Calcium Polysulfide Applications in Mining Site Restoration

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URS

Mining Site Cleanup

- Sites are typically large and remote.
- Approach must be practical.
- In-situ Approach – Create subsurface reactors to avoid costly excavation and pump and treat.

Primary Contaminants of Concern at Mining Sites

- Heavy Metals: Hg, As, U, Pb, Cr, Mb, Cu, Cd, Ni, Zn, Se, Ag
- Acidic Leachate: pH < 3
- Cyanide
- Nitrates

In-situ Geochemical Fixation for Metal Remediation

Goal: To convert soluble, reactive, toxic metal compounds to insoluble, stable and less toxic forms.

No Excavation, No Pump and Treat

Calcium Polysulfide
(lime sulfer)

- Aqueous solution of CaS_x, where x = 2-5
- Strong Reducing Agent: decomposes to release reactive sulfides (H_2S)
- Alkaline - pH = 11.3 to 11.5

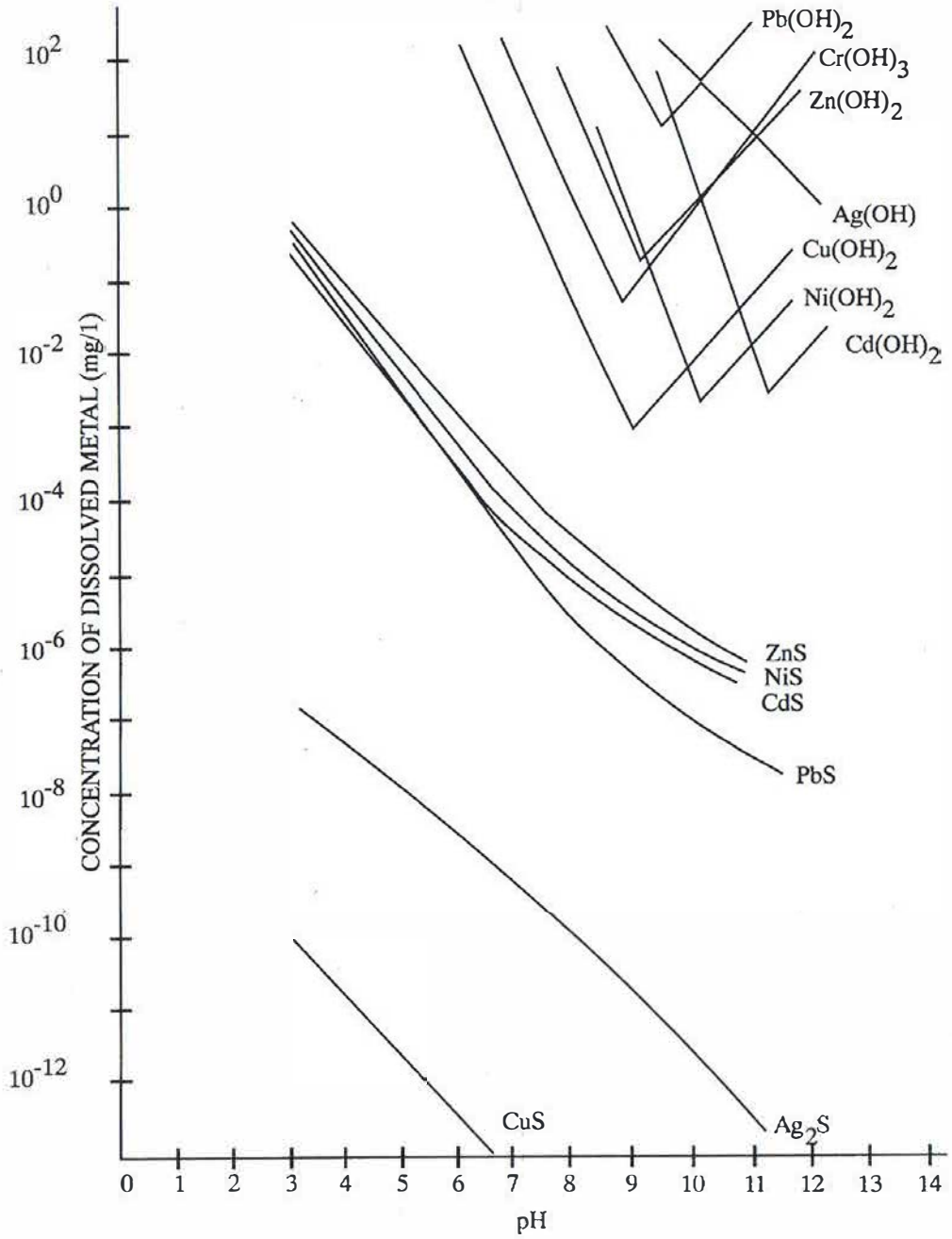
Why CaSx for Mining Sites?

- Effects metal sulfide precipitation.
- Reacts with CN^- to form less toxic SCN^-
- Good pH buffering capacity
- More stable and persistent than other reductants.
- Relatively inexpensive at $1/gallon.

Metal Sulfide Precipitation

$$M^{2+} + H_2S + 3OH^- + H^+ \longrightarrow MS + 3H_2O$$

Solubility of Metal Hydroxides and Sulfides as a Function of pH



Chemical Manufacturing Site

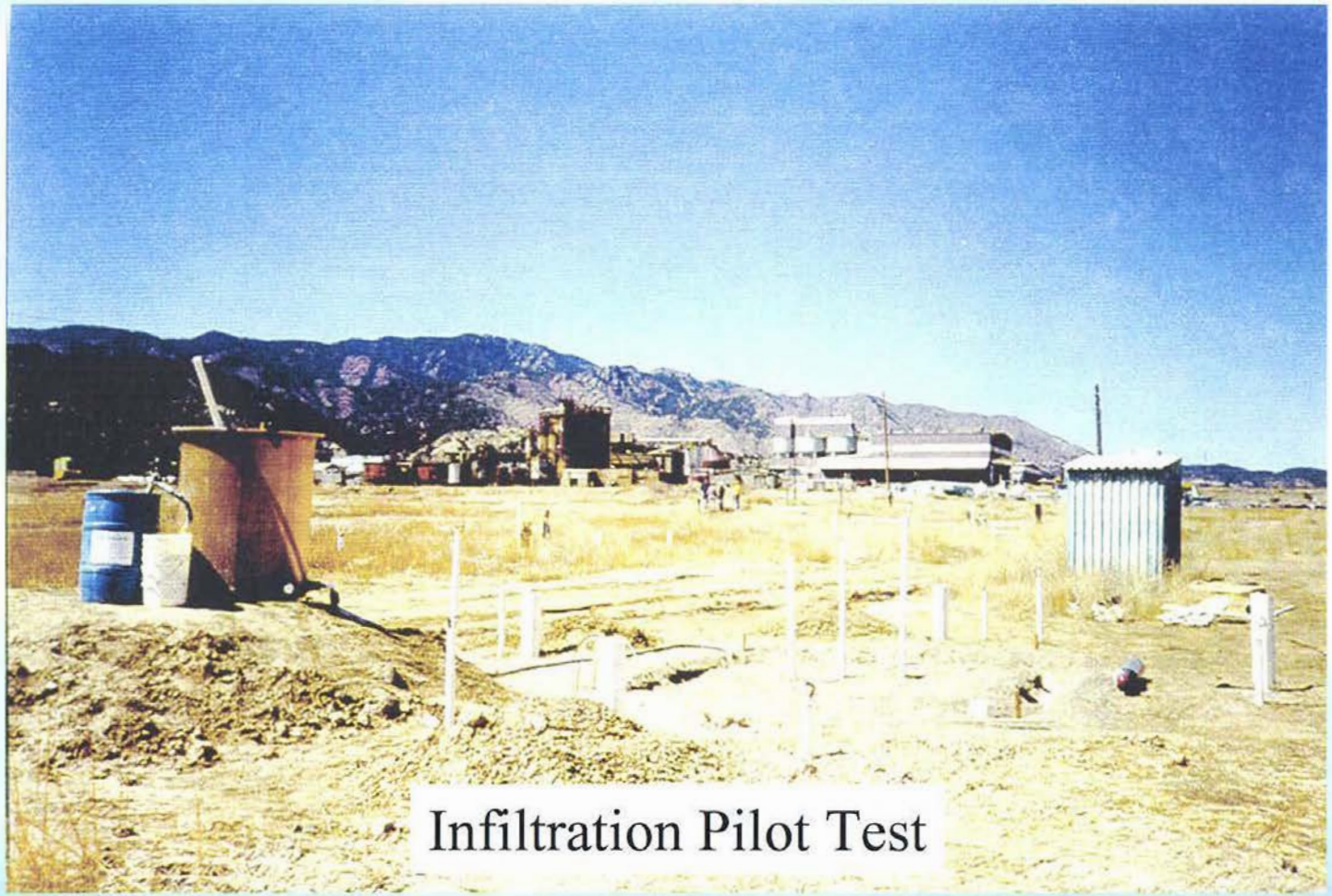
California

- High Cu (>10,000ug/L) Cd, Zn, and Ni
- 948 groundwater injection points
- % Reduction in groundwater with CaSx:
  - Cu – 99.8%
  - Cd – 94%
  - Zn – 73%
  - Ni – 59%
- Effective Buffering of pH to 7-8

Source: Peter Zawislanski, LFR Levine Fricke

Uranium and Moly Cleanup

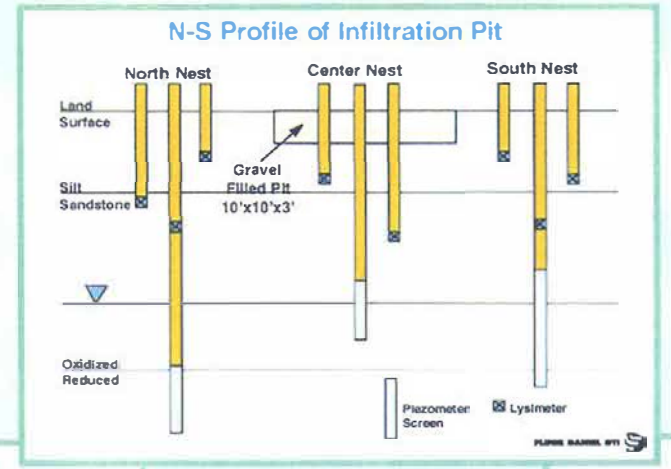
Uranium Mill Site- Colorado

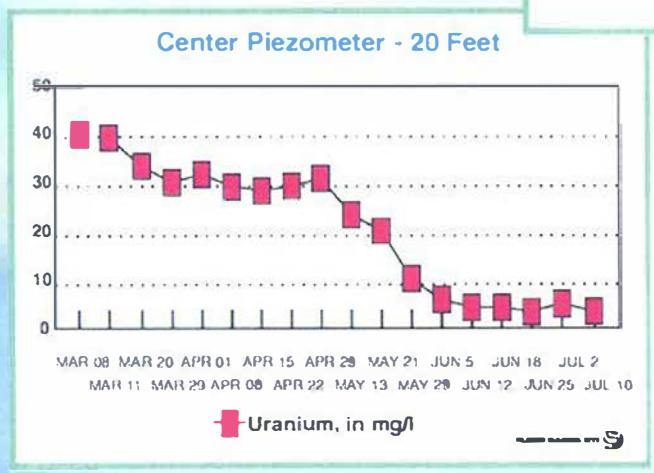


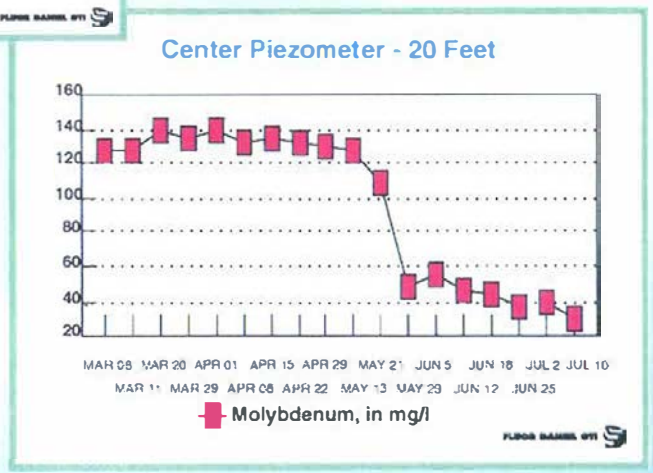
Infiltration Pilot Test

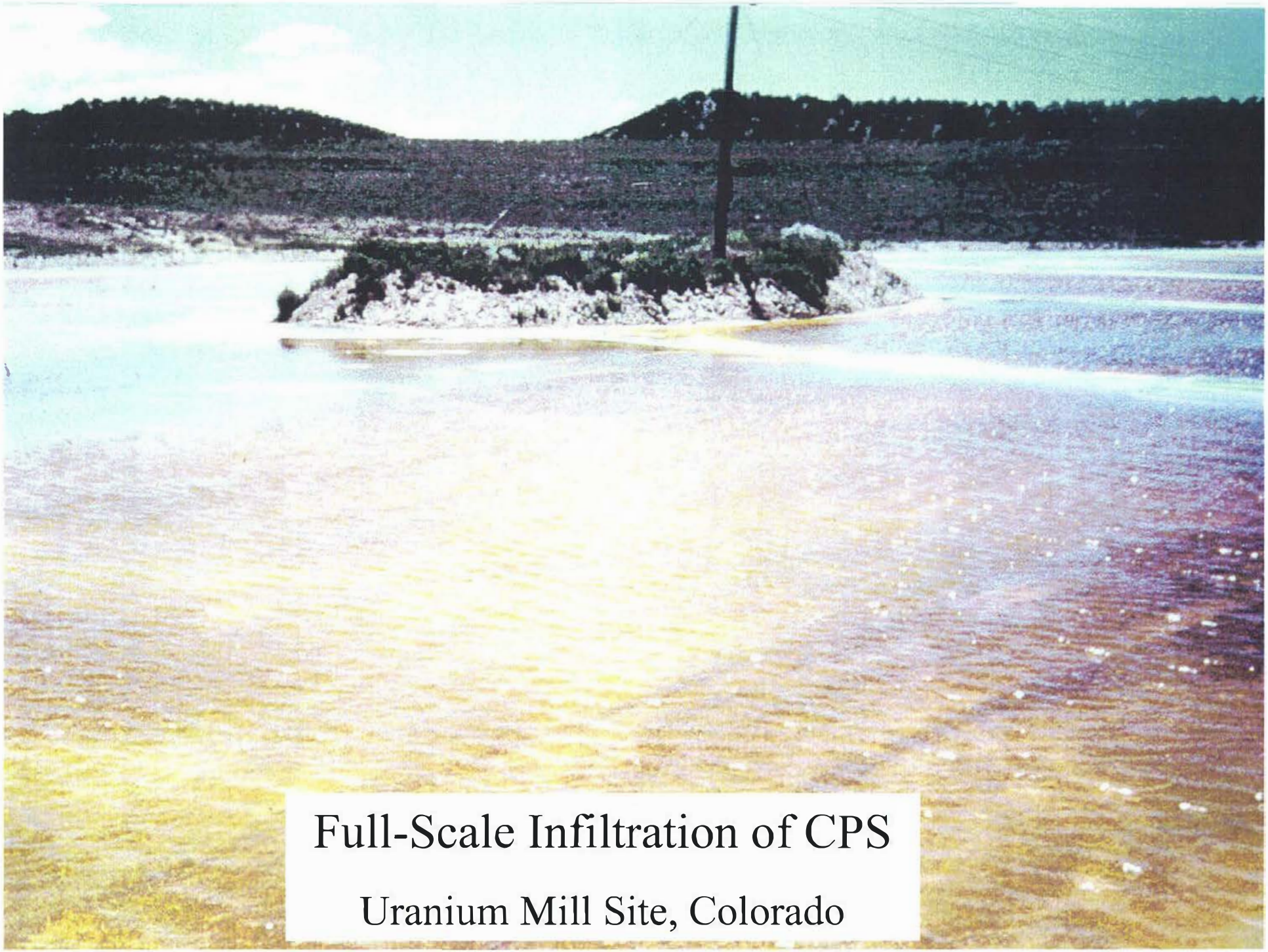
Uranium and Moly Cleanup

Uranium Mill Site- Colorado







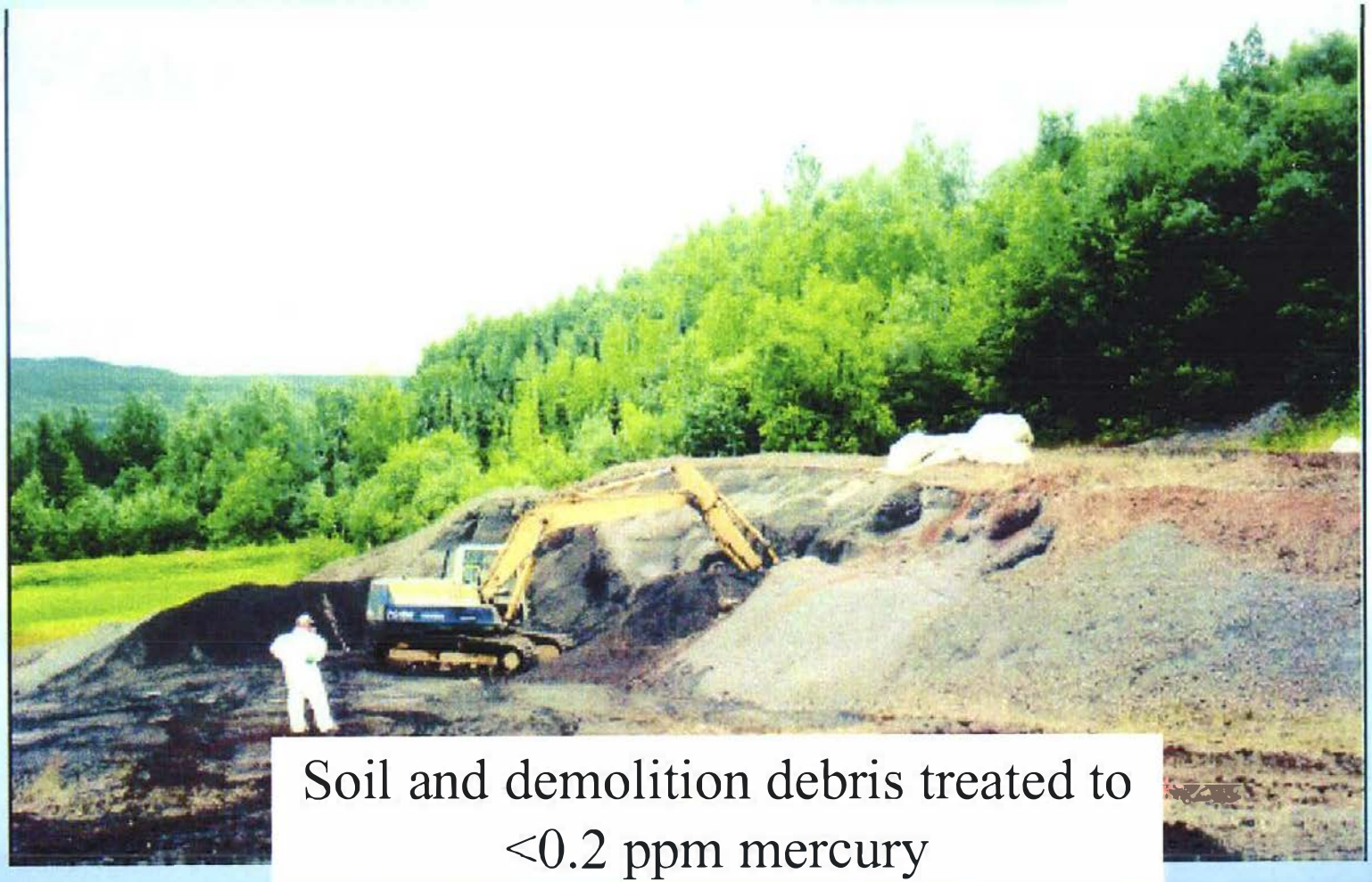


Full-Scale Infiltration of CPS

Uranium Mill Site, Colorado

Mercury Cleanup

Red Devil Mine, Alaska



Soil and demolition debris treated to <0.2 ppm mercury

Mercury Cleanup

Red Devil Mine, Alaska

STATE OF THE ART
In-situ Cr Remediation

(According to EPA, 1997)

Proven Technologies

- Geochemical Fixation
- Permeable Reactive Barriers

Developing Technologies

- Reactive Zones
- Soil Flushing/Extraction
- Electrokinetics

Emerging Technologies

- Natural Attenuation
- Phytoremediation

Chromium Cleanup

Cr Ore Processing Residue Site, Glasgow

Chromium Cleanup

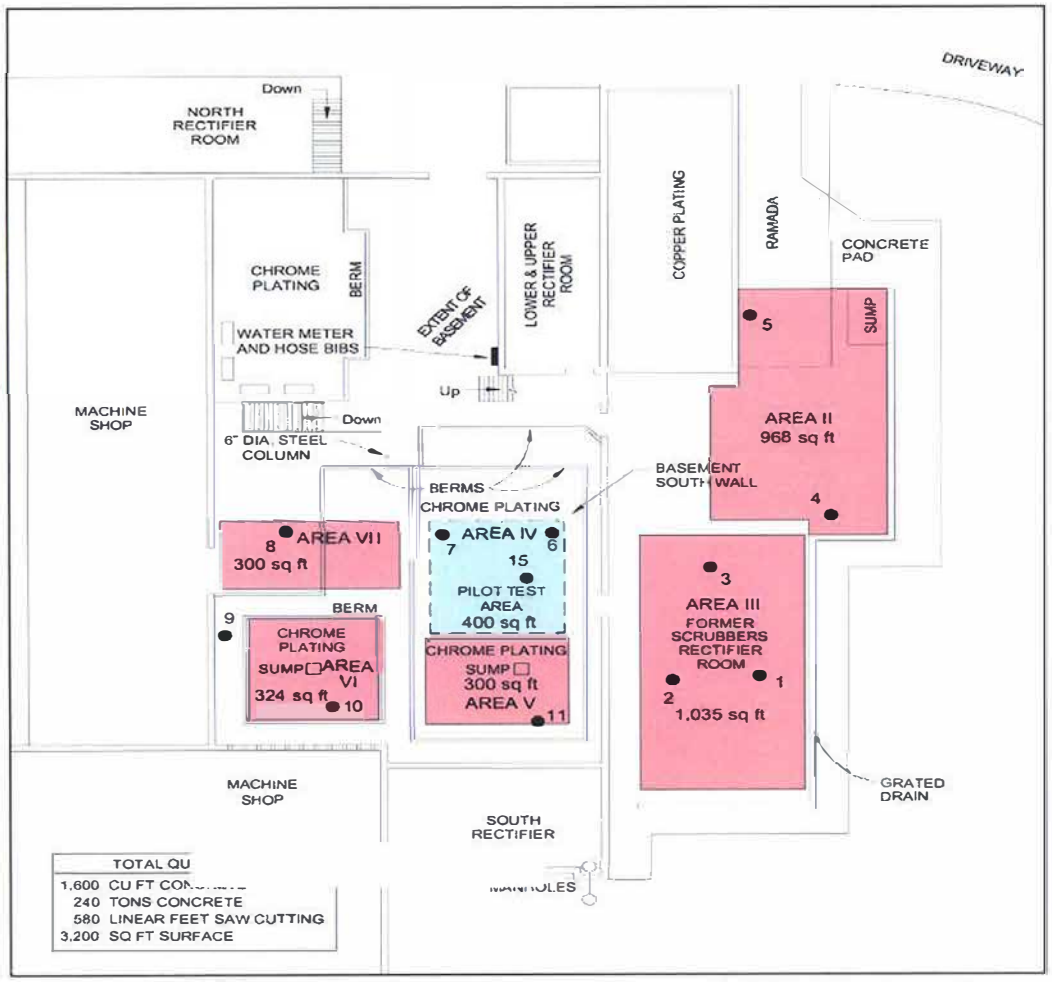
Cr Ore Processing Residue Site, Glasgow

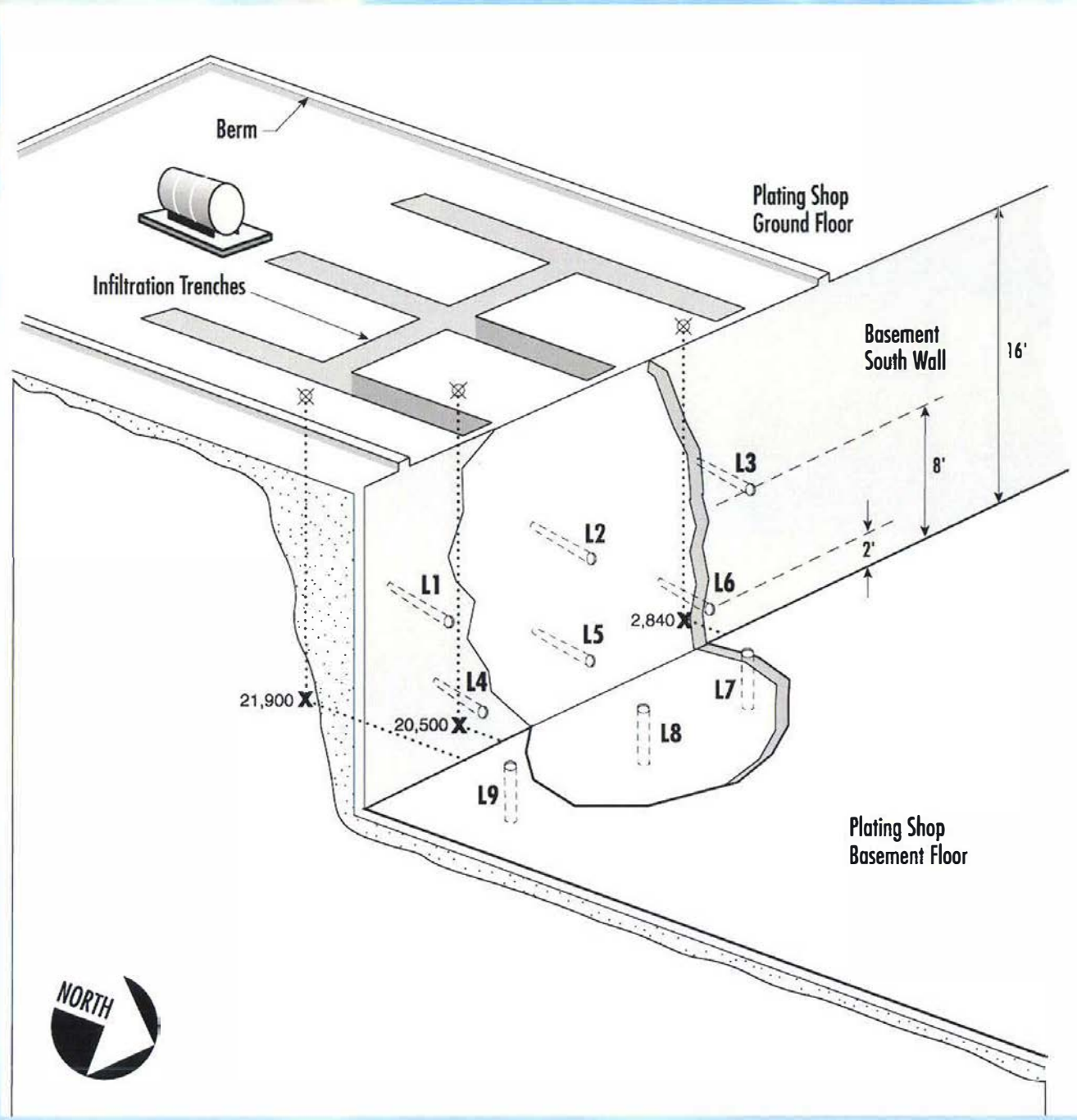
Chromium Cleanup

Cr Ore Processing Residue Site, Glasgow

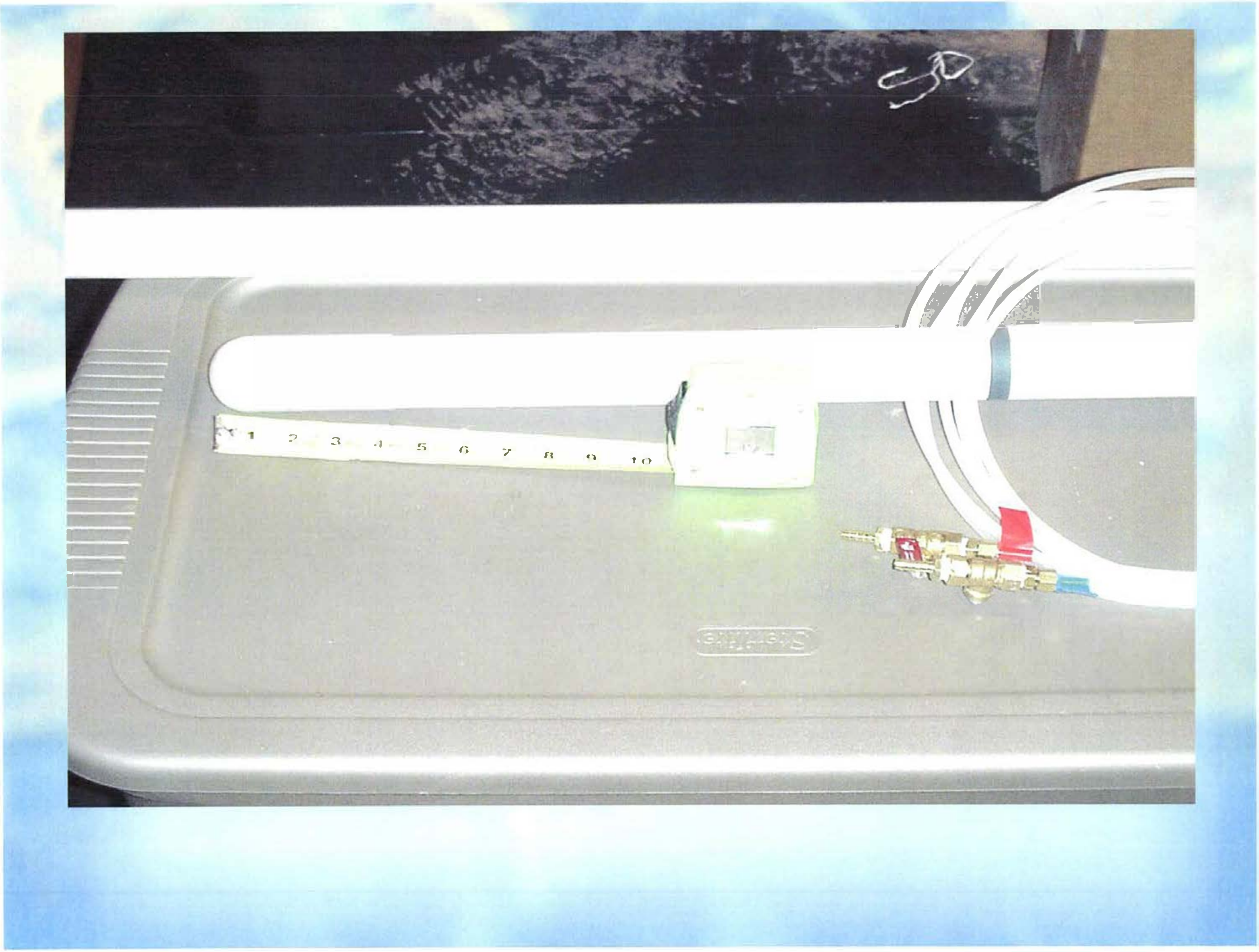
Chromium Cleanup

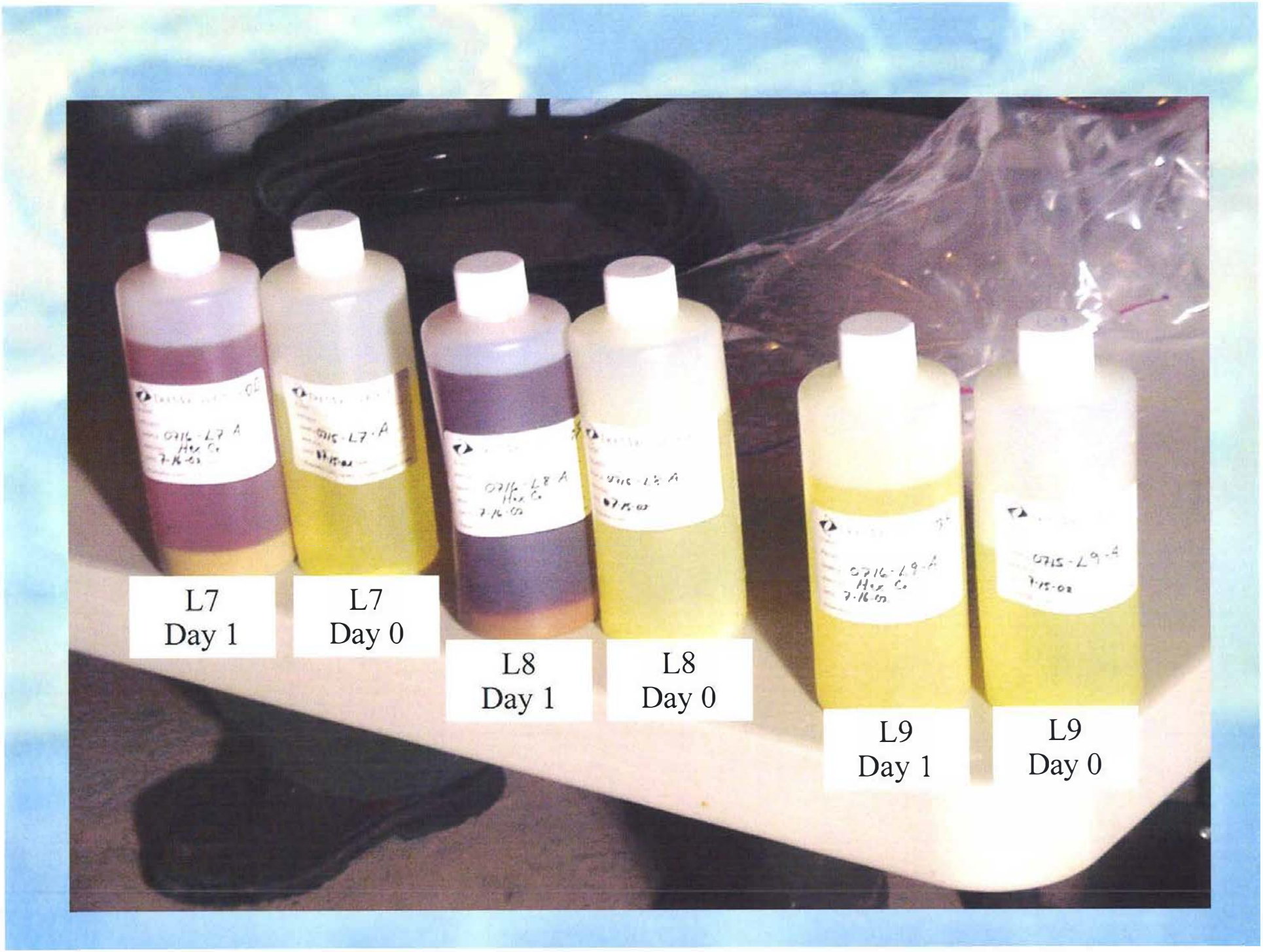
Metal Plating Shop, Arizona




Berm
Infiltration Trenches
Plating Shop
Ground Floor
Basement
South Wall
16'
8'
2'
L1
L2
L3
L4
L5
L6
L7
L8
L9
2,840
21,900
20,500
Plating Shop
Basement Floor
NORTH


L1
L2
L3
L4
L5
L6
L7
L8

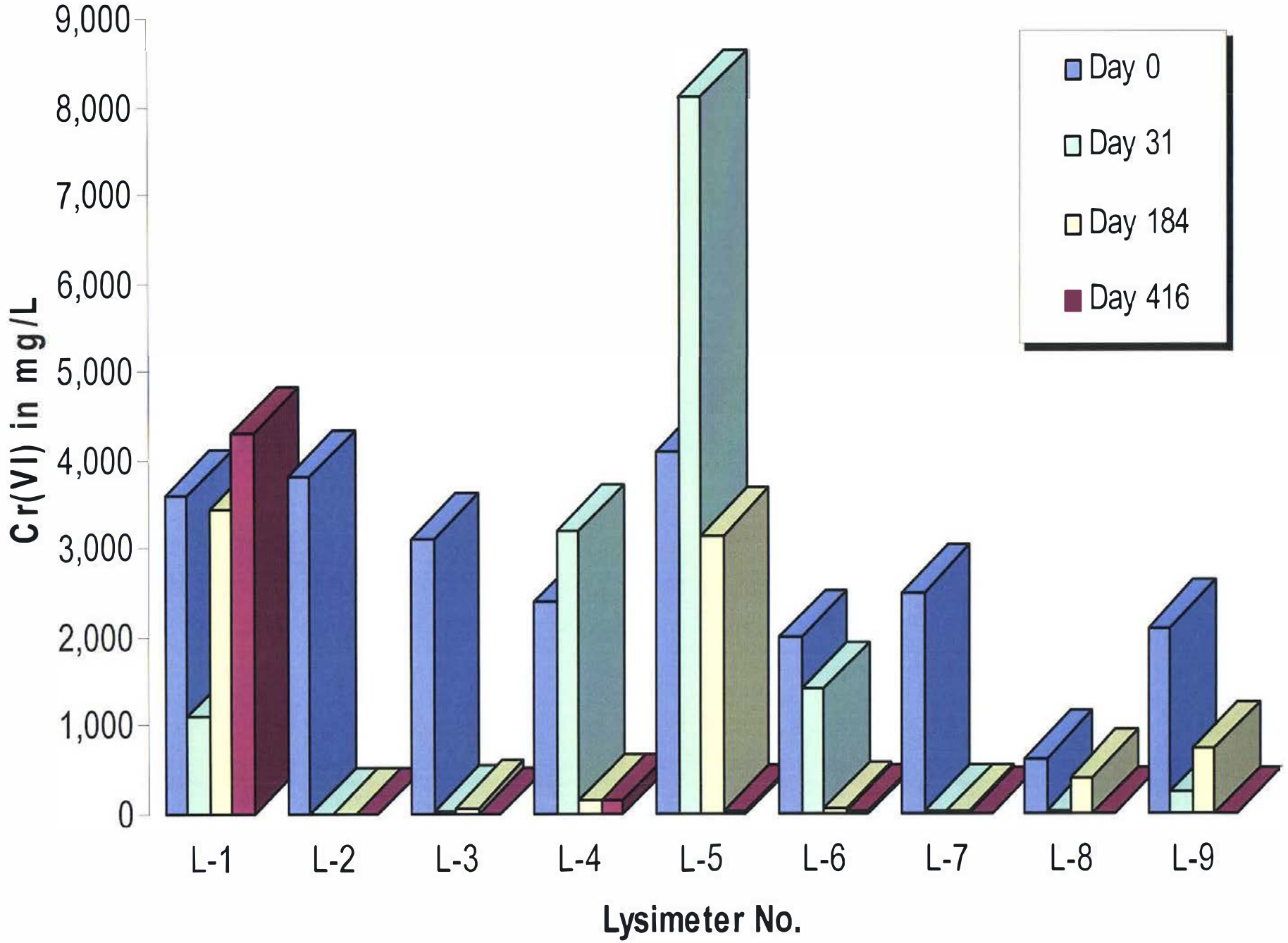

1 2 3 4 5 6 7 8 9 10


L7
Day 1
L7
Day 0
L8
Day 1
L8
Day 0
L9
Day 1
L9
Day 0

Full-Scale Remediation Summary

- 7 areas totaling 3,500 sq. ft.
- 9,000 gal of CaSx, 45,000 gal water applied.
- Continued monitoring of lysimeter points.
- In-situ monitoring of groundwater beneath the Plating Shop for ORP and pH.

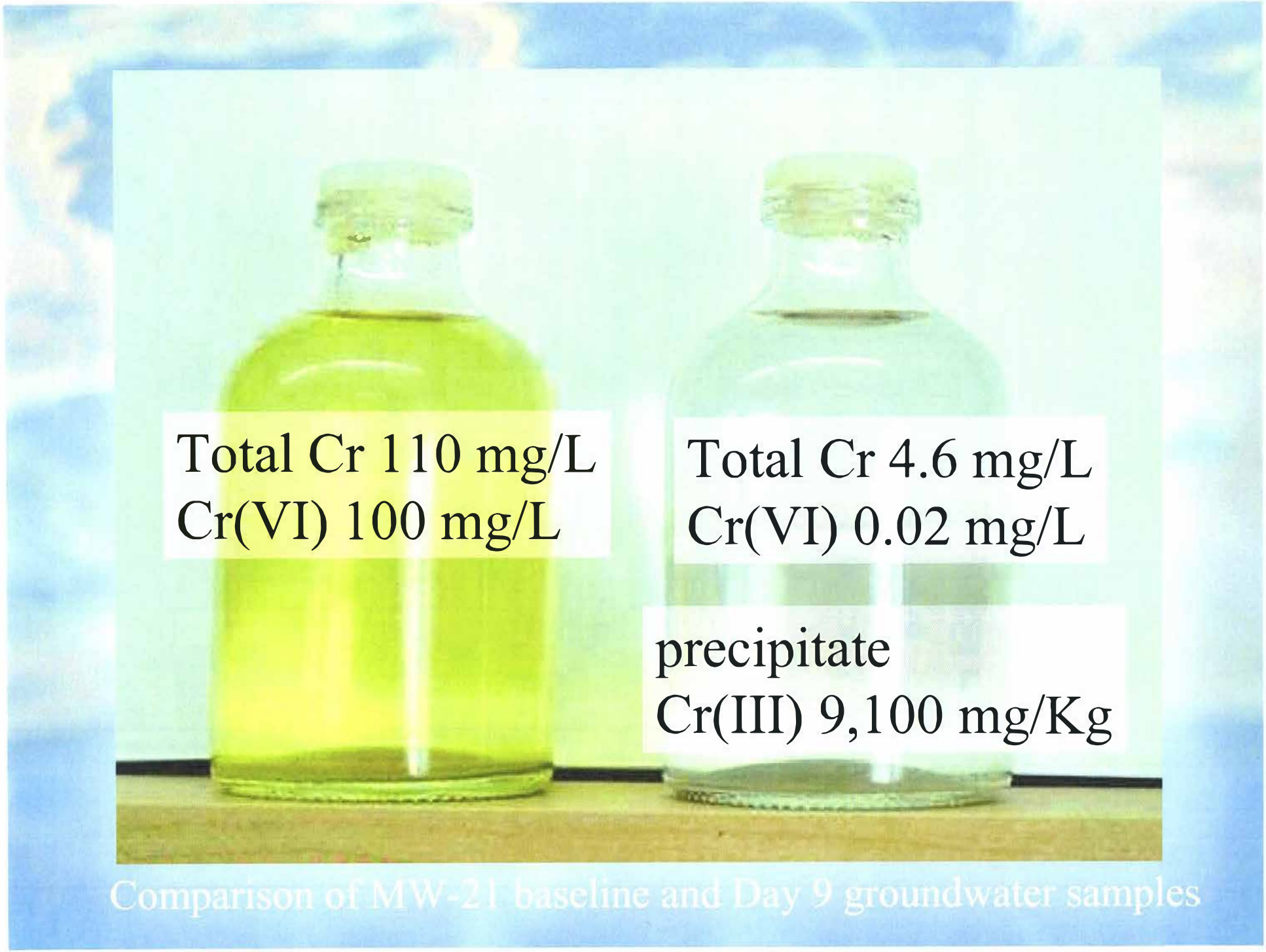

SPILL GUARD
1-800-743-7745


9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Cr(VI) in mg/L
Day 0
Day 31
Day 184
Day 416
L-1
L-2
L-3
L-4
L-5
L-6
L-7
L-8
L-9
Lysimeter No.

$$2\ CrO_4^{2-} + 3\ CaS_5 + 10H^+ \longrightarrow 2\ Cr(OH)_{3(s)} + 15\ S_{(s)} + 3Ca^{2+} + 2H_2O$$

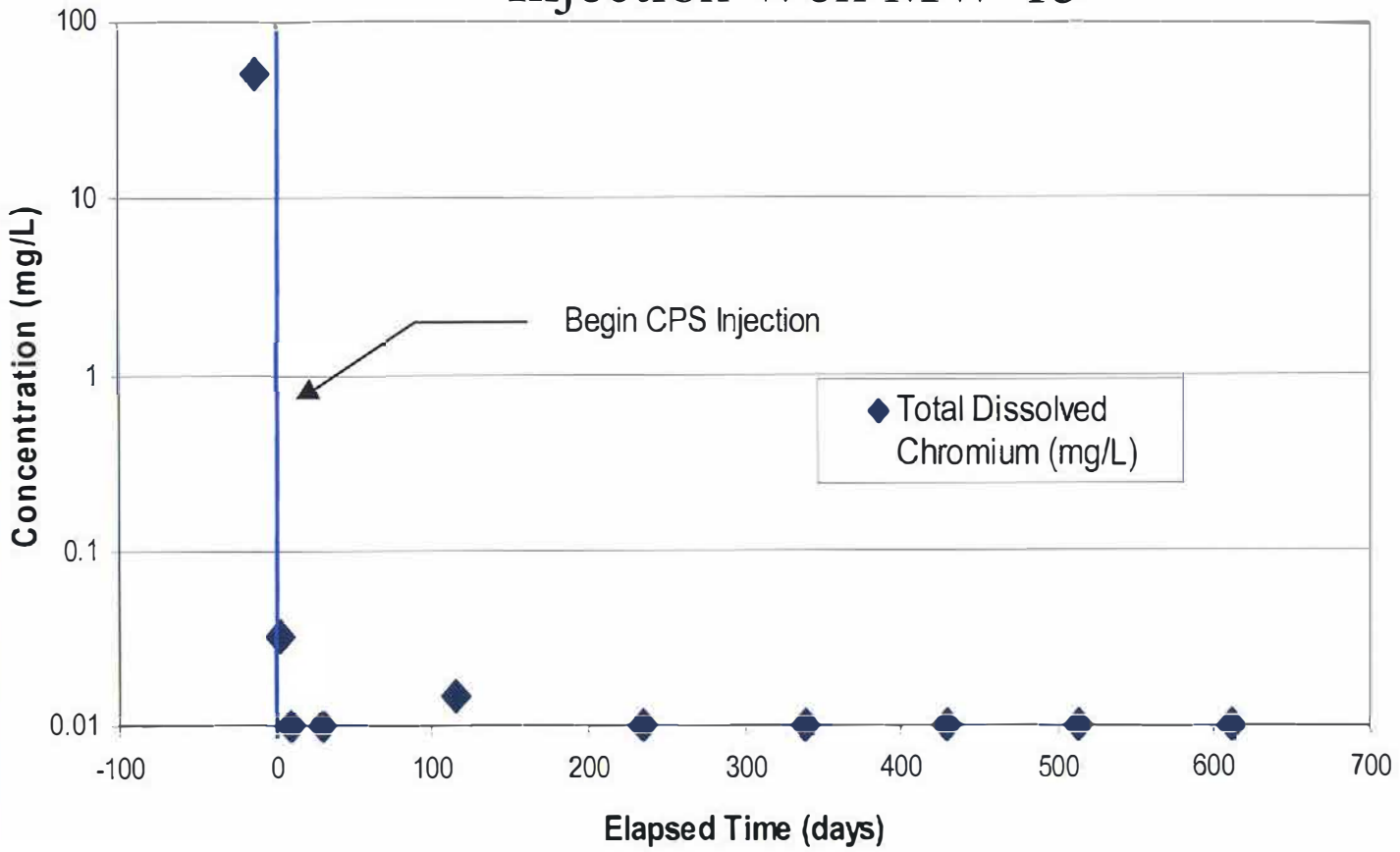
Groundwater Pilot Test

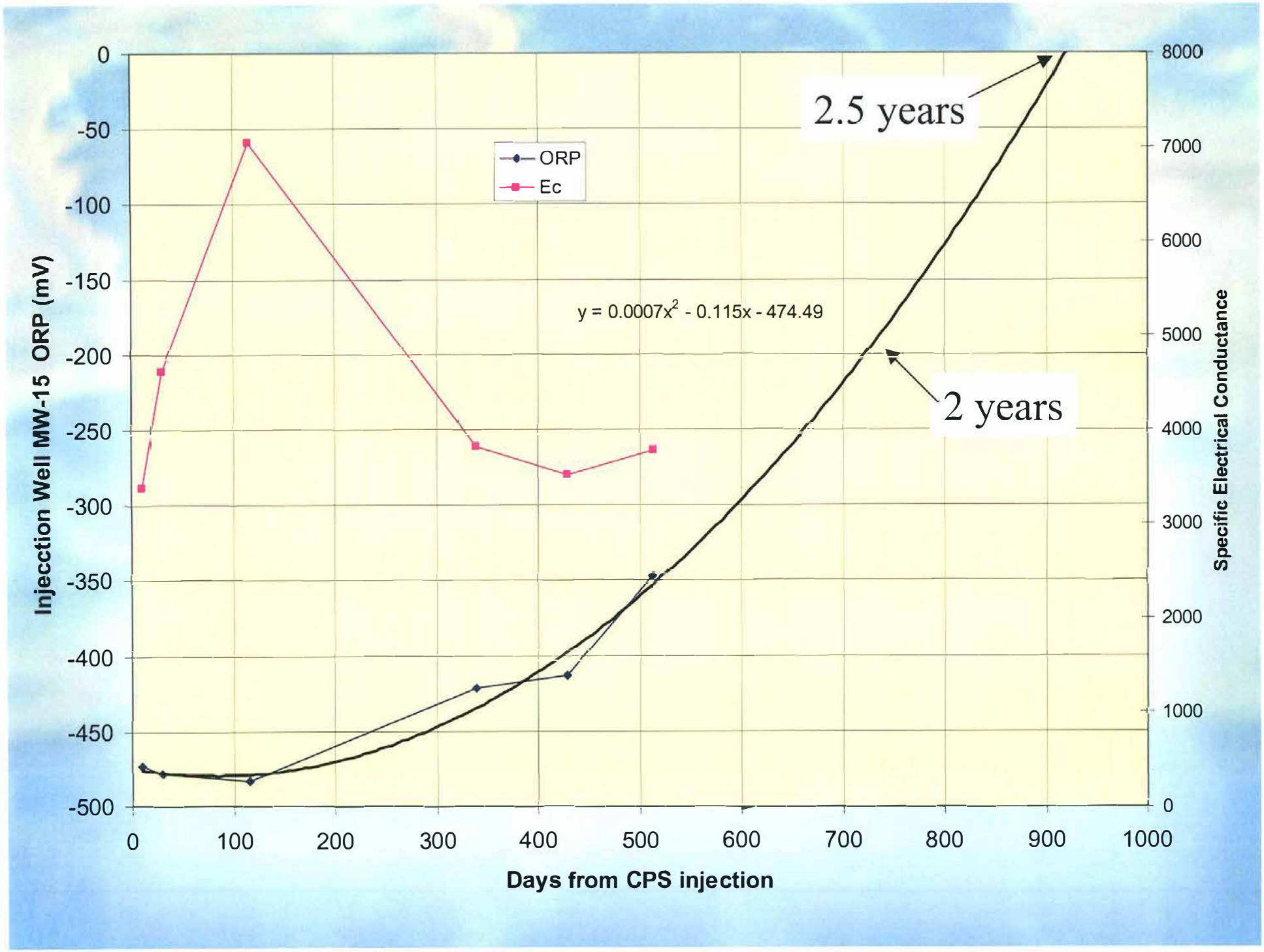
Metal Plating Shop, Arizona

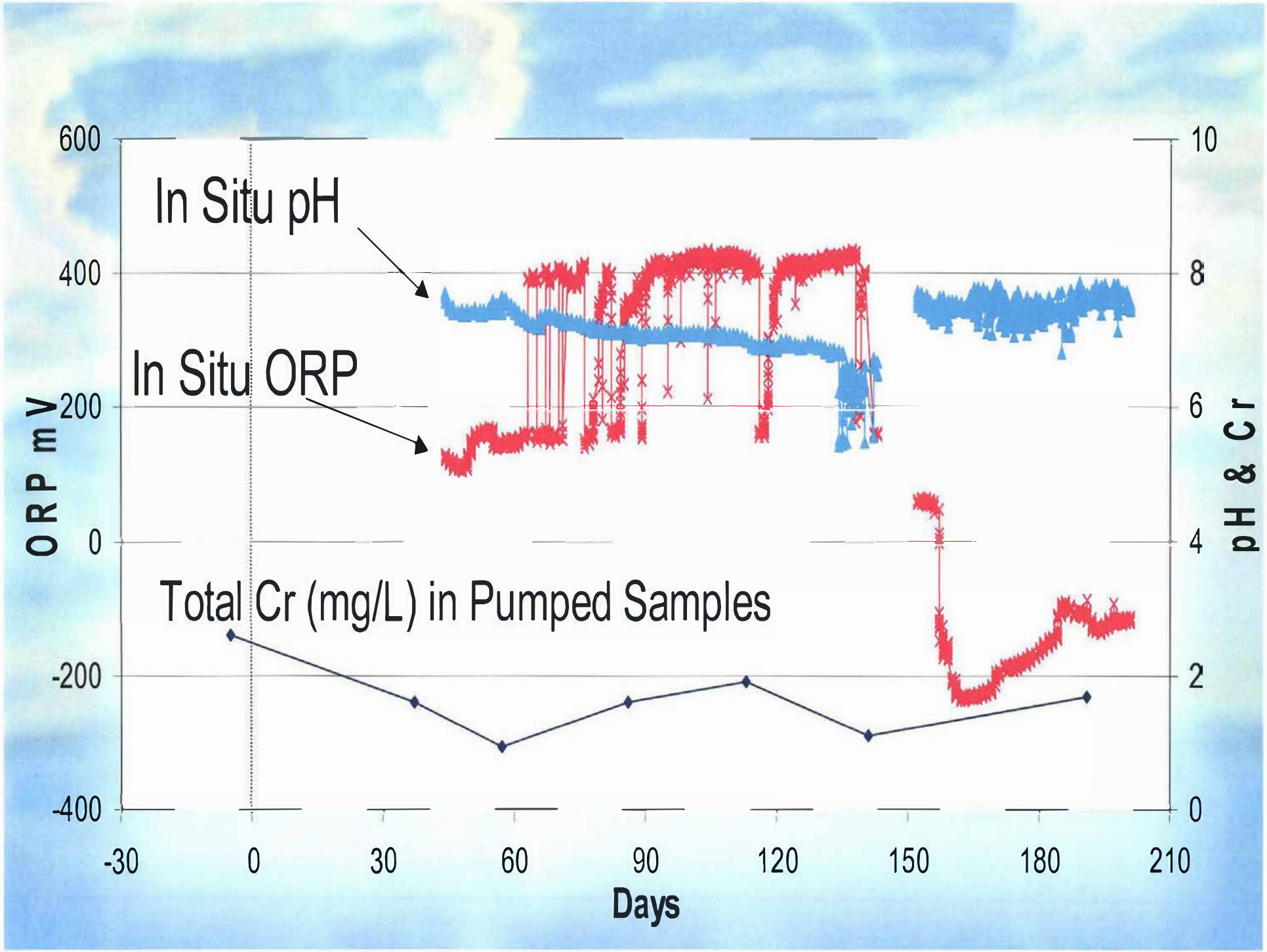


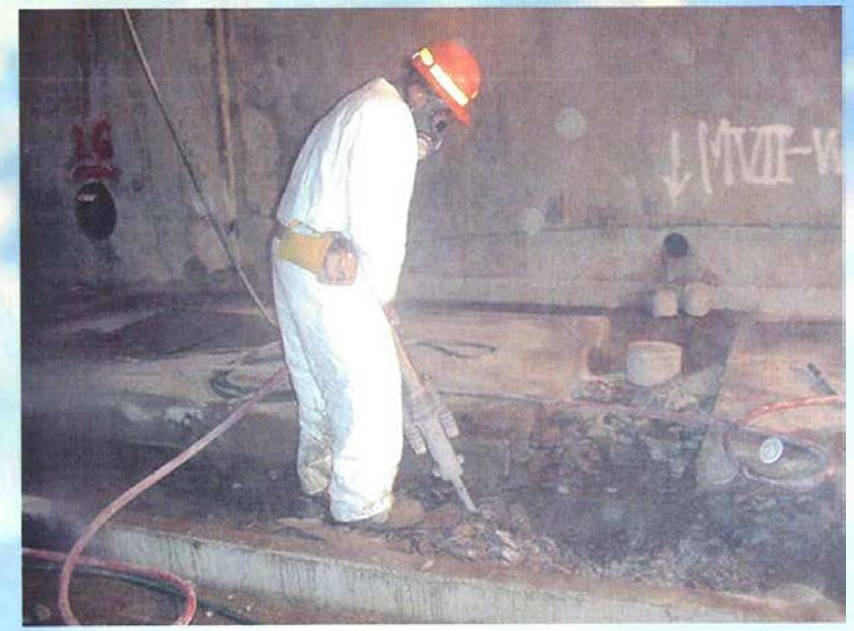
Comparison of MW-21 baseline and Day 9 groundwater samples

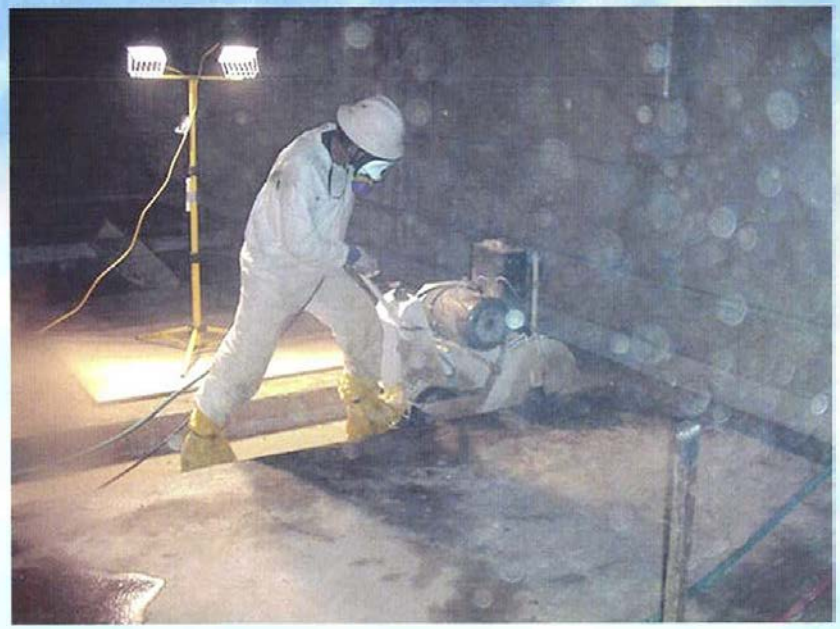
Impact of CPS on Chromium Injection Well MW-15




2.5 years
2 years
ORP
Ec
y = 0.0007x2 - 0.115x - 474.49
Injecction Well MW-15 ORP (mV)
Specific Electrical Conductance
Days from CPS injection
0
-50
-100
-150
-200
-250
-300
-350
-400
-450
-500
8000
7000
6000
5000
4000
3000
2000
1000
0
0
100
200
300
400
500
600
700
800
900
1000


In Situ pH
In Situ ORP
Total Cr (mg/L) in Pumped Samples
600
400
200
0
-200
-400
ORP mV
10
8
6
4
2
0
pH & Cr
-30
0
30
60
90
120
150
180
210
Days





Conclusions

1. Mining sites require a practical approach to minimize cost – insitu geochemical fixation (IGF).
2. IGF is a well-developed technology.
3. CaSx is the reagent of choice because it addresses major contaminants.
4. CaSx creates a persistent reducing zone in the subsurface.
5. No detrimental impact to the environment and public health and safety observed.