Dry-stack Tailings and Seepage Management La Coipa Mine, Chile

Dean Williams, Erling Villalobos, Julio Acosta – Kinross
Virginia Cullen and Jim Cassie – BGC
Jack Adams – U. of Utah
Rory Tibbals – Consultant
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Overview

- Location
- Climate
- Layout / Views
- Dry Stack Design
- Historical Review
- Groundwater Issues
- Remediation System
- Plume Extent
- Bioremediation Studies
- Final Thoughts

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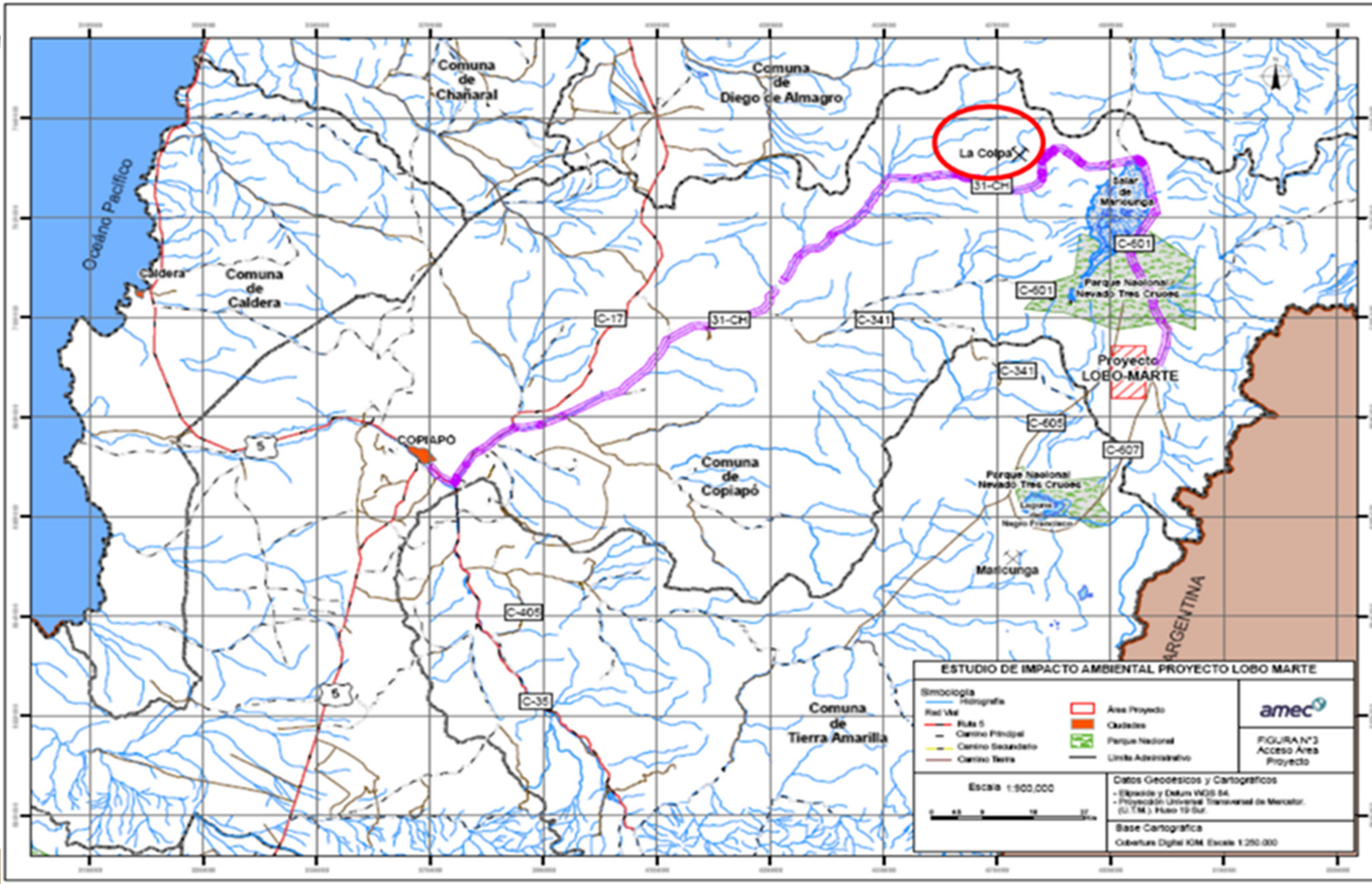
Location – 140 km from Copiapo



Climate

- Located on the edge of the Atacama Desert ("driest desert in the world")
- Average January and February high temperatures 29ºC
- Average June and July low temperatures -5ºC
- Average yearly rainfall totals 12 to 20 mm per year (in June and July only, mostly lost via sublimation)

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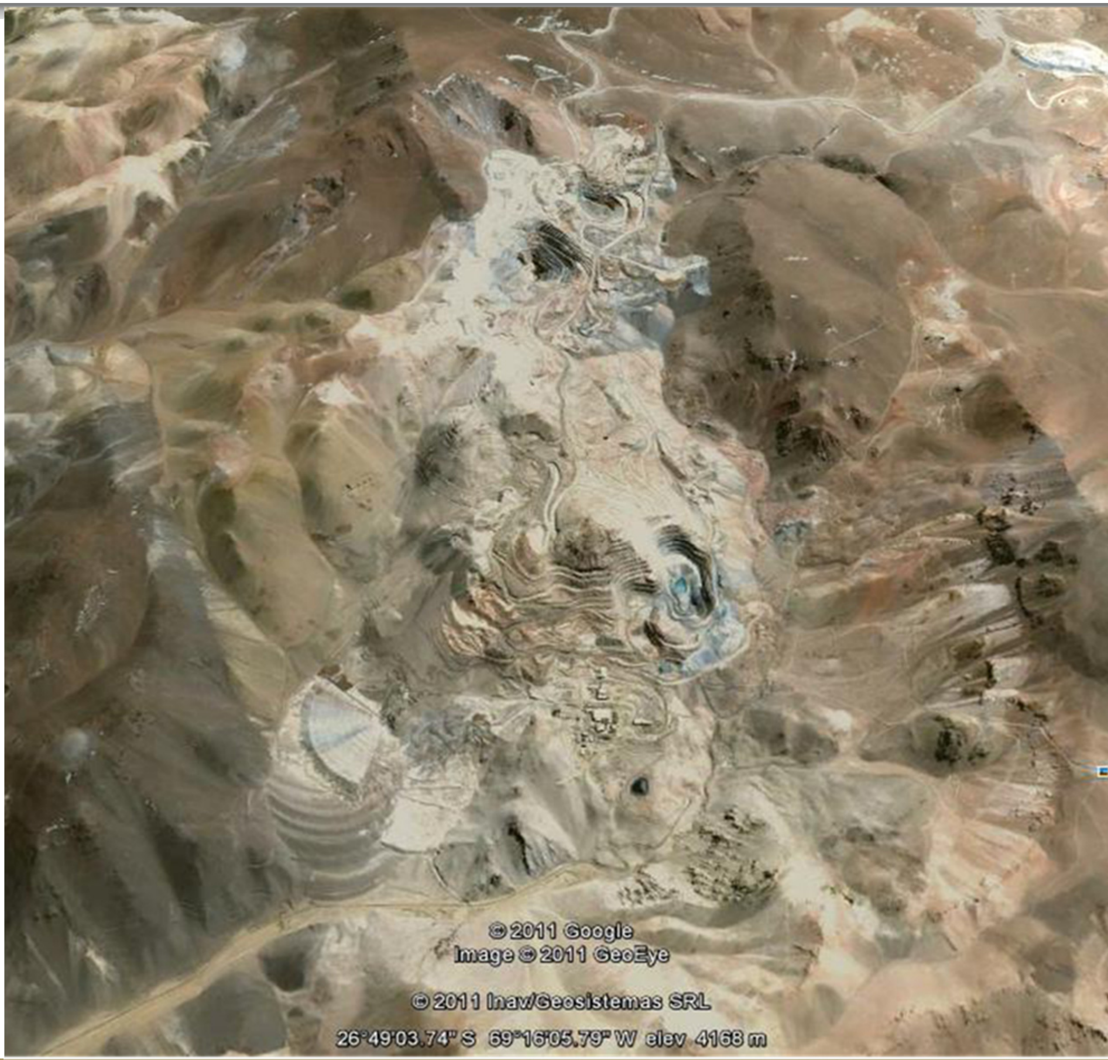
Mine Site / Dry Stacks

- Open Pit Mining at 3,800 to 4,300 m
- Approximately 5M tonnes/year processed via Merrill Crowe
- Due to high seismic hazard, limitations on available storage space and water conservation requirement; tailings placed into dry stacks



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La Coipa Tailings

- Prior to disposal, excess water is removed from tailings via filter belt to <25 percent moisture
- Tailings are transported from the filter plant to the dry stacks via conveyor
- Most tailings are disposed in the Rahco facility where they are distributed by a mobile stacker
- During periods when the filter plant or mobile stacker are not working effectively, tailings are deposited in the Rakito facility
- Dry stacks are designed to contain 150 Mt
- Due to their low moisture and forecast of insignificant seepage, the stacks were not lined

TAILINGS FILTRATION

- 12 Delkor Filter Belts
- Reduce tailings moisture 20-25%
- 99% of tailings filtered
- Rinse Efficiency: 98.5%
- Filtration Capacity : 600 kg/m^2h

Tailings Mineralogy

Quartz:	64.9 – 99.4%	
Alunite:	0.5 – 35.1%	$KAl_3(SO_4)_2(OH)_6$
Jarosite:	0.5 – 3.3%	$KFe_3(SO_4)_2(OH)_6$
Scorodite:	0.5 – 1.3%	$FeAsSO_4\ 2H_2O$
Cinnabar:	≤ 0.5%	HgS
Hematite:	≤ 0.6%	Fe_2O_3
Barite:	≤ 0.5%	$BaSO_4$
Calcite:	≤ 0.5%	$CaCO_3$
Gypsum:	≤ 0.5%	$CaSO_4\ 2H_2O$

Dry Stack Design

Rahco (engineered) and Rakito (emergency) dry stacks located on southwest area of the mine, overlooking the access road




Physical Properties

- Dry stack design objectives
  - Min. dry density = 1.5 t/m^3
  - Or 85% Standard Proctor max. dry density (SPMDD)
- In situ measurements
  - Dry density from 1.55 to 1.8 t/m^3
  - 85 to 100% SPMDD (Rahco)
  - 83 to 100% SPMDD (Rakito)
- Friction angle
  - 28^o to 43^o

Groundwater - Historical Sequence

- During 1994-1995, during start-up of nitric leaching to remove mercury at the Refinery, large quantities of mercury oxide were not captured and went to the tailings.
- In 1994 the first traces of mercury were detected in the groundwater below the tailings.
- In 2003 it was concluded that mercury mobilization had been accelerated by the presence of residual cyanide in tailings

Tailings Pore Water Chemistry

pH: 8-11	
Alkalinity: 778 mg/L	(159-2697 mg/L)
Total Hg(II):	(0.05 µg/L - 99 mg/L)
Total CN: 533 mg/L	(100-2000 mg/L)
WAD-CN: 118 mg/L	(1.8-425 mg/L)
SCN: 1806 mg/L	(100-4500 mg/L)
As: 11 mg/L	(0.7-58 mg/L)
SO_4: 2875 mg/L	(1420-4640 mg/L)

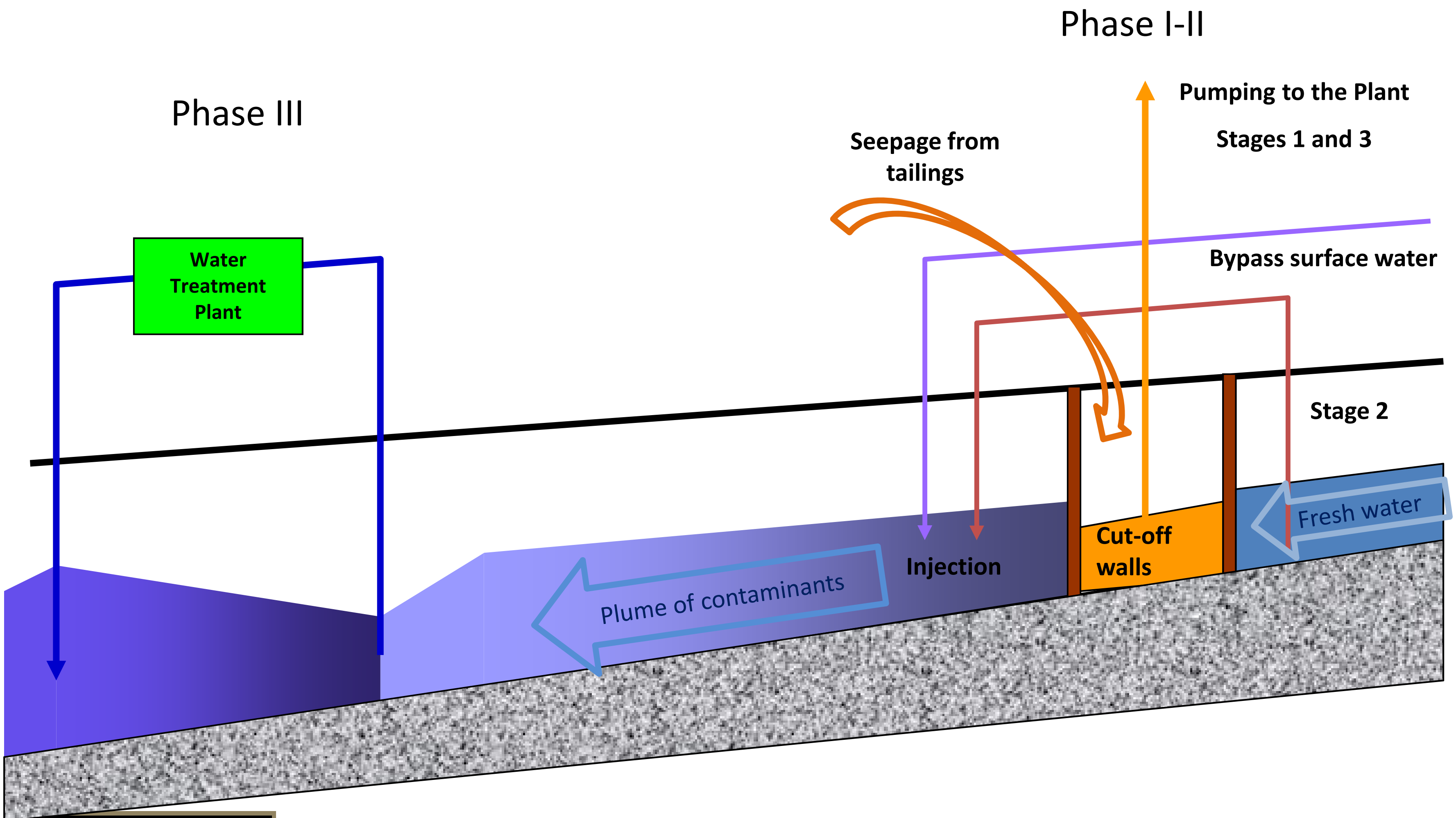
NH_3-N: 53 mg/L **NO_3-N**: 65 mg/L **NO_2-N**: <17 mg/L

DOC: 510 mg/L	(164-1480 mg/L)

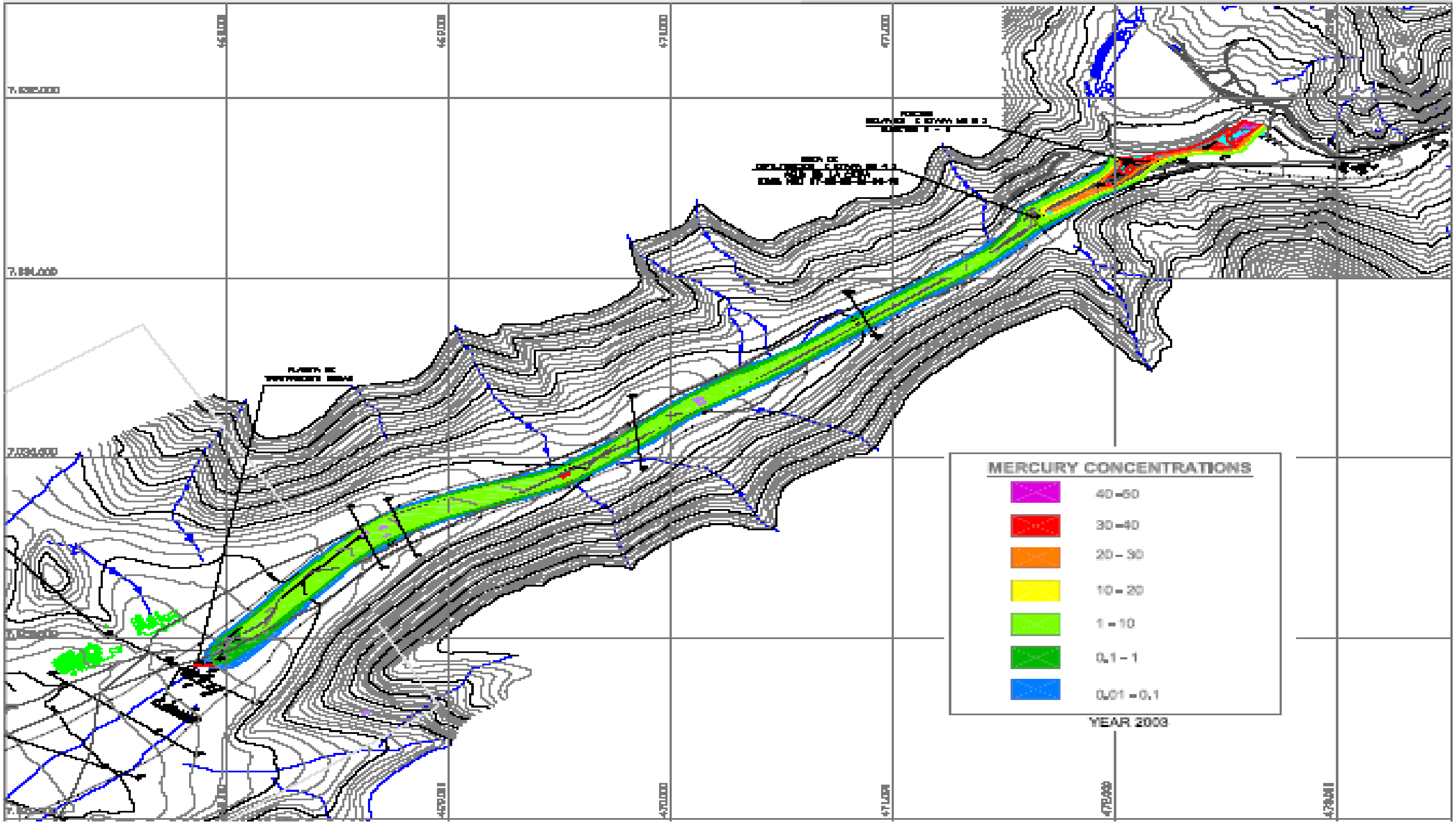
Groundwater Capture and Remediation Phases

- 1995 – Five interception wells were installed at the toe of Rakito (Phase I).
- 1997 – Six monitoring curtains were completed along La Coipa valley.
- 1998 – An additional interception system was installed in the valley at the toe of tailings piles (Phase II):
  - The contaminated water was captured and pumped back to the Plant
  - The fresh water from the upper reaches of the valley was bypassed to an infiltration trench.
- 2000 – A pump/treat/injection system was installed at the lower reaches of the valley to contain the plume within the property boundaries (Phase III).
- 2007 – Two cut off walls were constructed across the valley to contain the contamination at the toe of the tailings piles.
- 2008 – La Coipa began the addition of ferric sulfate to tailings to destroy residual cyanide.
- 2008 to Present – Progressive management improvements to remediation systems and continued studies.

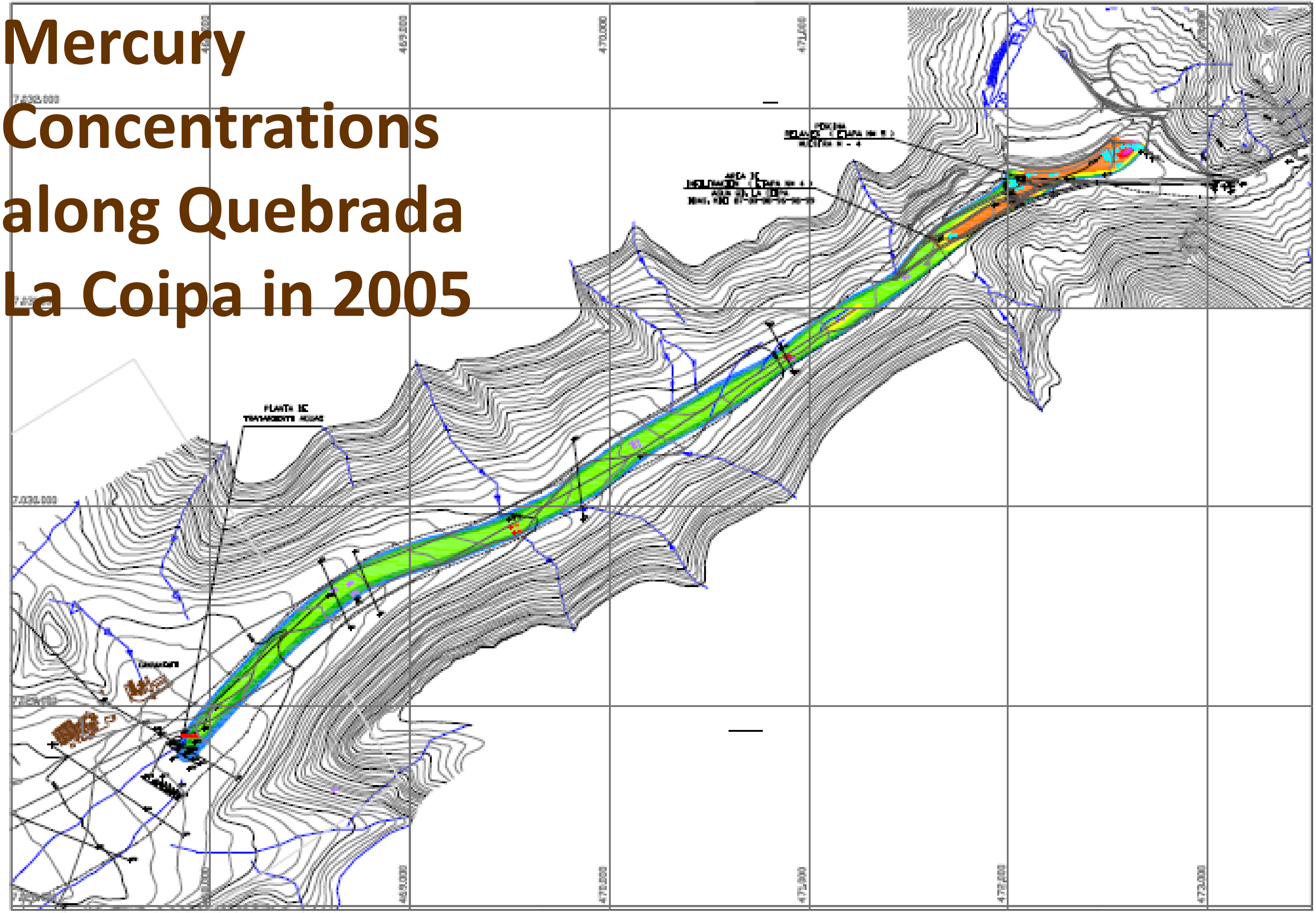
Current Remediation System



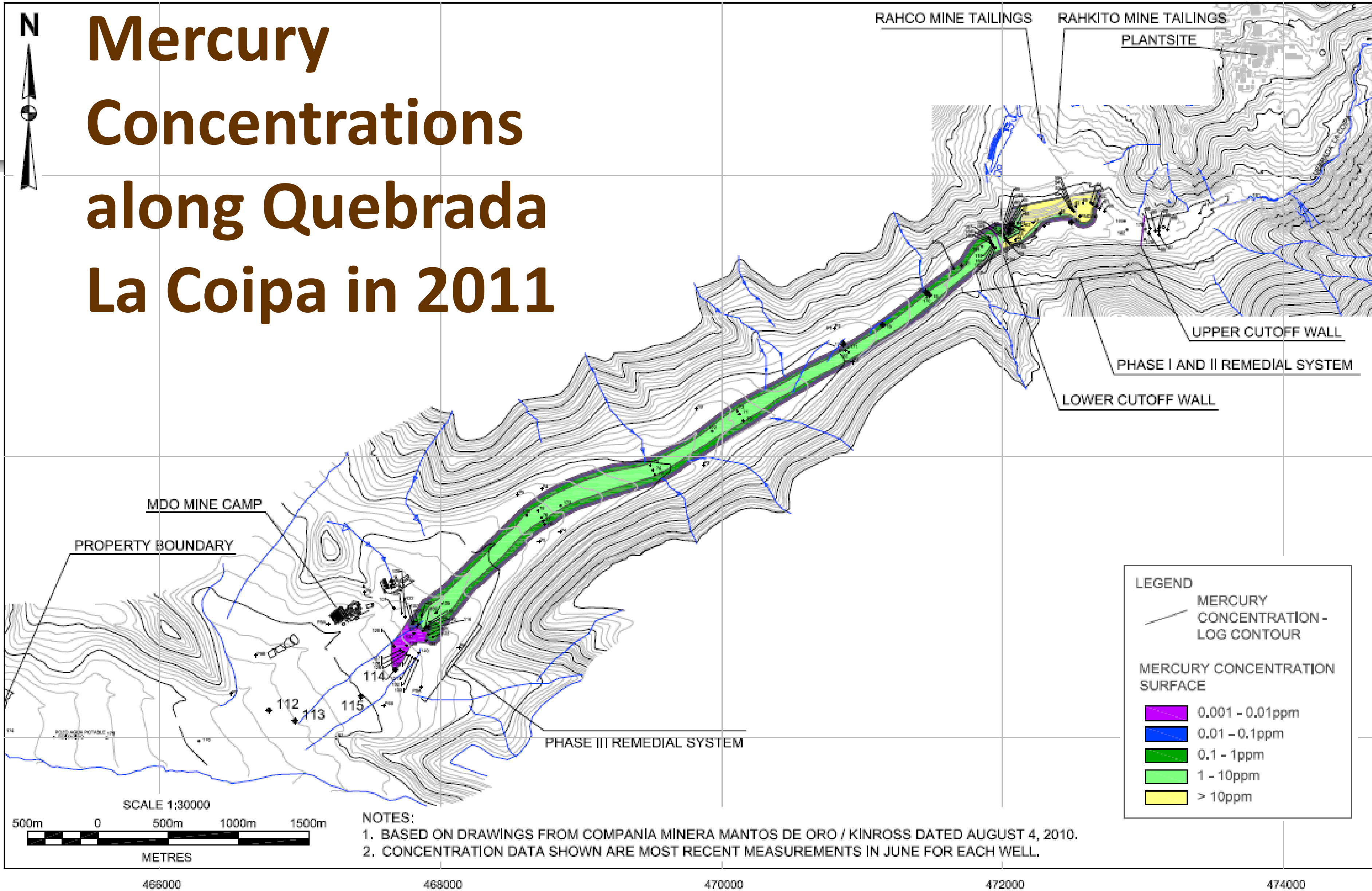
Mercury Plume 2003



Mercury Concentrations along Quebrada La Coipa in 2005



Mercury Concentrations along Quebrada La Coipa in 2011



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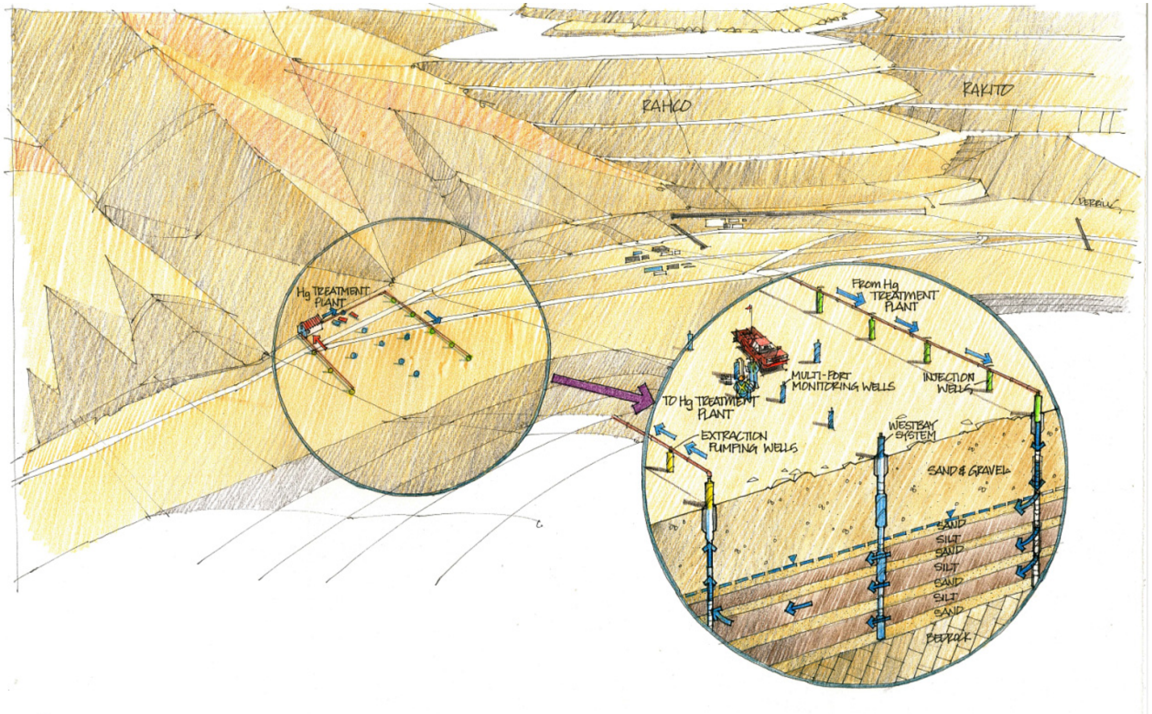
Enhanced Flushing



Column testing - currently in progress

Field testing - planned for 2013/2014 to investigate efficacy of large scale flushing and assess:

- Spacing of flushing cells
- # of pore volumes required to reduce contaminant concentrations to acceptable levels
- Residual concentrations
- Rebound rates

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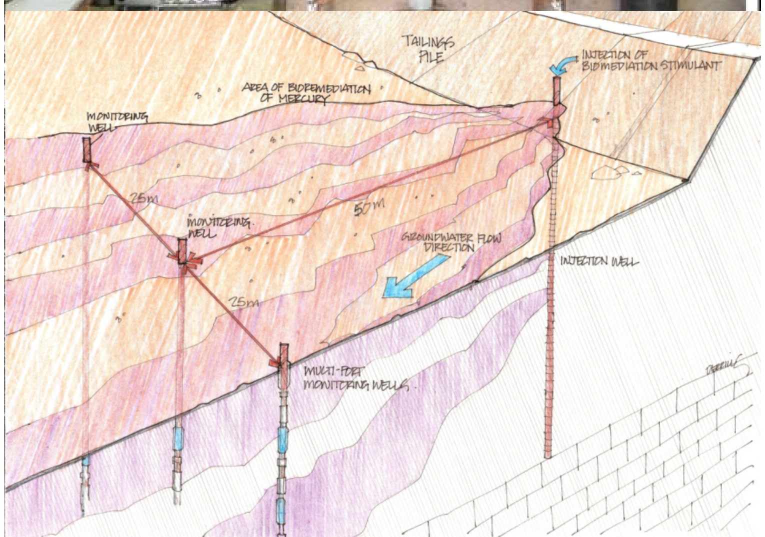
Bioremediation Studies



- **Column Tests have demonstrated:**
  - Mercury can be reduced in pore water to near background levels
  - Nitrate levels can be reduced to undetectable levels
  - Cyanide levels can be reduced to undetectable levels
  - Thiocyanide can be significantly reduced (improvement expected)
  - Sulphate can be reduced significantly
- **Field testing planned for 2013**

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Final Thoughts

- Dry stack tailings chosen to work within the significant site constraints (dry climate and seismic loading) posed at La Coipa Mine
- Method is scalable for large tonnage and future expansion
- Engineering assessment and stability review on-going for large stack
- Dry-stack tailings contain significant quantities of water which will emerge as seepage unless contained or collected
- The presence of cyanide, even at low concentrations, increases mercury mobility in groundwater
- Phase III has successfully contained the mercury plume within the property
- The cutoff walls have effectively prevented further migration of high mercury levels down the valley
- Groundwater remediation is projected to continue for many years
- Closure planning still in works but will combine elements of tailings stability with toe seepage and groundwater collection