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Guaranteed Business Solutions

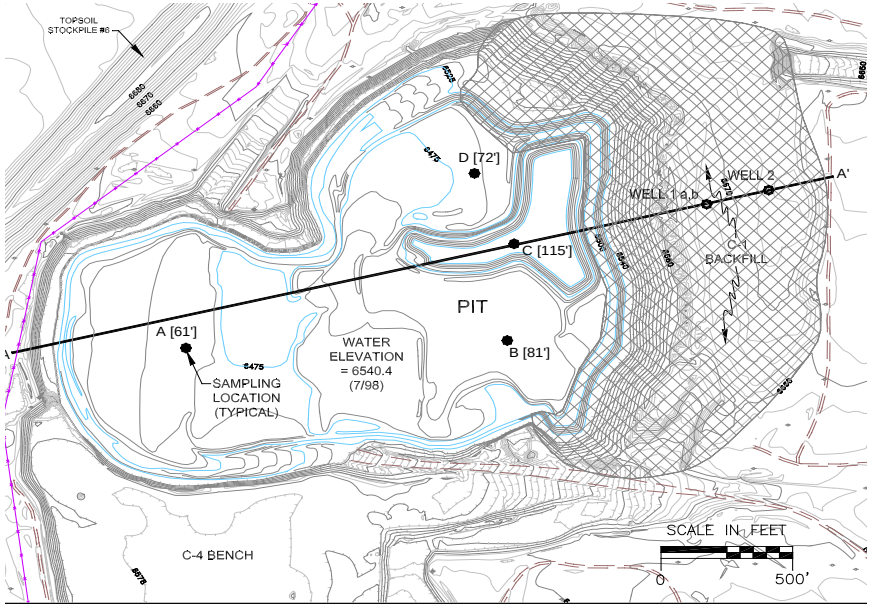
ARCADIS Technology

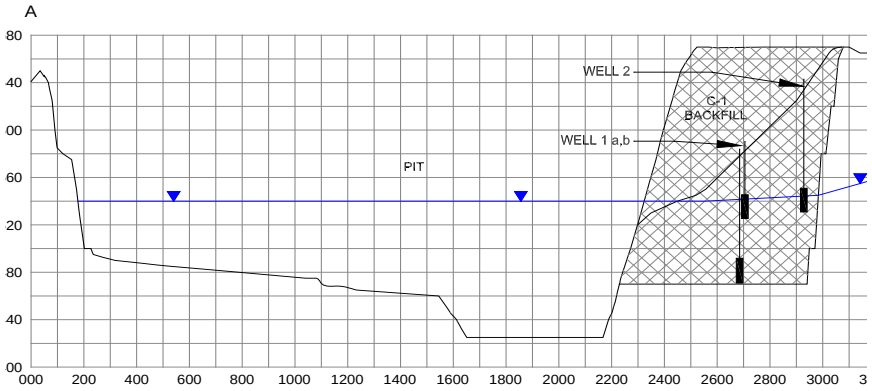
- US Pat. 5,632,715 Immobilization of heavy metals in waste stacks/zones
- `` 5,710,361 Immobilization in earth materials (CIP of `715)
- `` 6,196,765 Inhibiting AMD by displacing oxygen in rock heaps (includes underground workings)
- `` 6,350,380 In Situ Treatment of pit lakes
- `` 5,554,290 In Situ Reactive Zones

Metals Patents (‘361 & ‘715)

- Claimed process is one action step:
  - **Add a microbial nutrient**
  - Can be conveyed in a treatment liquid
    - Either percolated, injected, pooled
  - Can be conveyed in a waste liquid
    - Such as a tailings deposition line, recirculated waste water or land application disposal
  - Must be at a concentration and in a form that stimulates bacteria to generate microbial sulfides, which reacts with a metal to form MeS, and inhibits one or more (same or other) metals’ migration.
- Microbial nutrient not limited to carbohydrates, and sulfate is not required to be added

Sweetwater Uranium Mine Pit Lake





- 1.3 billion gallons contained in 60 acre pit lake
- 0.3 billion gallons contained in backfill zone
- 16 years filling (1983)
- Regional groundwater sink
- Regulated under WY livestock/wildlife standards

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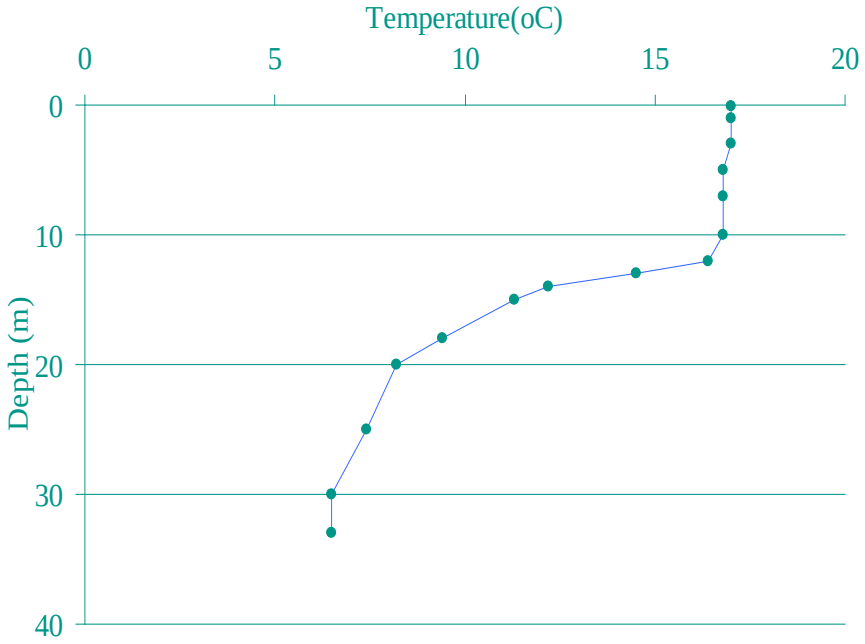
Remediation Objectives

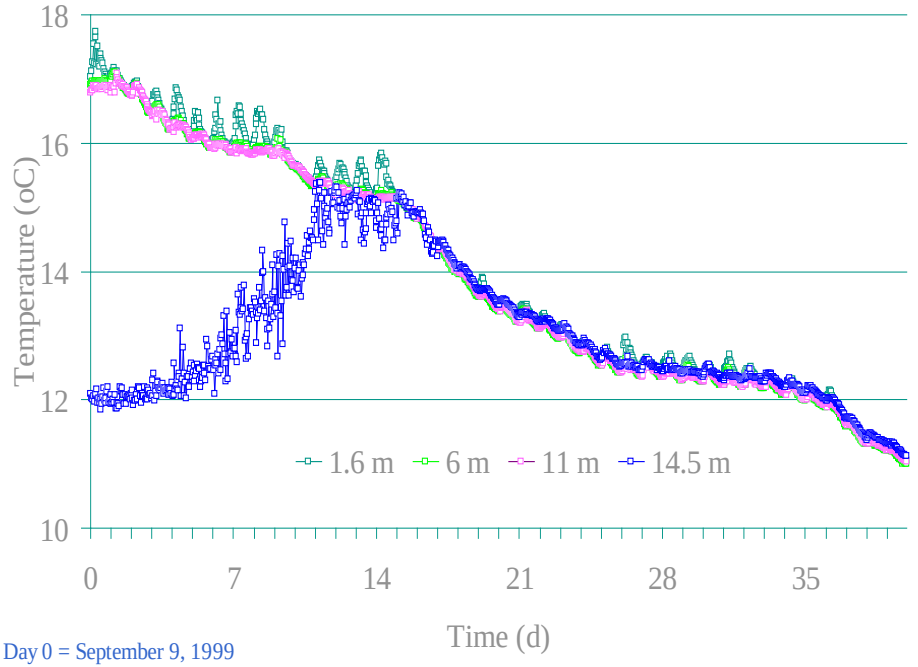
- **Selenium**
  - **453 ppb vs site standard 50 ppb**
  - **98% selenate ($HSeO_3^-$)**
- **Uranium**
  - **8.4 mg/L vs. site standard 5 mg/L**
  - **U^{6+} (UO_2^{2-}) carbonate species**
- **Stable ecosystem**

Monitoring

- In Situ
  - pH
  - temperature
  - redox
  - dissolved oxygen
- Water quality
  - selenium, uranium, TOC
  - nitrate, sulfate, bicarbonate, iron, and manganese

Limnology: Lake Mixing





Day 0 = September 9, 1999

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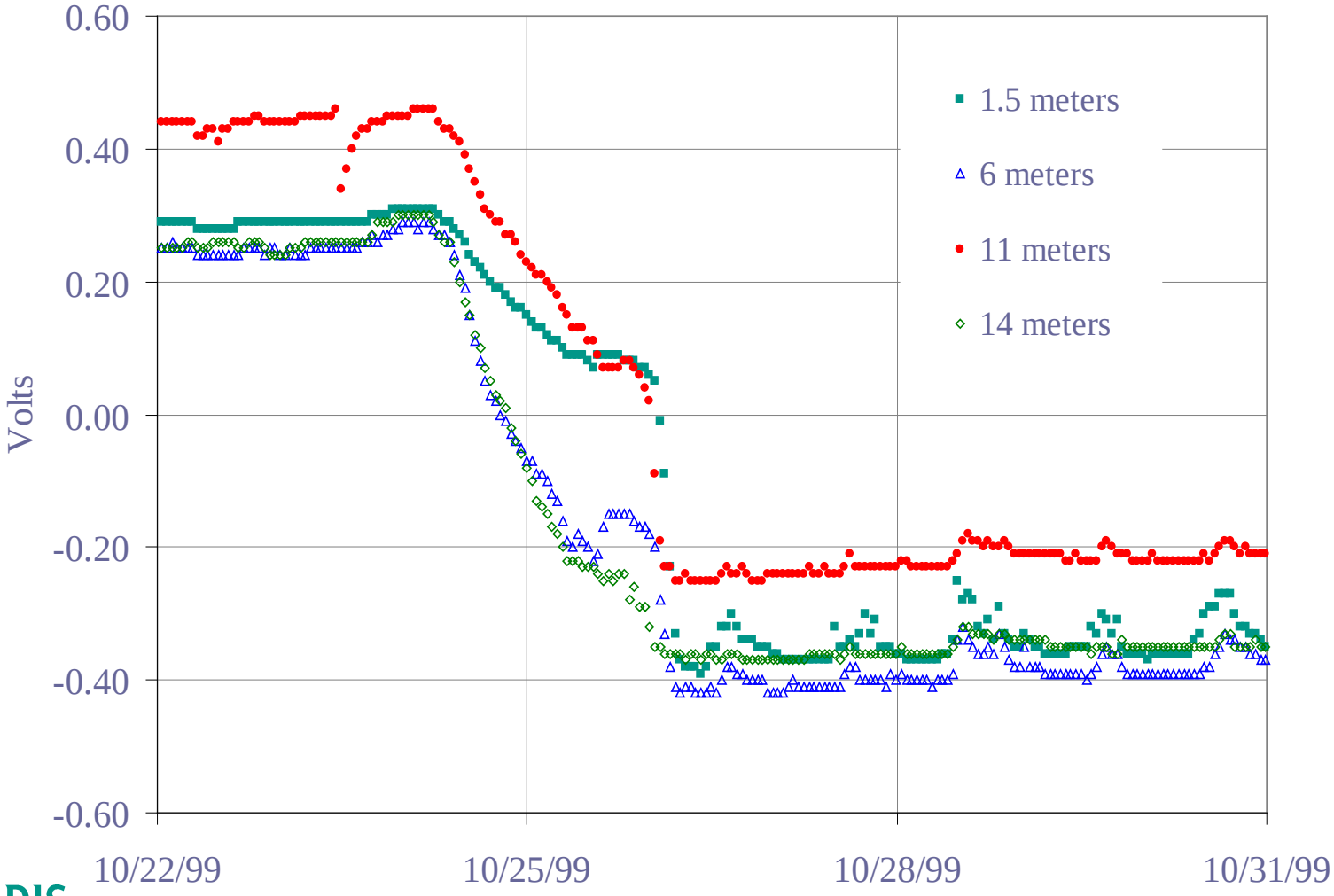
Treatment: October 19-23, 1999

Oxidation-Reduction Potential



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Pit Lake During Treatment

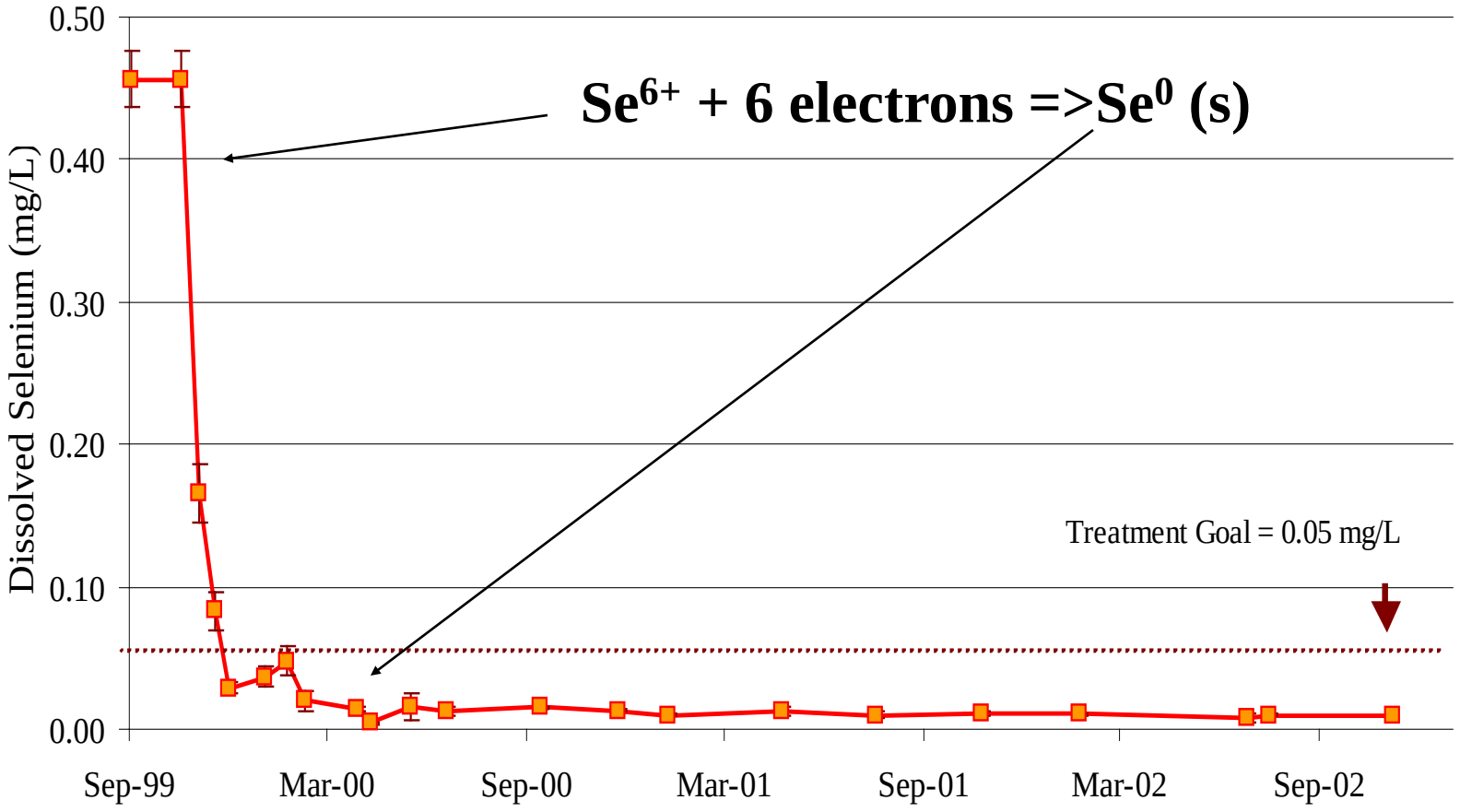
Denitrification (fine bubbling
Observed during week 1)

Reddish color/foam related to
selenium reduction (week 2)

Reddish color/foam related to
selenium reduction (week 3)

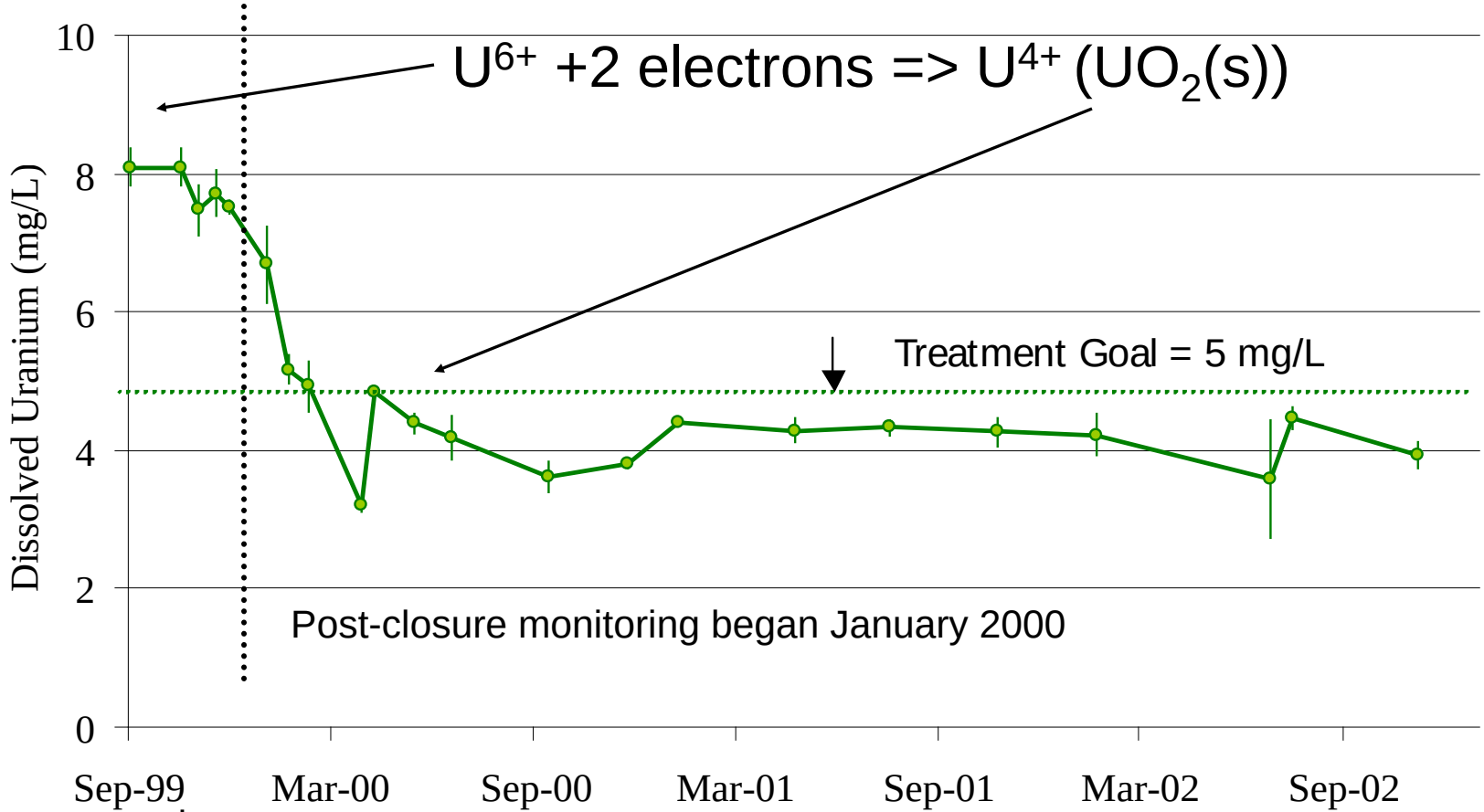
Lake tan to brown color
Uraninite precipitation (week 4)

Selenium Treatment Progress



Elemental Selenium Formation

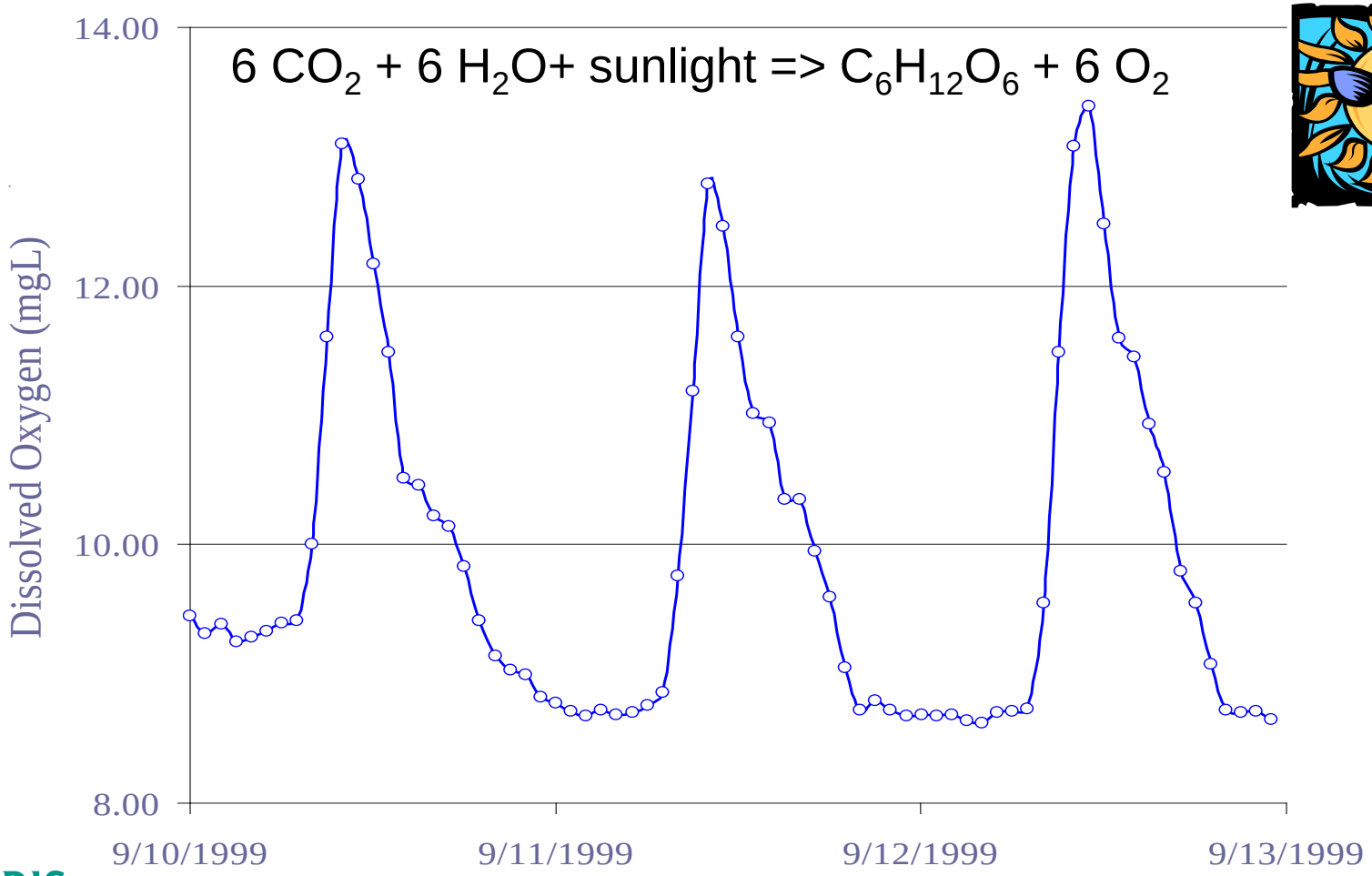
Pit Lake Uranium Results



Treatment phase:
10/99 to 1/00

Algae Organic Carbon Productivity

(Shown by Diurnal Fluctuations in Surface Water Dissolved O_2)



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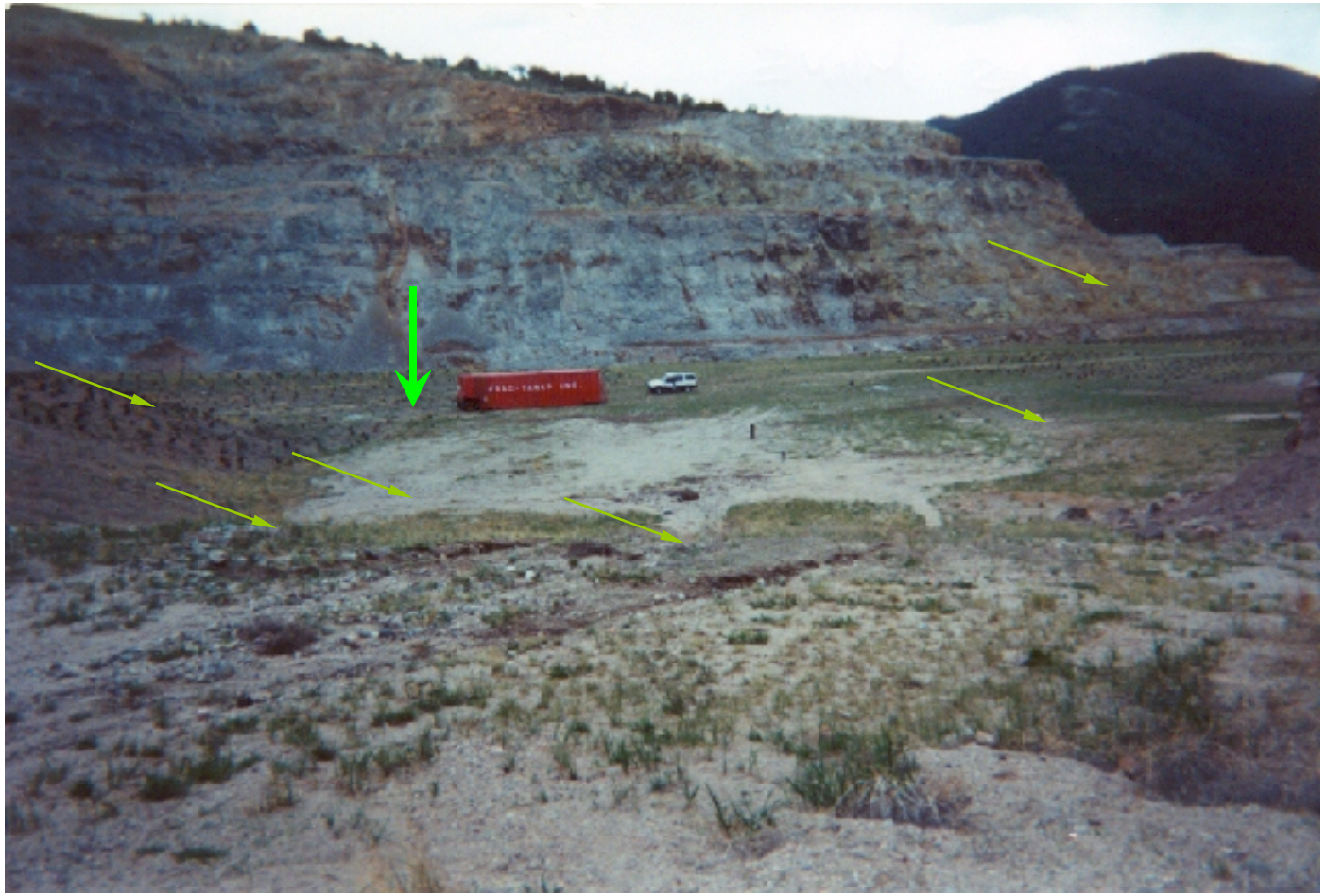
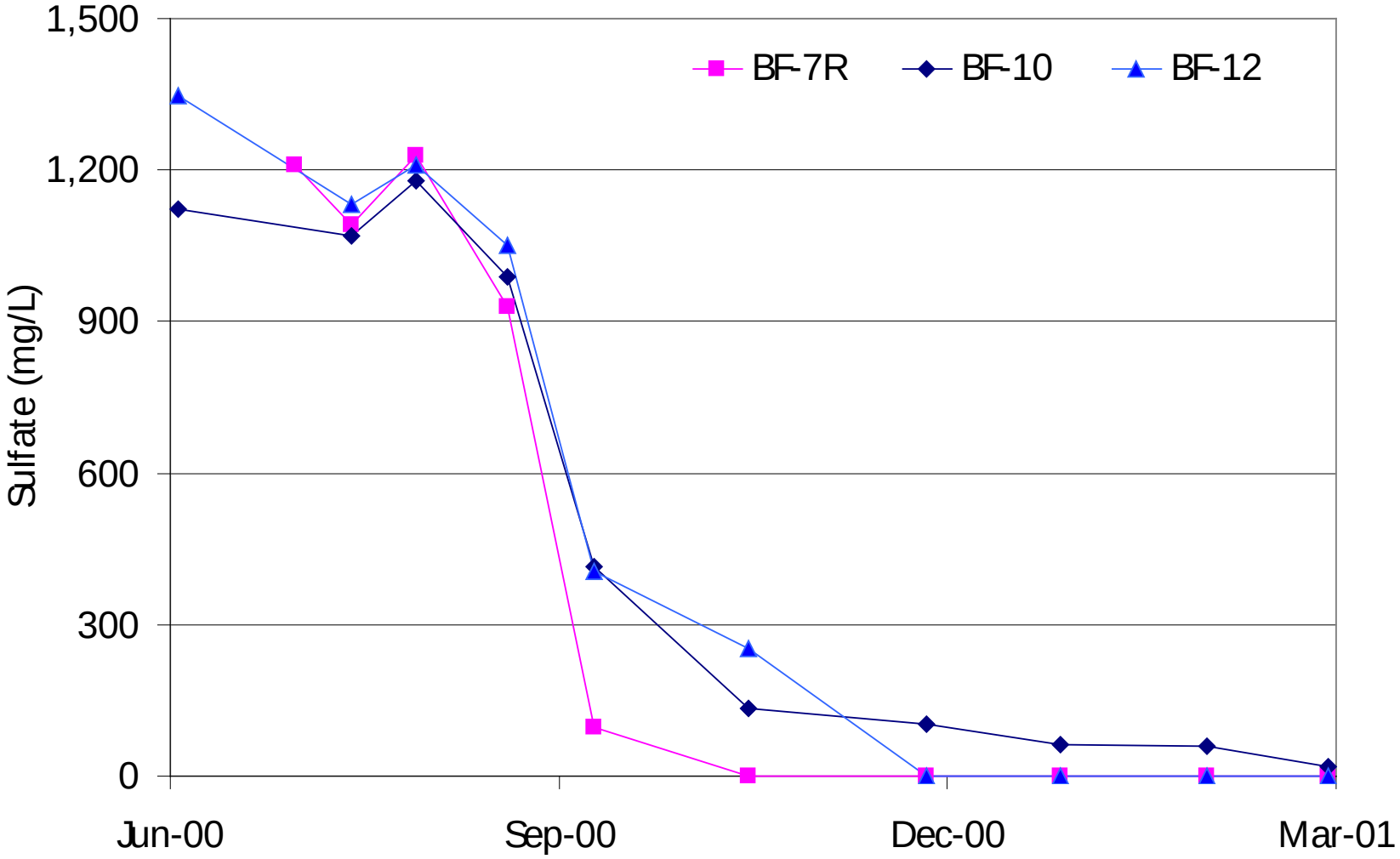
Newmont – San Luis Pit Backfill/G. W.



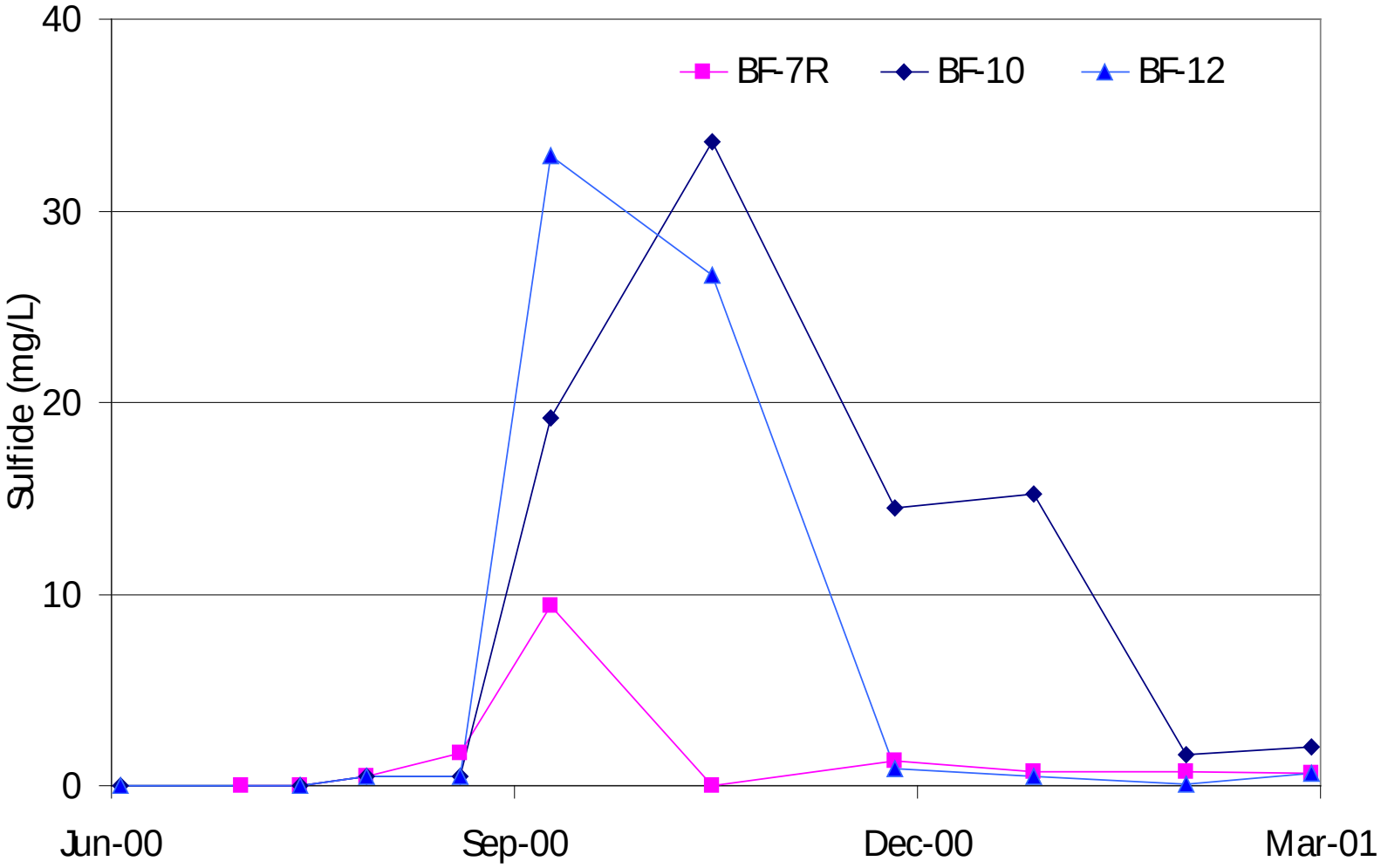
Sulfate and Metals Precipitation at San Luis

- In situ sulfate reduction began July 2000
- Sulfate removal from 1,500 to less than 250 was primary goal
- Iron was initially reductively dissolved by sulfide (initial iron concentration was less than 1 mg/L)
- Dissolved iron provided the metal with which sulfate was removed to a solid phase:
  - $Fe^{2+} + HS^{-} \rightarrow FeS\downarrow + H^{+}$

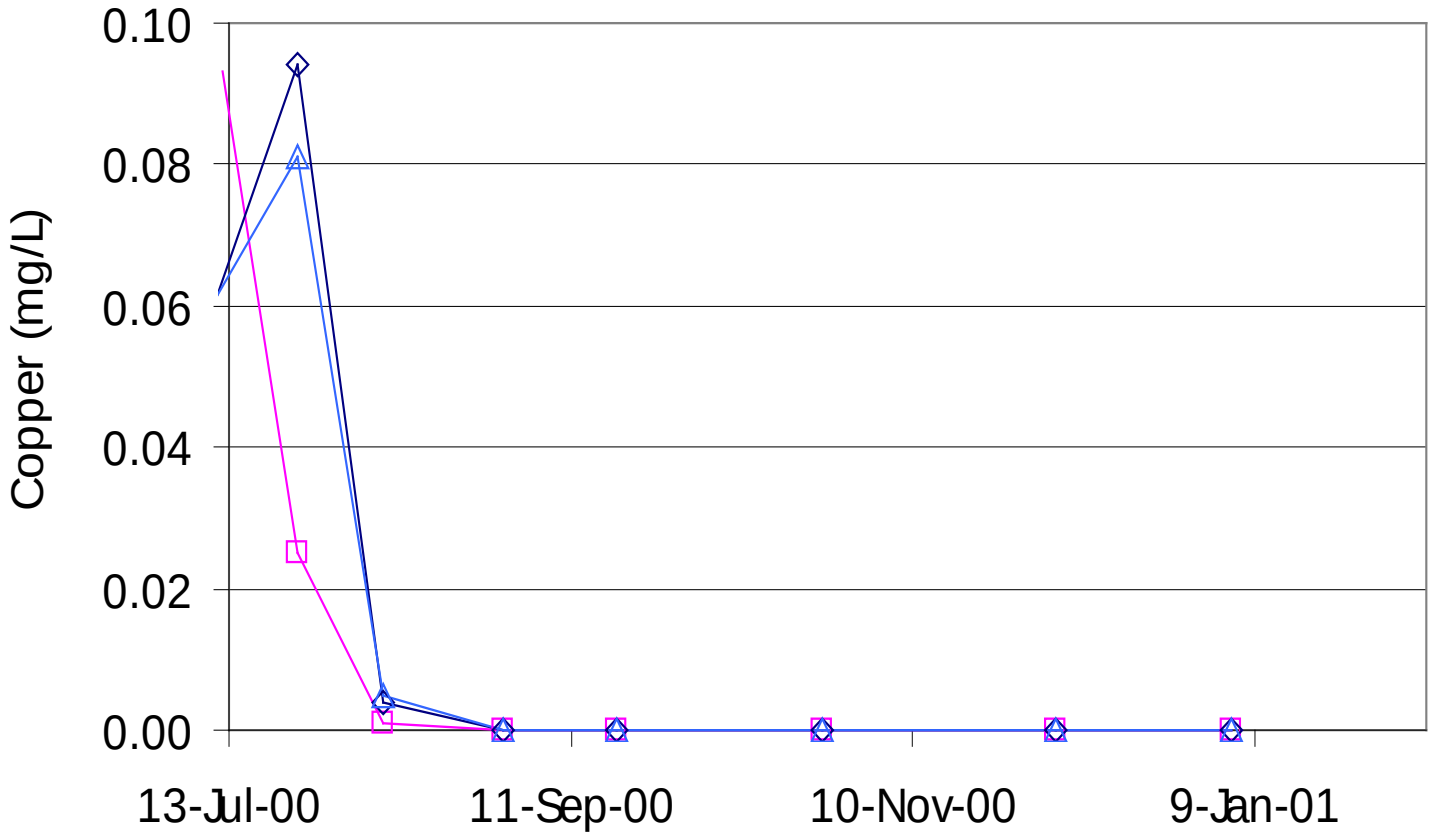
Sulfate Reduction



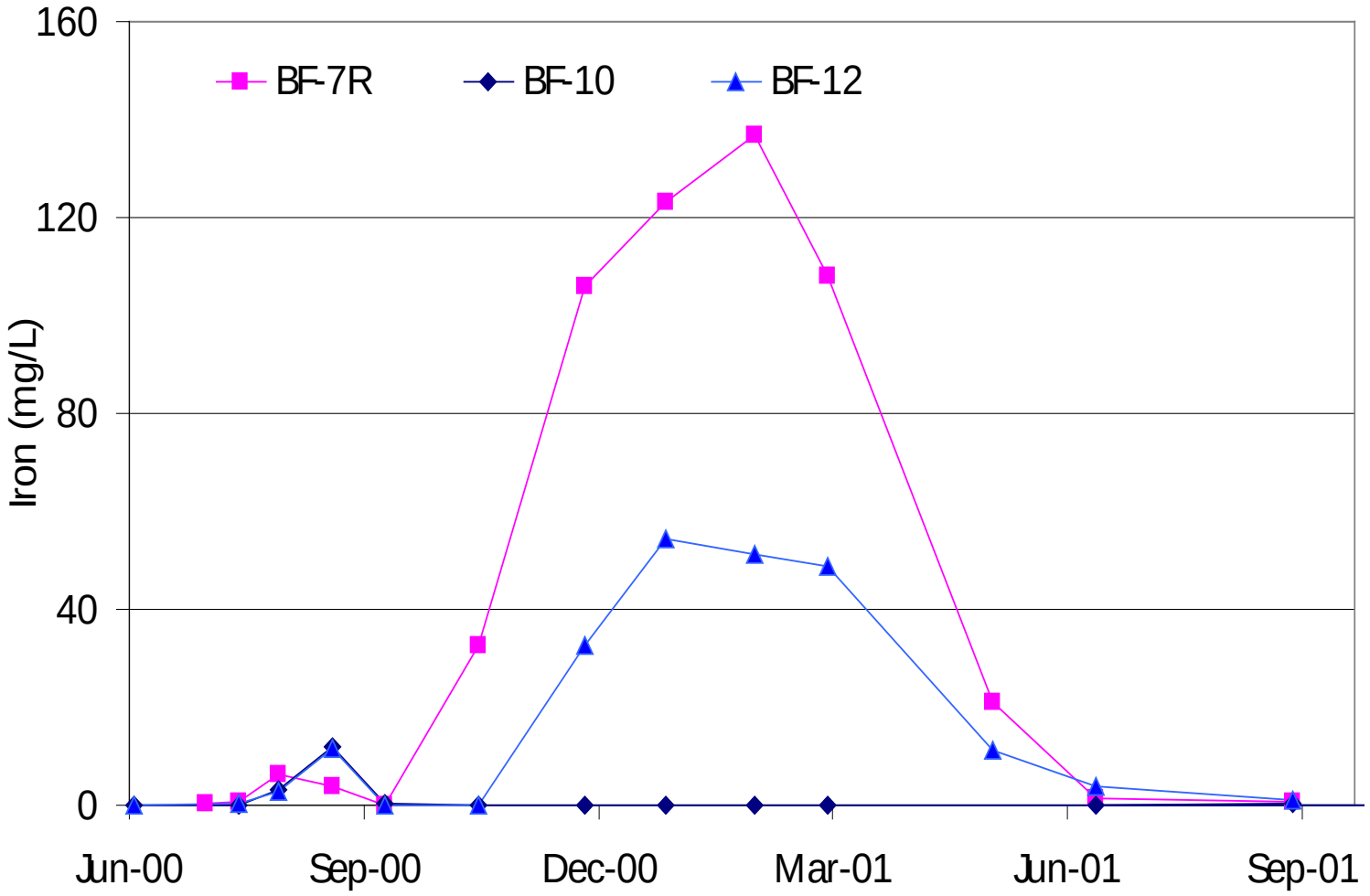
Production of Sulfide



Precipitation of Copper



Iron: Reductive Dissolution and Re-Precipitation

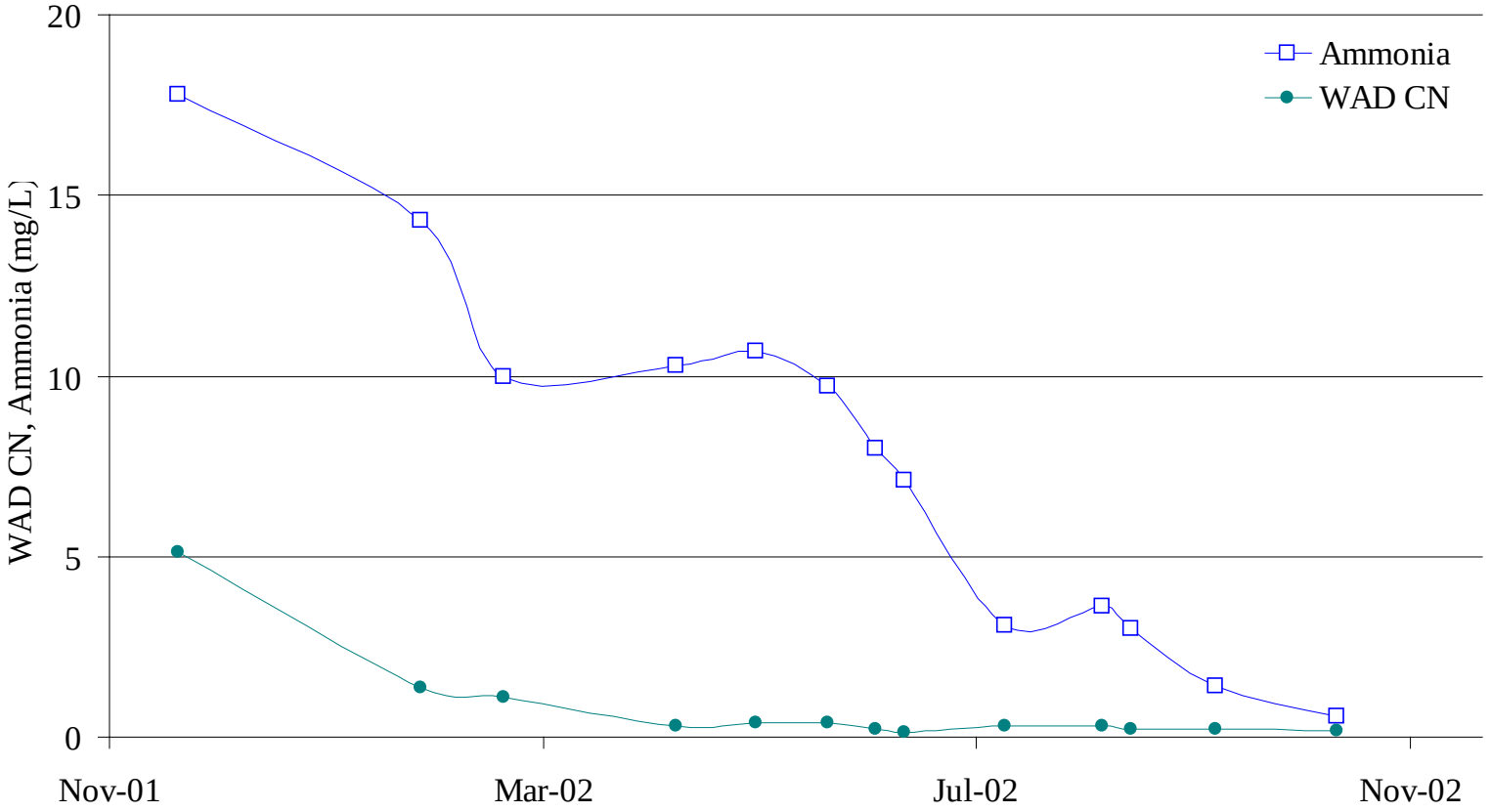


Brewery Creek Heap Treatment

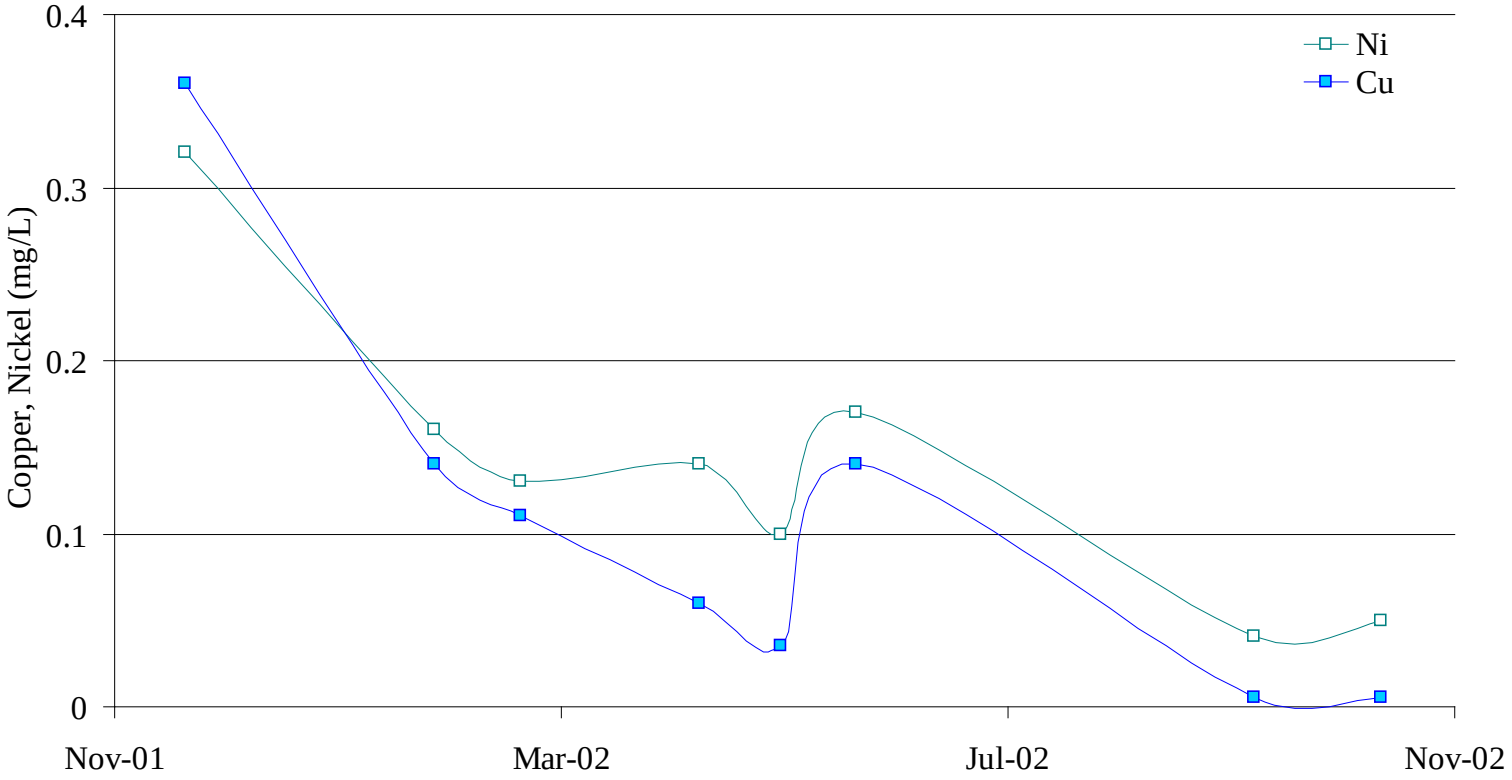
- Cyanide additions to the 9MM ton heap leach occurred from 1997 – 12/01
- Nutrient phosphate was added upon leach cessation to enhance native organisms to couple ammonia oxidation to metals reduction and biomass formation
- Bioreductants were then added throughout the summer 2002 to further reduce metals in microenvironments and these precipitated metals were encapsulated within the heap
- Water quality attained Water License land application standards in late summer – 2002 and 50,000 m^3 were discharged to surface

Biomass Formation

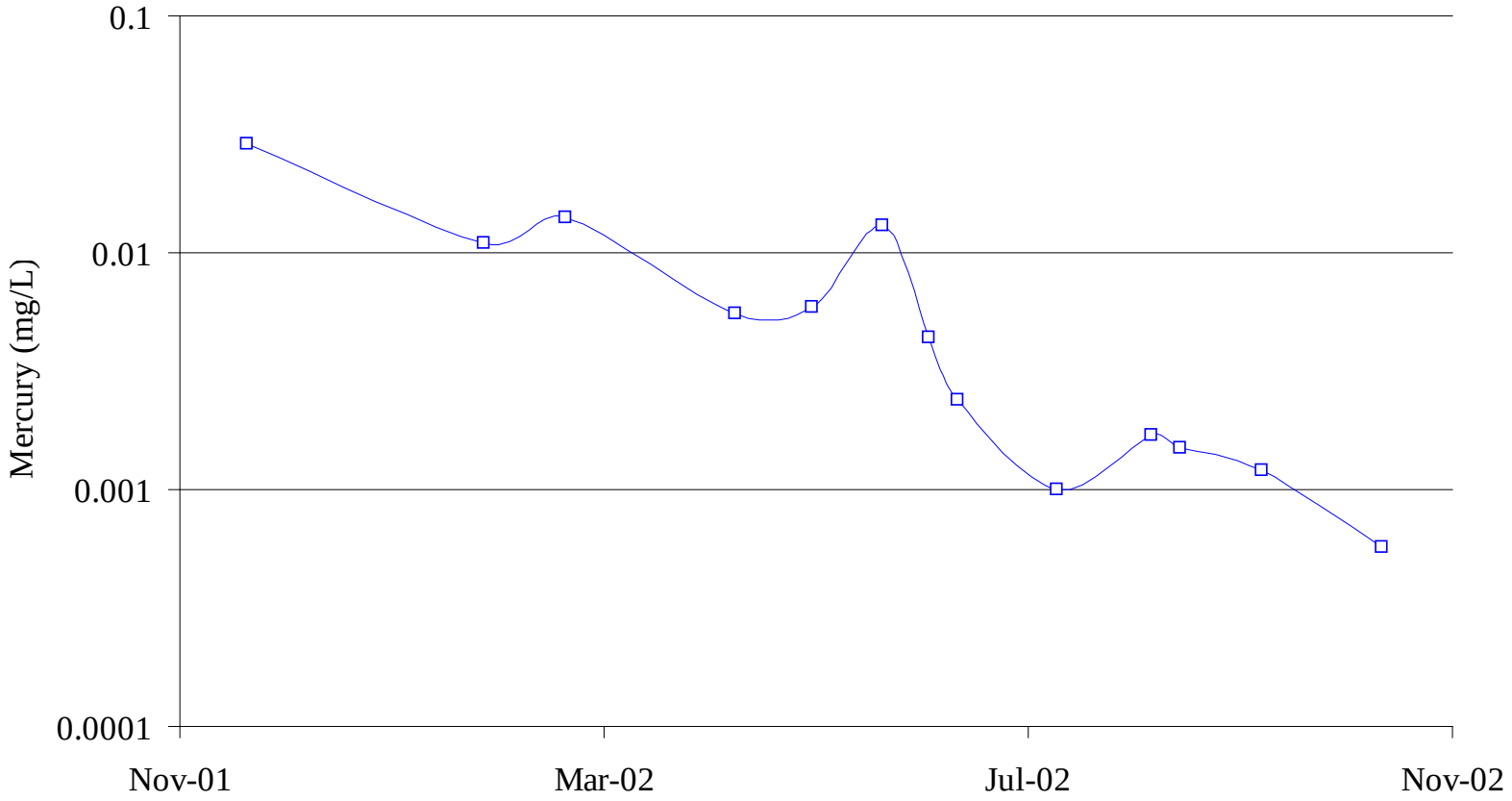
Cyanide and Ammonia



Copper and Nickel



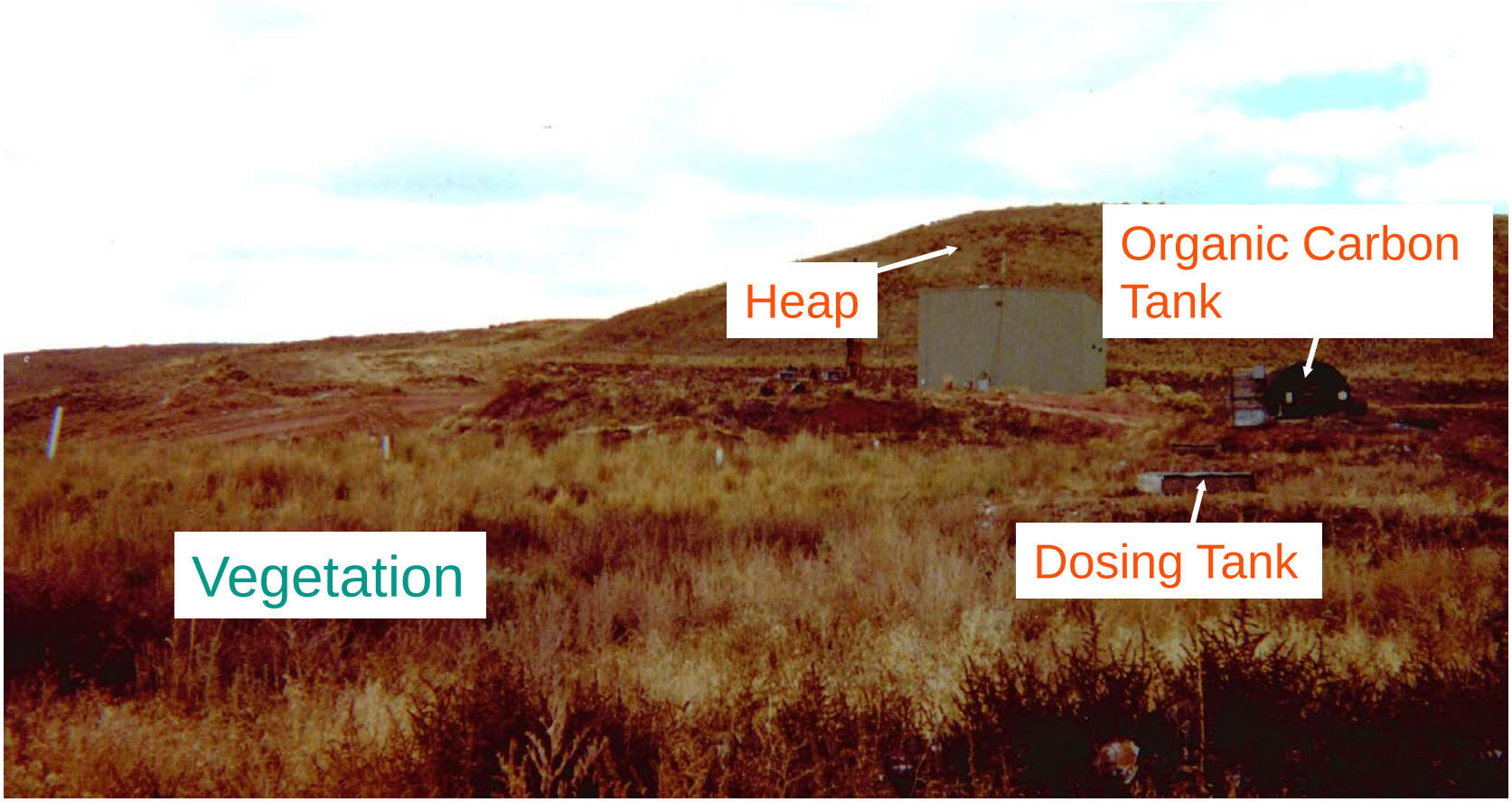
Mercury



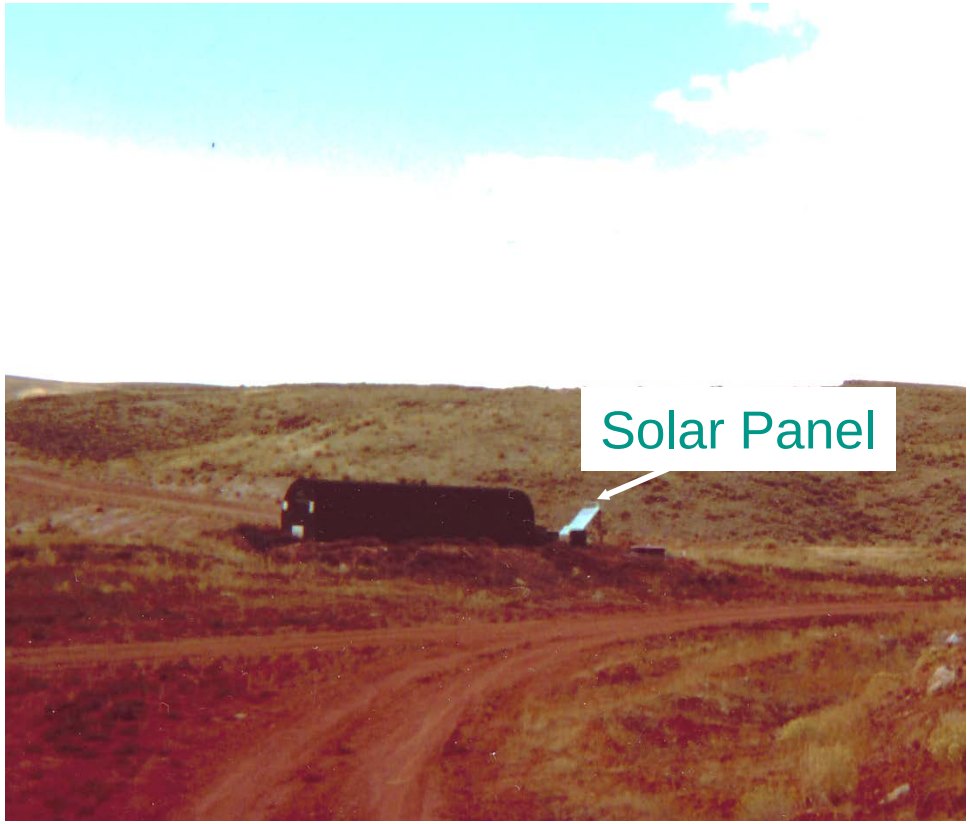
Bioreduction in Infiltration Field

Newmont Hollister Mine, Leach Pad Drainage Treatment

Infiltration Field Development



Automated Dosing Detail



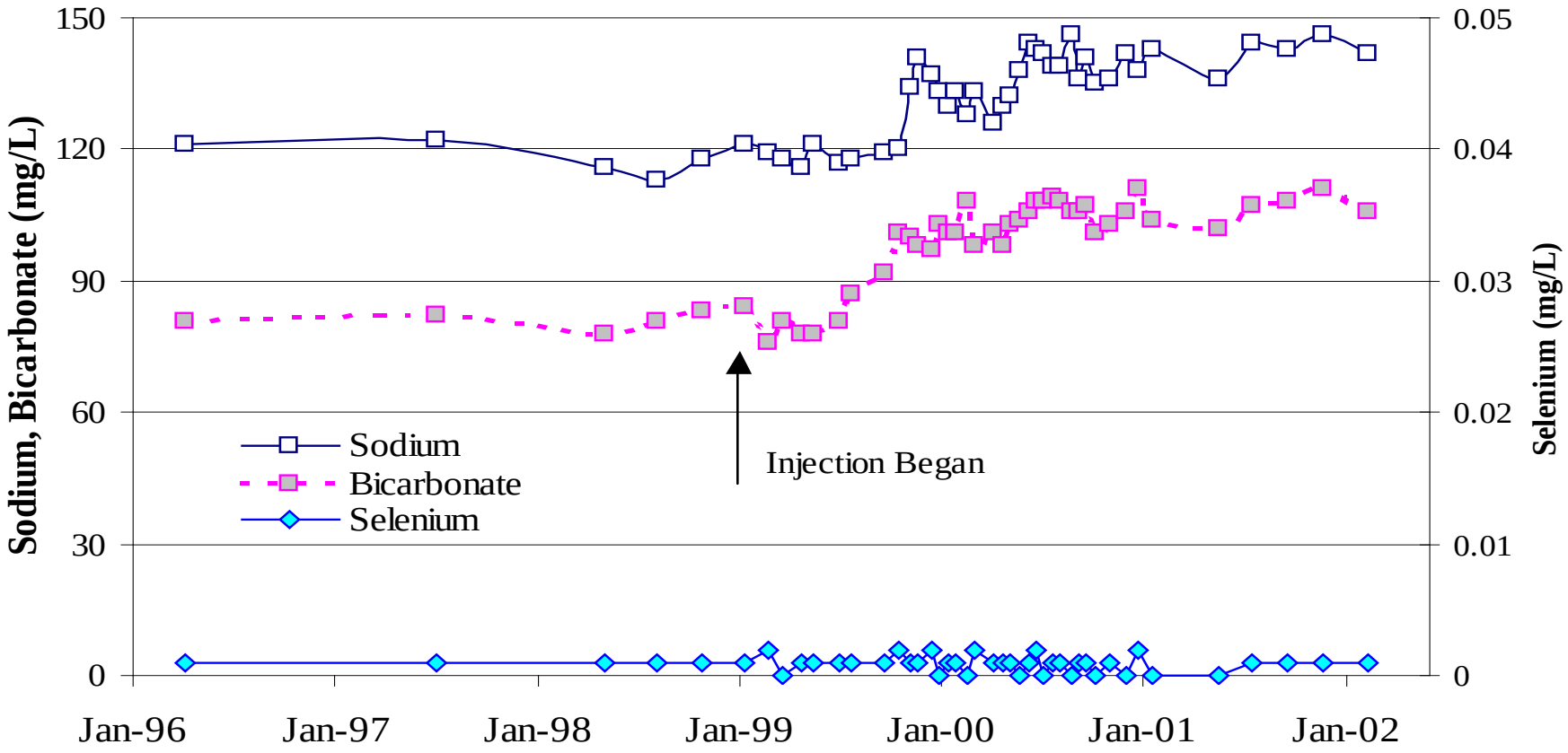
- 8,000 gallon alcohol tank
- All dosing systems battery operated
- Battery recharged by solar energy
- Tank refilled once per 3-5 years

Leachate Disposal Injection Technology

- Drainage from gold heap leach treated by adding organic carbon and infiltration into a leach field.
- This leach field has successfully disposed of the heap drainage at 10 gpm for 4 years without impact to GW.
- Samples taken 40 feet below the infiltration field indicate no impact of constituents of concern to waters of the State of Nevada.

Species	Heap	40’ below leach field
WAD CN	0.34	0.01
Nitrate	110	4.59
Selenium	1.08	0.032
Arsenic	0.21	0.03
TDS	1660	1360
Sulfate	745	419
Iron	0.2	0.02
Bicarbonate	14.2	456
pH	8.8	8.2

Groundwater Monitoring Results



ARCADIS Sites & Experience

- 130 Sites across US and Europe creating sulfate-reducing conditions in situ
- Species treated include divalent metals, sulfate analogs, radionuclides (U, Tc, Po, Pu), Chlorinated solvents (TCE, PCE, 1,2 cis DCE, CT)
- Subsequent encapsulation in iron sulfide matrix can prevent mobilization of arsenic, uranium and amphoteric species that are unstable in changing pH or [HS^-] conditions.
- ARCADIS places itself at risk and guarantees water quality improvements based on this extensive portfolio of experience, and can provide substantial financial assurance and bonding through the application of these cutting edge technologies for mine sites throughout North America