Electro-Biochemical Reactor (EBR) Technology Demonstrates Low Selenium Effluents in Hardrock Mining Wastewaters

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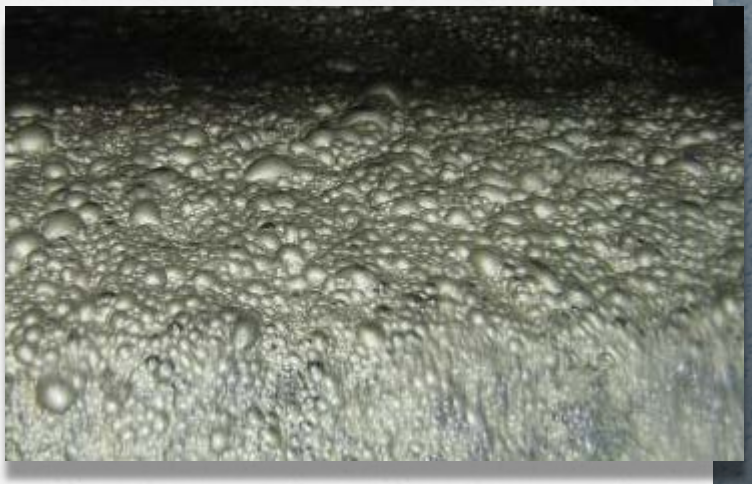
Problem Statement

- Underground mine in the Yukon, Canada, producing:
  - Zn, Cu, Pb, Ag, Au
- Comminution liberates the desired metals as well as contaminants, e.g., Se (typically at 2,000-6,000 µg/L in tailings waters).
- Recovery - floatation.
- Discharged to a tailings impoundment where tails are settled and water is re-circulated to the mill.



Problem Statement

- Positive water balance:
  - Excess water accumulates in the tailings impoundment
  - Needs to be treated and discharged according to the discharge standards
- Chemical precipitation methods and biological treatment approaches were examined:
  - Chemical methods ineffective at removing selenium to the required effluent discharge limit of 20 µg/L
  - A newly developed Electro-Biochemical Reactor (EBR) treatment system was evaluated starting in 2010

The Electro-Biochemical Reactor

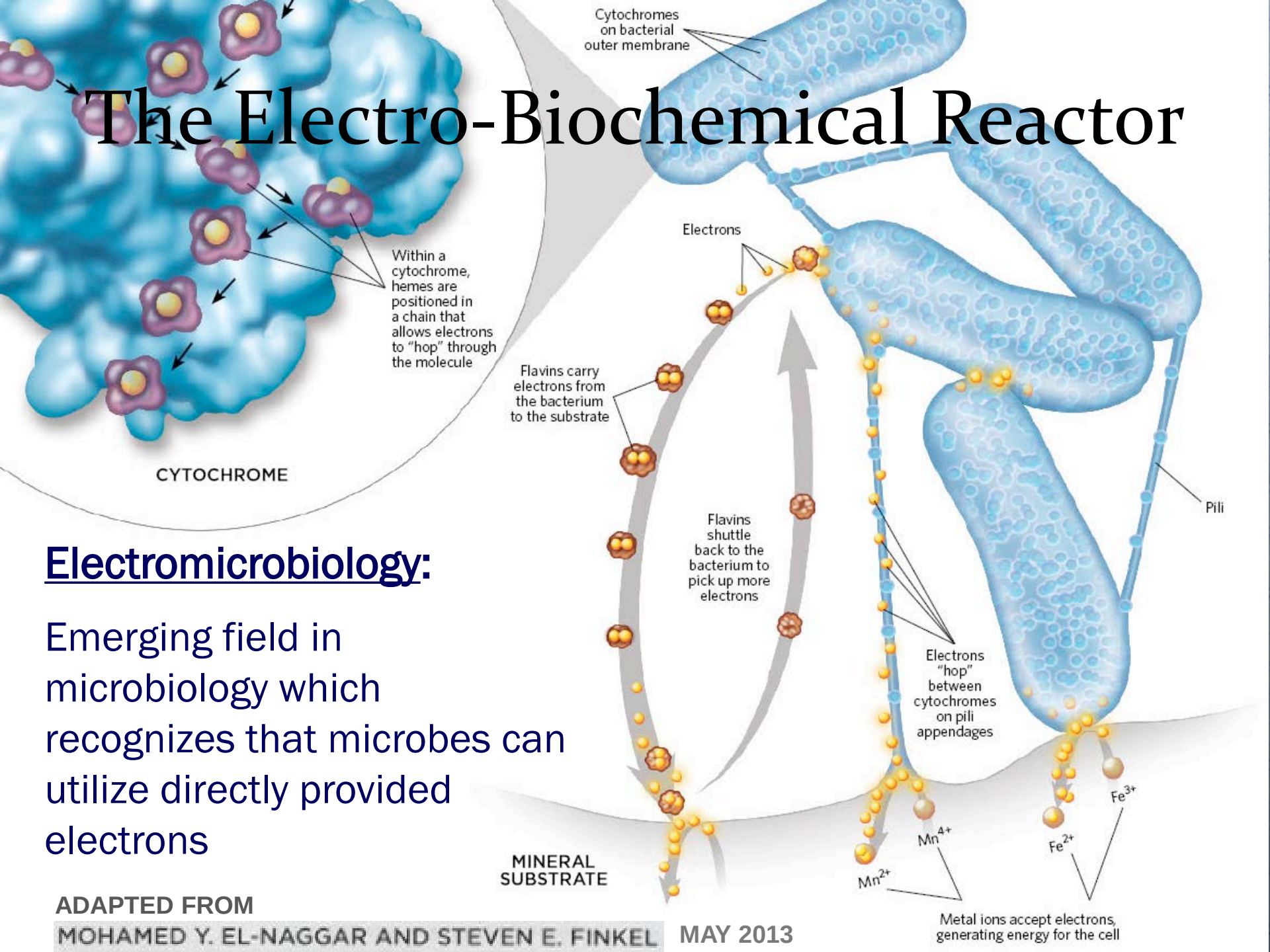
- Low voltage (1-3 Volts potential) provides:
  - Electrons and electron acceptor environments for controlled contaminant removal environment
  - Compensation for inefficient and fluctuating electron availability through nutrient metabolism
- 1 mA provides 6.24×10^{15} electrons/second
  - Replaces up to 2/3 of the nutrients/electron donors required, while producing lower contaminant concentrations
  - Produces much less TSS (bio-solids)
- As a comparison, other electrons donors (nutrients) provide electrons only under metabolism

Selenium Reduction

$SeO_4^{2-} + 3H^+ + \mathbf{2e^-} \leftrightarrow HSeO_3^- + H_2O$

$HSeO_3^- + 5H^+ + \mathbf{4e^-} \leftrightarrow Se_{(s)} + 3H_2O$

The Electro-Biochemical Reactor



Electromicrobiology:

Emerging field in microbiology which recognizes that microbes can utilize directly provided electrons

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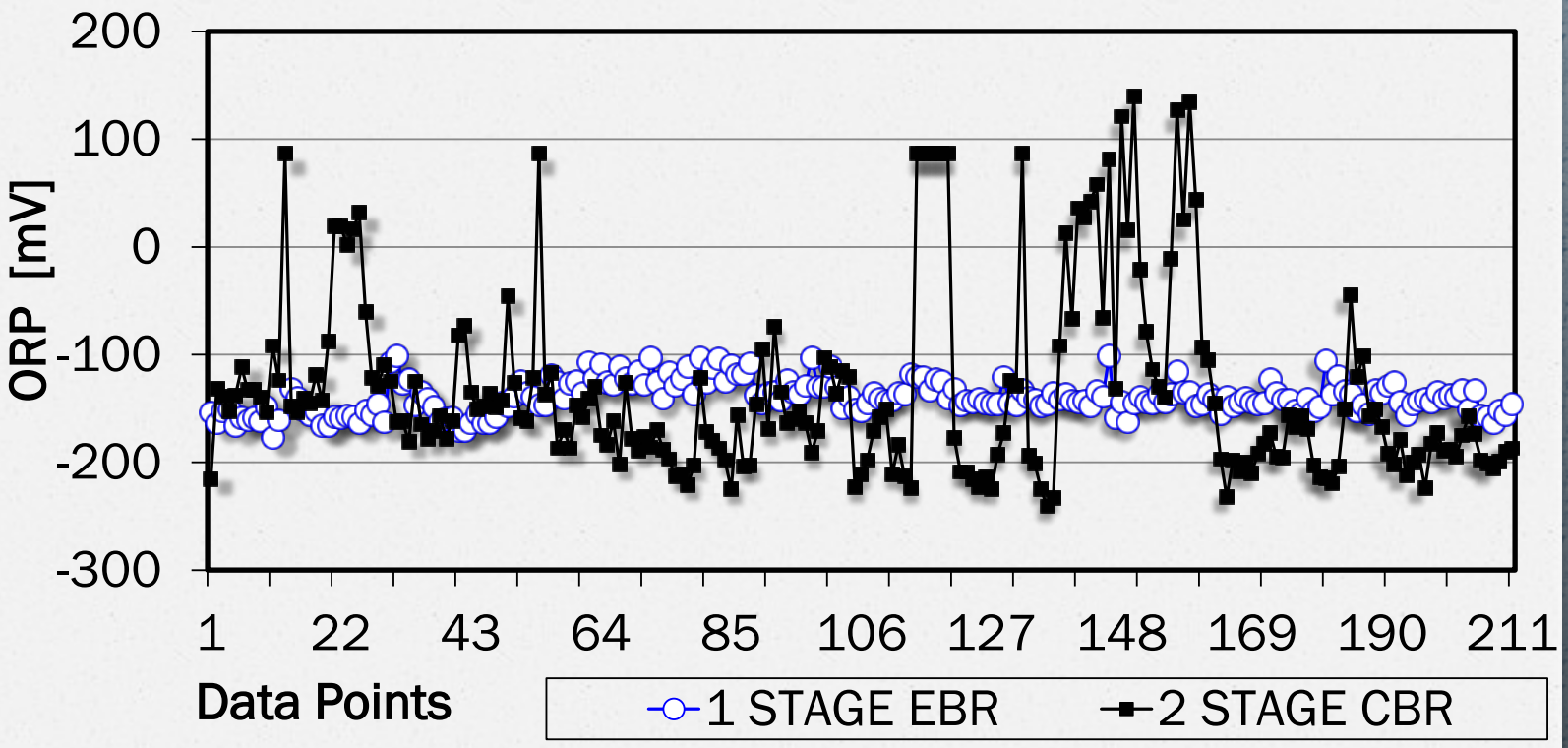
The Electro-Biochemical Reactor

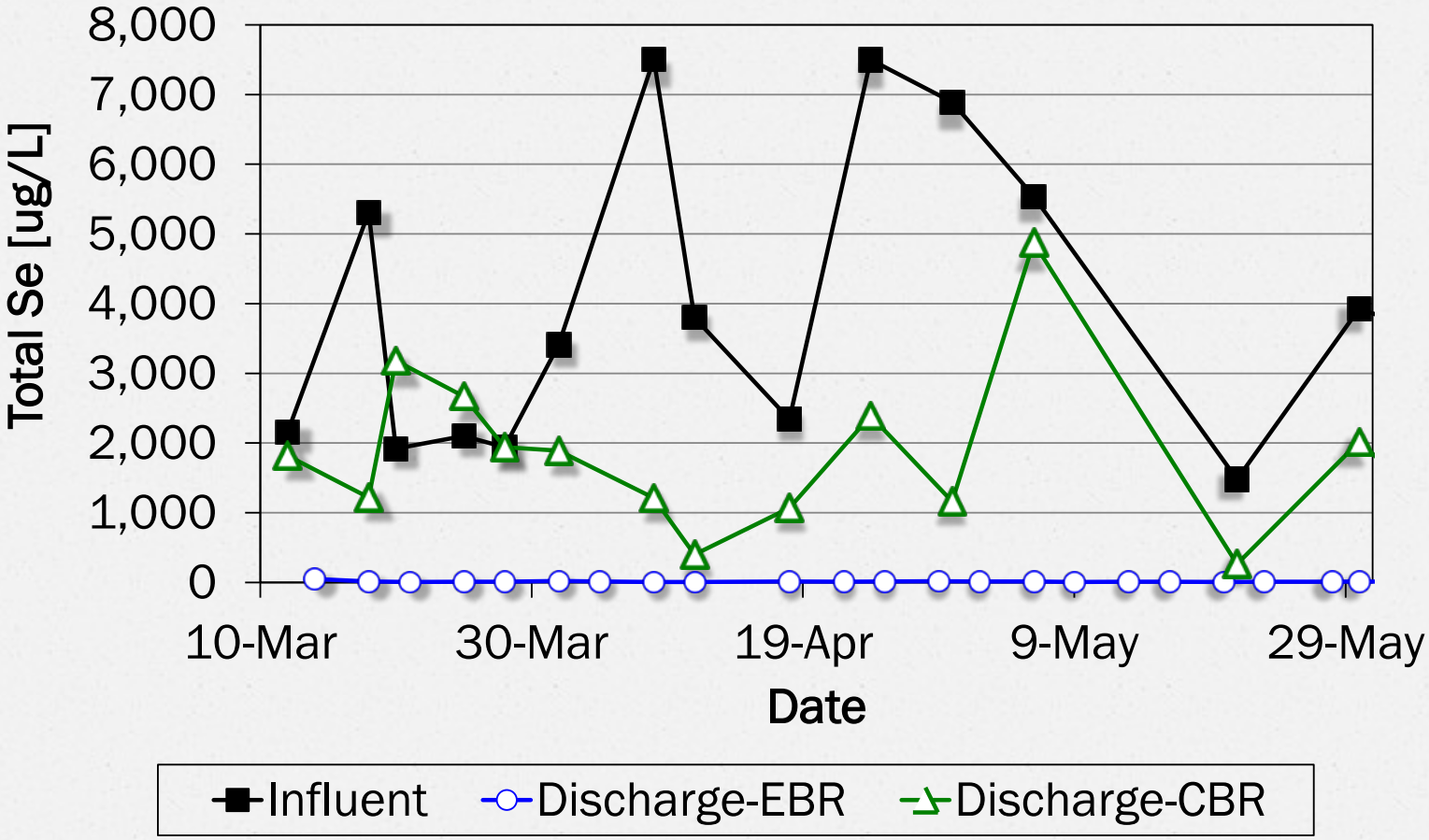
Providing electrons directly has numerous benefits including better ORP control and stability.



Results: Comparative Study

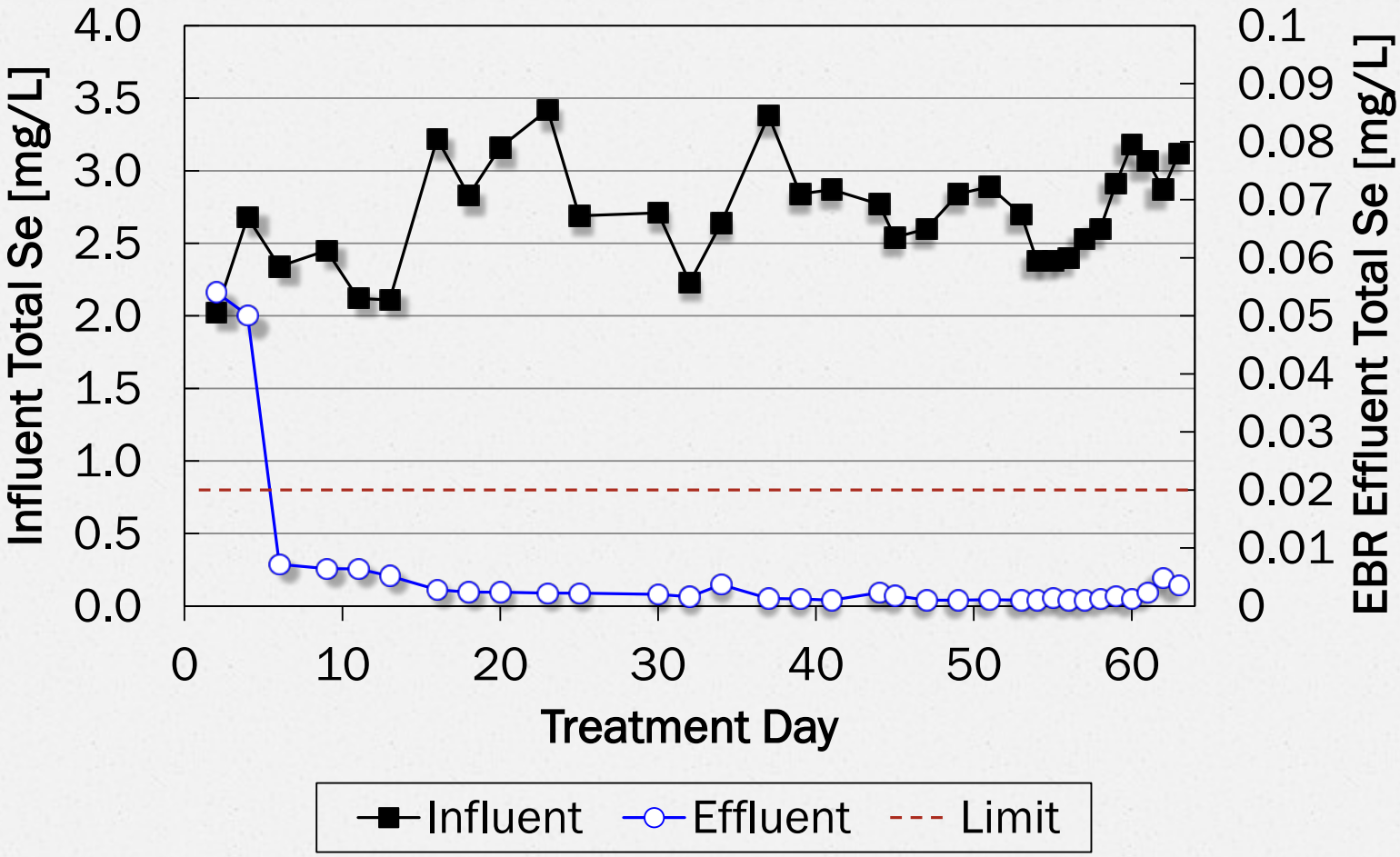
- Comparative study:
  - Between the EBR and a competing bioreactor technology.
  - A split water sample obtained from the Yukon Mine.
  - Testing was performed at the two respective labs.
  - Using the same hydraulic retention times.
  - Analysis done by the same analytical lab in Salt Lake City, UT.

Results: Comparative Study



Results: Pilot Studies

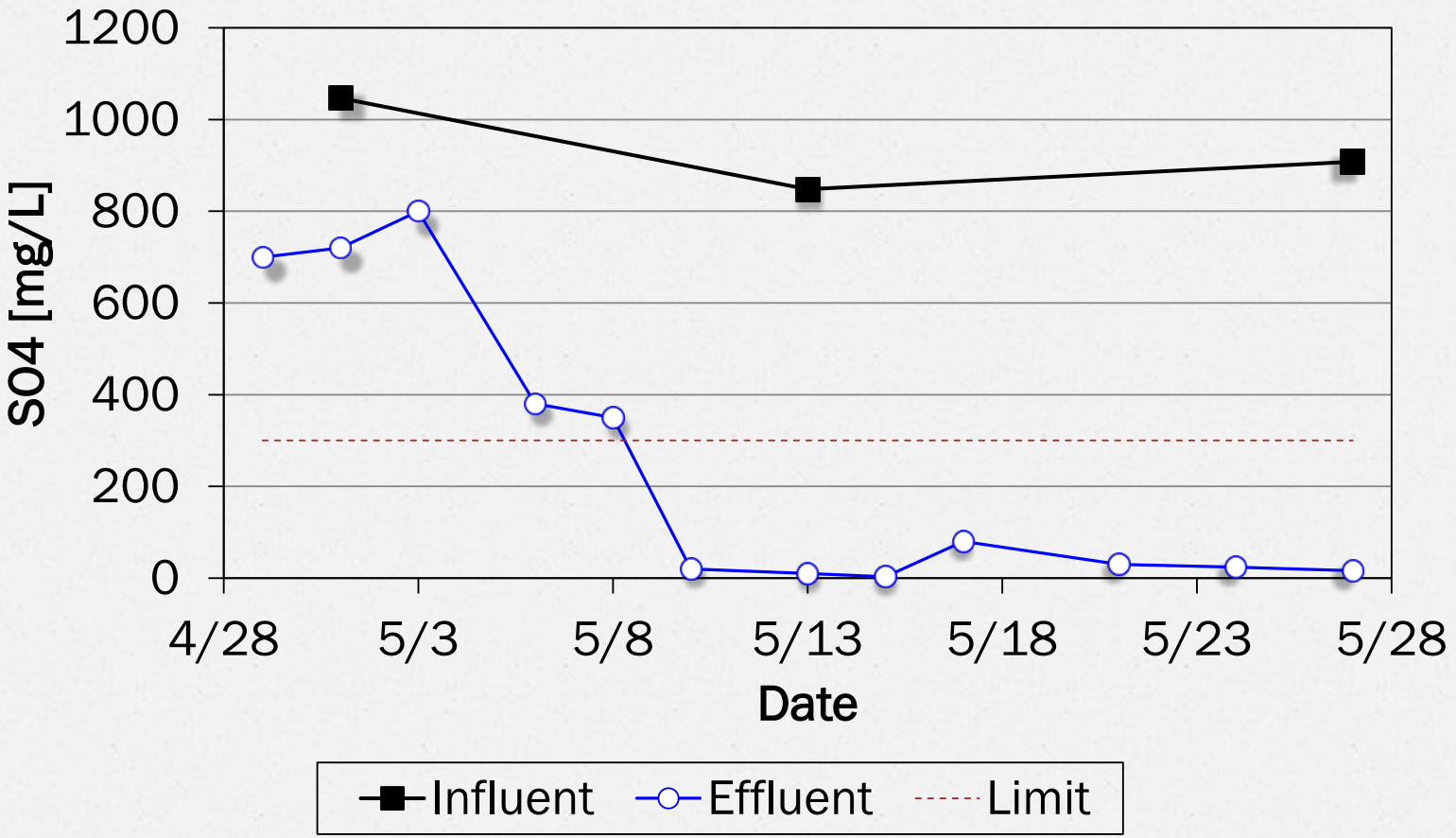
Results: EBR Pilot Studies

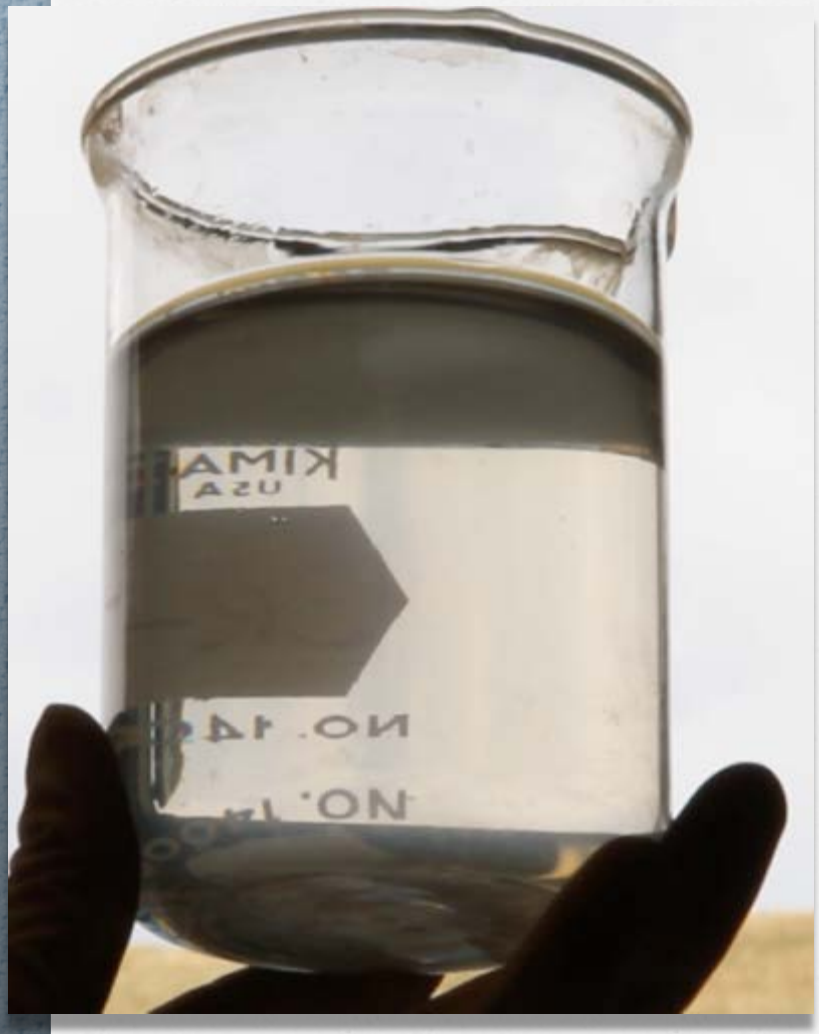


Results: EBR Pilot Studies

Parameter [mg/L]	Average Influent	Average Discharge	% Removal
Antimony	0.15	<0.001	>99.3%
Cadmium	0.014	<0.0002	>98.0%
Copper	0.41	<0.005	>98.7%
Lead	0.30	0.0008	99.7%
Molybdenum	0.10	<0.0005	>99.5%
Selenium	2.73	0.002	99.9%
Silver	0.041	<0.0001	>99.8%

Results: EBR Sulfate Removal



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Full-Scale Design

- Design criteria:
  - Six months operation during the year;
  - Treatment flow of 10 L/s;
  - Meeting discharge criteria with a 25% safety factor.
- Process design:
  - An anaerobic pre-treatment system with an 8-hour HRT for removal of residual mill organics;
  - A two-stage EBR system each with a 6-hour HRT to remove the total selenium and other metals;
  - An anaerobic post-treatment system with a 6-hour HRT to polish the EBR system effluents and remove the residual nutrients prior to discharge; and
  - A 24-hour holding pond prior to discharge – site specified.

Full-Scale Costs

50% Preliminary Estimates	EBR	Competing Bioreactor Provider
Reagents (nutrients, pH adjustment)	$108k	$338k

Full scale EBR conversion underway – Landusky, Montana

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Thank You

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