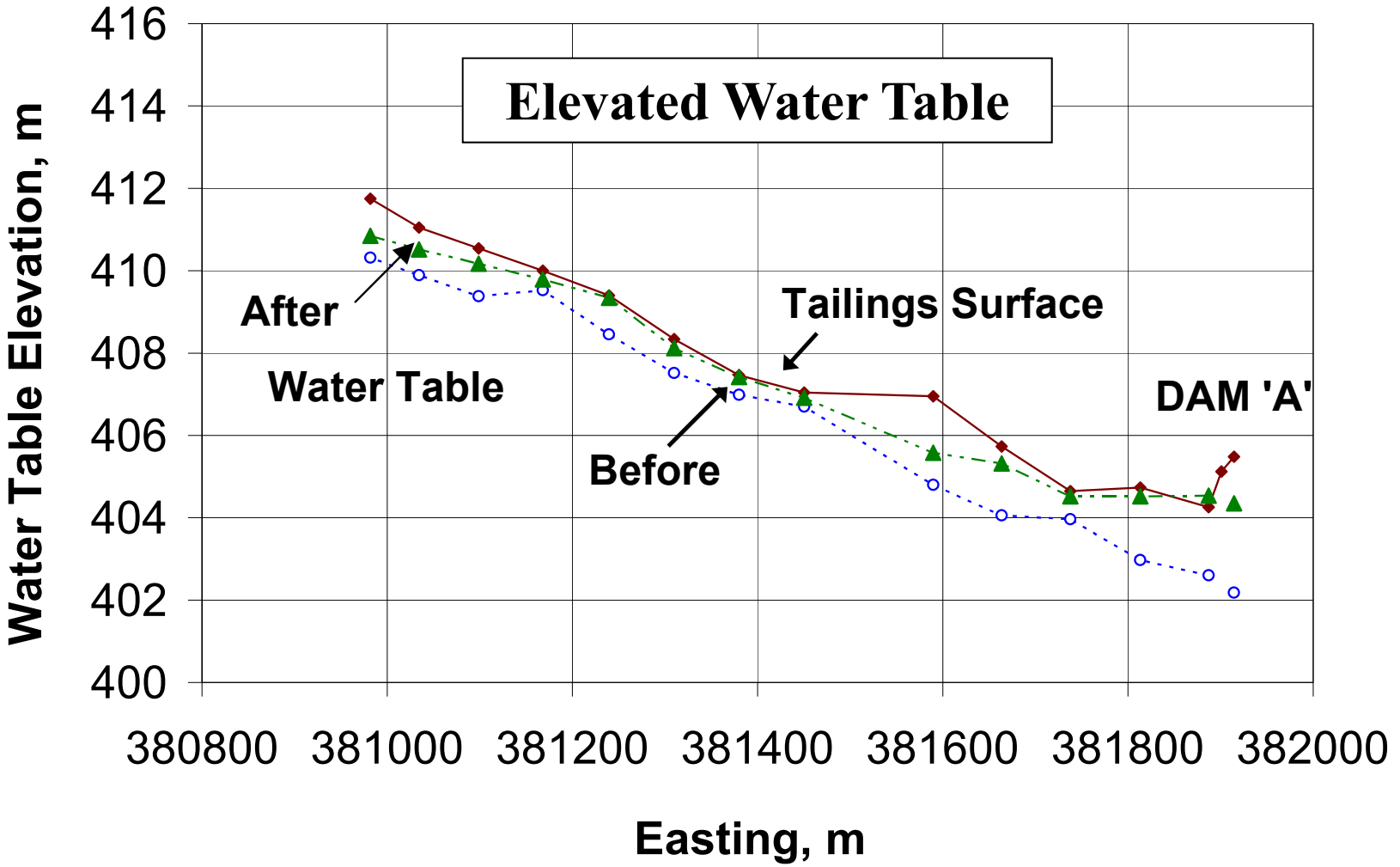
Stanrock TMA –Decommissioning

- In-situ water cover not feasible
- Tailings relocation to nearby Moose Lake for water cover application – cost prohibitive
- Selected decommissioning option – in-situ elevation of water table to above the un-oxidized zone
- Upgraded and designed new engineered dams to minimize seepage losses; clay/till core to bedrock
- Surface rehabilitation with vegetation cover
- Effluent collection and treatment

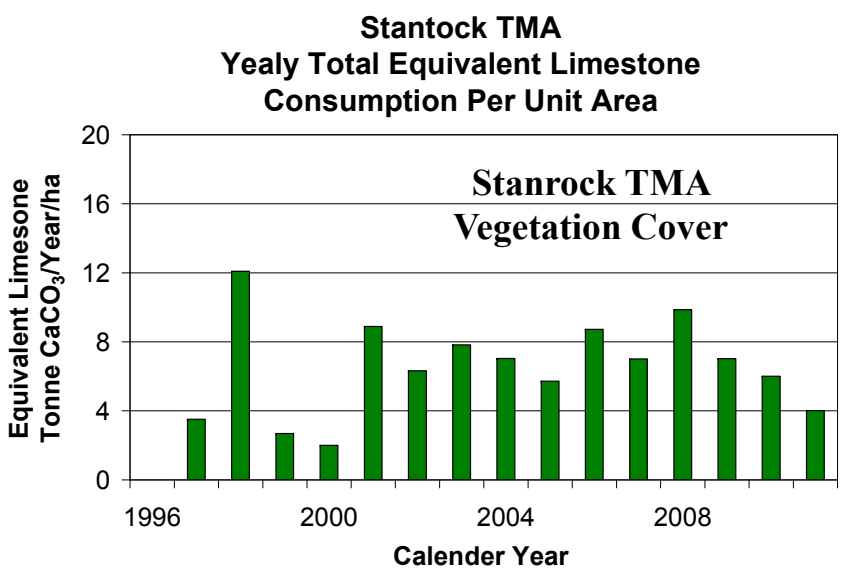


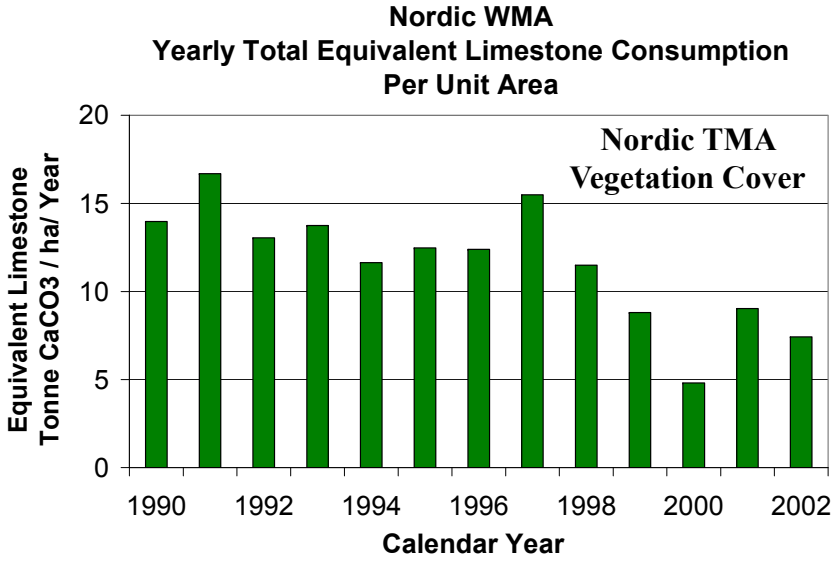
Stanrock TMA –After Decommissioning

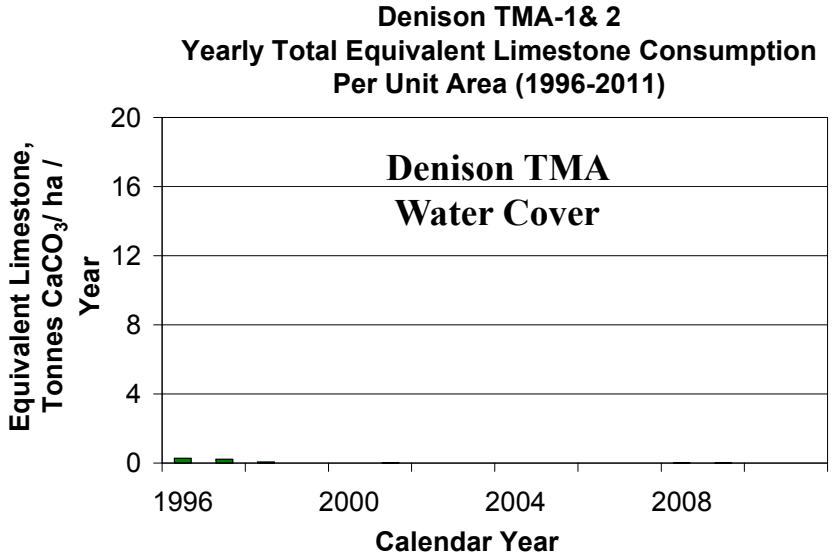
Stanrock TMA – Performance



Stanrock TMA – Performance







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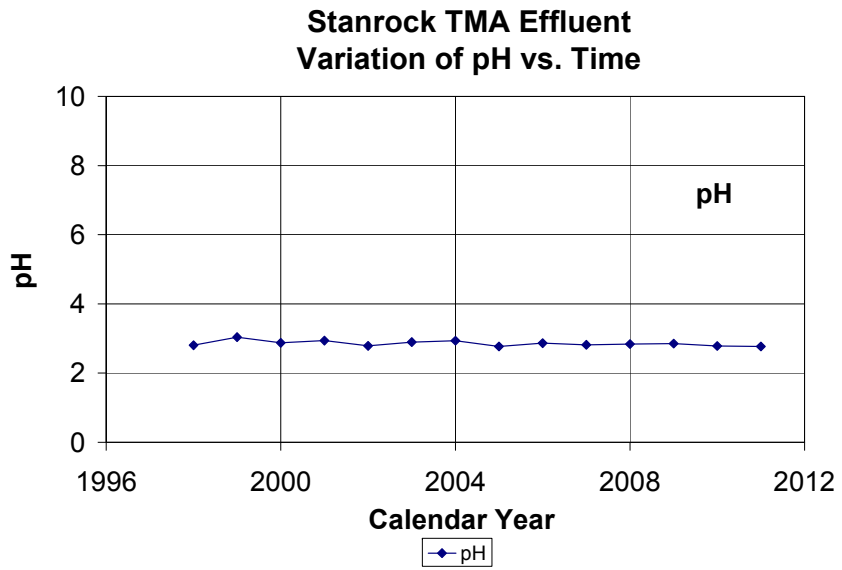
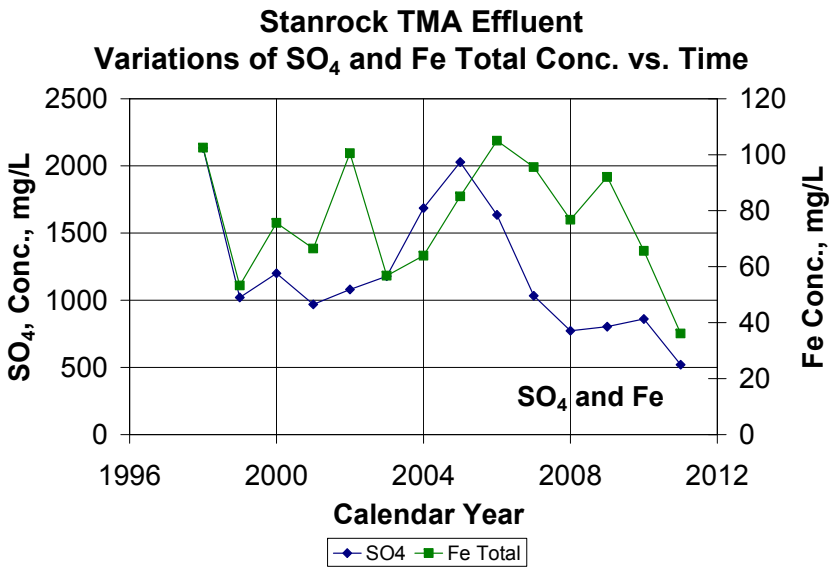
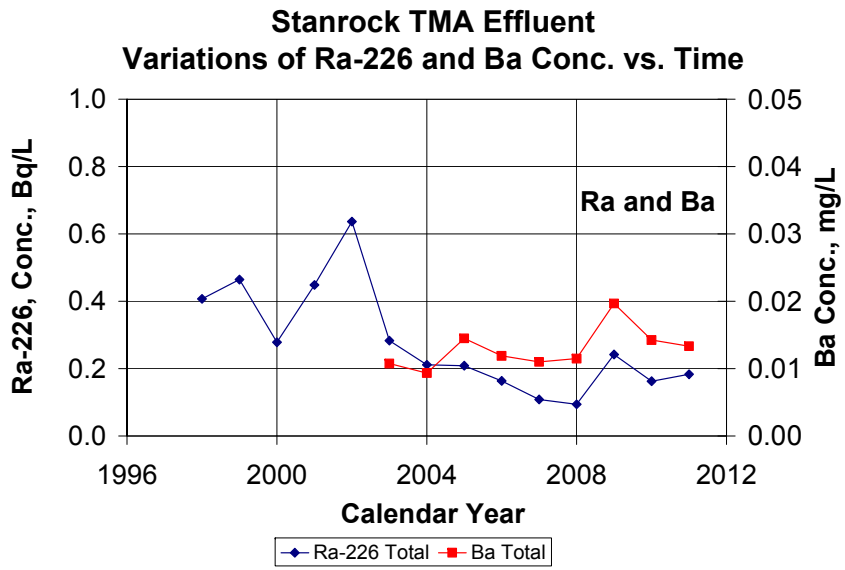
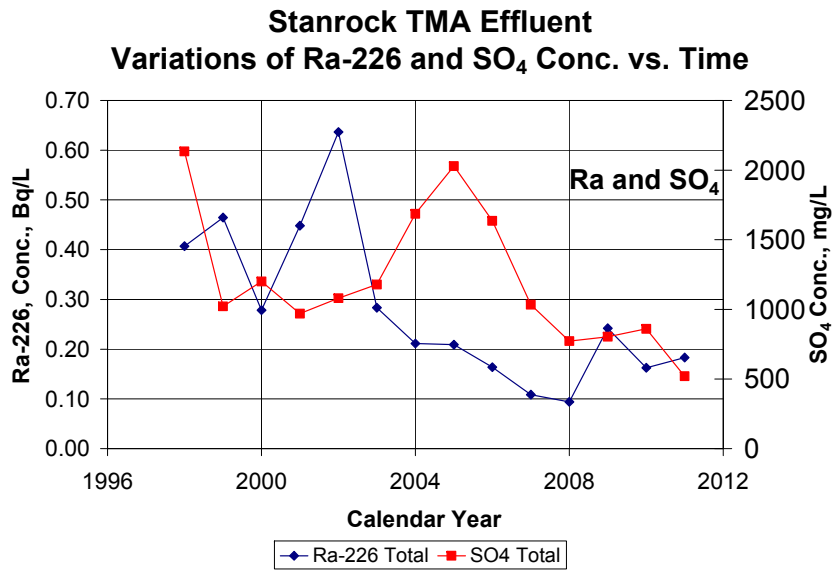








Stanrock TMA – Performance Summary

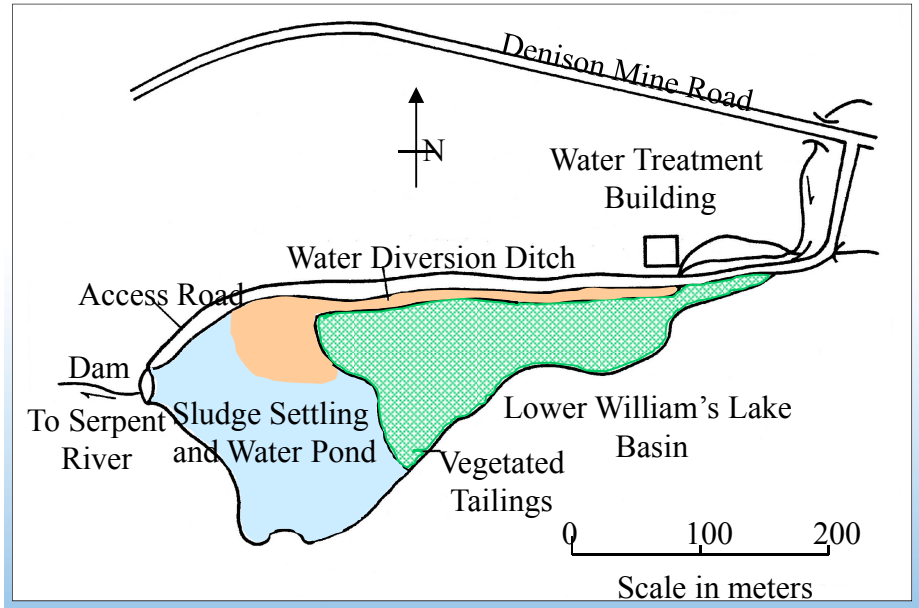
- Site functioning as per design specifications with ongoing effluent collection and treatment
- Anticipated benefits of elevated water table yet to be fully realized with continuing drainage of acidic pore water and release/flushing of stored oxidation reaction products
- Post closure effluent treatment predicted for ~ 50 years
- Low concentrations of Ra-226 in the drainage effluent during acid generation/drainage phase with significantly elevated SO_4 concentrations

Lower Williams Lake TMA
Before Decommissioning

- Small 2 ha site, downstream of Upper Williams Lake Basin (Denison TMA-2)
- Former bog area; tailings deposited due to accidental spillage from TMA-2 during late 1950s to early 1960s
- 20,000 tonnes tailings, shallow ~0.3 to 1.25 m in depth
- Fine pyritic uranium tailings, ~ 2 - 4% pyrite
- 70% dry tailings, 30% totally or partially submerged tailings under shallow water cover
- Seepage from upstream tailings
- Dusting and discharge water quality issues

Lower Williams Lake TMA Decommissioning Activities

- Site reclaimed in late 1970s
- Initial unsuccessful attempt of collection and treatment of incoming seepage and discharge of treated water onto the exposed tailings surface
- Diversion of treated water via lined ditch; lime/limestone amendment to exposed tailings
- Low load bearing capacity and trafficability of mostly wet tailings
- Borrow material till/sand/gravel cover on exposed tailings, ~ 1m in thickness
- Vegetative reclamation of the terrestrial tailings
- Water cover and wetlands in the remaining basin



Lower Williams Lake TMA
After Decommissioning

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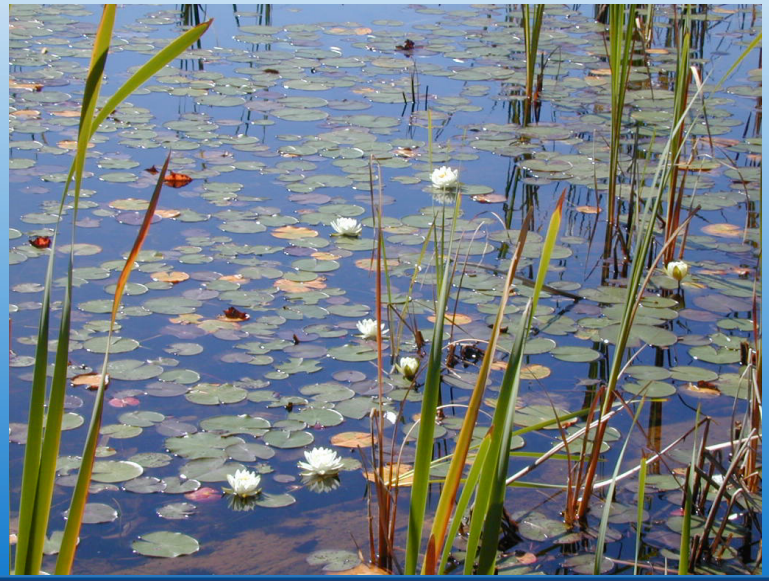
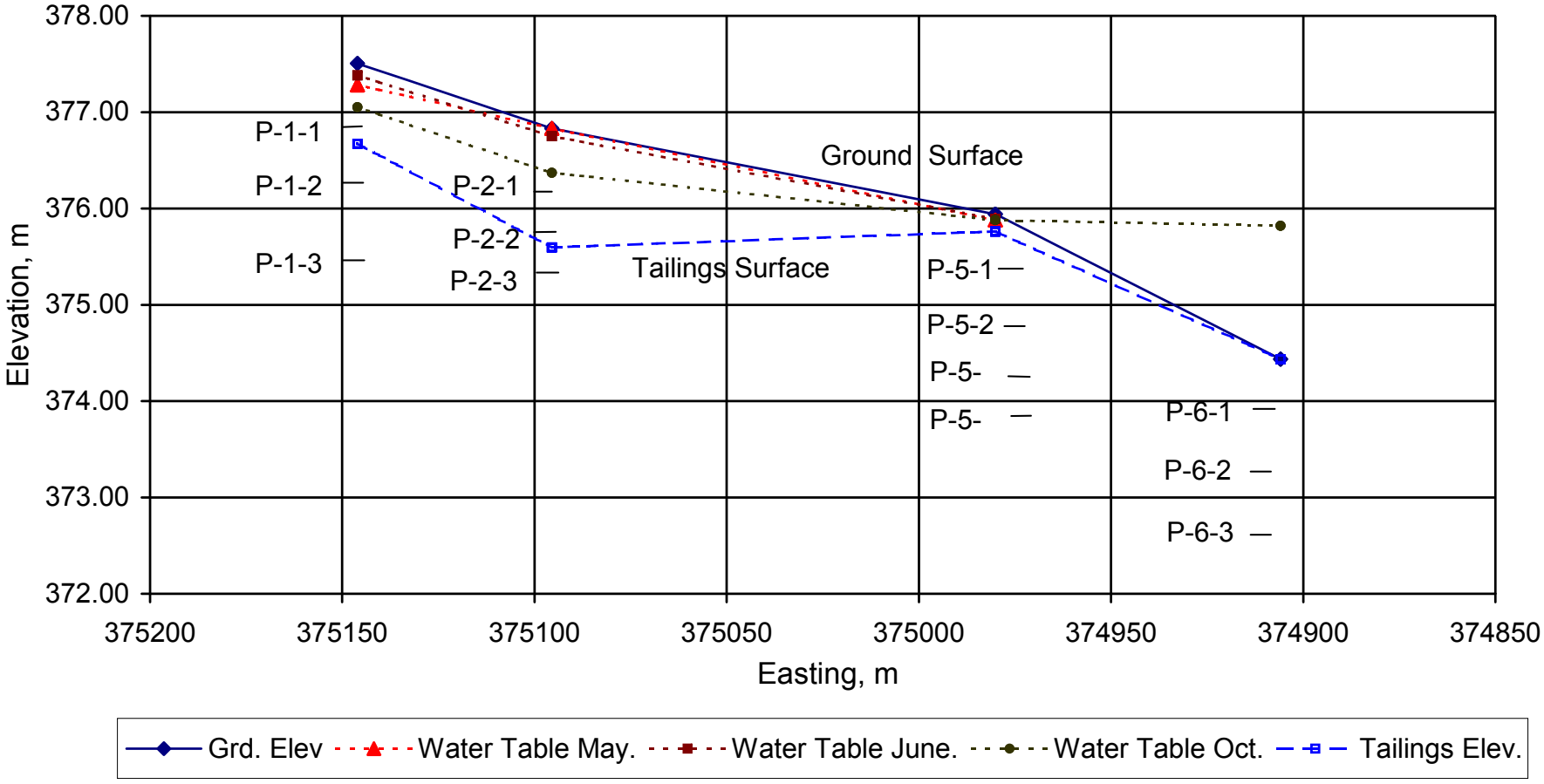


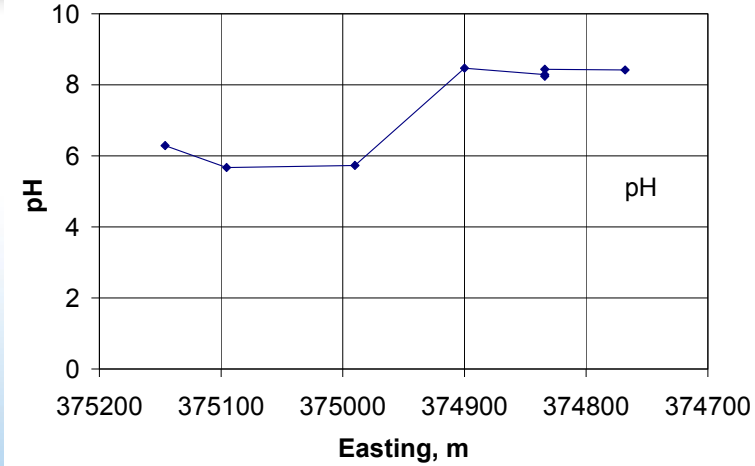
Lower Williams Lake TMA Performance

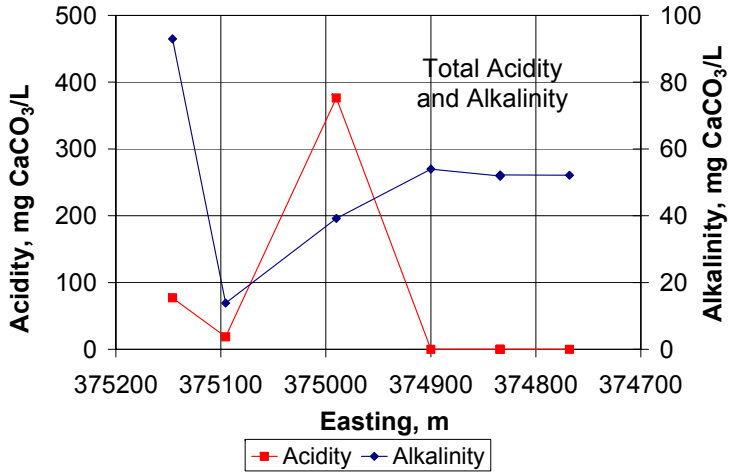
Elevation of Water Table

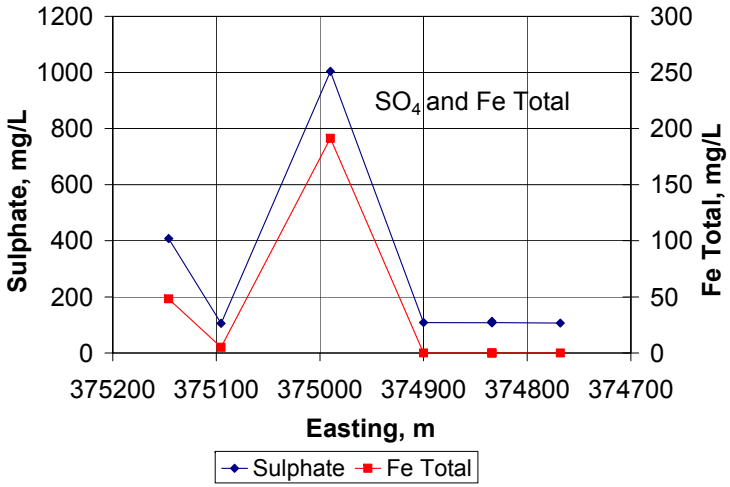


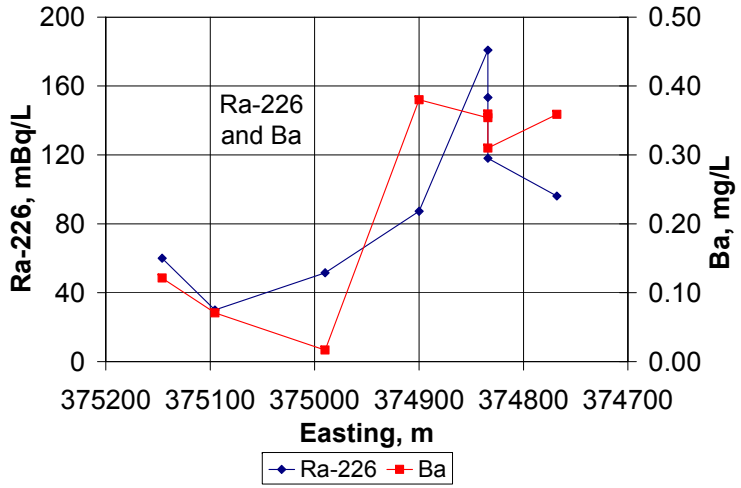
Lower Williams Lake TMA Performance

Surface Water Quality









Lower Williams Lake TMA Performance

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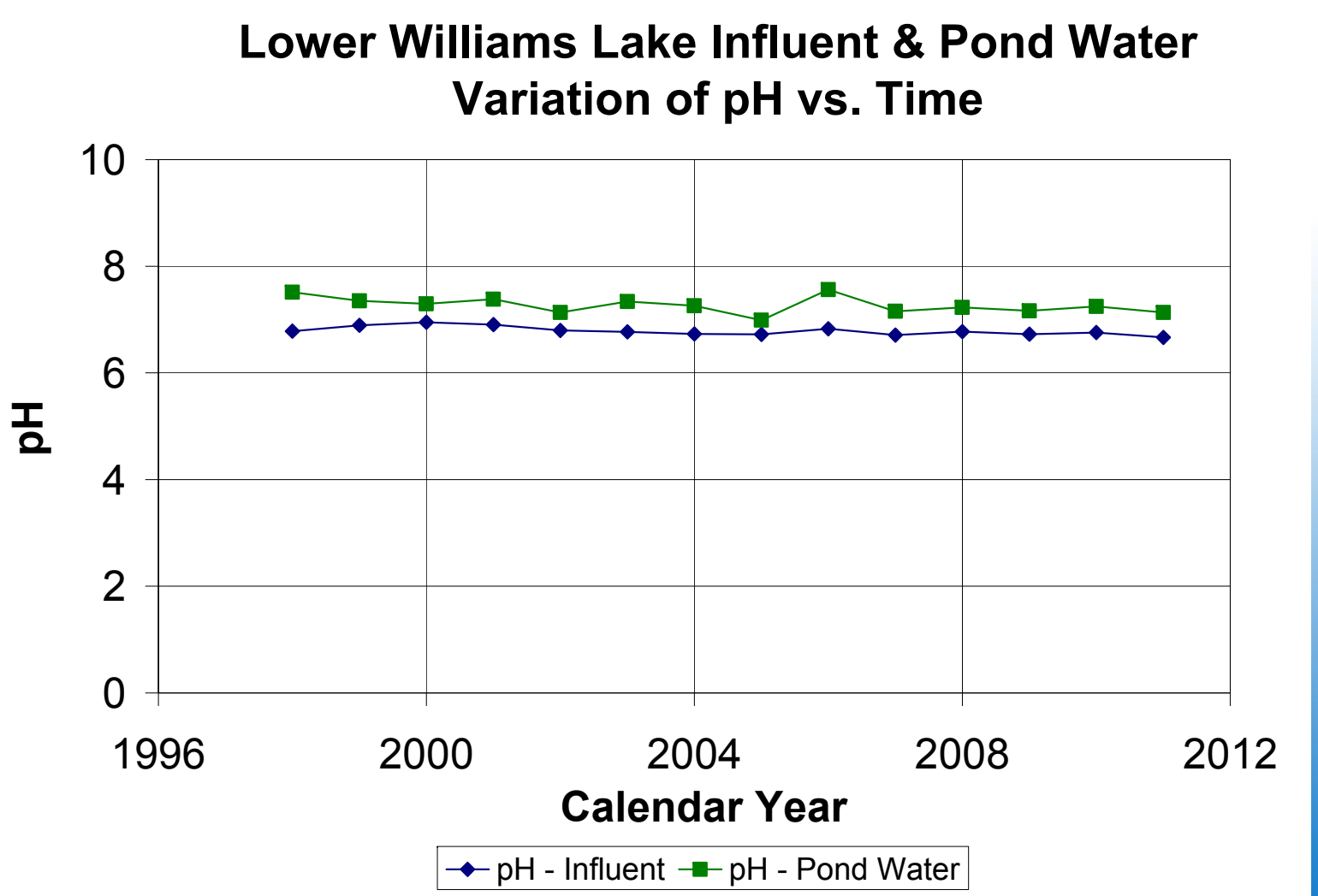
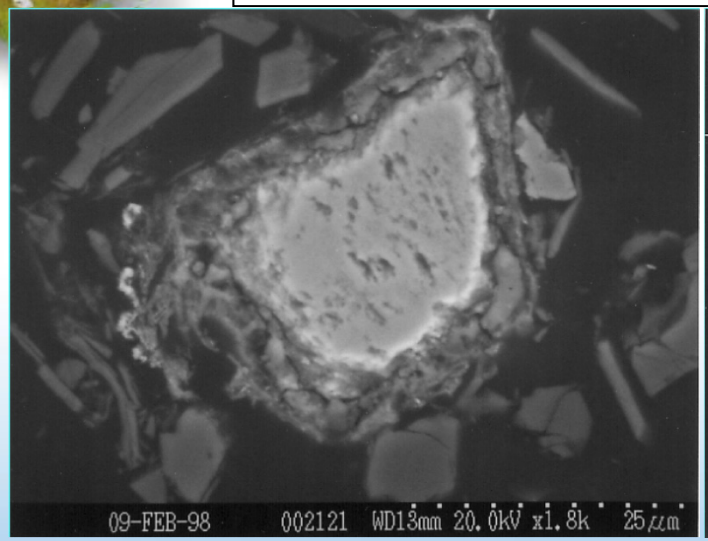
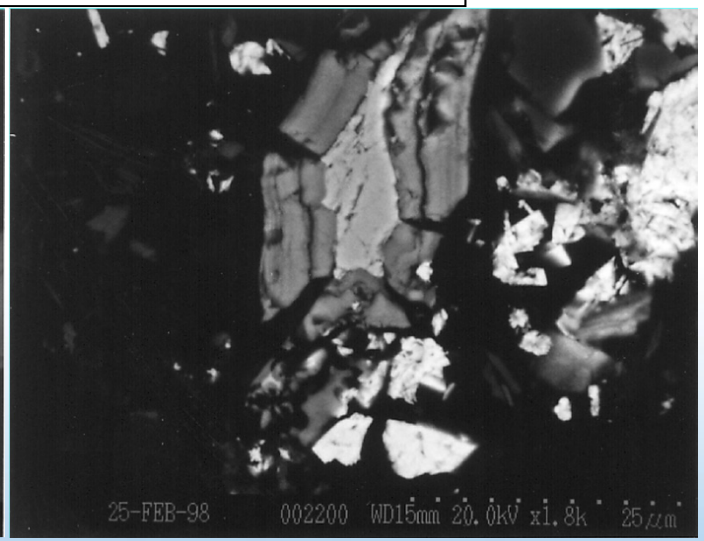


Lower Williams Lake TMA Performance

Secondary Minerals Precipitation

Hydrated Fe Sulphate





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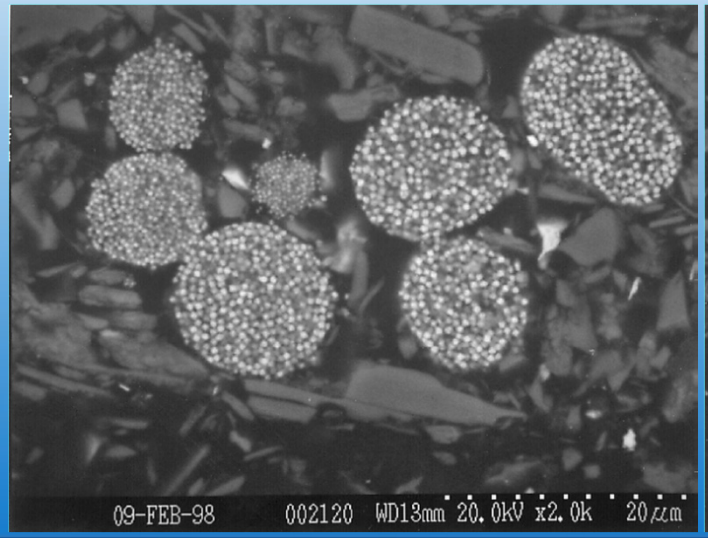
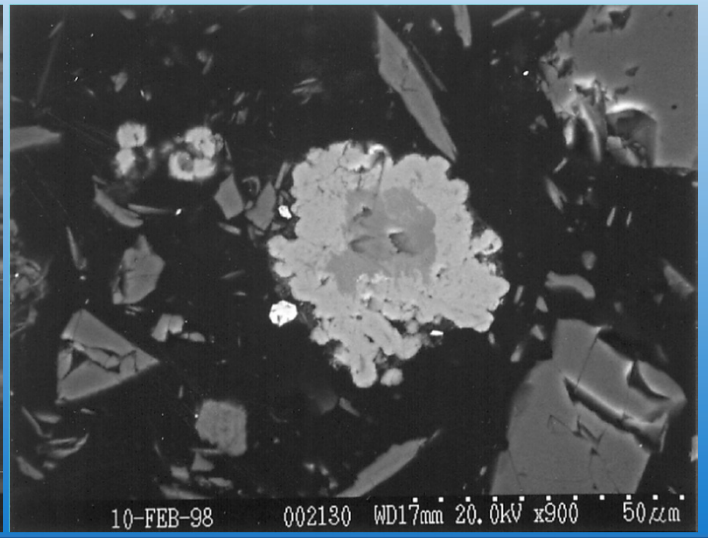
Framboidal pyrite





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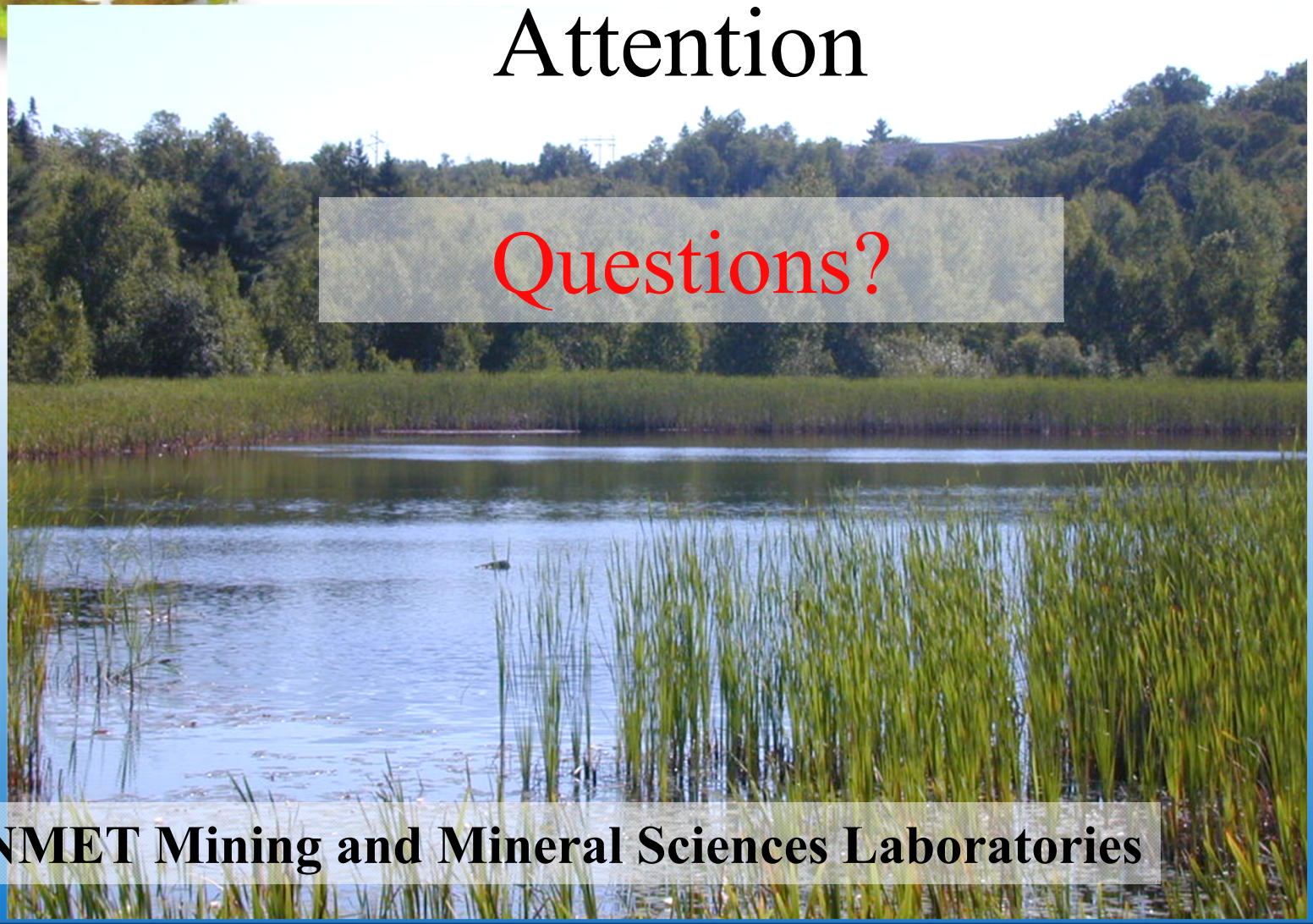
Lower Williams Lake TMA Performance Summary

- Successful reclamation of the site with elevated water table/wet barrier and partial water cover
- Net alkali generation at the site; no treatment required for pH, acidity and dissolved metals control
- Periodic treatment for Ra-226 control required
- Site evolution and blending with the surrounding natural environment; very little to low maintenance required
- Role model as a suitable decommissioning option at other sites

Denison TMAs Summary / Conclusion

- Very successful rehabilitation and decommissioning of all sites
- Water cover at Denison TMA working as designed, acid generation reduced to a very low rate
- Benefits of elevated water table at the Stanrock TMA not fully realized as yet; post closure effluent treatment predicted for ~ 50 years
- Lower Williams Lake TMA in advanced state of blending with the surrounding natural environment
- Ongoing treatment for Ra-226 control required at all sites

Thank you for your Attention



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