Managing Acid Generation and Metal Leaching in High Sulphide Thickened Tailings During Operation: Lessons Learned at Xstrata's Kidd Metsite

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Gilles – The Se/Mo Review -- It's Done

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A REVIEW OF ENVIRONMENTAL MANAGEMENT CRITERIA FOR SELENIUM AND MOLYBDENUM

Report prepared for:

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Kidd Metallurgical Site

- Three mines: Kidd upper mine, Kidd mine D, and Montcalm mine.
- Produces zinc and copper from Kidd mines and Nickel from Montcalm.
- Produces 2 - 3 Mt tailings per year
- Thickened tailings (65% solid) are mixed and deposited with other effluent streams in the tailings management area (TMA)
- Original TMA occupied about 1,200 ha
- Tailings contain Pyrite / Pyrrhotite (6% S)
- NP/AP < 1 – Therefore acid generator when disposed on land

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THICKENED TAILINGS

- What is “THICKENED” tailings?
  - Higher Density / % Solids – produced in Thickener
  - Greater viscosity
  - Faster Settling
  - No or Little Segregation of Grain Sizes in Impoundment when Discharged

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WHY THICKENED TAILINGS

- No need for Dams – only berms to contain solids
- No classic "Beaches" and "Slimes"

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Kidd TMA 2005

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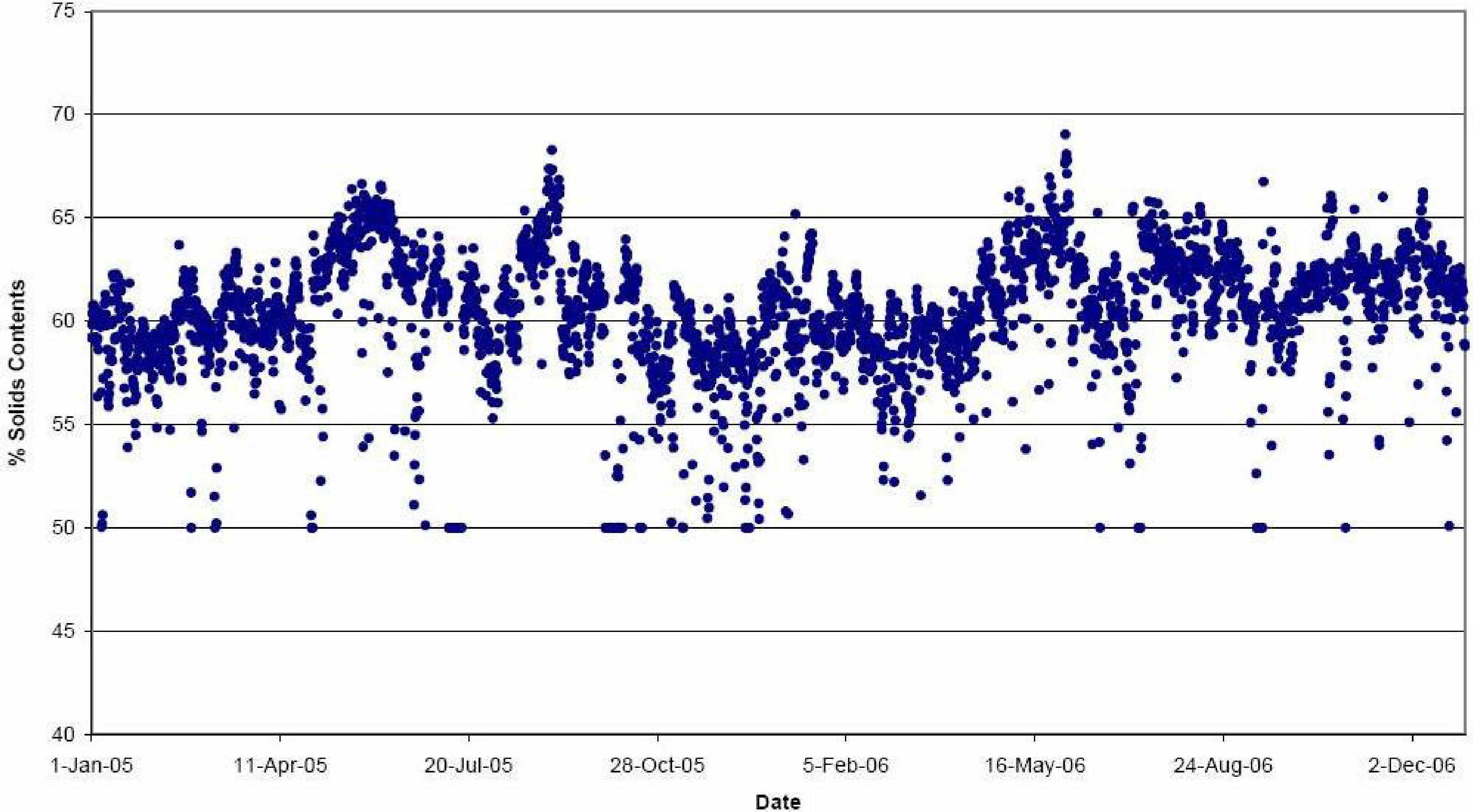
Thickener Underflow - % Solids



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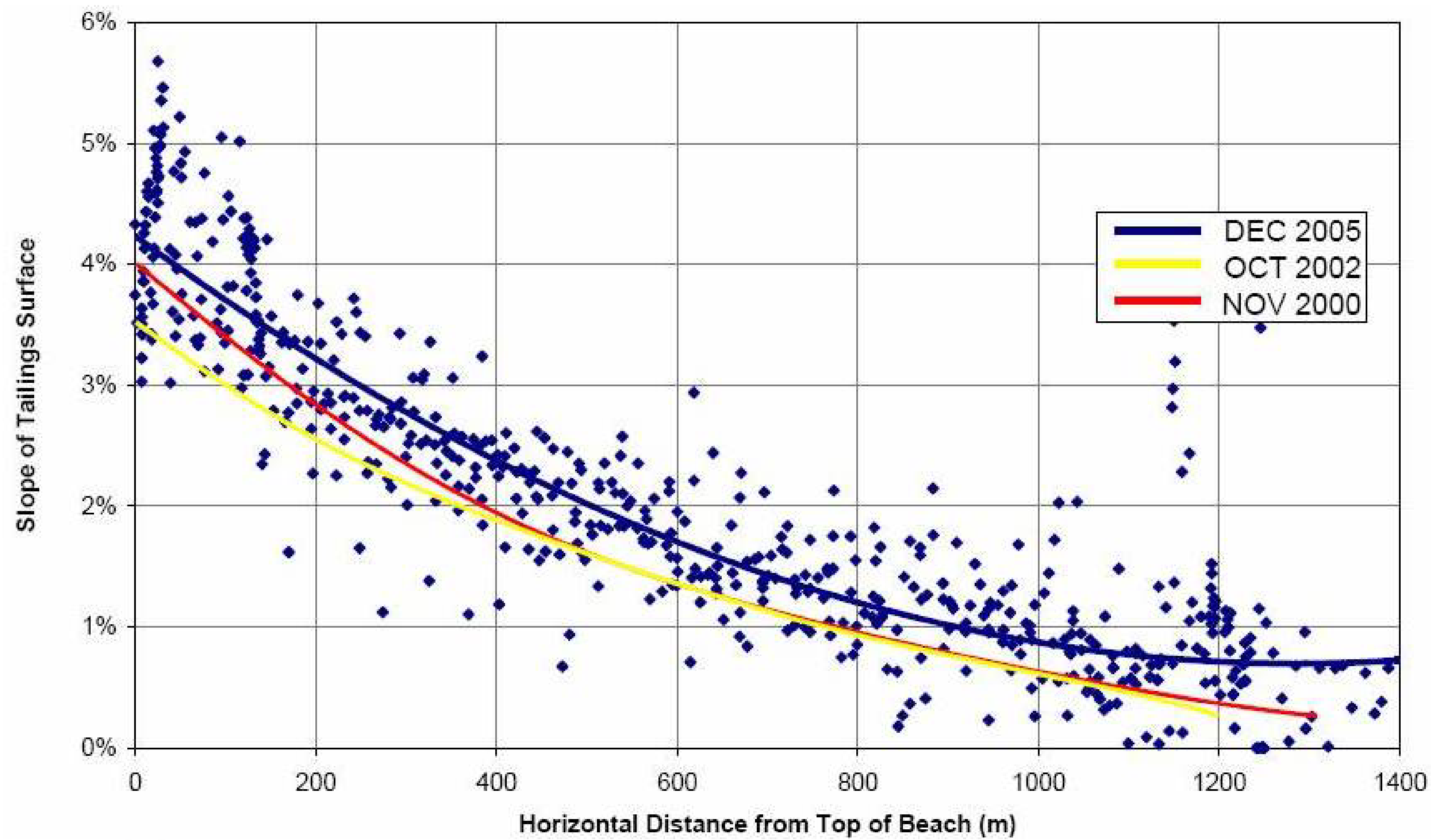

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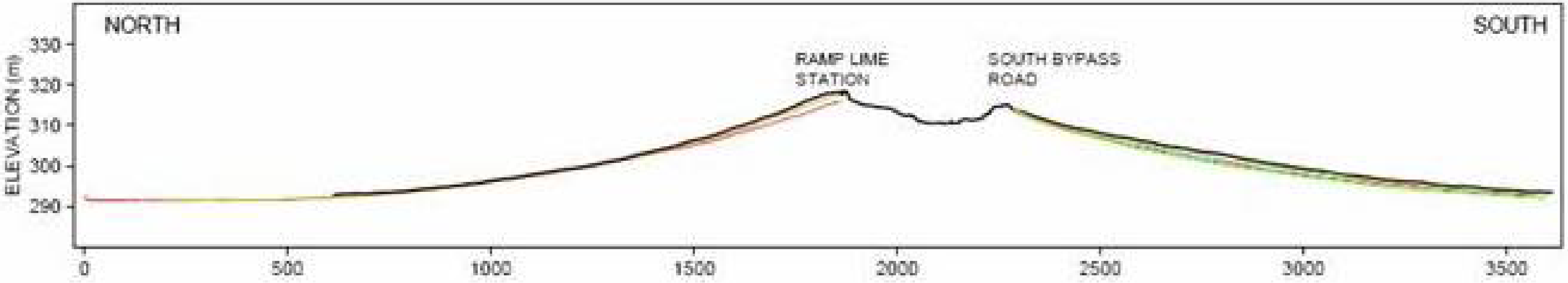
Tailings Profile



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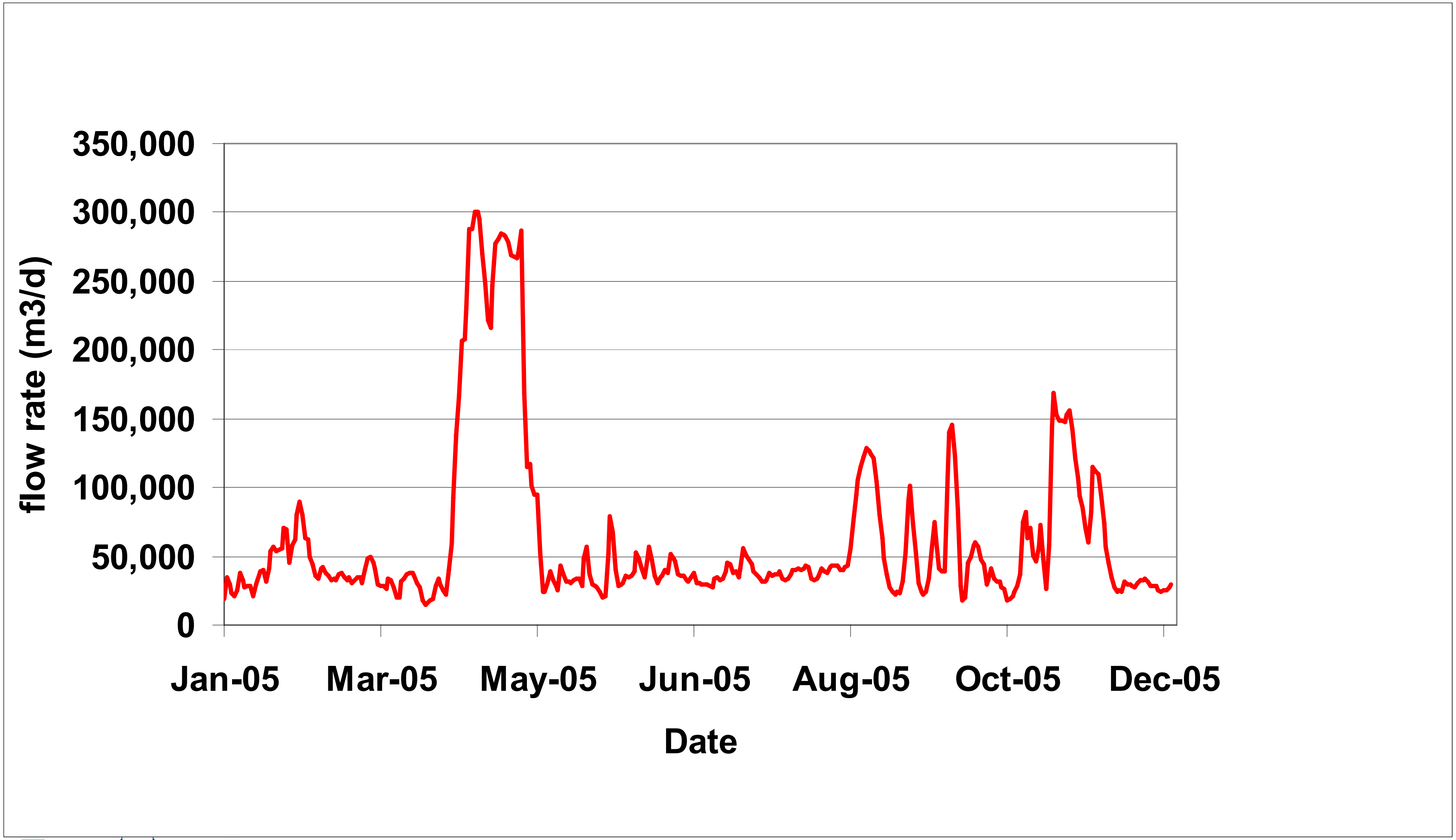
Lesson 1 – Efficient at Shedding Water – Results in High Runoff



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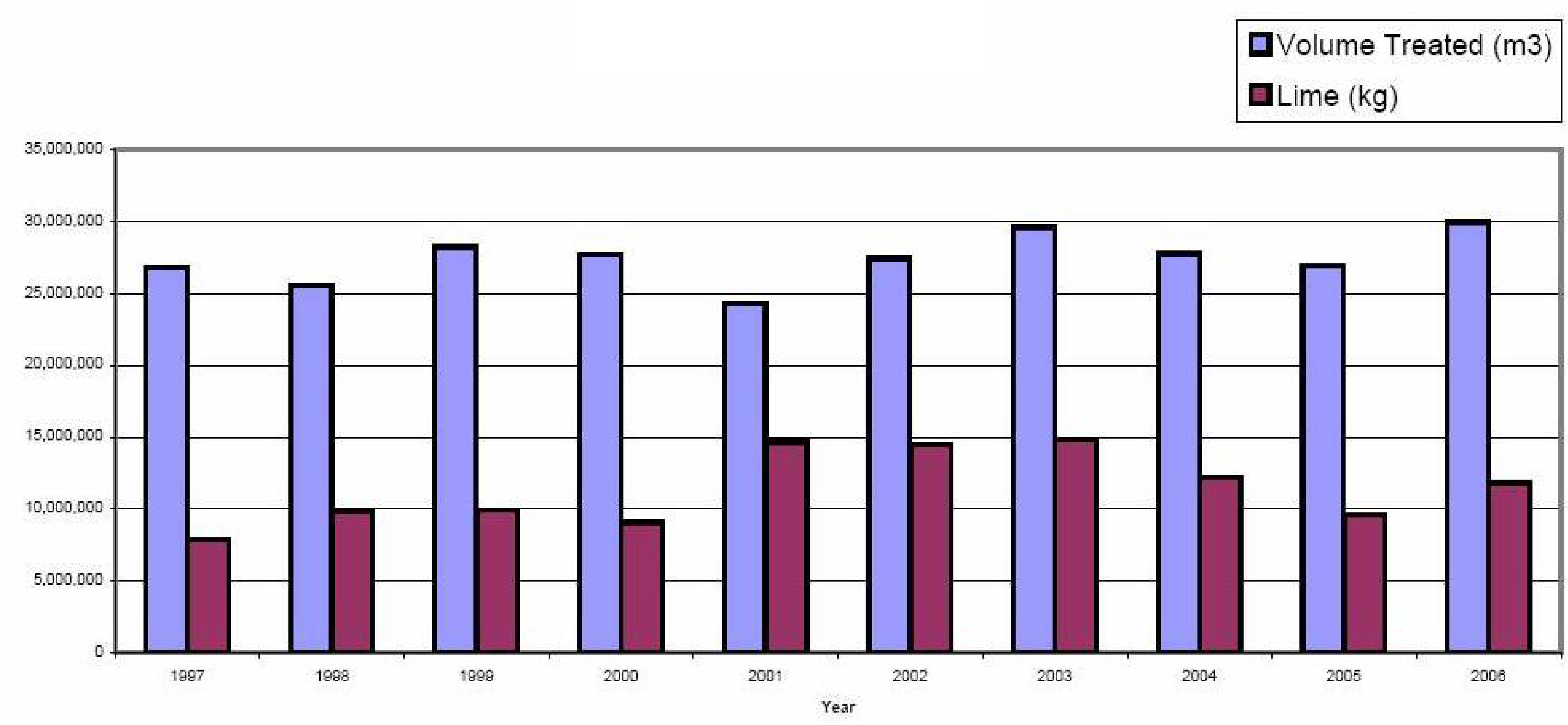
Annual Lime Use and Flows



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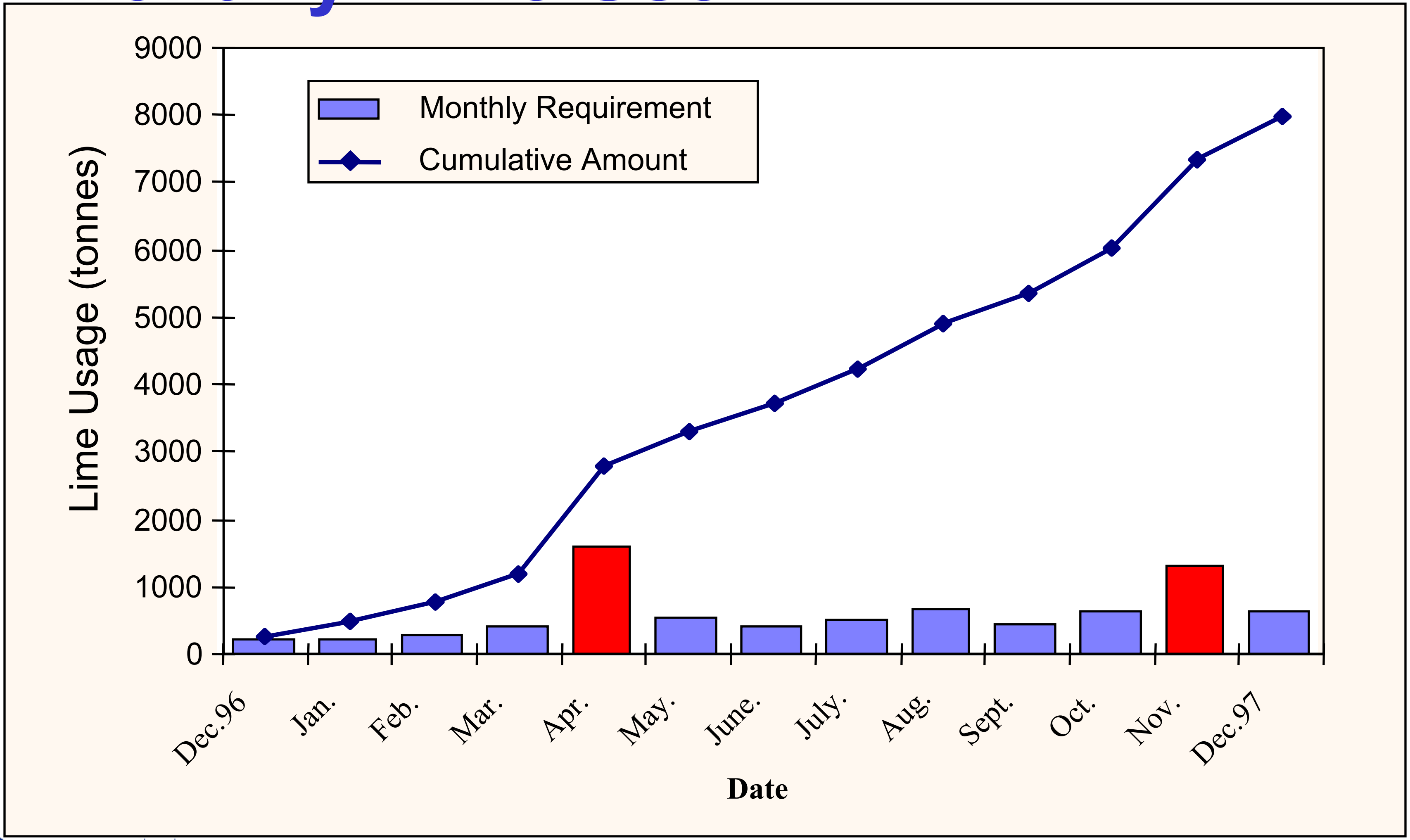
Monthly Lime Use



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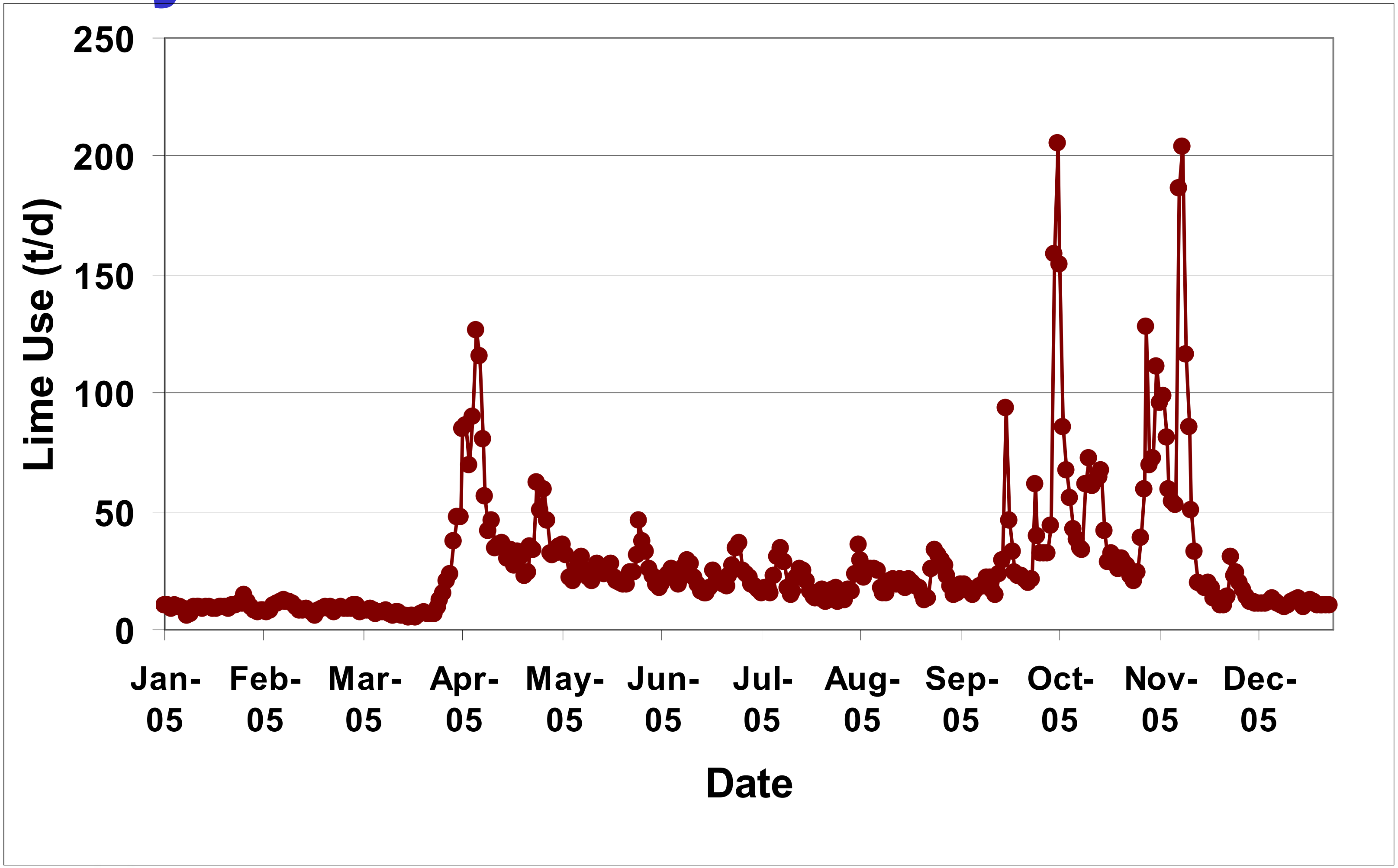
Daily Lime Use



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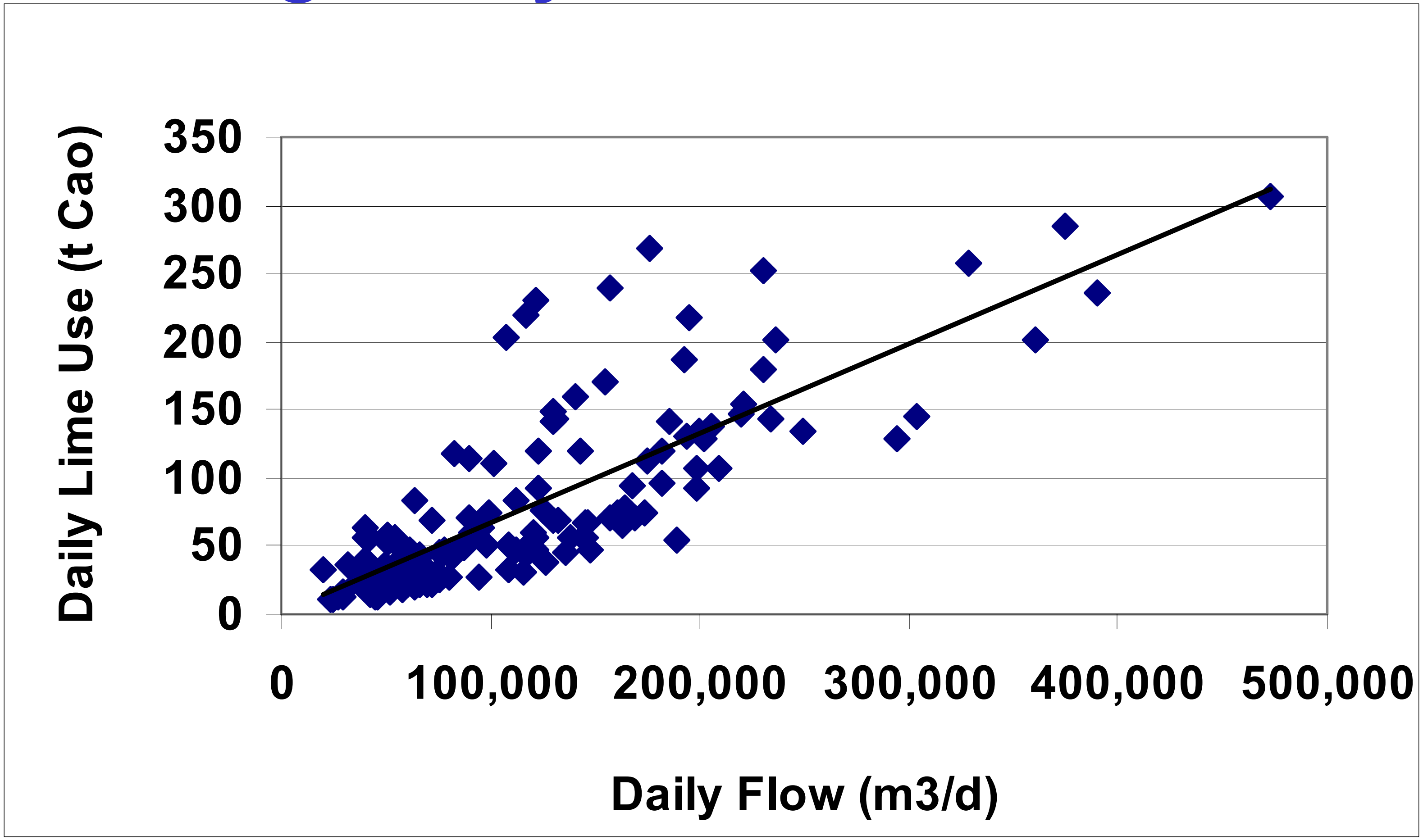
Lesson 2 – Efficient Acid Generator with High Daily Lime Demands



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Acid Generation Studies

- Early 1990's –
  - David Blowes and Tom Al (U of Waterloo)
    - Pore waters / above and below water table
  - Noranda Technology Centre (NTC) – Surface Hydrology / Cover test plots
- Mid 1990's – 2000's
  - Beak International
    - Modelling
    - oxygen consumption measurements
    - soluble extractions for regular monitoring

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Acid Generation Studies

- Mid 2000's –
  - EcoMetrix
    - Jarosite studies – NP Consumption
    - Lime demand modelling / optimization

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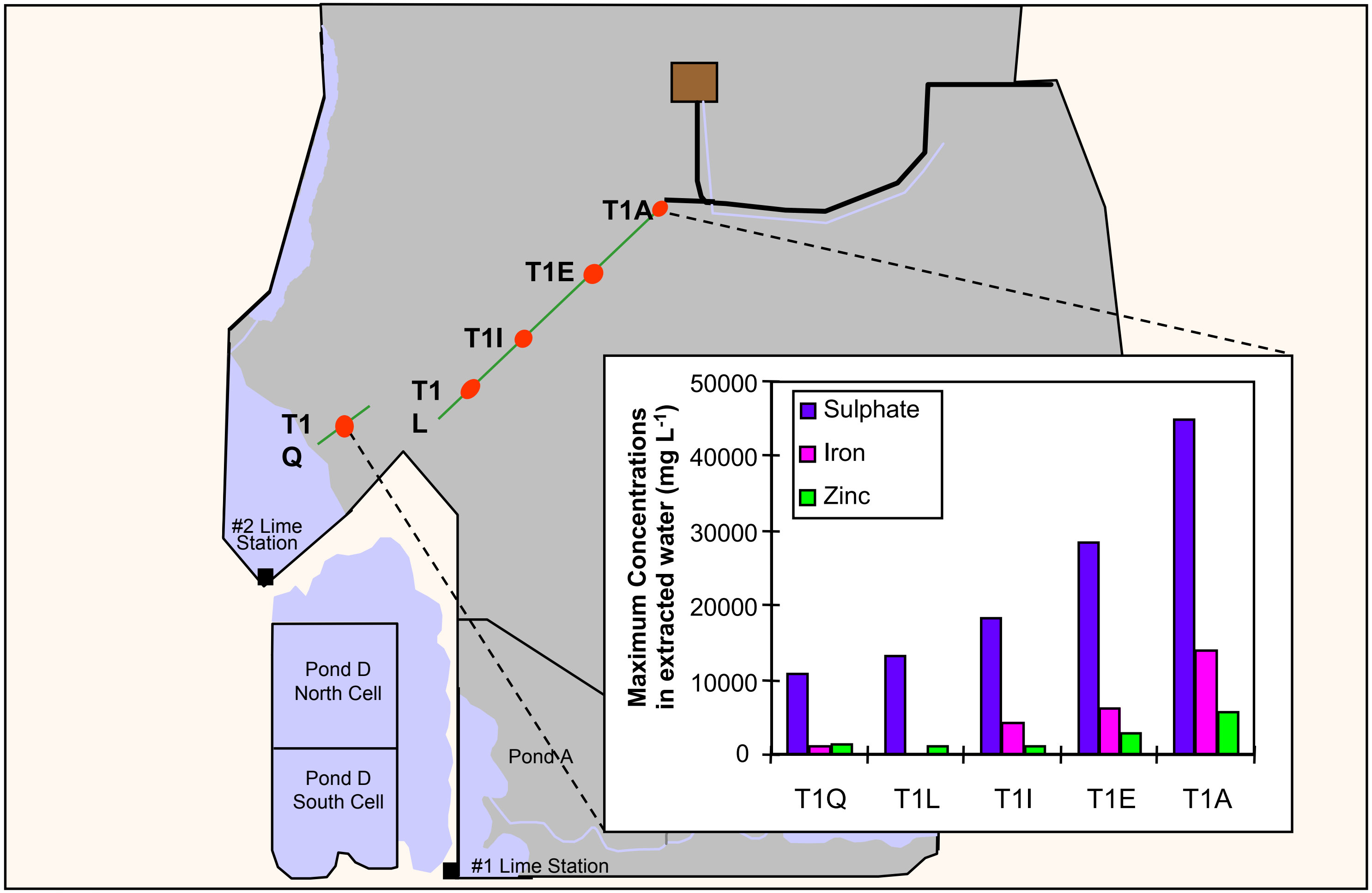
Spatial Trends of Dissolved Sulphate, Iron and Zinc in Pore Water



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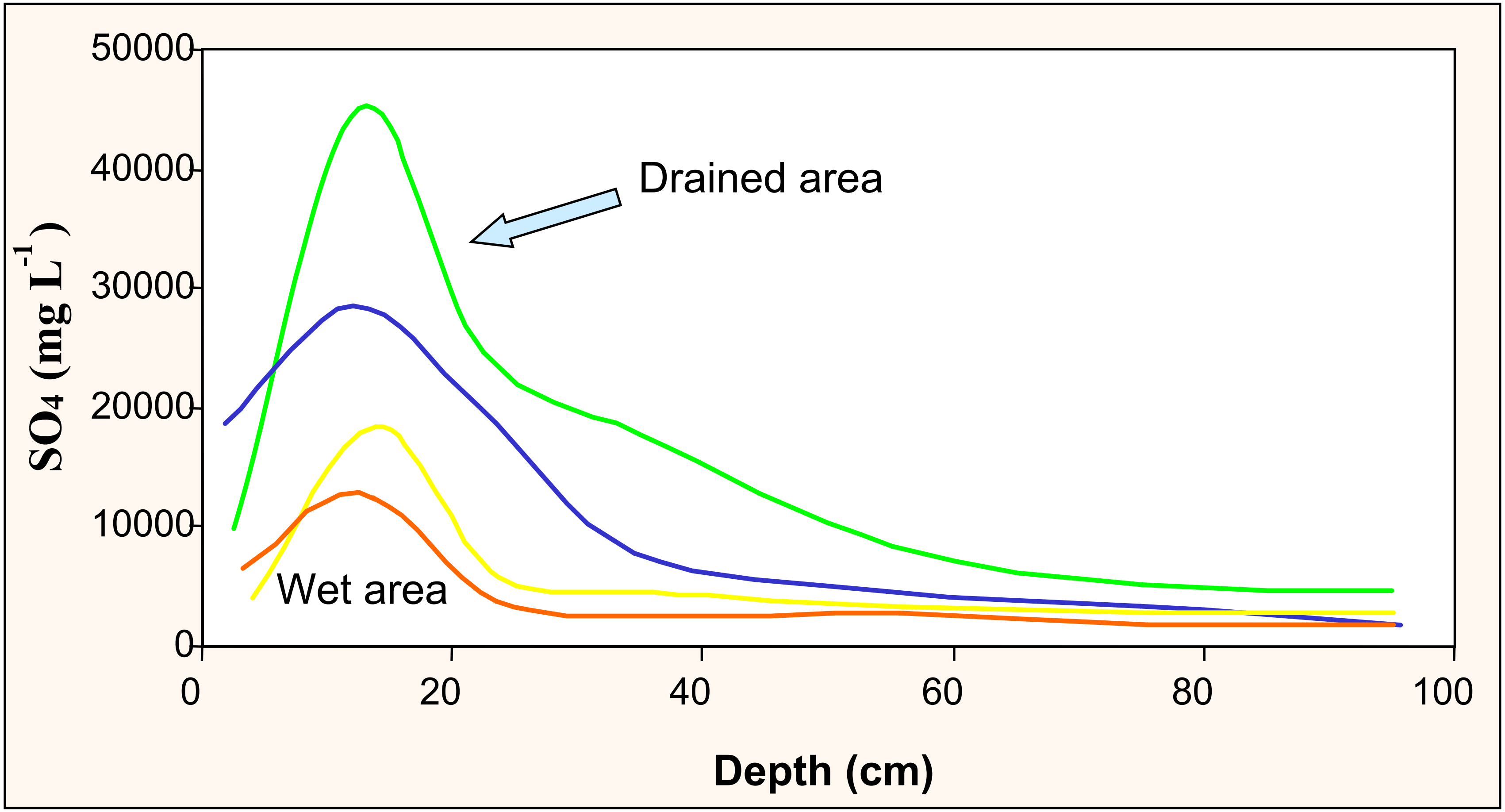
Tailings Pore Water Variation from Drained to Wet Areas



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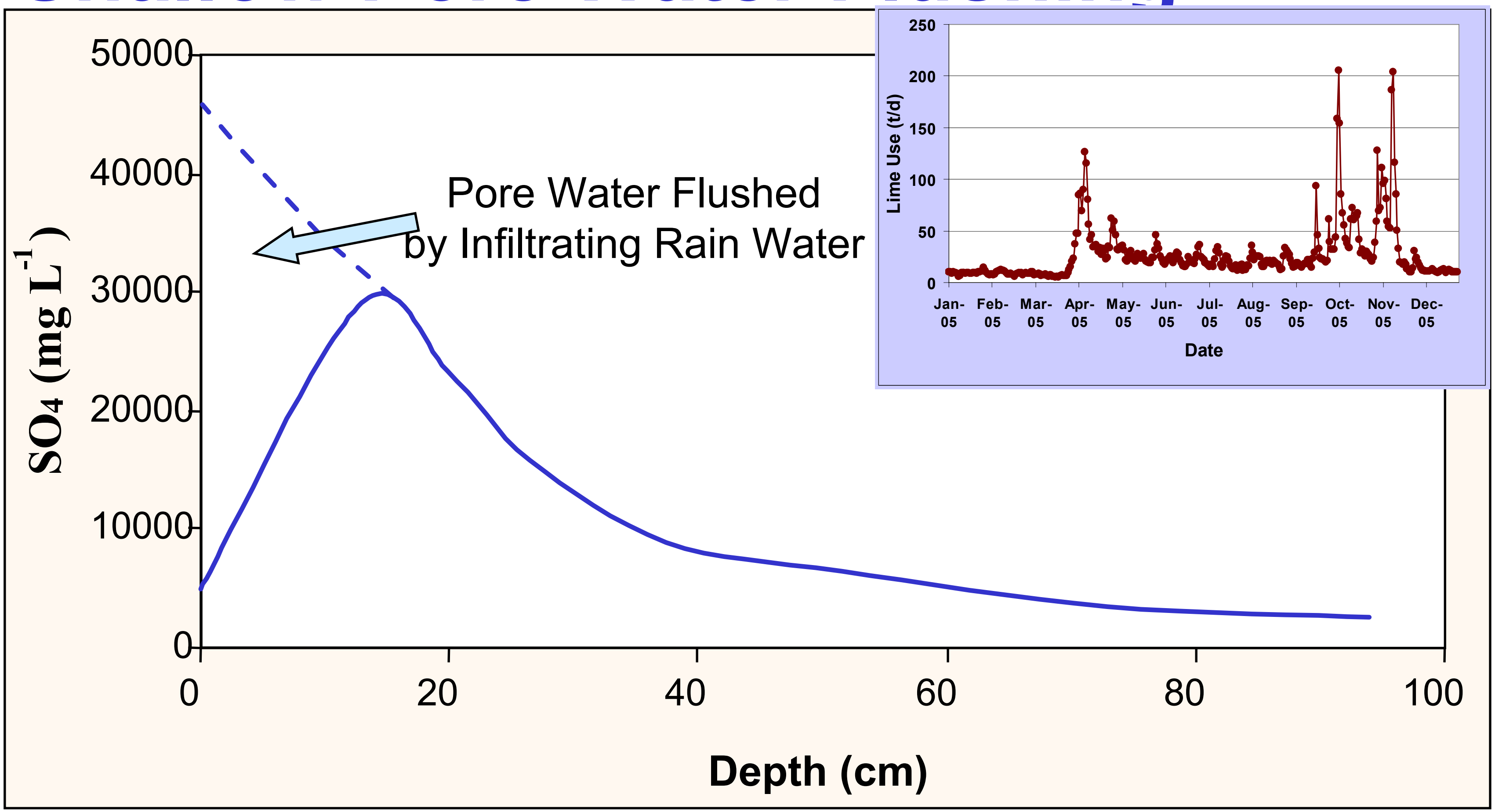
Acidity and Metal Loads from Shallow Pore Water Flushing



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Lag Time for Acid Generation

- Fresh tailings are neutral with reasonable Neutralization Potential (NP) values
- Sulphide Oxidation generates acid and consumes NP
- High acidity and metal loads only after NP depleted
- Lag time between start of oxidation and NP depletion is critical and depends on:
  - Oxidation rates
  - Available NP

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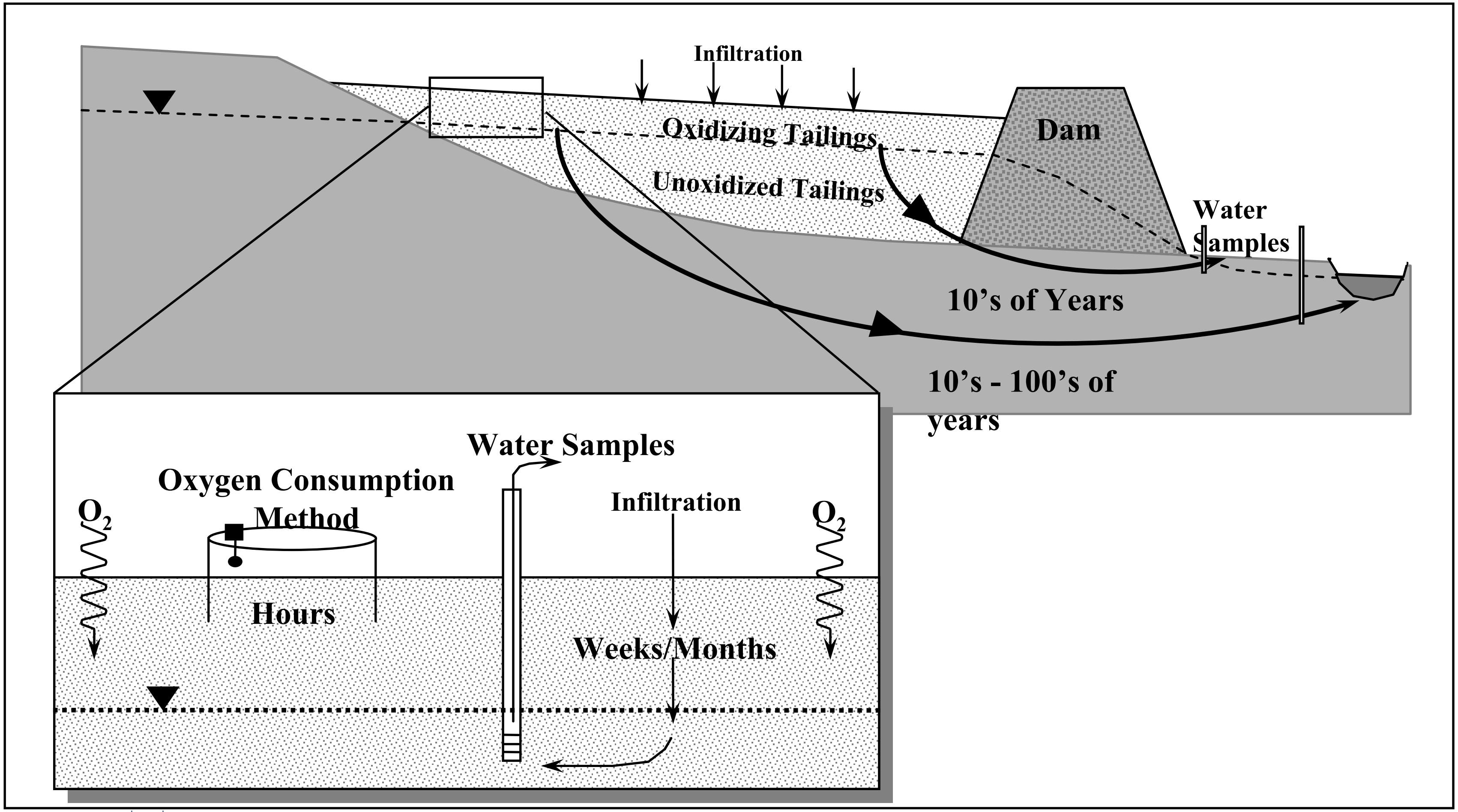
Oxygen Consumption Measurements In-Situ / Real-Time Rates



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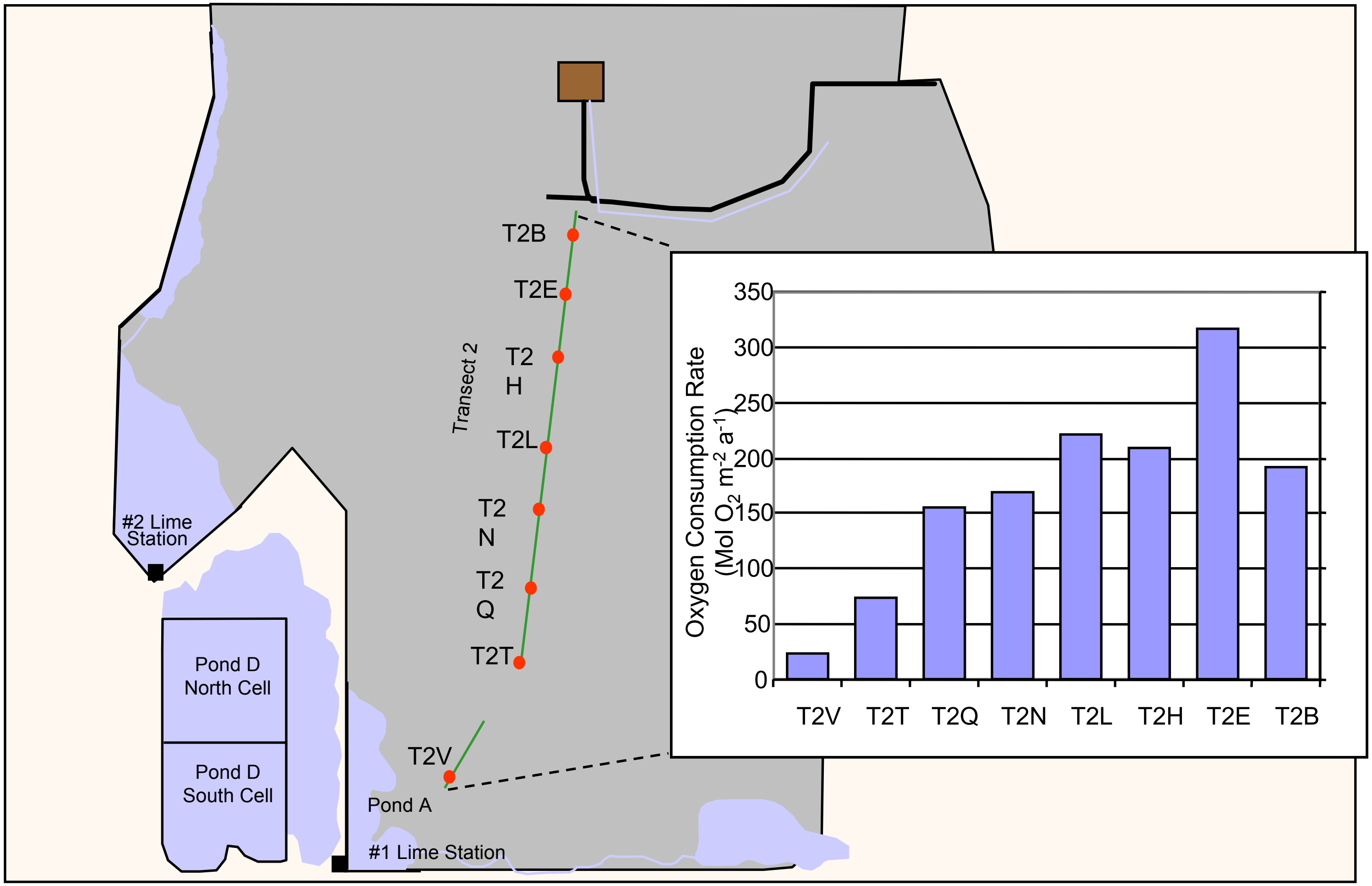
Spatial Trends of Oxygen Consumption Rates



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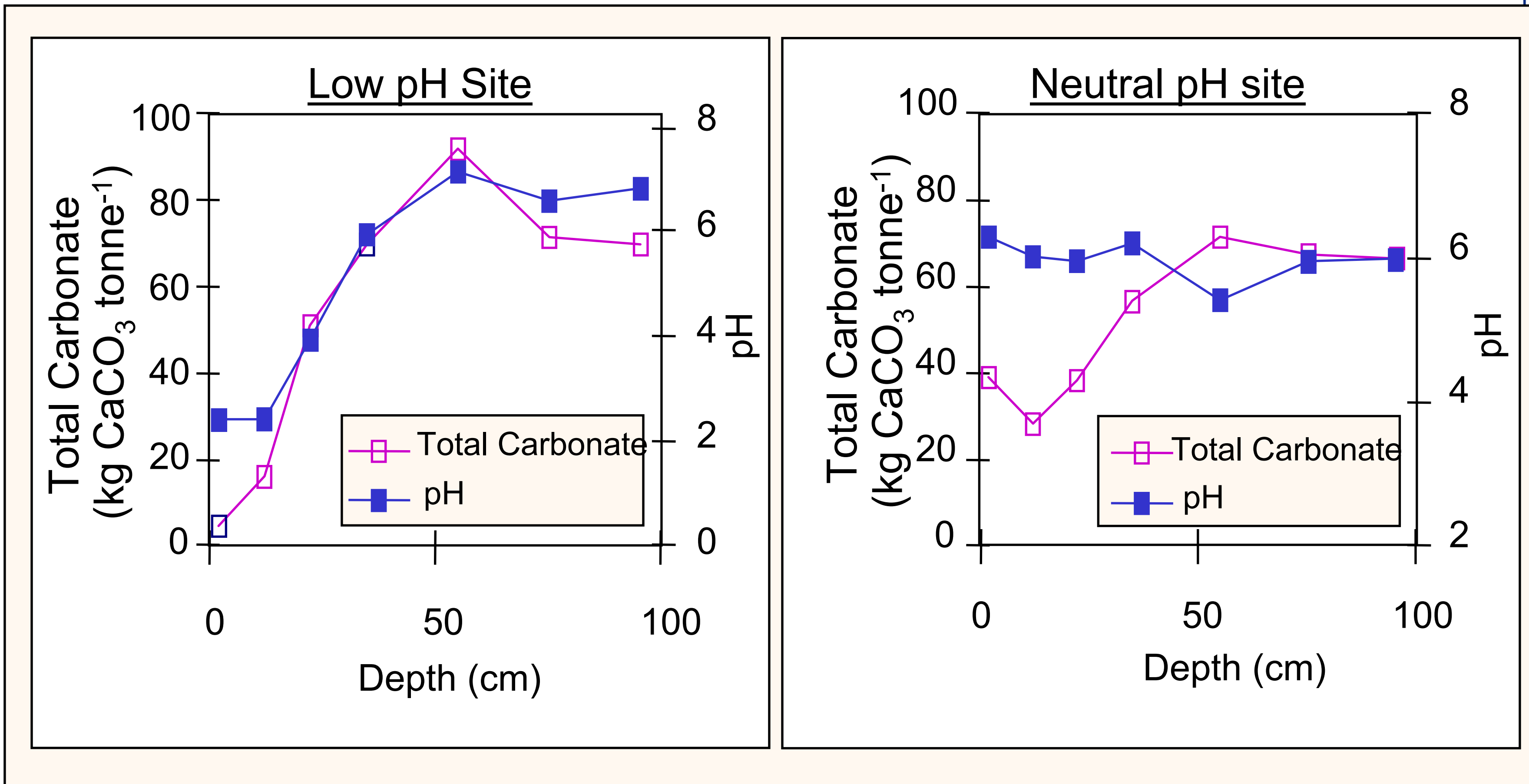
Carbonate Content (NP) and Pore Water pH As a Function of Depth



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Lesson 3 – Lime Demand Increases after NP at Surface is Depleted

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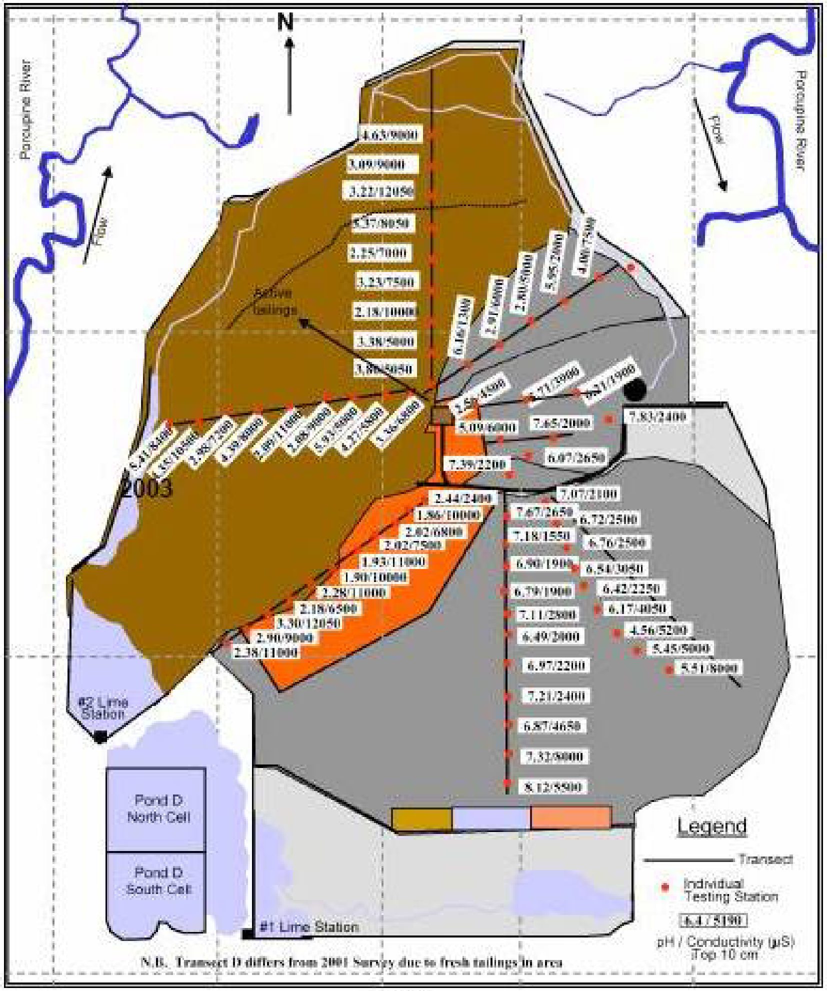
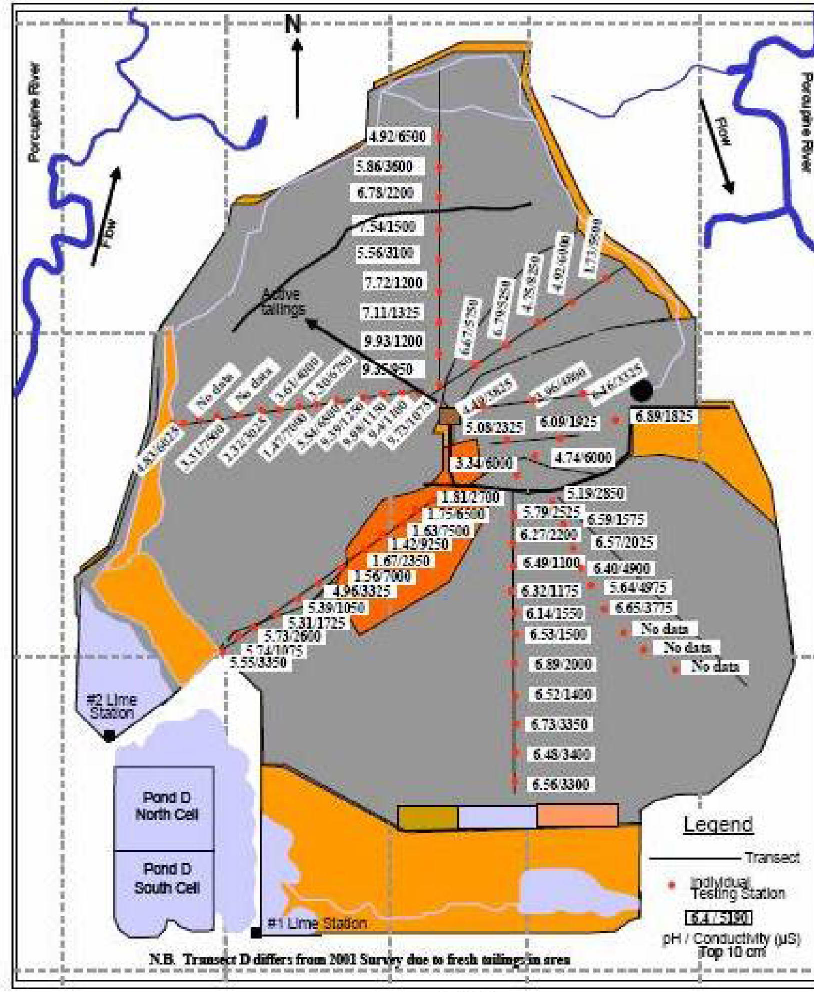
Annual pH / Conductivity Surveys



2003



2004

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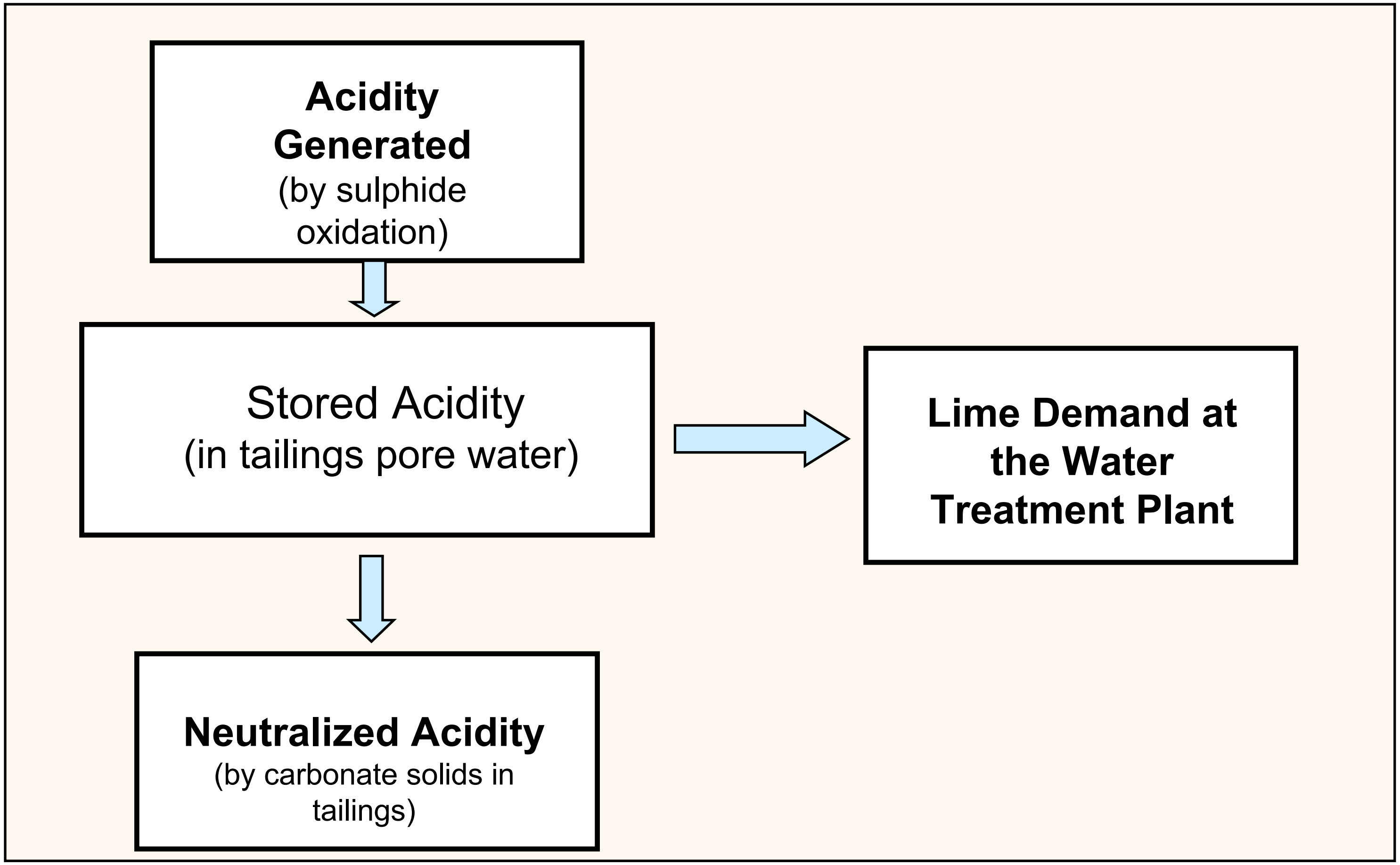
Acidity Mass Balance



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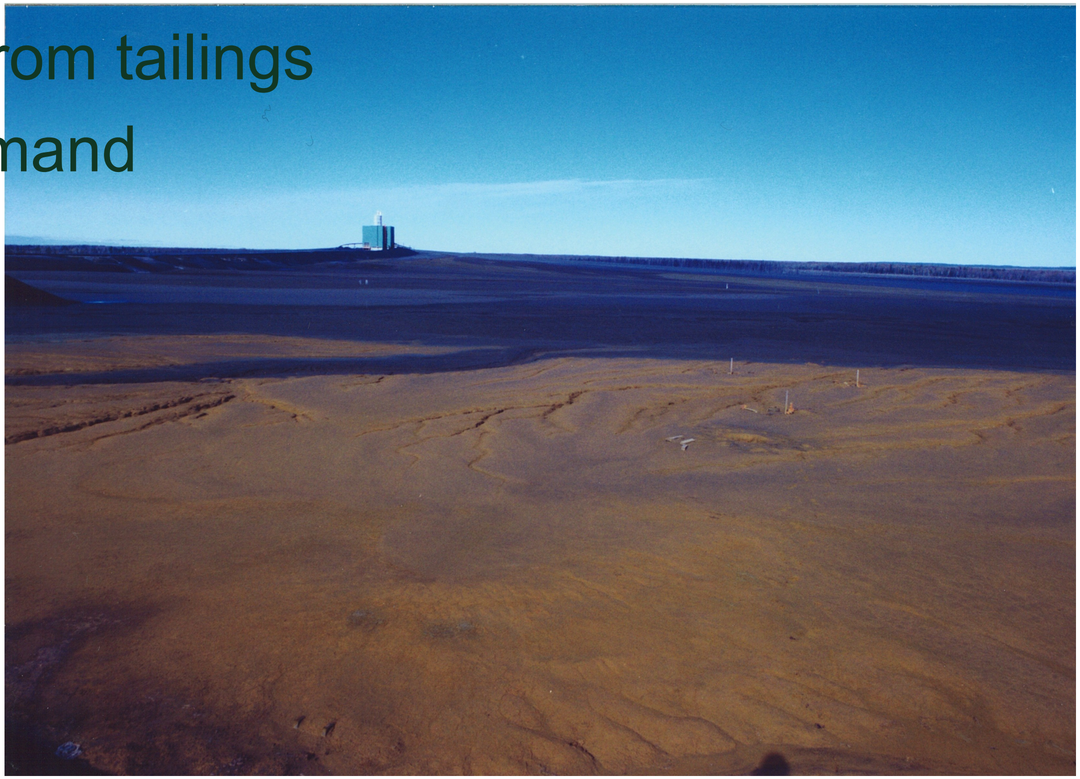
Need for Refinements

- Stop depositing in small areas for long periods – reducing exposure times in older areas
- Reconfigure deposition areas
- Remove Jarosite from tailings
- Evaluate Lime Demand
  - Annual
  - Maximum Daily



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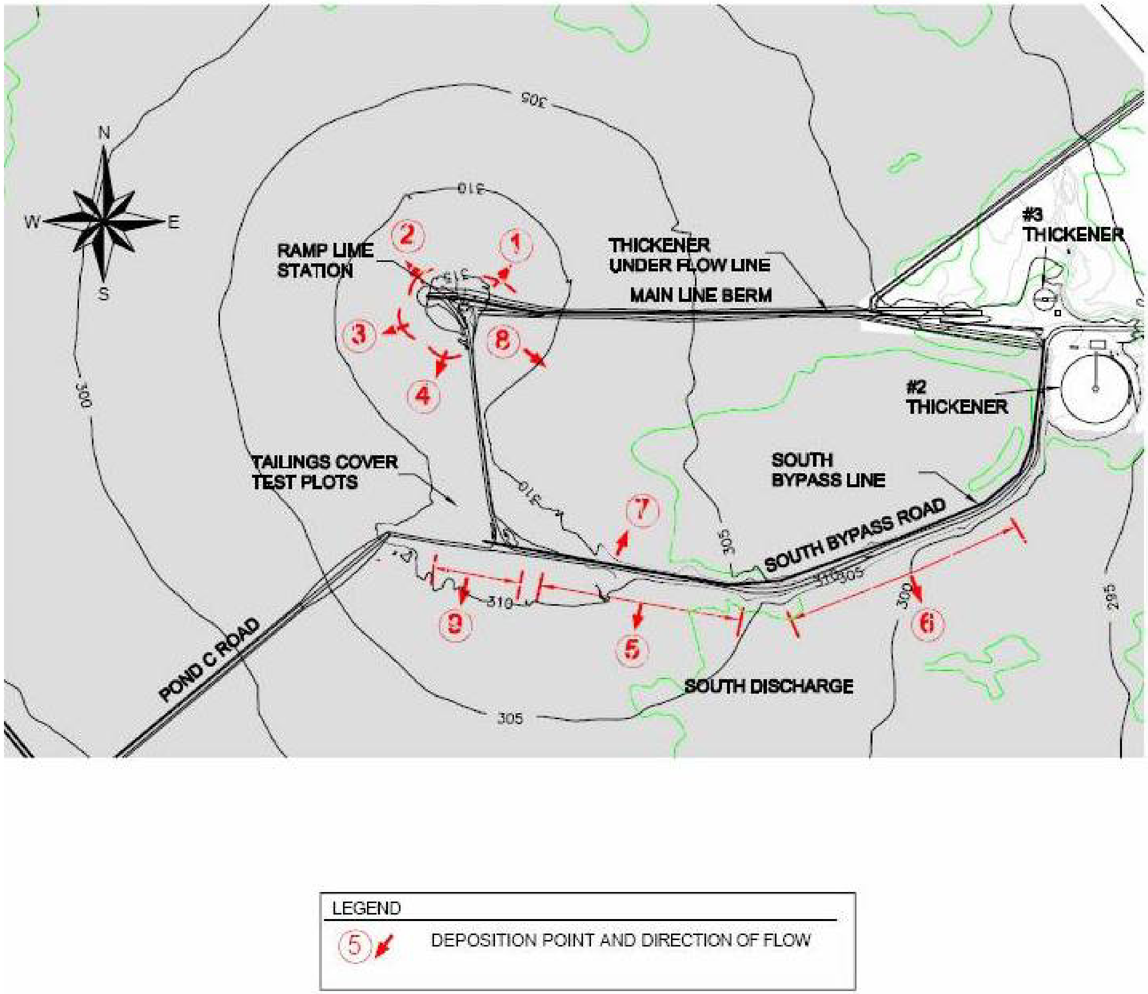
Multiple Discharge Points



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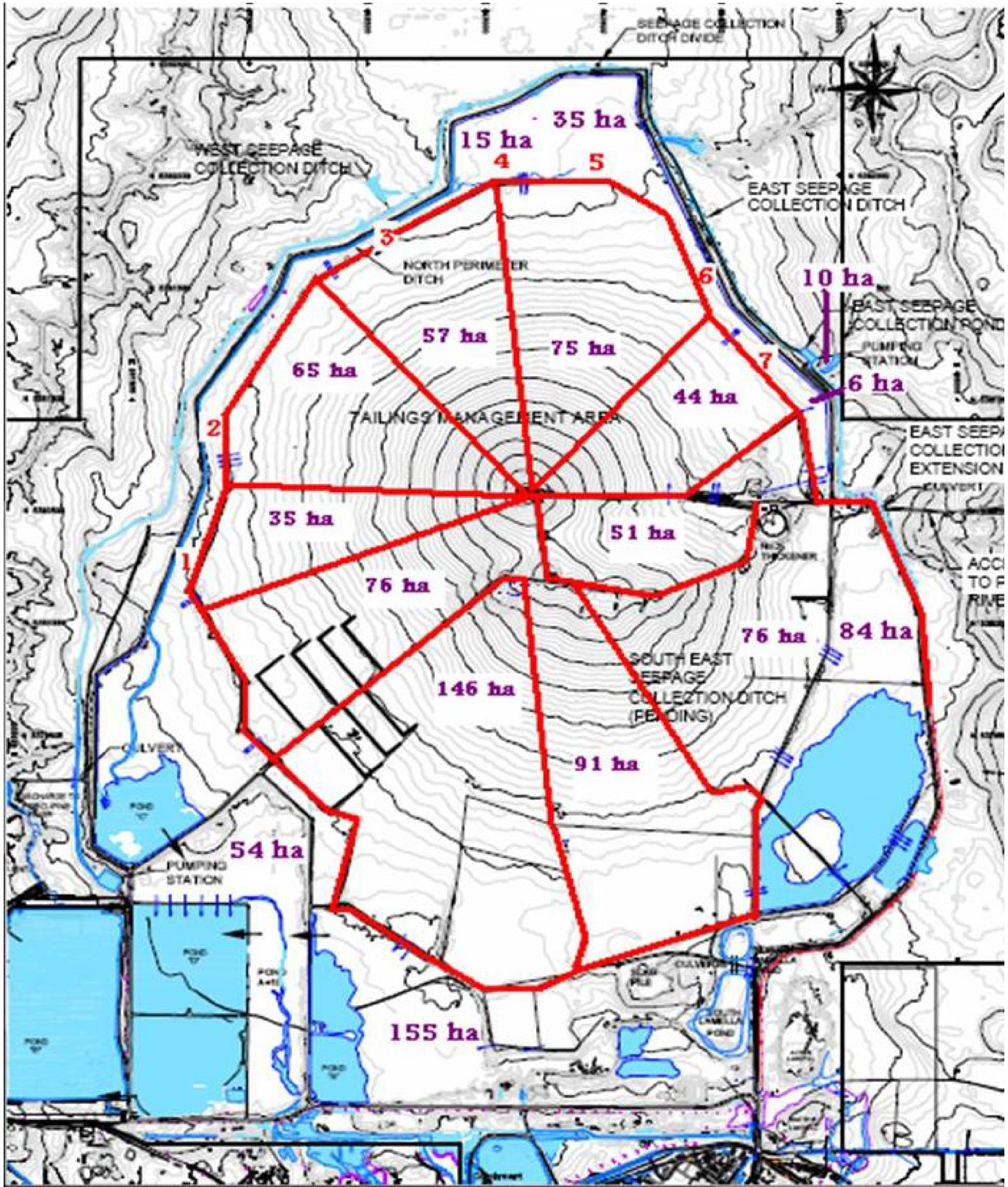
New Deposition Cycle and Internal Berms



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The Lime Demand Model

- **Sources of acidity:**
  - ➢ oxidation of the sulphides near surface prior to covering with fresh material
  - ➢ acid released from the aged acidic tailings
  - ➢ jarosite dissolution (iron sulphate bi-product of zinc process that dissolves and releases acid)
  - ➢ oxidation of thiosalts in mill process water

- **Variables affecting lime demand:**
  - ➢ acid generating factors (above)
  - ➢ tailings Neutralizing Potential (NP)
  - ➢ deposition cycling period (and LAG time)

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Past Investigations

- **Field study:**
  - The inactive area (base load) was estimated by pore water measurements to be 2,600 t-CaO/a.
  - NP depletion rate from sulphide oxidation is 4 kg-$CaCO_3$/t/a.
- **Laboratory testing:**
  - Mixture of jarosite in tailings showed that the half-life of jarosite is between 1 and 3 years.
  - Pilot studies showed that the NP of mine D tailings (uncertain among the three) ranges from 5 to 23 kg-$CaCO_3$/t.

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Calibration of the Model

- The lime demand from the active tailings using measured oxygen consumption rates.
- Jarosite dissolution rates from lab studies.
- The lime demand from the inactive perimeter tailings (base load) from field measurements.
- The model was then calibrated for the base-case conditions using the historical data.

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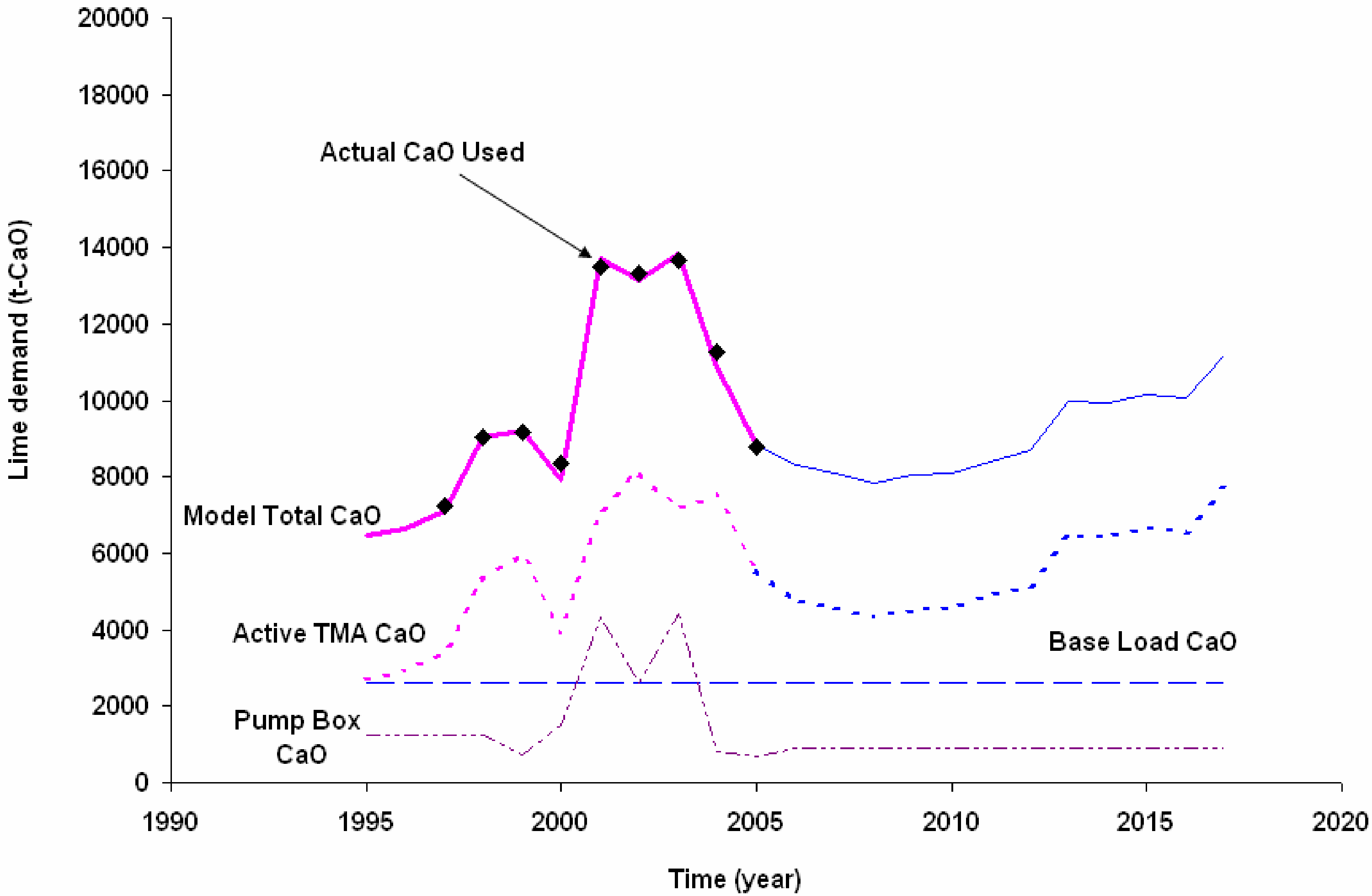
Calibration of the Model and Prediction of Future Lime Demand



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Sensitivity Analysis

- Sensitivity analysis was performed to address uncertainty
- The factors and their levels are (**bold for base-case**):
  - Tailings deposition time: 1.5 – **3** years
  - Jarosite disposal: separate disposal – **codisposal with tailings**
  - Tailings NP content: 5 – 10 – **14** – 23 kg $CaCO_3$/t
  - Jarosite dissolution half-life: 1 – **1.5** – 2 years
  - Sulphide oxidation rate: 2 – **4** – 6 kg $CaCO_3$/t/a

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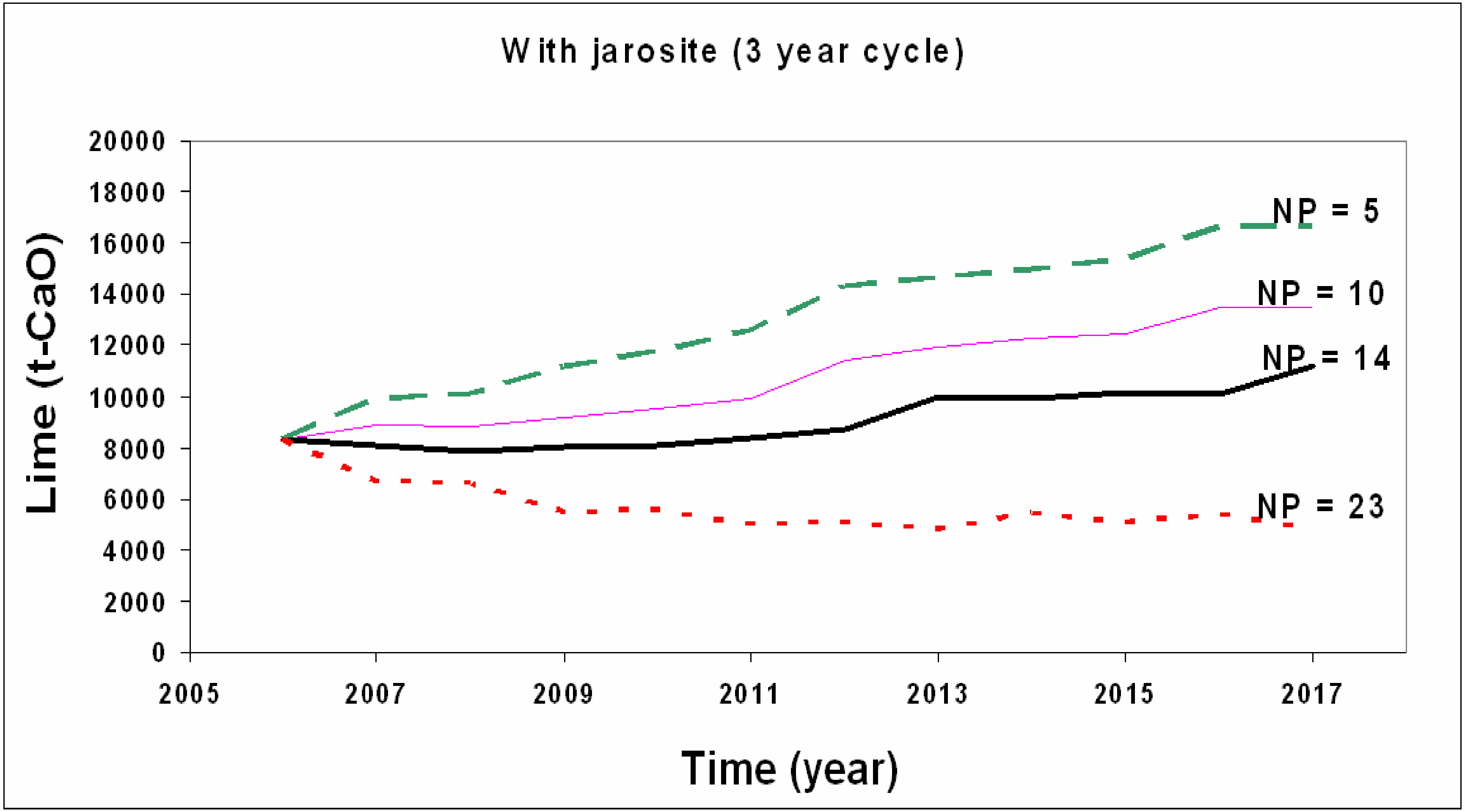
Effects of NP of Mine D Tailings on the Lime Demand



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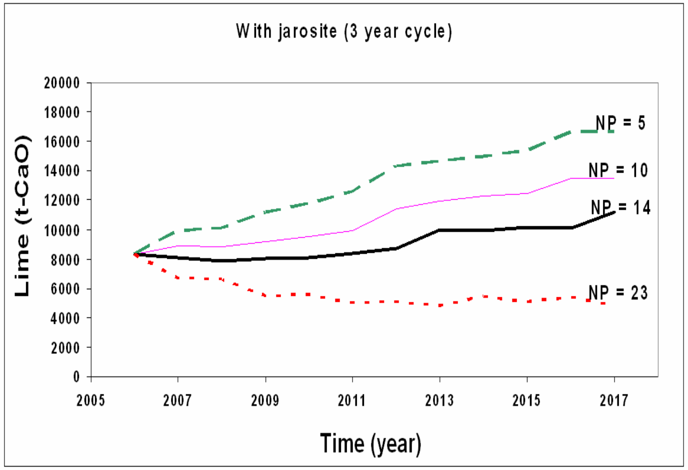
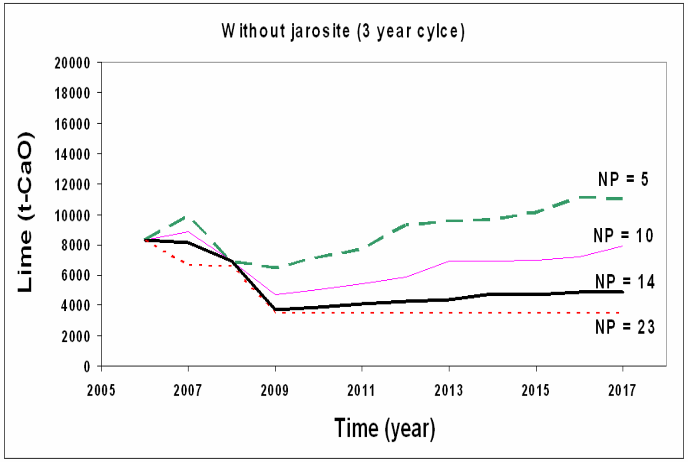
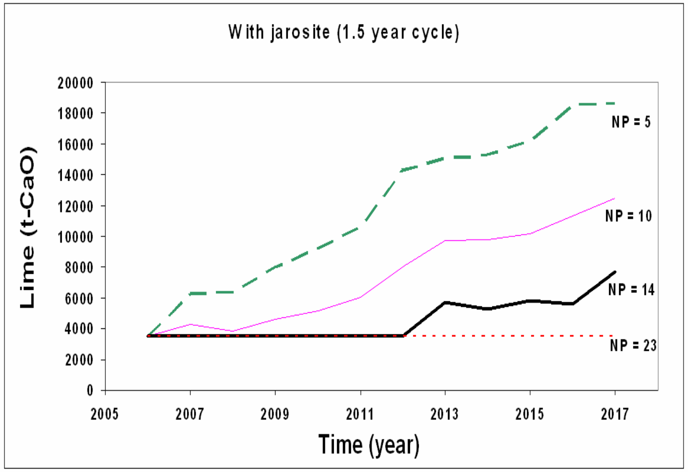
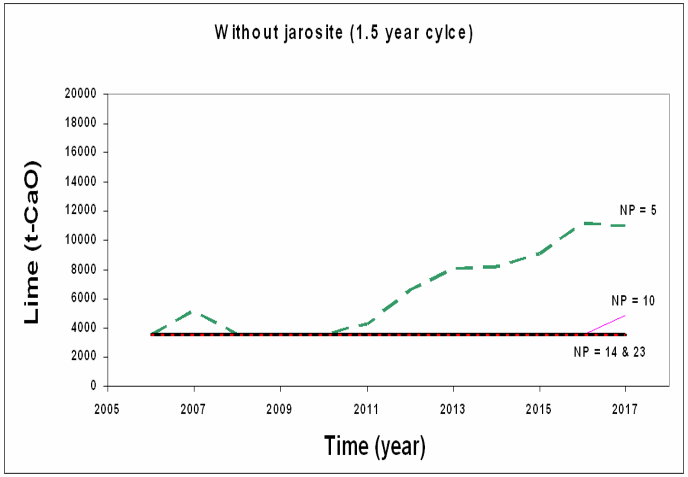
Effects of Jarosite Co-Disposal / Deposition Cycle Time









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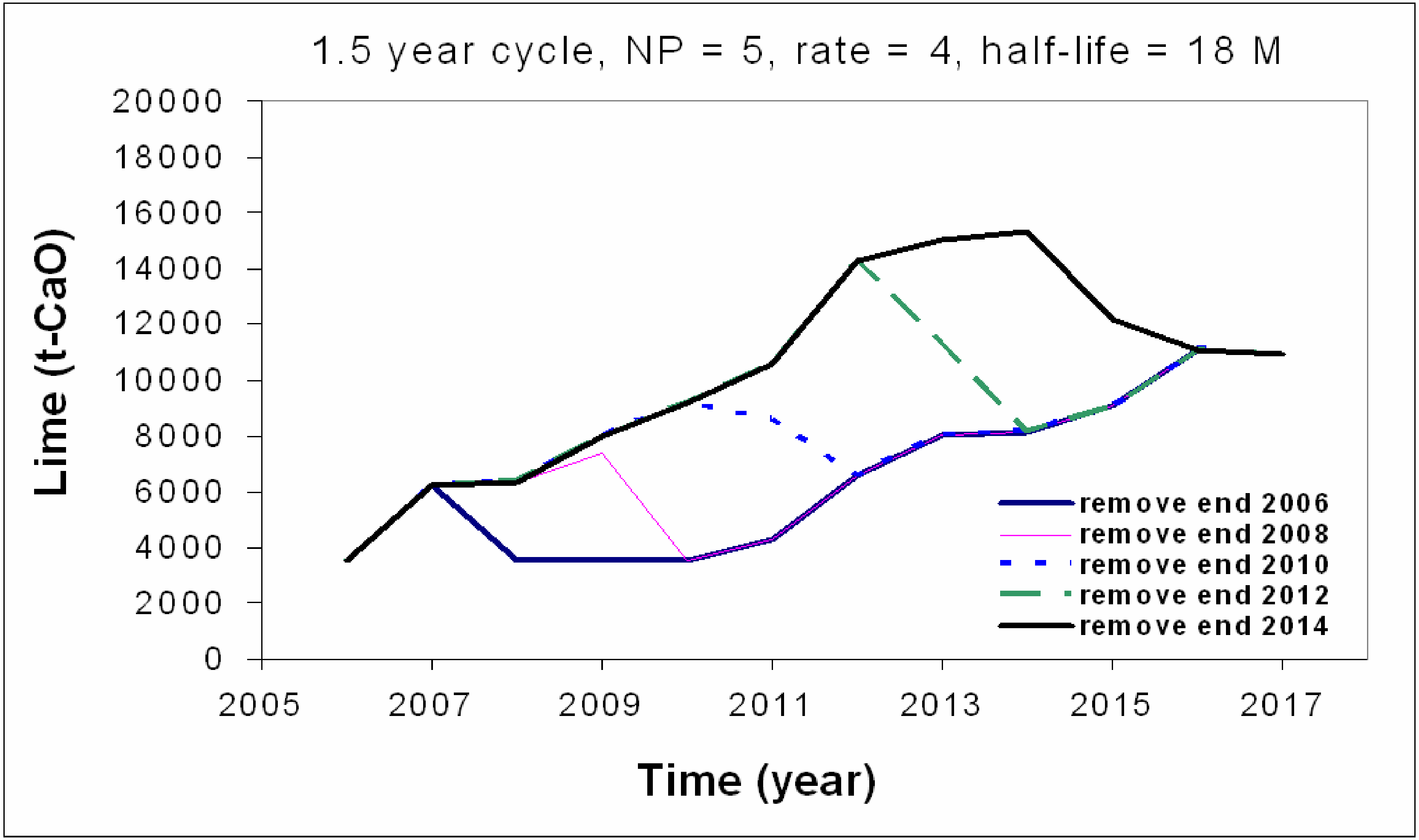
Effects of Jarosite Removal in Future Years



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Partitioning of Lime Demand to different Components

Base case – 2010:

- Active area: 17%
- Jarosite dissolution: 38%
- Thiosalt oxidation: 14%
- Inactive area: 23%
- Pump box: 8%
- **Total Lime demand: 8100 t CaO**

No-Jarosite – 1.5 year cycle – 2010:

- Inactive area: 72%
- Pump box: 28%
- **Total Lime demand: 3600 t CaO**

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Conclusions

- Optimal cycle time for 0.3 m fresh tailings per cycle (1.5 years).
- The NP of the Mine D tailings and the average annual oxidation rate of sulphides are the two most important variables that will control lime demand.
- The presence of jarosite in the tailings can increase lime demand by 5,000 to 6,000 t-CaO/a and scheduled to be removed by late 2007 / early 2008.
- Proper cycling and deposition management can eliminate lime demand during operations.
- The largest uncertainty is the NP of the tailings and appropriate characterization is required to predict actual lime demand

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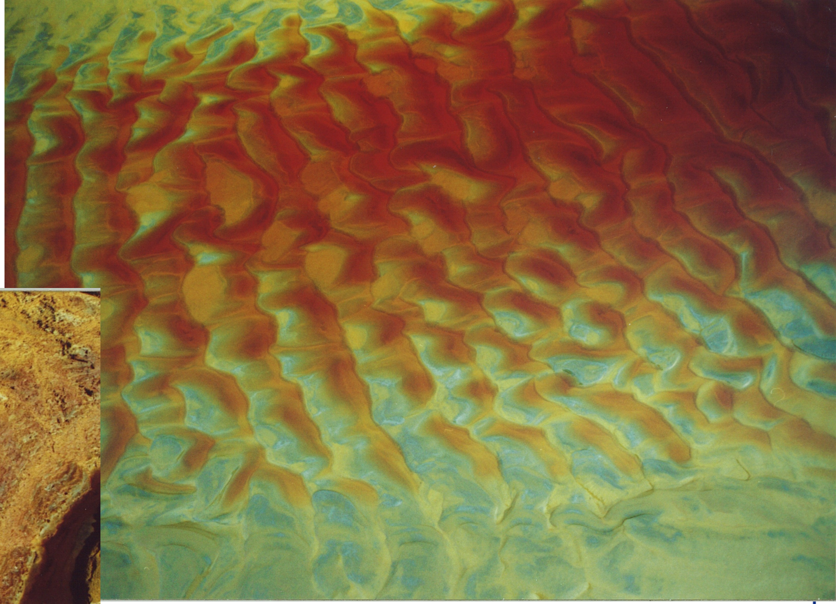
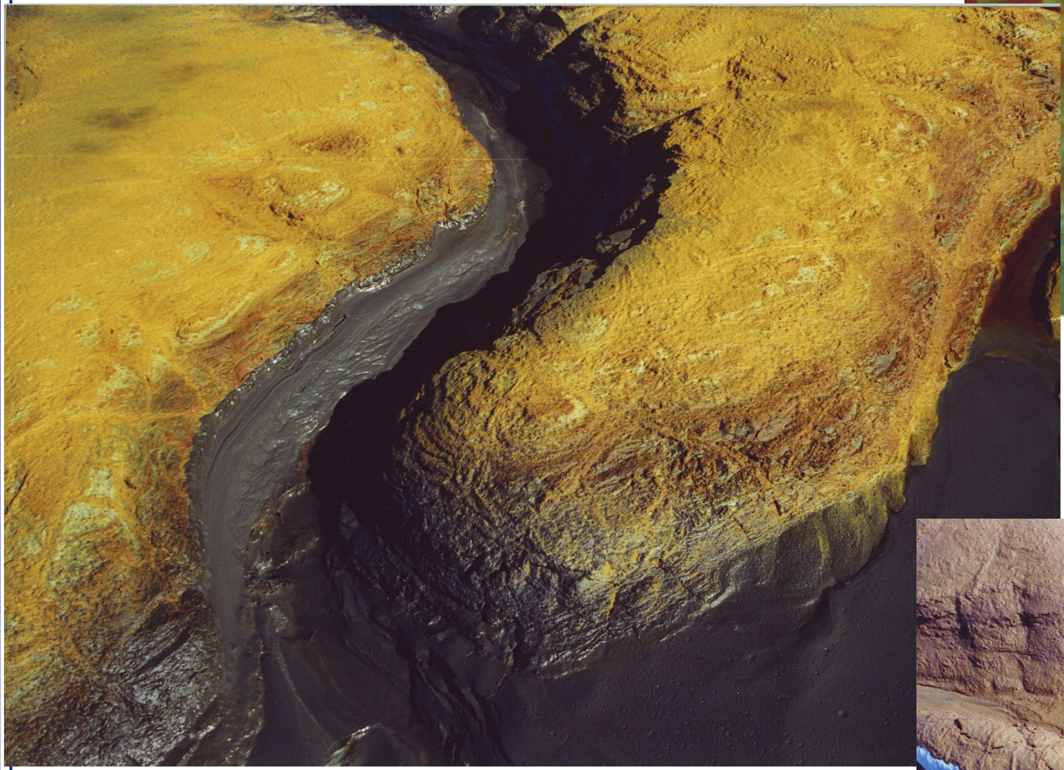
The Art of Tailings Management





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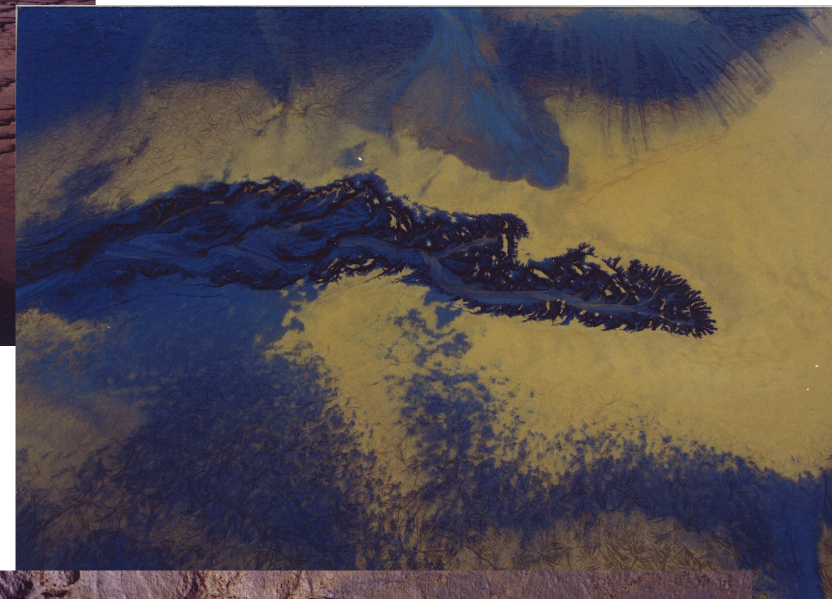

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