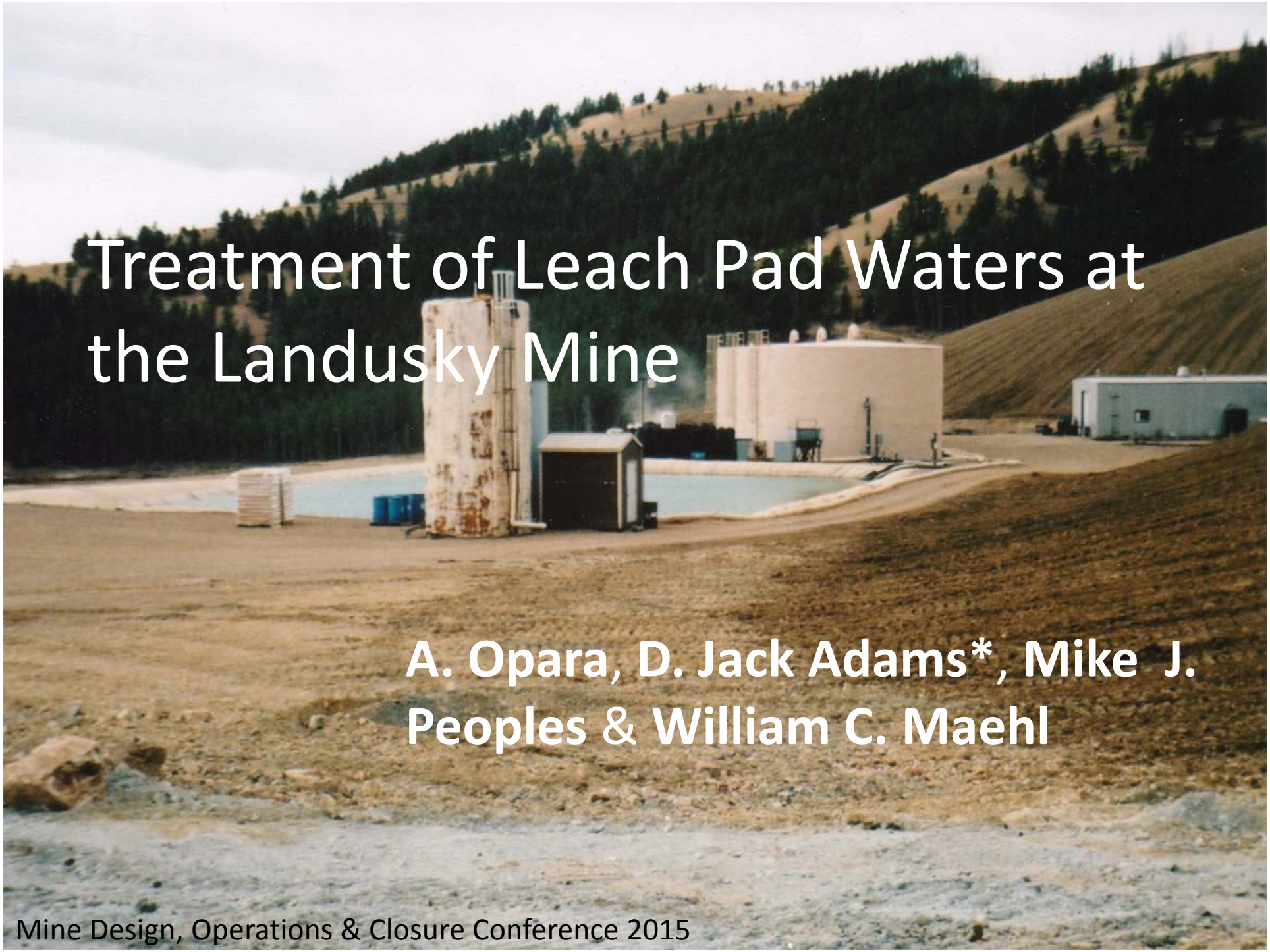
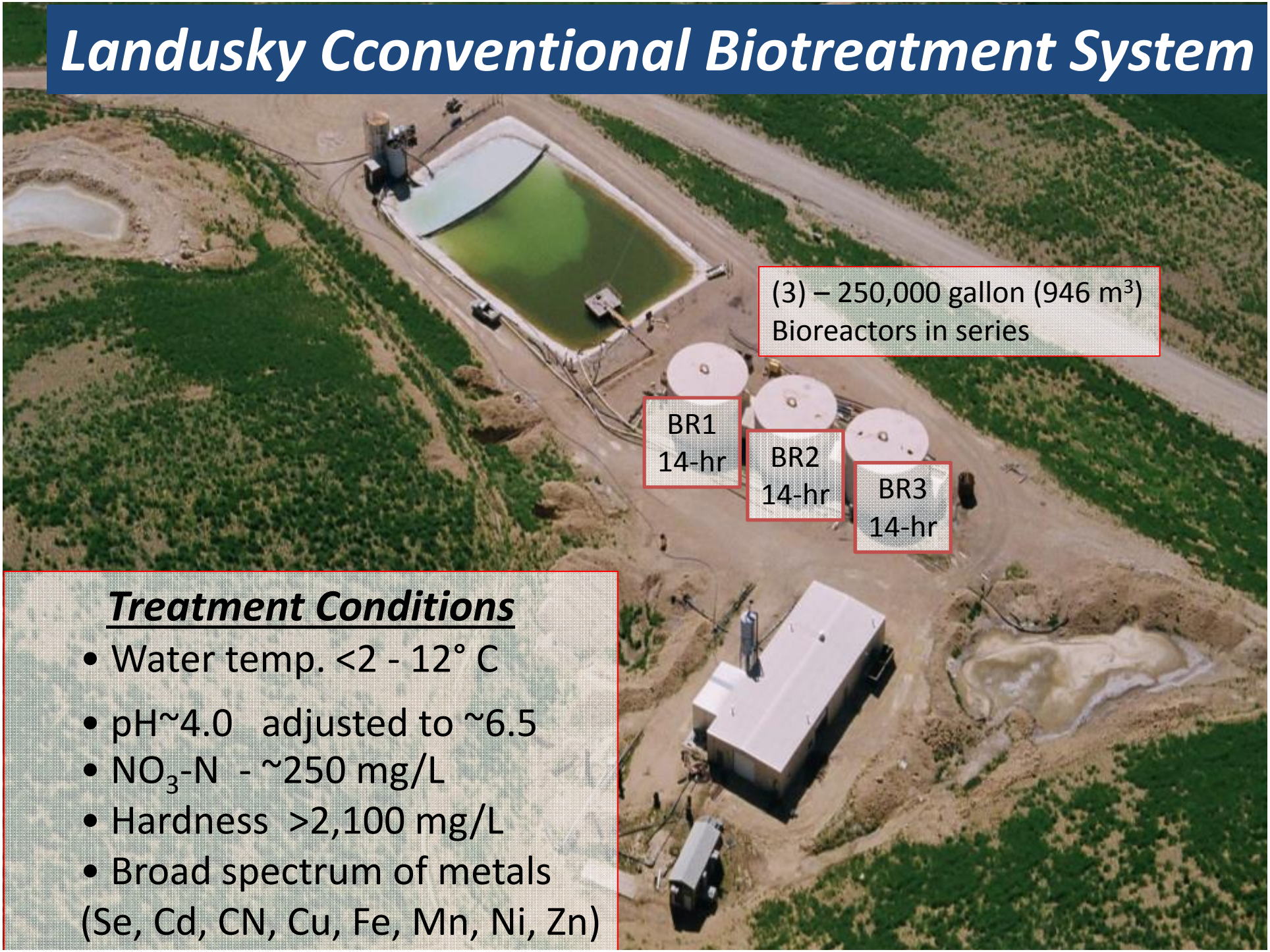


Treatment of Leach Pad Waters at the Landusky Mine

A. Opara, D. Jack Adams*, Mike J. Peoples & William C. Maehl

Mine Design, Operations & Closure Conference 2015

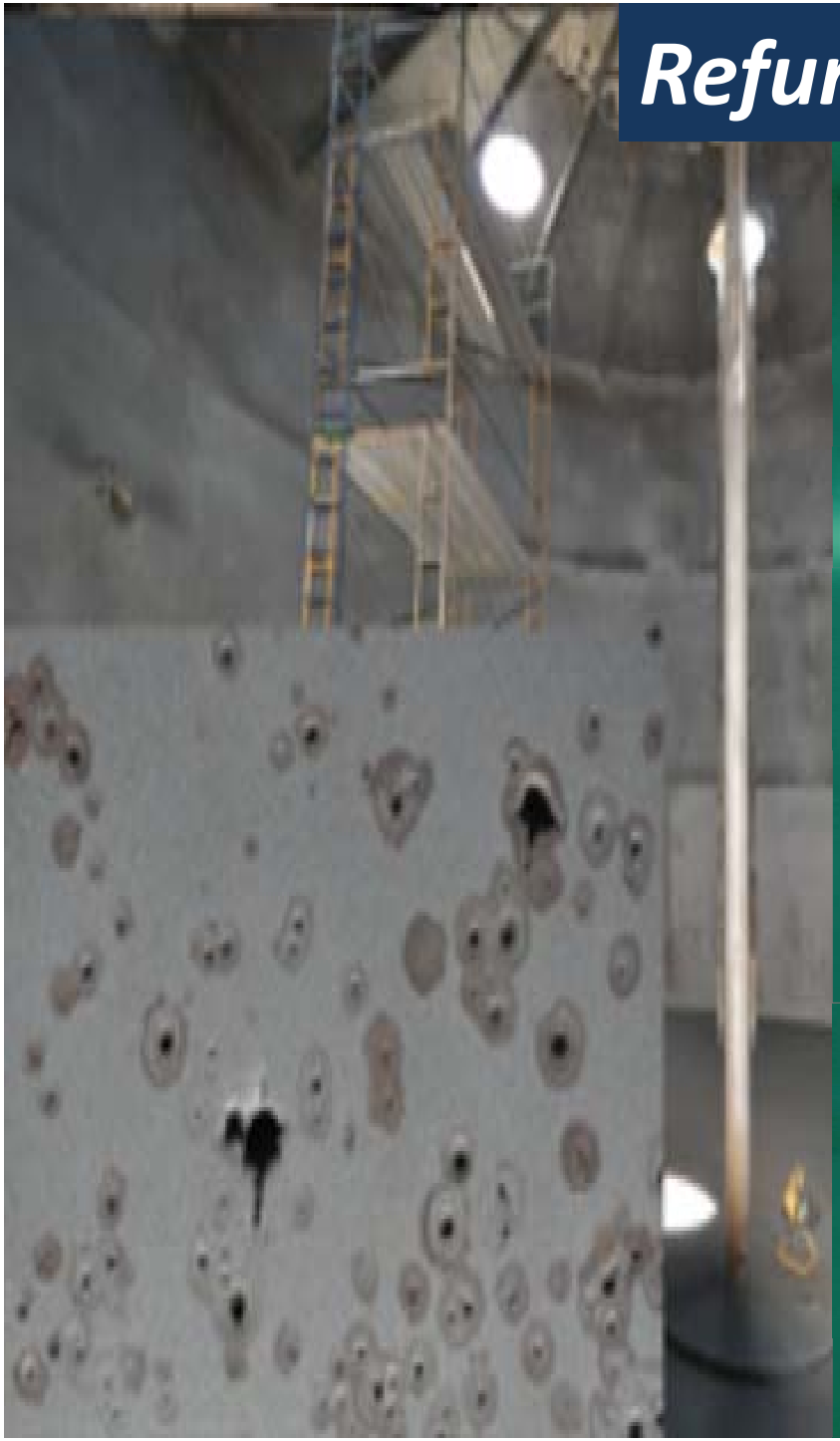
Landusky Cconventional Biotreatment System



Treatment Conditions

- Water temp. <2 - 12° C
- pH~4.0 adjusted to ~6.5
- NO_3-N - ~250 mg/L
- Hardness >2,100 mg/L
- Broad spectrum of metals (Se, Cd, CN, Cu, Fe, Mn, Ni, Zn)

Refurbishing Bioreactors 1 & 2



Electro-Biochemical Reactor Technology (EBR)

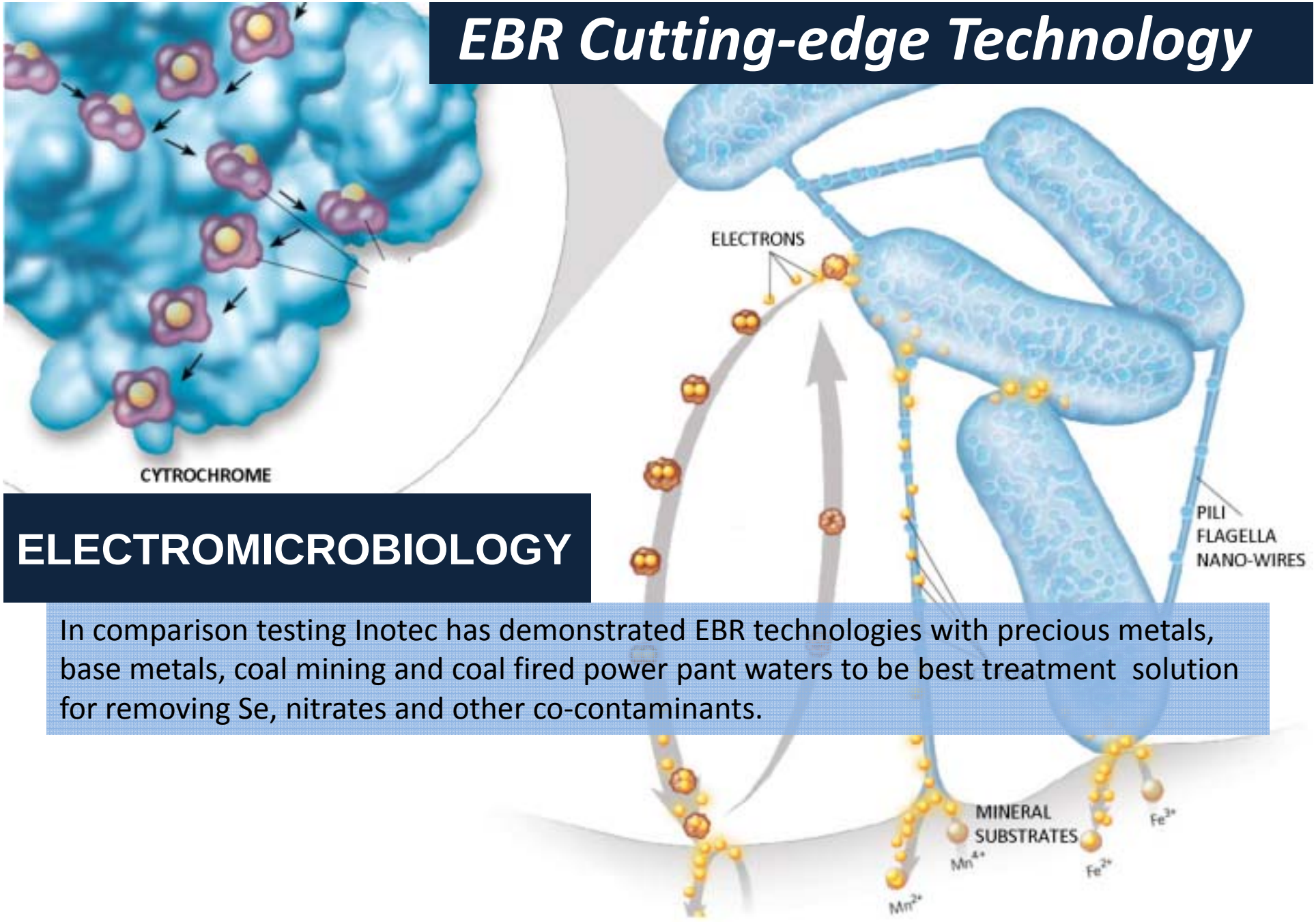
(EBR Plot-Testing During Refurbishing)

Results Comparison (Average)

	Influent	LBS Effluent	EBR Effluent	Discharge Limit
CN[1] (TOTAL)	0.084	NA	<0.005	0.005
CN[1] (WAD)	0.012	0.072	<0.005	NA
Al [mg/L]	0.34	1.99	0.04	NA
Cd [mg/L]	0.135	0.125	<0.001	0.005
Cu [mg/L]	0.061	0.122	0.014	0.031
Mn [mg/L]	57	55	29	NA
Ni [mg/L]	0.832	0.893	0.007	NA
Se [mg/L]	0.858	0.417	0.039	0.050
Zn [mg/L]	2.26	2.94	0.04	0.388
NO3-N [mg/L] (2011-2014 Ave)	255	25	<1	10.0

[1]After EBR system aerobic step.

EBR Cutting-edge Technology



ELECTROMICROBIOLOGY

In comparison testing Inotec has demonstrated EBR technologies with precious metals, base metals, coal mining and coal fired power pant waters to be best treatment solution for removing Se, nitrates and other co-contaminants.

Adapted from
Mohamed Y. El-Naggar and Steven E. Finkel - May 2013

EBR Technology

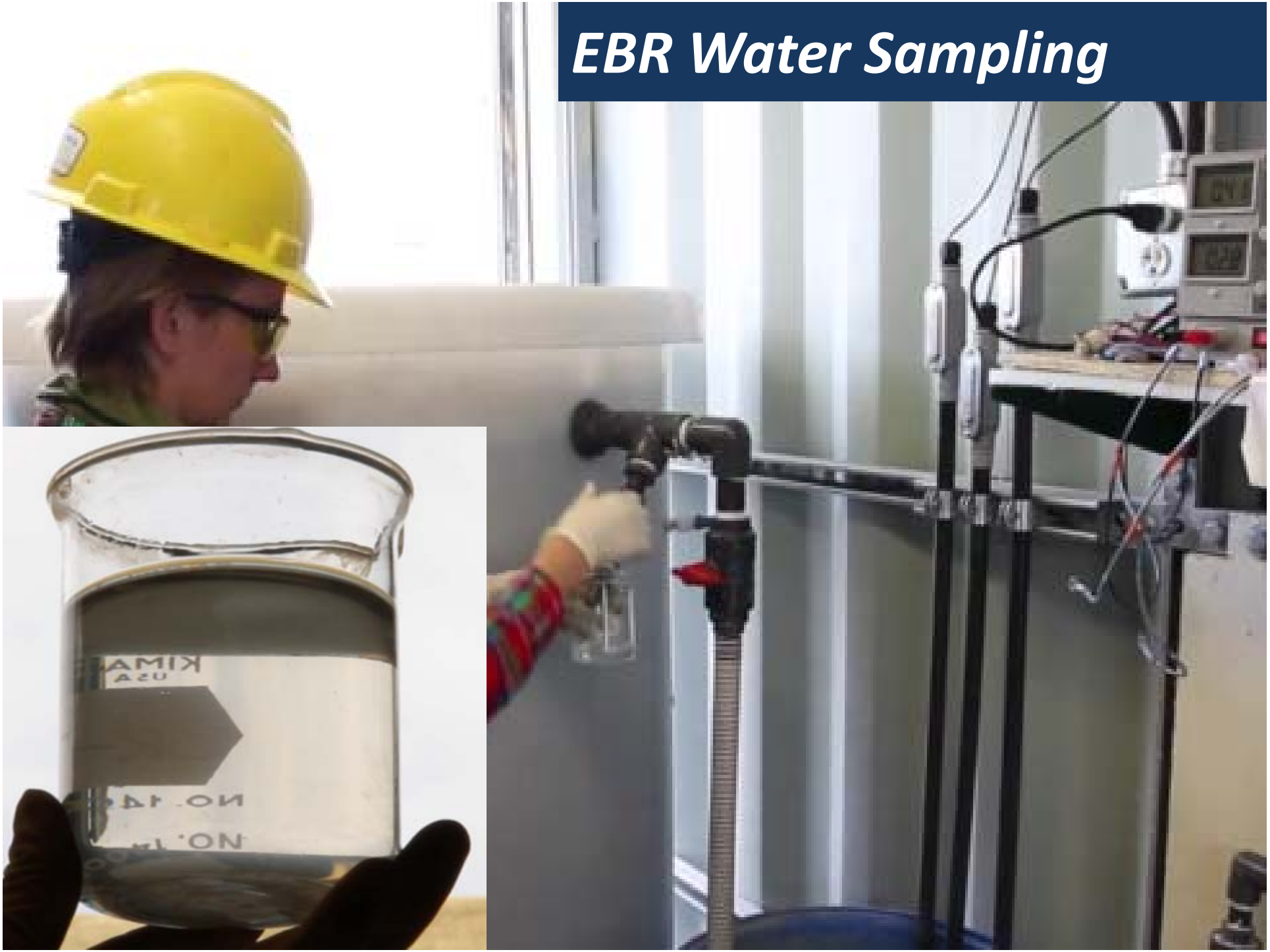
- EBR technology utilizes directly supplied electrons to provide energy for cell growth and contaminant conversion
- Low voltage (1-3 Volts potential and low milli-amps) provides:

  1. Electrons and electron acceptor environments for controlled contaminant removal environment

  2. Compensation for inefficient and fluctuating electron availability through nutrient metabolism

- 1 mA provides ~6.24 x 10^{15} electrons/second
- to the EBR system.
  - Replaces excess nutrients – Lower OPEX costs
  - Results in a more robust system with better contaminant removal
  - Produces less TSS (bio-solids) – Lower CAPEX Costs

EBR Water Sampling

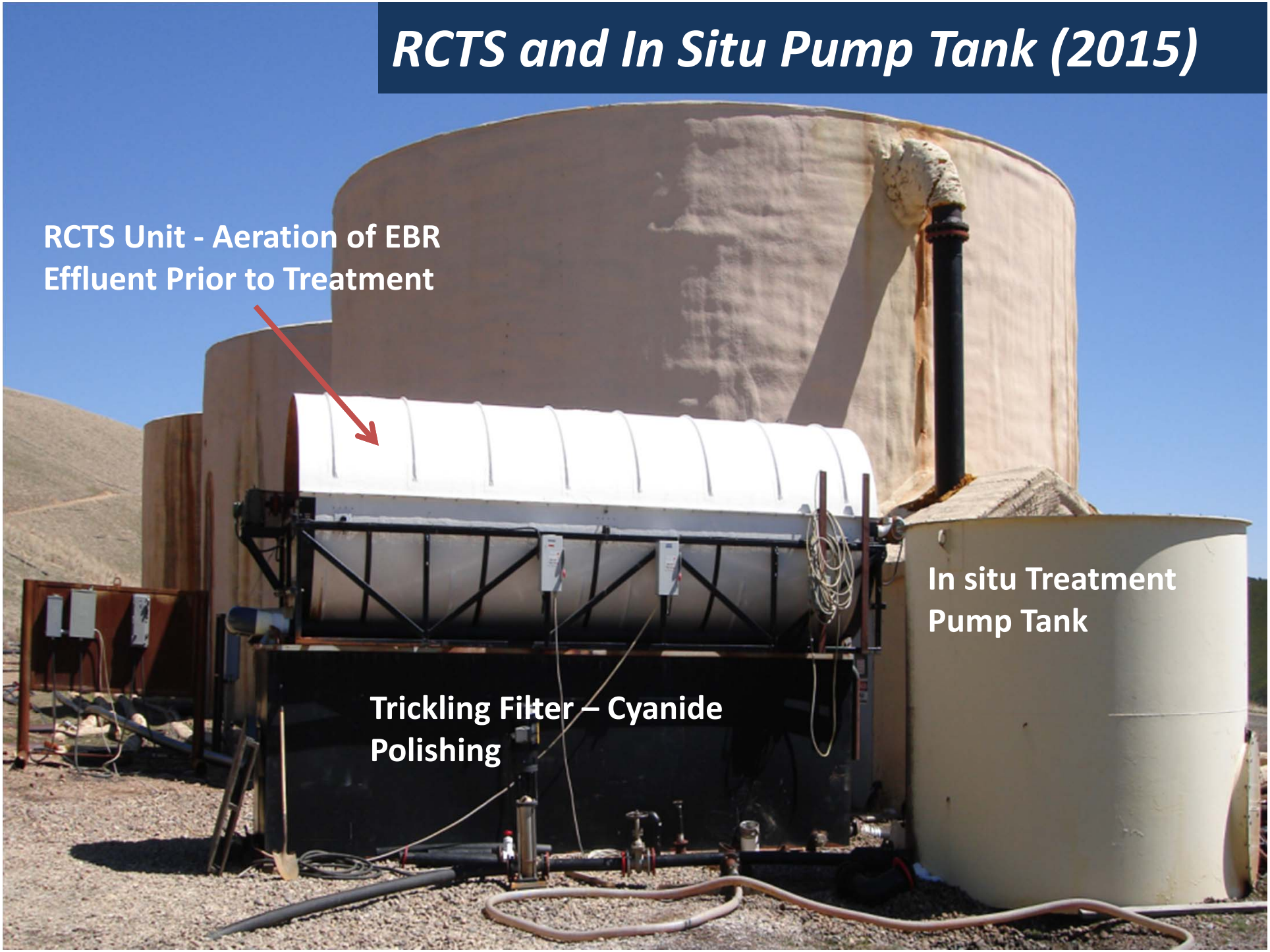


Conversion to EBR Technology 2014

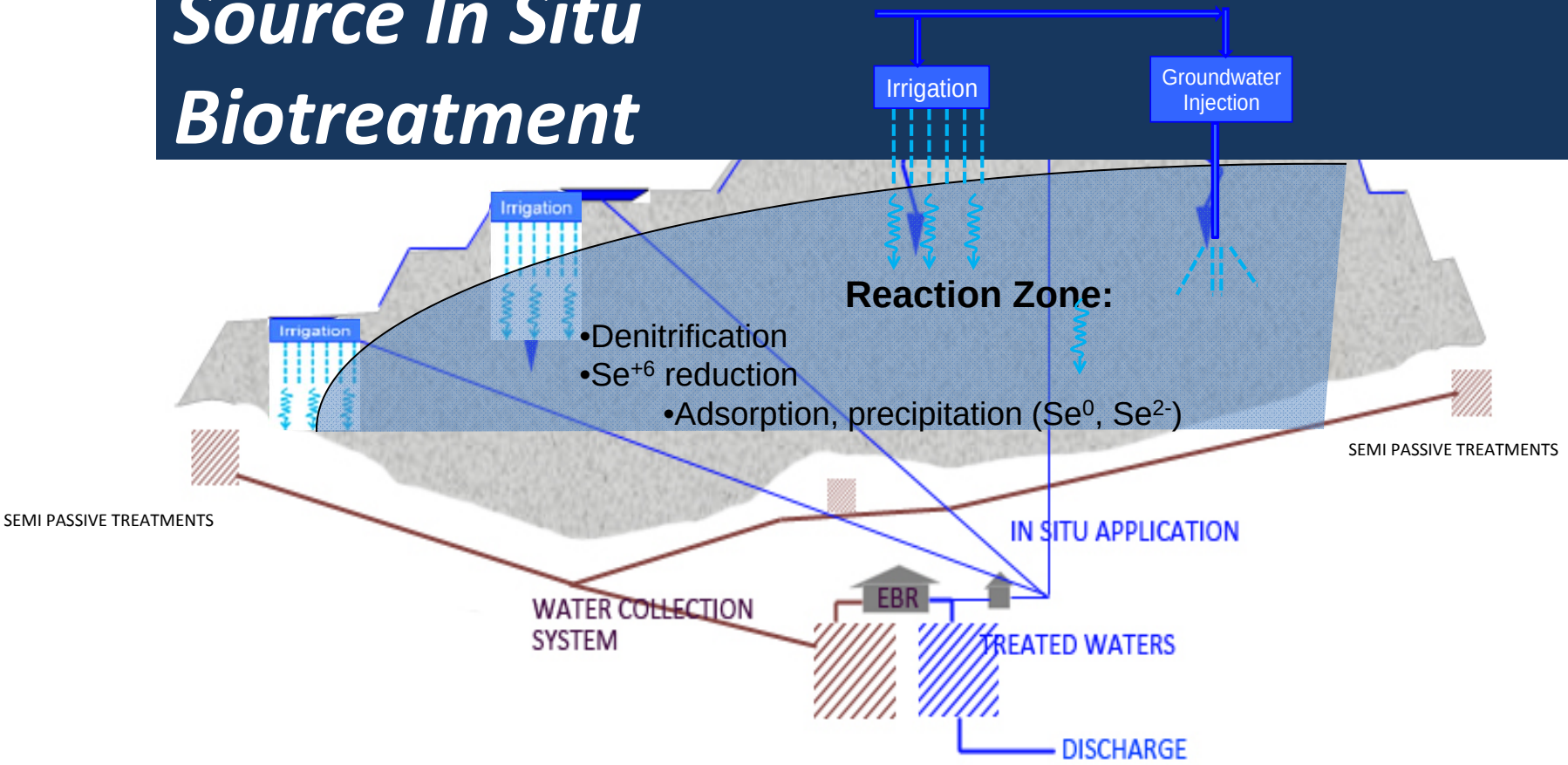
(Preliminary Full-Scale EBR Results)

	Influent	LBS Effluent	EBR Effluent	Discharge Limit
Al [mg/L]	0.11	0.19	0.04	NA
Cd [mg/L]	0.21	0.12	0.009	0.005
Cu [mg/L]	0.01	0.12	0.003	0.031
Ni [mg/L]	1.45	0.89	0.55	NA
Se [mg/L]	0.830	0.417	0.035	0.050
Zn [mg/L]	2.25	2.94	0.87	0.388
NO_3-N [mg/L]	220	25	0.03	10

RCTS and In Situ Pump Tank (2015)



Source In Situ Biotreatment



- Reconfiguring the Landusky EBR system 2014 for partial redistribution of the EBR effluent to in situ heap treatment

- Approaches have been proven in full-scale applications at several US hard rock mines at elevations >3,200 meters

Initial In Situ Treatment of L-87 Pad (2014)

- ~220,000 gallons of inoculum
- ~550,000 gallons of rinse water
- Less than 1 treatment volume per 80 volumes of L-87 Pad Water to be treated.
- ~112 Million tons of Pad Materials
- ~150 Million gallons of water per year

L87 in 2014 was 223
L87 in 4/2015 is 221
L91 in 2014 was 218
L91 in 4/2015 is 225

In Situ Control Valves and Distribution System

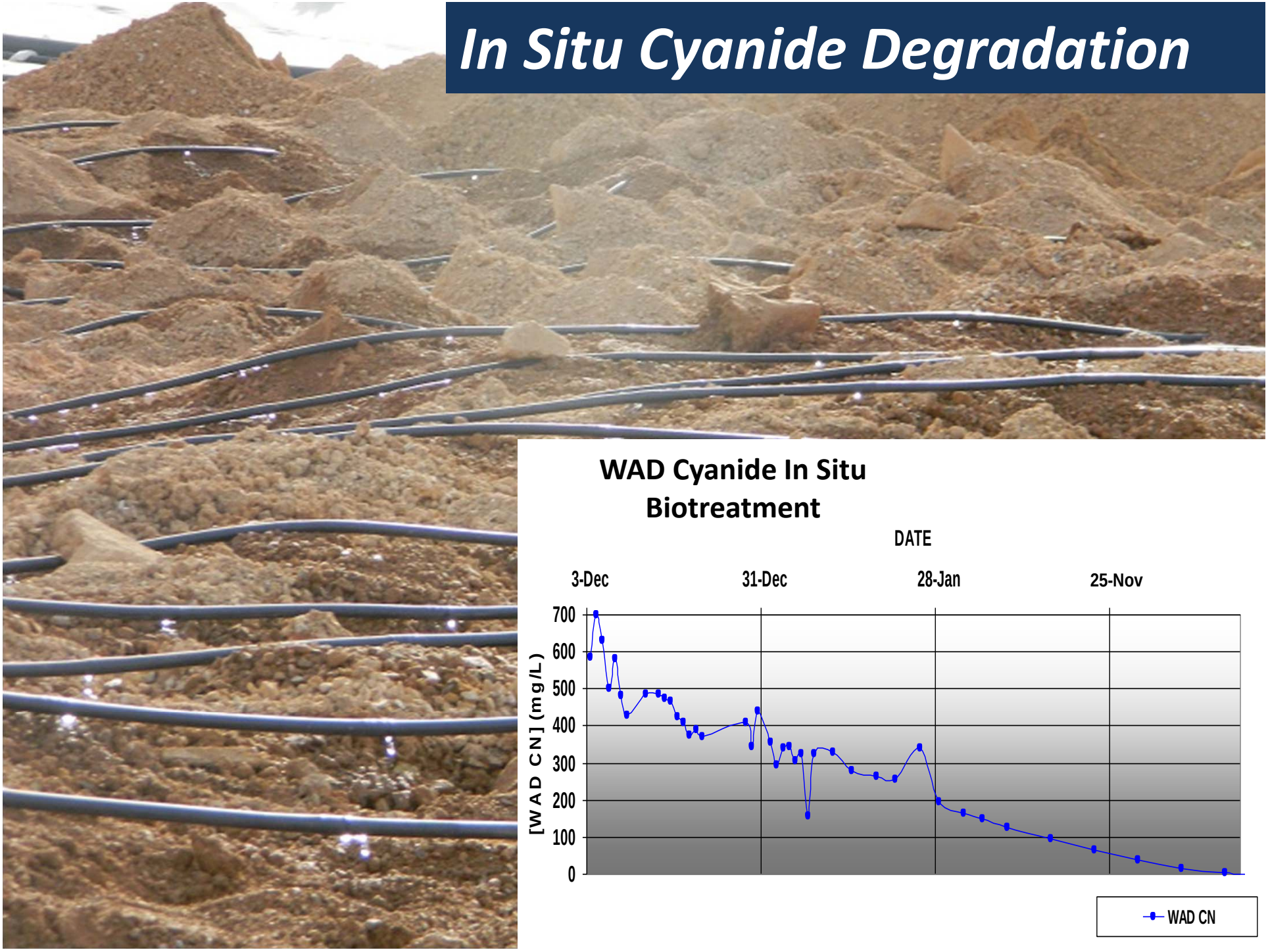
Additional Source Treatment Examples

- A lined spent ore depository constructed in 2002/2003
- ~2,500,000 tons of spent ore
- A total nitrate/ nitrite load of ~24.73 tons
- Nitrates were from ANFO and cyanide degradation

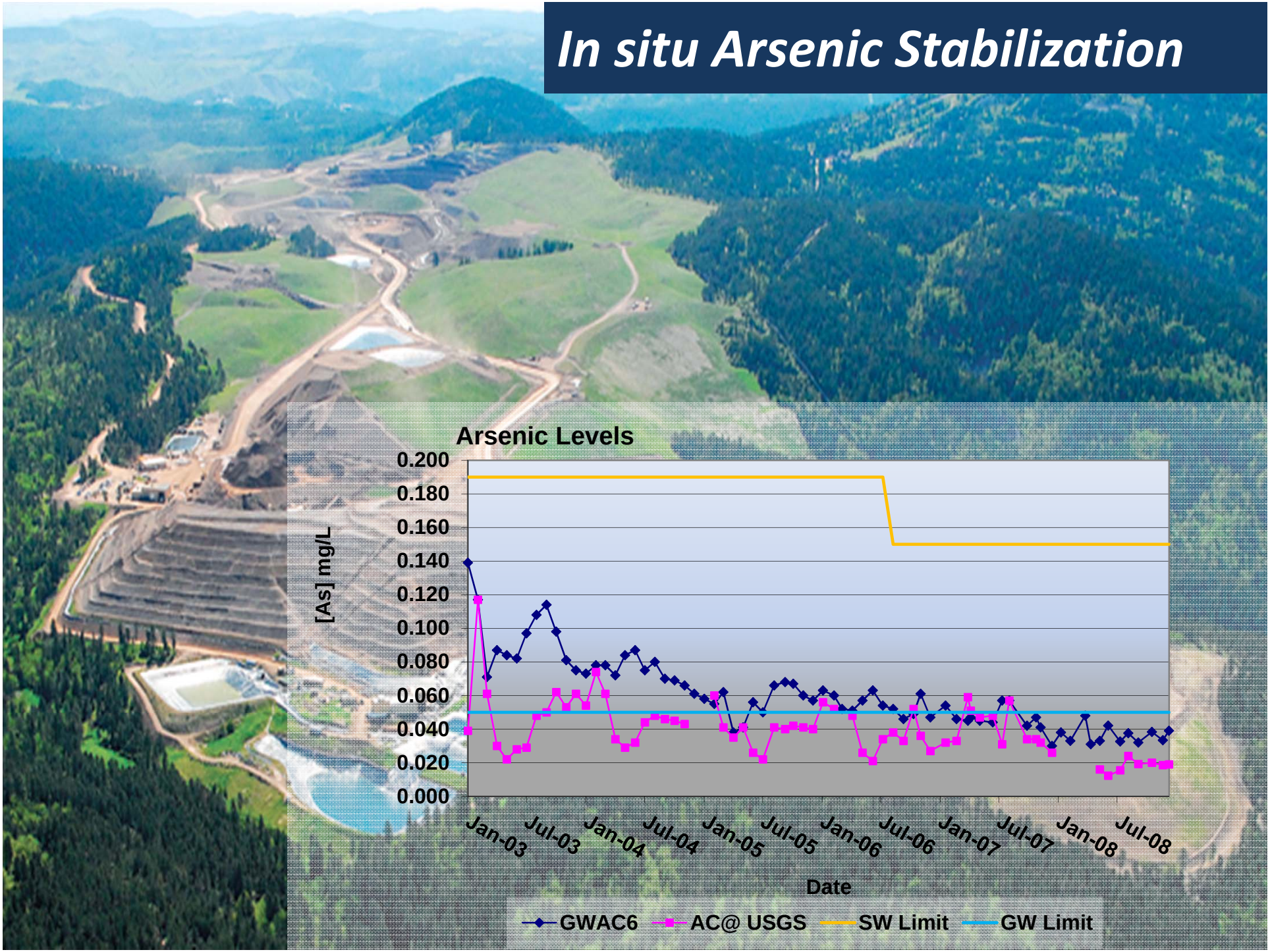
Active Treatment (2004 -2006)

- Treated with ~13 million gallons of re-circulated treatment/rinse water solution from a constructed treatment system pond
- Sampling results and kriging analysis indicated in situ denitrification was highly effective, reducing the estimated nitrate load by approximately 90%
- Treatment completed by 2007 and site was reclaimed

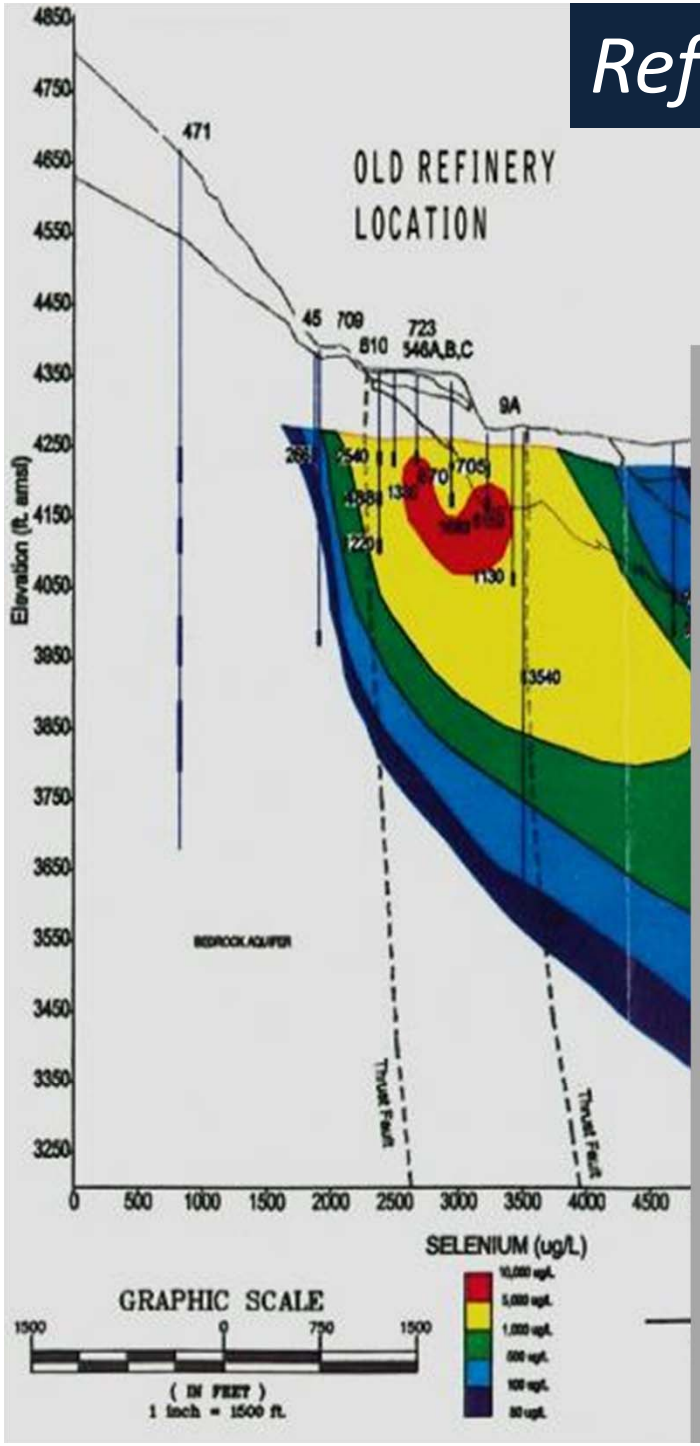
In Situ Cyanide Degradation

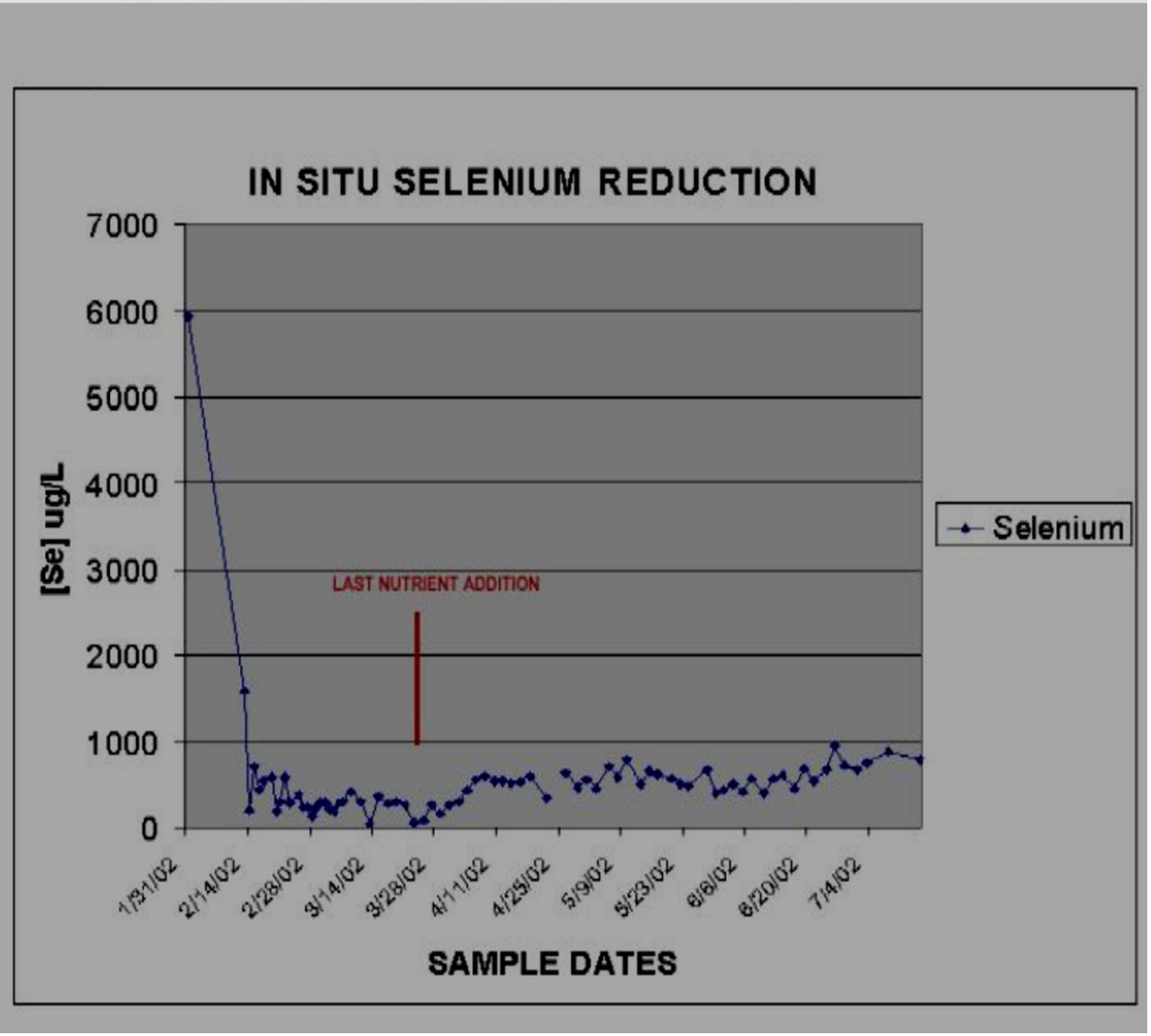


In situ Arsenic Stabilization



Refinery Site – In Situ Se Stabilization





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Thank You

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