Surface Paste Disposal of High-Sulphide Tailings at Neves Corvo - Evaluation of Environmental Stability and Operational Experience

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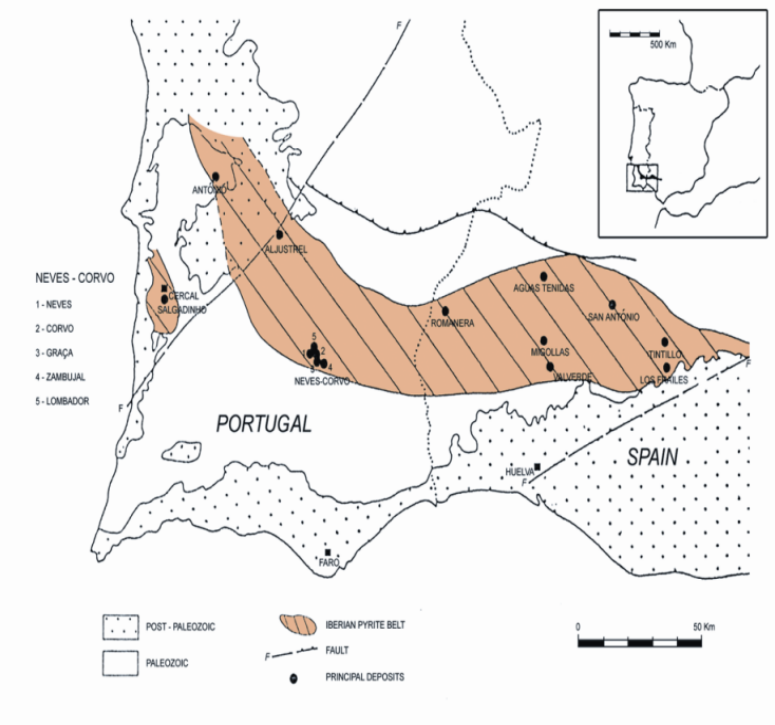
Neves Corvo Mine - Background



- Underground high-grade Cu-Zn mine in Iberian Pyrite Belt
- In operation since 1989
- Volcanogenic Massive Sulfide (VMS)
- 1.5-2.5 Mtons/yr tailings (0.5 Mtons backfill)
- ≈ 50 wt% pyrite (highly acid generating)

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Site Overview

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Tailings Management

- Unlined tailings impoundment (135 ha)
- Late 1990s: additional production anticipated
- Sustainable operational and post-closure tailings management: dry disposal (paste) vs. subaqueous deposition

- No requirement for new dam raises (cost, risk)
- No increase in footprint
- No requirement for maintaining pond in perpetuity (semi-arid climate)
- Co-mixing with PAG waste rock
- Concurrent reclamation
- Regulatory pressures

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Paste Investigation

- Objectives:
  - Evaluation of long-term environmental stability
  - Identification of operational constraints
  - Assessment of closure options (covers)

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Paste Program – A Decade in the Making

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Summary of Bench-Scale and Field Cell Results

- Consistent with expected relationships between moisture content, amendment, and sulfide oxidation
  - Best performance for highest moisture content
  - Lime/cement provide early buffering capacity, but not for long term
  - Lime/cement do not affect oxidation rate
  - Bactericide shows short-term benefit

Paste Trial - Objectives

- Operational-scale test: 35,000 m^3 in 1-hectare area
  - Difficult to predict operational geotechnical properties from lab/pilot scale experiments
- Experience with plant operation, paste placement, berm design (PAG waste rock)
- Environmental monitoring
  - Suction lysimeters, piezometers, standpipes
  - Runoff collection
- Trials of cover designs (Ward Wilson, U of Alberta)
  - Low-flux cover without capillary break
  - Low-flux cover with capillary break
  - Barrier cover (sand/bentonite)

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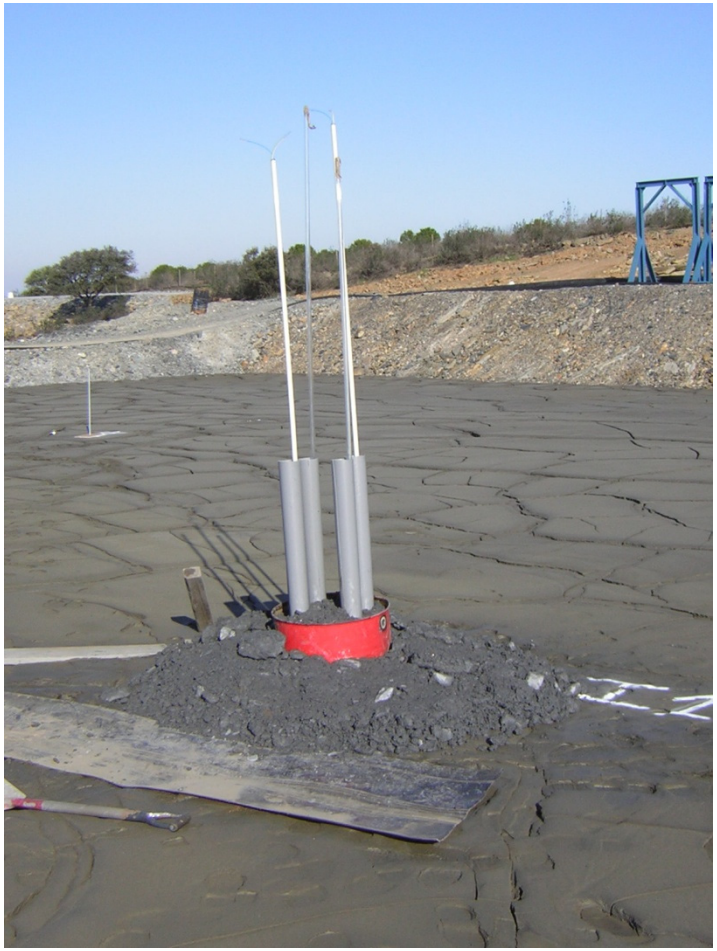
Overview of Pilot Trial Area

Paste Trial - Construction

Paste Trial - Construction



Paste Trial - Completion

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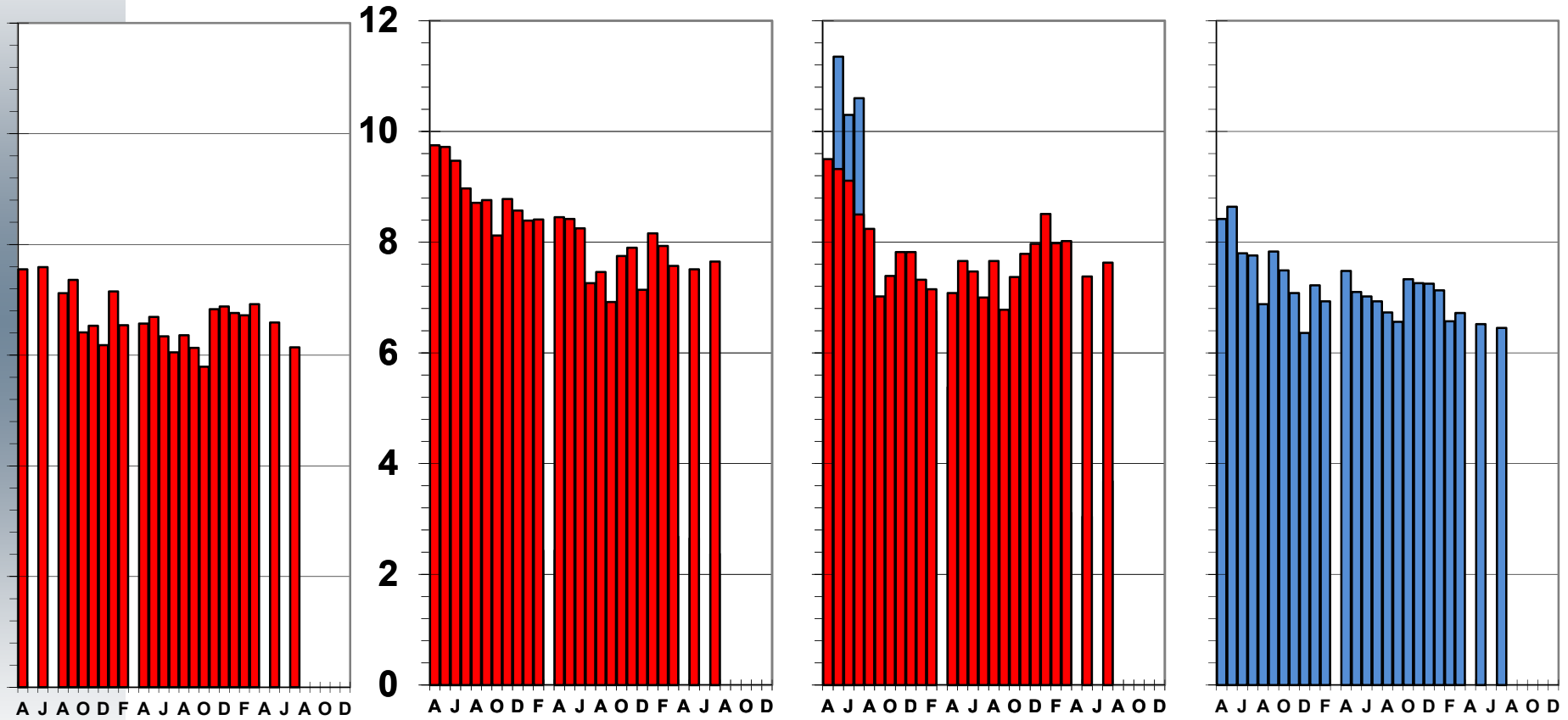
Water Quality (pH) in Paste Trial

Control (no cover) | **Cover**

Waste Rock | **250 mm** | **500 mm** | **1,000 mm**



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Paste Trial - Now

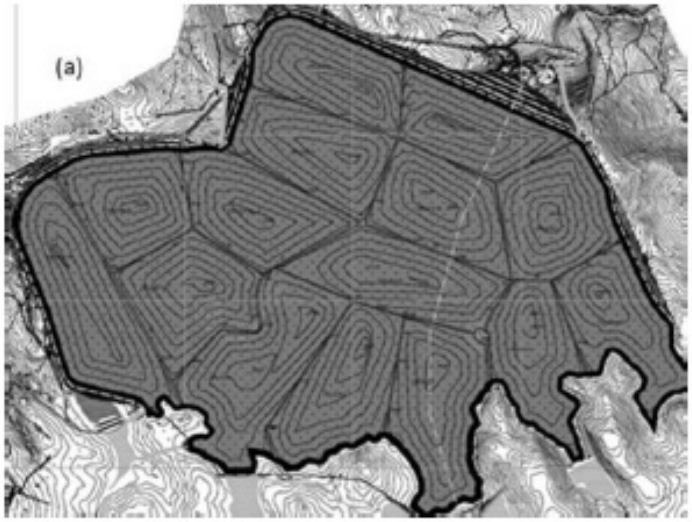
Trenching in Paste Trial

Low flux cover with capillary break

Low flux cover without capillary break

Trenching in Interim Cover

Operations – 2005 LOM Plan



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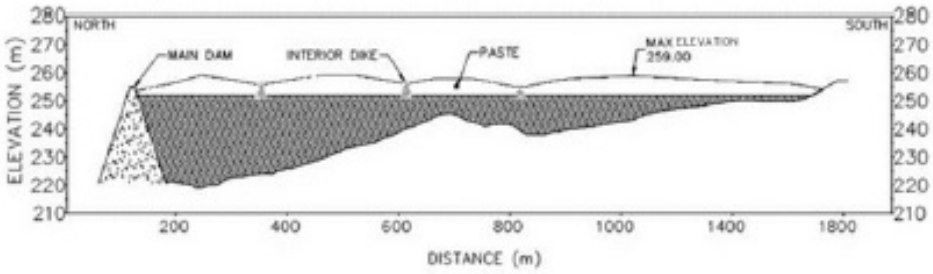

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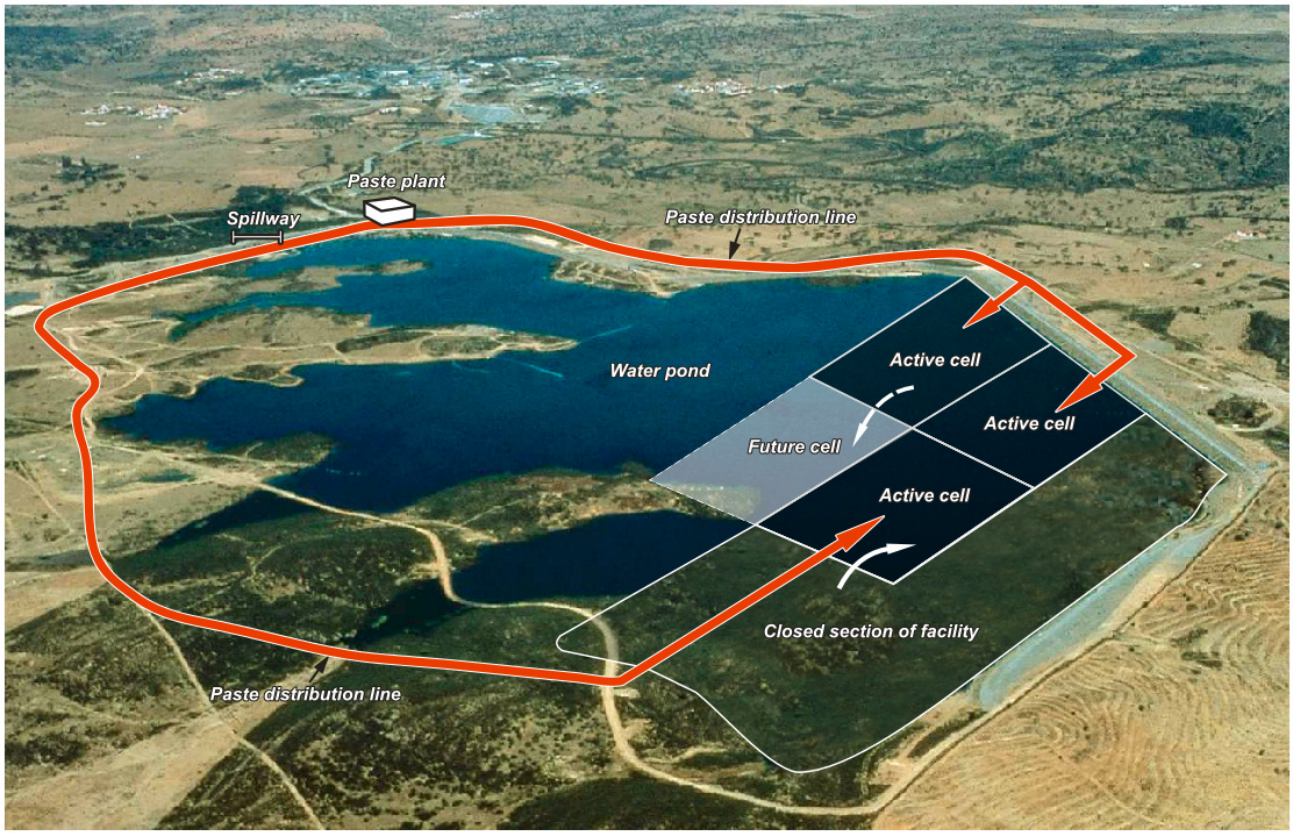
Conceptual Paste Placement



Progressive paste placement

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Operations – Aerial View in July 2013 (2½ years of deposition)

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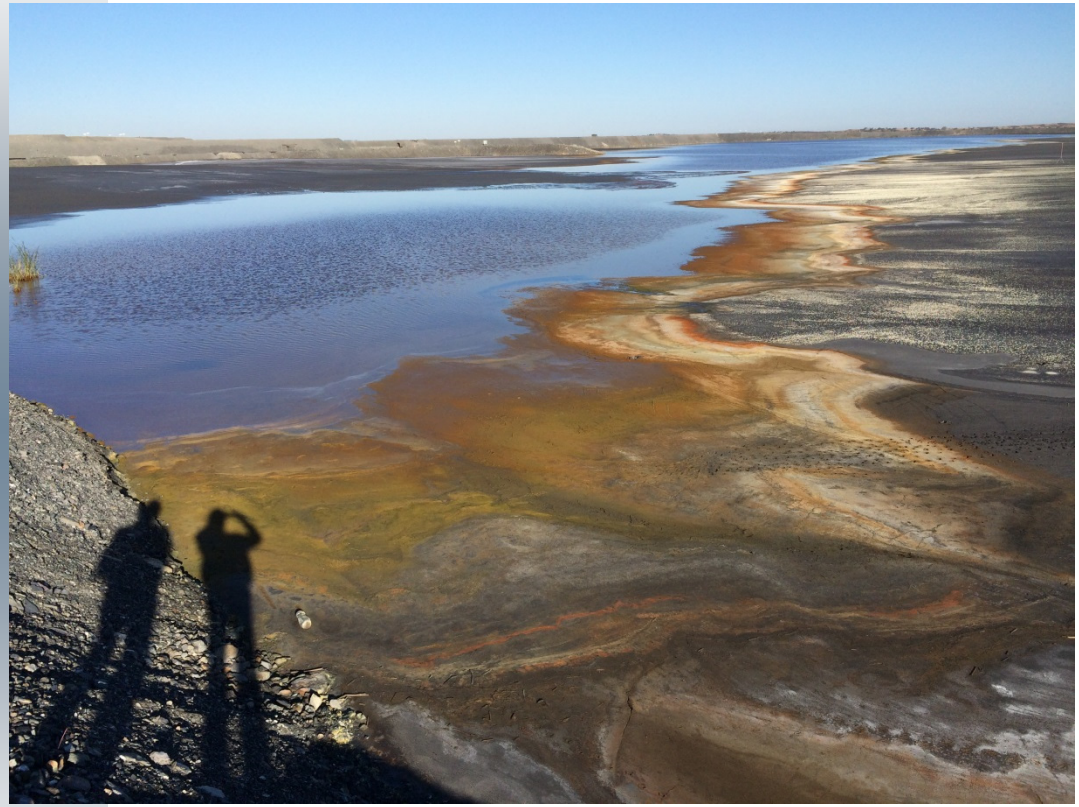

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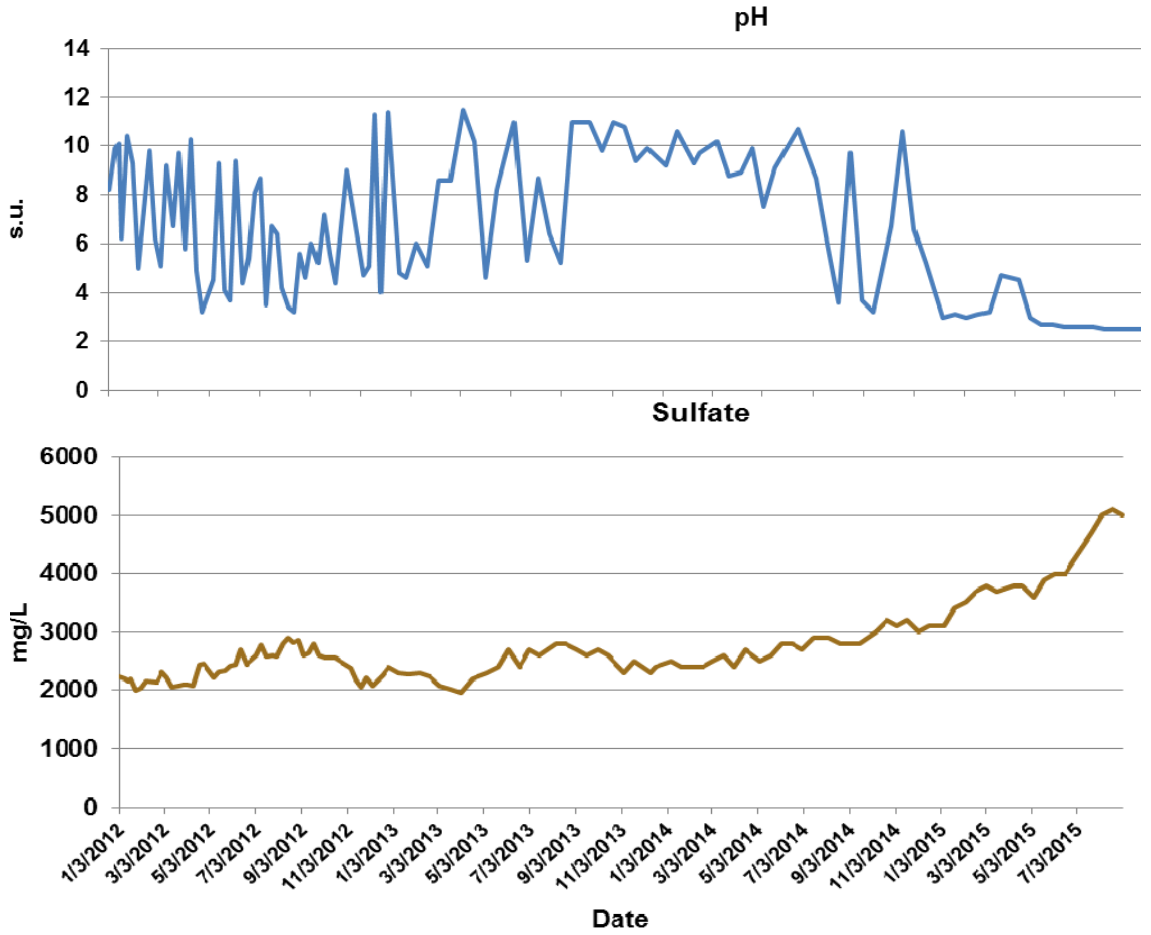
Operations – Water Quality



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Future – 2014 LOM Plan

- Two scenarios:
  - Base Case - 2024: 30 Mt (21 Mt tailings; 9 Mt waste rock)
  - Expansion Scenario - 2034: 50 Mt (36 Mt tailings; 14 Mt waste rock)
- Alternatives study:
  - stacking vs. raising dam

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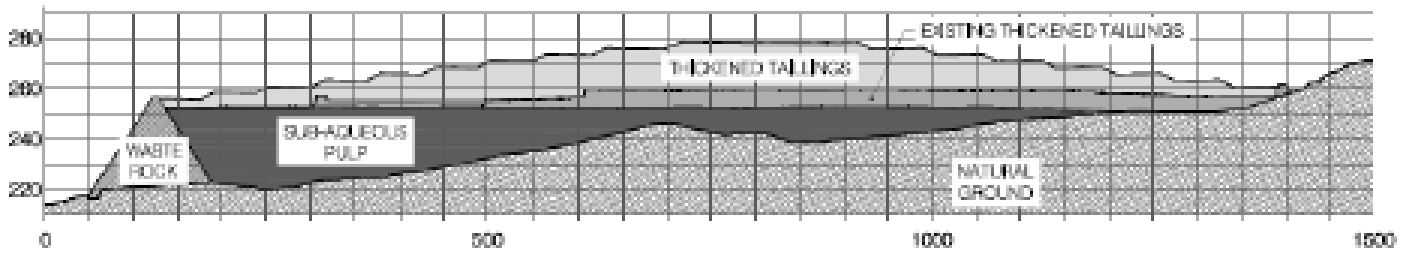
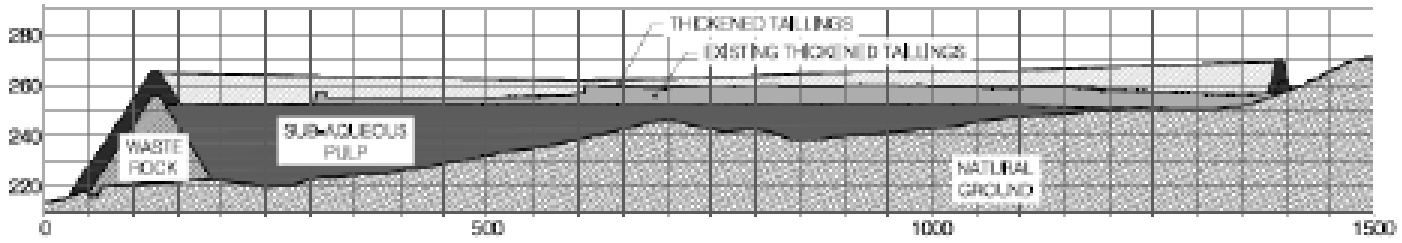
Future – Stacking vs. Dam Raise

Base Case Stacking Strategy Alternative - Long Section Profile



Base Case Full Containment Strategy Alternative - Long Section Profile



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Conclusions

- Paste geochemical behavior consistent with predictions
- Using engineered controls, limiting oxidation is feasible
  - Oxidation of uncovered paste is very shallow, even after prolonged exposure
- In semi-arid climate, low-flux cover better than barrier cover
  - Additional cover testing planned on quasi-operational scale
- Co-placement of waste rock with paste is feasible
- Rigorous pre-operational testing and modeling program necessary to demonstrate proof of concept
- Ongoing operational learnings
  - Berm construction
  - Paste placement sequencing
  - Water management

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