

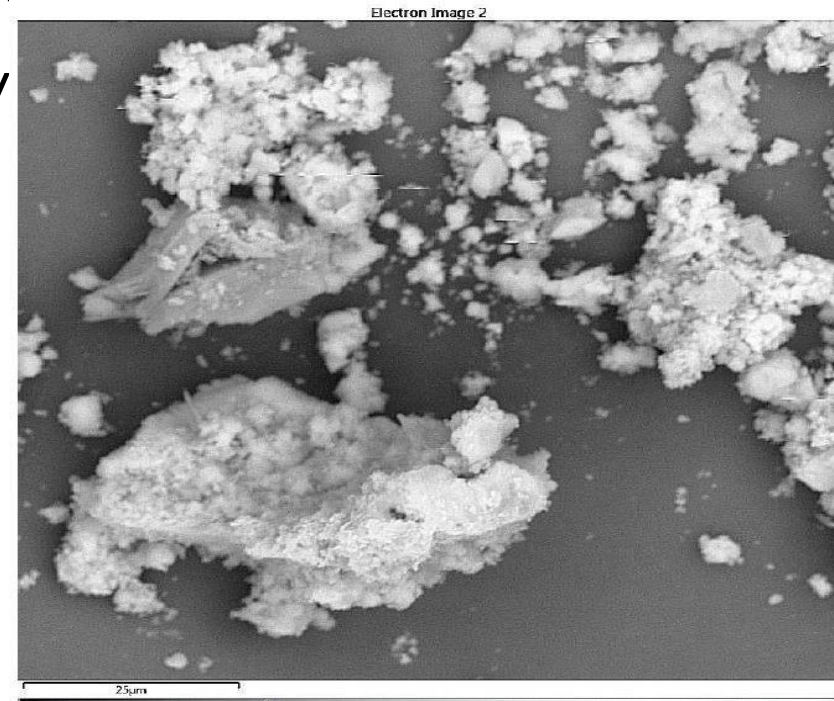
The background of the slide is a photograph of a landfill. A clear plastic bag is visible, partially filled with a brown, fibrous material. A white, cylindrical object, possibly a cup or a piece of debris, is lying on the ground near the bag. The overall scene is dimly lit, with a mix of brown and grey tones.

# Geochemical Modeling for Class I UIC

## **CCR Leachate Case Study**

# OVERVIEW

- Managing Complex Liquids with Class I UIC
- Proactive Avoidance of Plugging Formations
- Simulating Downhole Precipitate
- CCR Leachate Case Study





# Typical Treatment Analysis

- Very Scientific Bench Scale Test
- Equally as Scientific Materials Analysis
- Calculate Dosing Rates



# Typical Treatment Analysis

- Implement Treatment
- Verify Treatment





# CASE STUDY

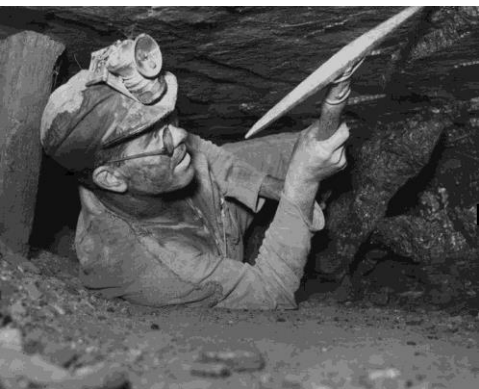
CCR LEACHATE AT ELECTRIC UTILITY

**SCS ENGINEERS**

# CASE STUDY FACILITY

## Electric Utility Compound

- Mine Mouth Coal-Fired Power Plant
- Coal Combustion Residuals Landfill
- Zero Discharge Facility
- Recirculates >50M gal
- Class I UIC for Leachate Management





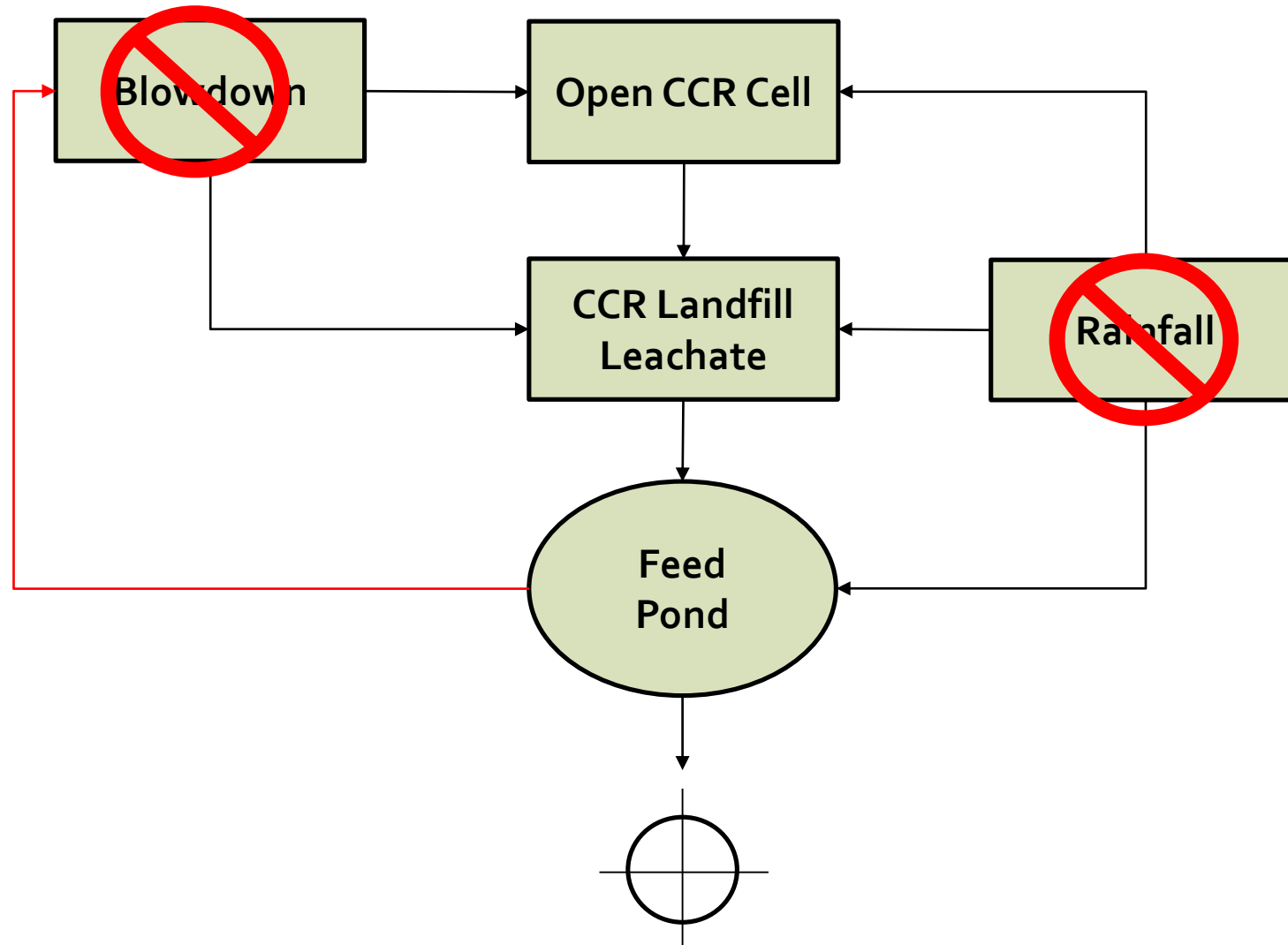
# OUR CHALLENGE

## Surface Variables

- Liquids Handling Inconsistent
- Fluctuating pH in Feed Pond
- Surface Piping Always Plugged



# OUR CHALLENGE





# OUR CHALLENGE

Ion/Parameter	(mg/L)	Leachate Sumps Max. (mg/L)	Leachate Sumps Min. (mg/L)	Feed Pond Max. (mg/L)	Feed Pond Min. (mg/L)
TDS	15,962.00	29,500.00	12,600.00	23,100.00	
pH	4.50	9.14	5.56	6.10	2.89
Ca	2,645.00	5,360.00	1,450.00	4,320.00	
Mg	134.50	1,480.00	8.58	330.00	
Ba	0.20	0.34	0.07	0.29	
Sr	14.40			14.10	
Na	2,448.00	2,360.00	1,170.00	1,910.00	
K	627.60	1,210.00	324.00	859.00	
Li	3.03			2.09	
Fe	4.58	790.00	1.55	183.00	16
Ammonia	0.00	49.40	1.12		
Al	0.17	22.50	0.10	0.08	
Mn	1.72	11.50	0.02	3.17	
Zn	0.08	1.30	0.05		
Cl	8,500.00	14,700.00	4,800.00	11,200.00	939
S	1,325.00	2,600.00	968.00	1,160.00	
Br	0.00				
Total carbonate	94.40	342.00	38.00	0.00	0.00
SiO2	0.00				
P	0.00	2.50	0.27	0.73	
F	0.00	9.32	0.45		
N (NO3-)	0.00	0.96			
B	37.46	158.00	14.50	77.60	
H2CO3	70.00				
HCO3-	24.40	158.00	6.00		
CO3-2	0.00	184.00	32.00		

# OUR CHALLENGE

Middle Ordovician Sandstone Injection Reservoir

- Rounded, Well Sorted, Poorly Cemented
- Porosity ~ 13%
- Pore Throat Diameter: 90% >10  $\mu$

*"If we can't keep the surface piping from plugging,  
how can we expect the downhole formation to stay open?"*



# THE APPROACH

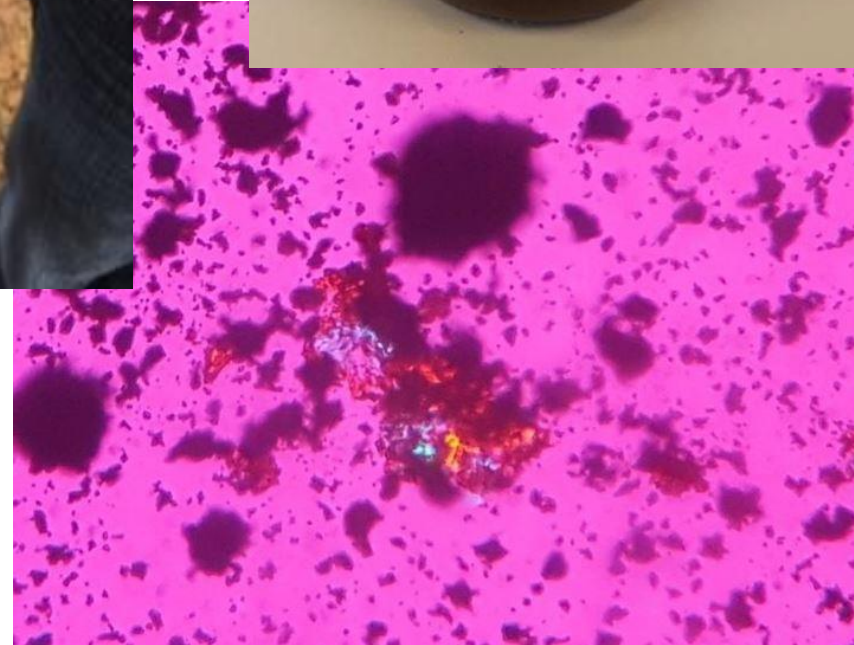
- Simulate Downhole Reactions
- Identify Potential Formation of Precipitates





# OUR APPROACH

- Collect/Analyze Fluids & Materials





# OUR APPROACH

- Interview Operators & Samplers
- Understand Processes & Variations

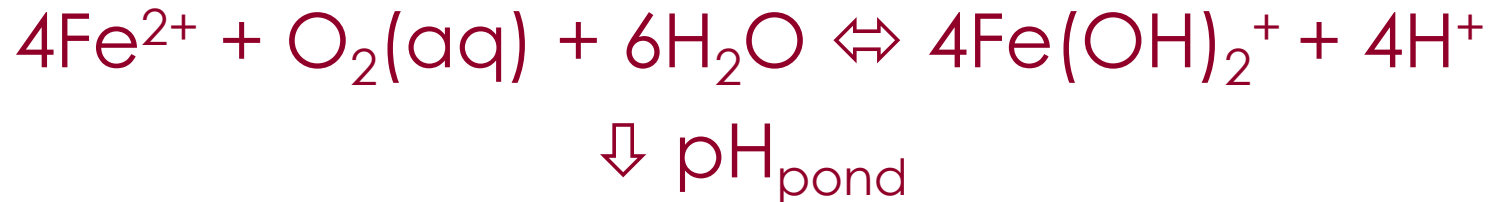
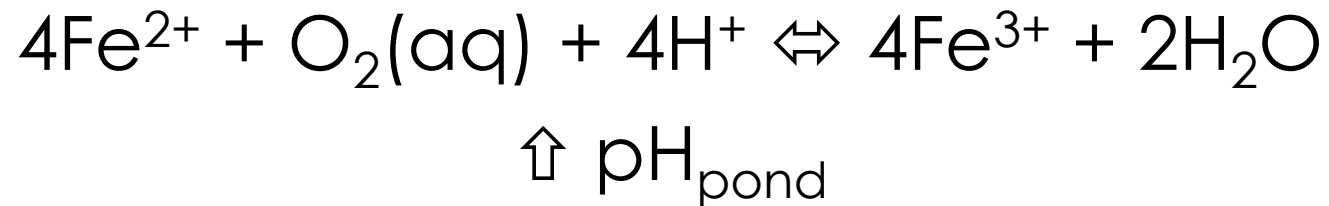


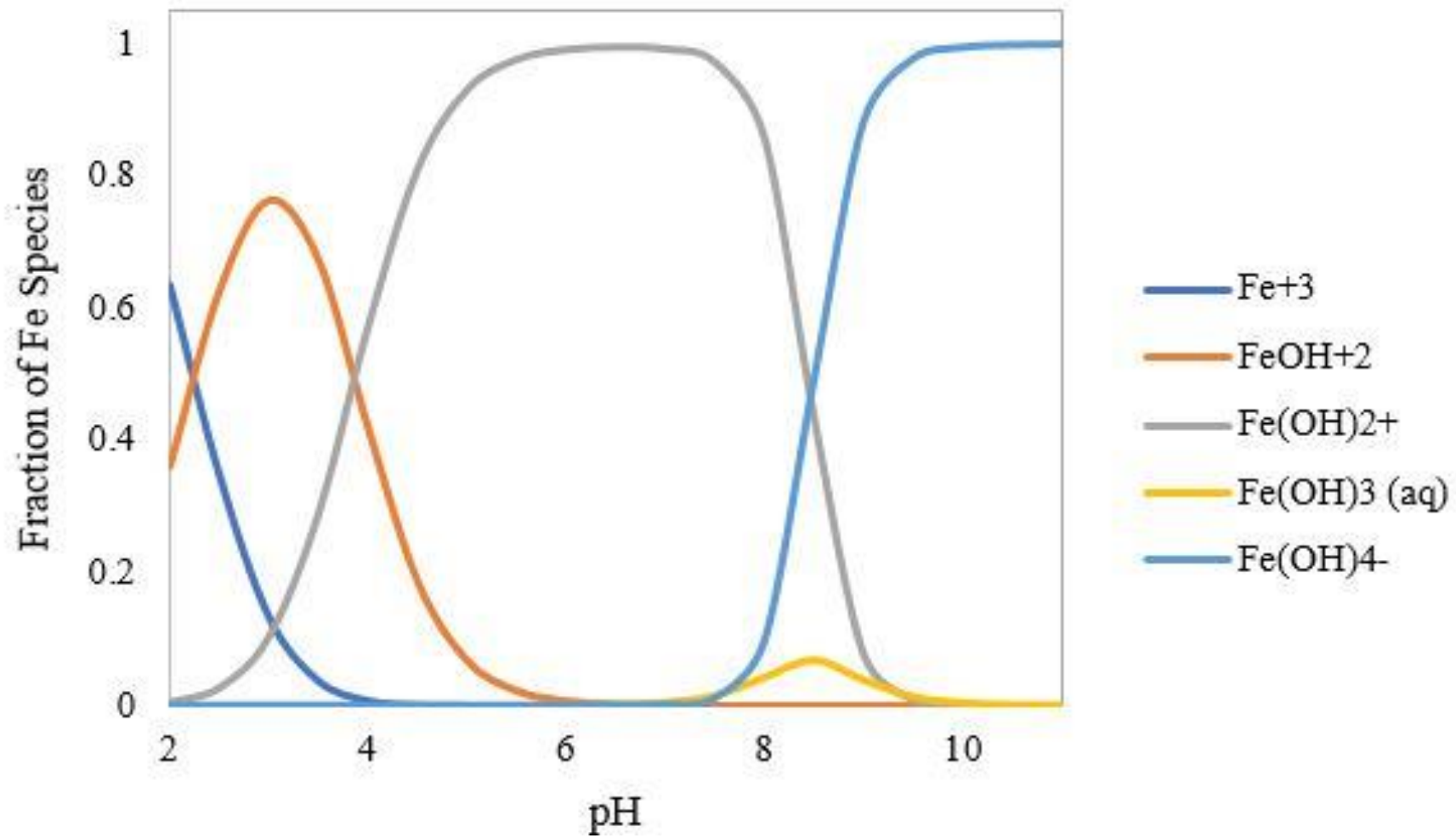
Rainfall + Drainage Layer =  
 $\downarrow$   $\text{pH}_{\text{sump}}$  and  $\uparrow$  precipitate

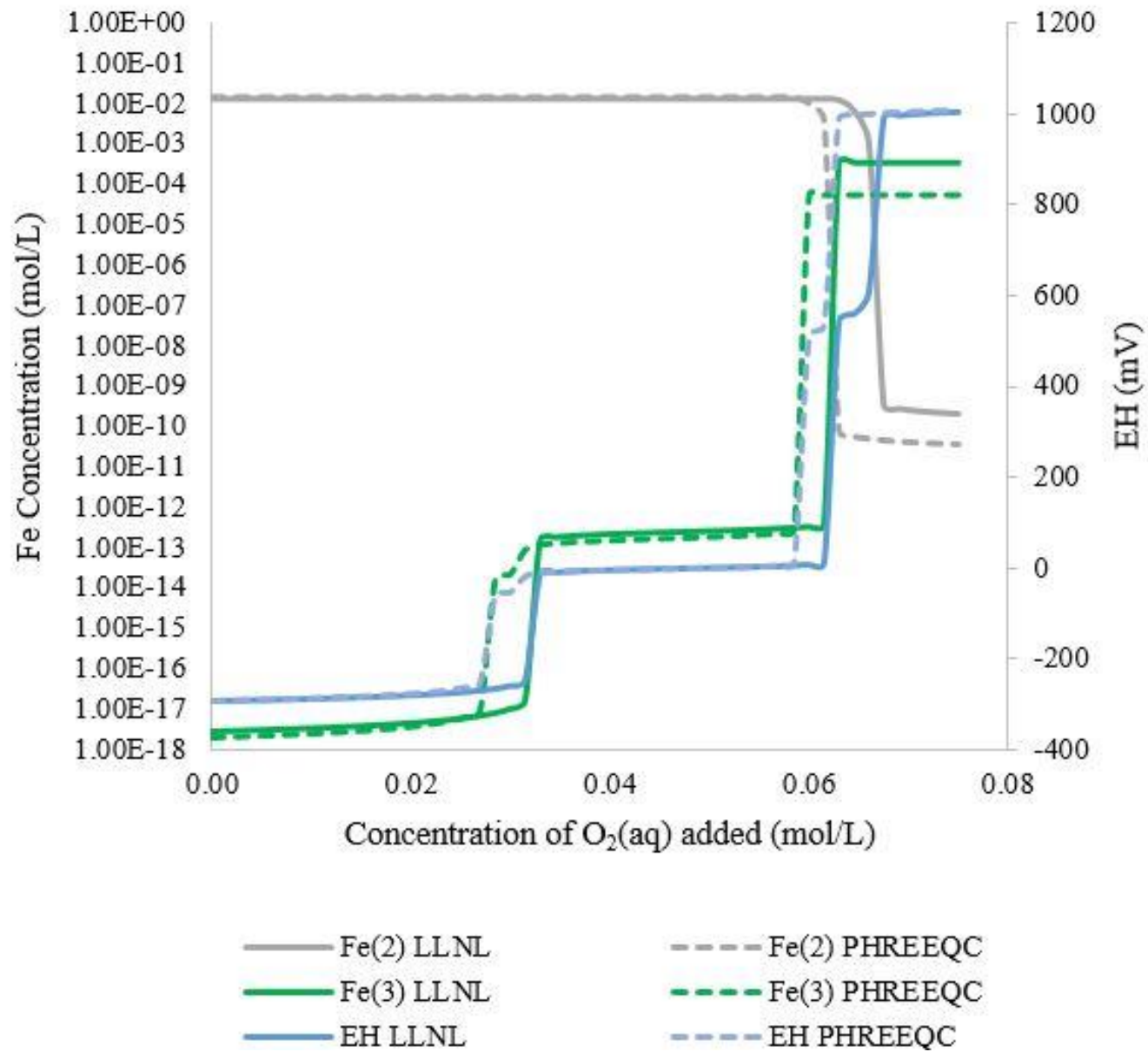
No Rainfall =  
 $\uparrow$   $\text{pH}_{\text{sump}}$  and  $\downarrow$  precipitate  
...but...  
 $\downarrow$   $\text{pH}_{\text{pond}}$

# OUR APPROACH

- Geochemical Simulation of Oxidation Between Sump and Feed Pond

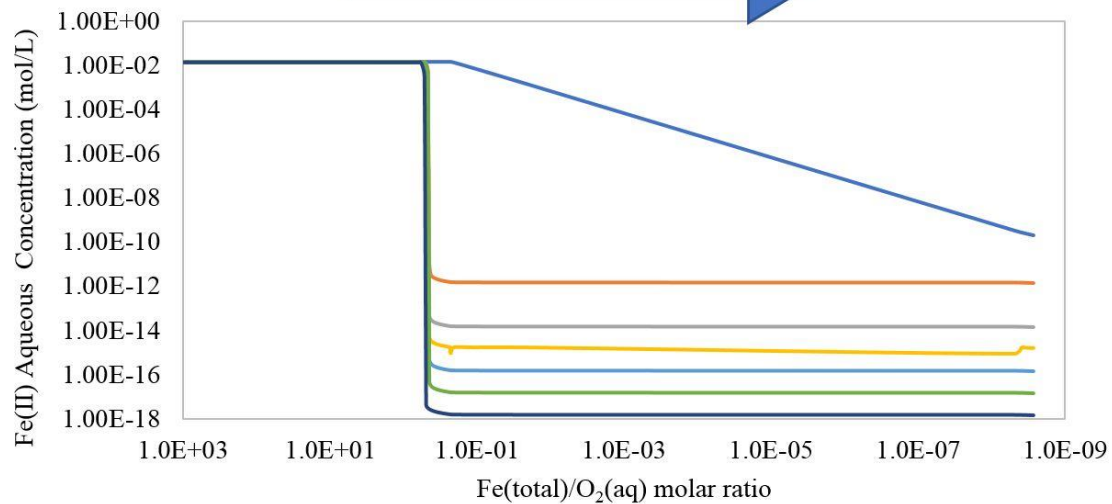






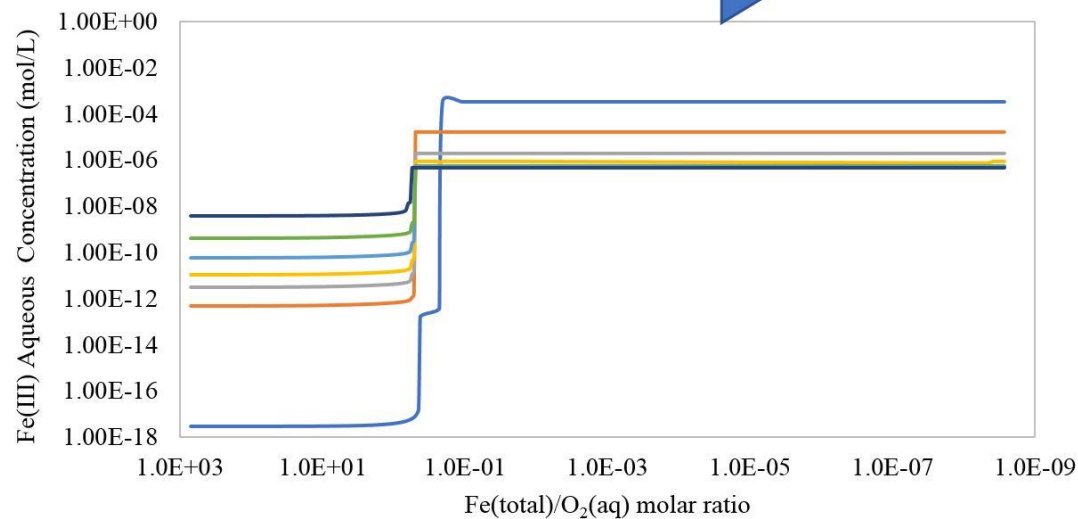


Increasing  $O_2(aq)$  concentration



— pH 4, Fe(2) — pH 5 Fe(2) — pH 6, Fe(2) — pH 6.5 Fe(2)  
 — pH 7, Fe(2) — pH 7.5, Fe(2) — pH 8.0, Fe(2)

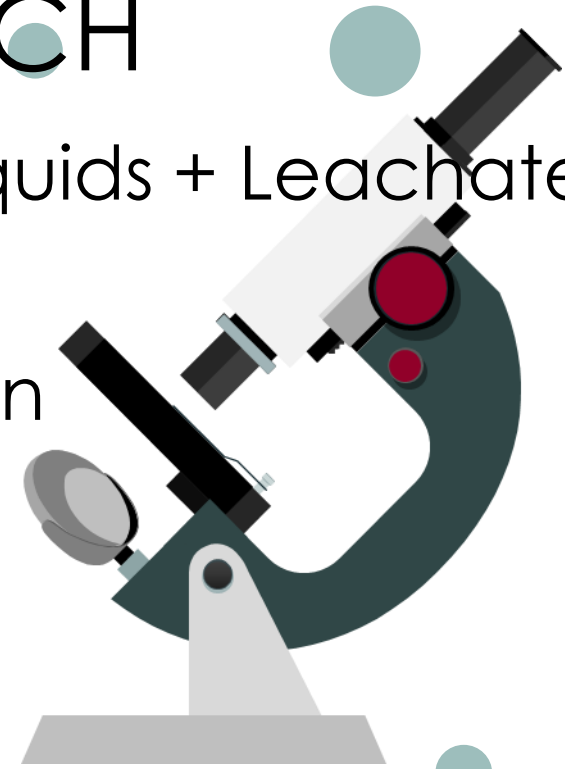
Increasing  $O_2(aq)$  concentration



— pH 4, Fe(3) — pH 5, Fe(3) — pH 6, Fe(3) — pH 6.5 Fe(3)  
 — pH 7, Fe(3) — pH 7.5, Fe(3) — pH 8.0, Fe(3)

# OUR APPROACH

- Simulate Interface: Downhole Liquids + Leachate
- 100% Leachate Simulation
- 100% Downhole Liquids Simulation
  - Temp ↑ to 50 °C
  - Pressure ↑ to 2500 psi
- 50%/50% Simulation
  - Pressure: Little Solubility Influence
  - Temp: Significant Alkali Earth Minerals Influence
  - pH: Significant Alkali Earth Carbonate Minerals Influence
- Back Analysis for Mass Removal



# OUR SOLUTION

- Custom Liquids Management Plan
- Combination Physical/Chemical Treatment



# THE SOLUTION

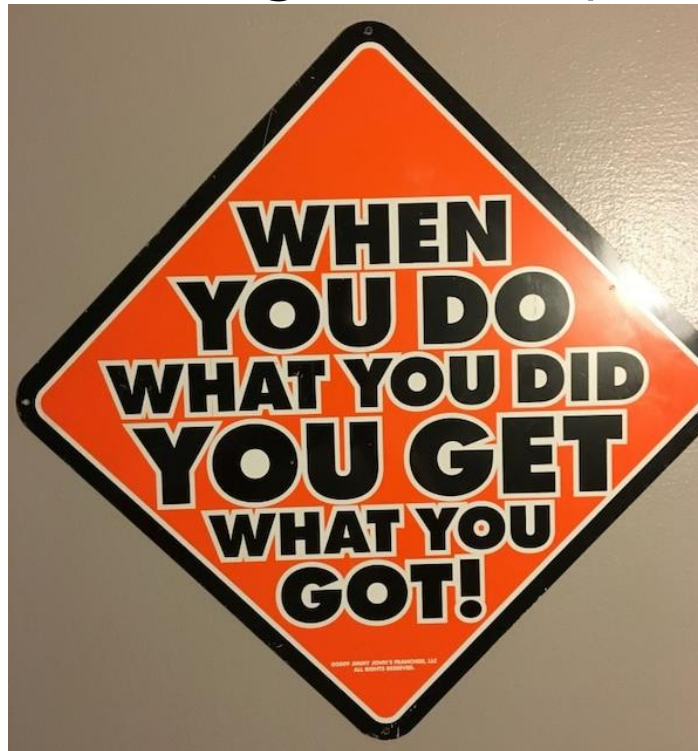
- Define Constraints/Bracket Parameters
- Programmable Logic Controller

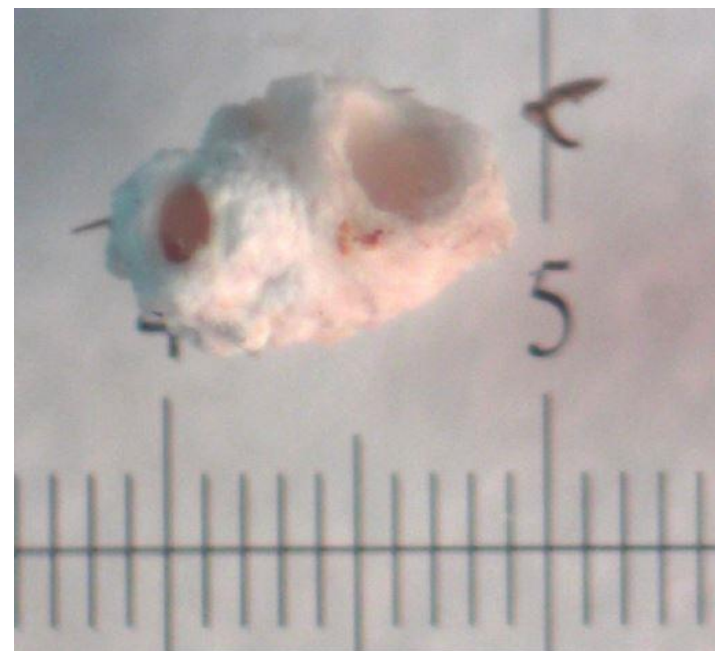
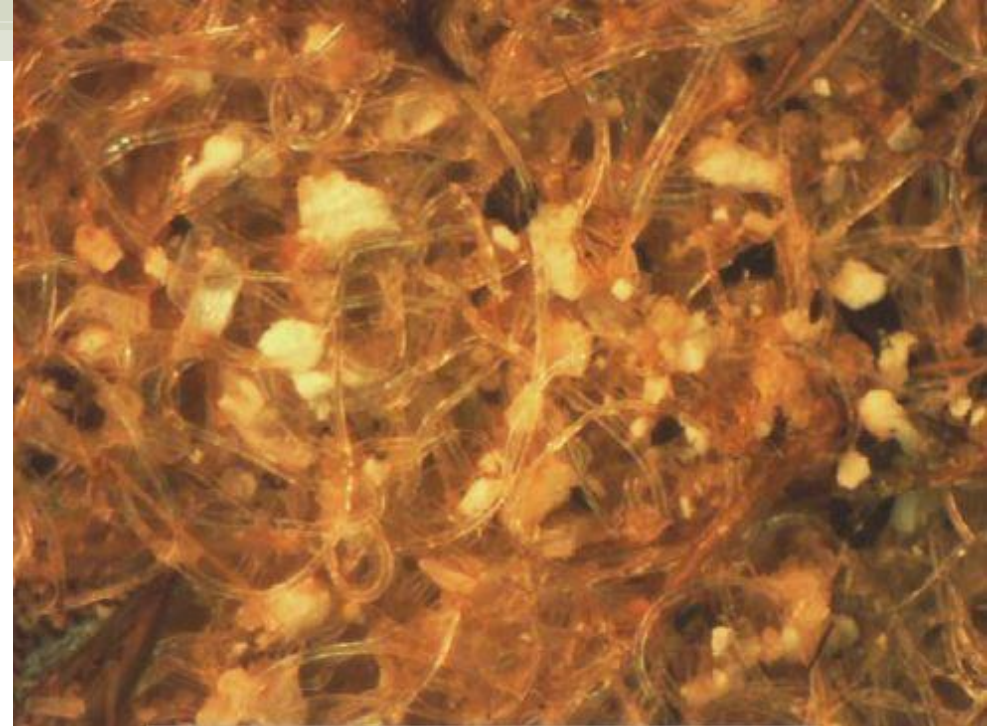




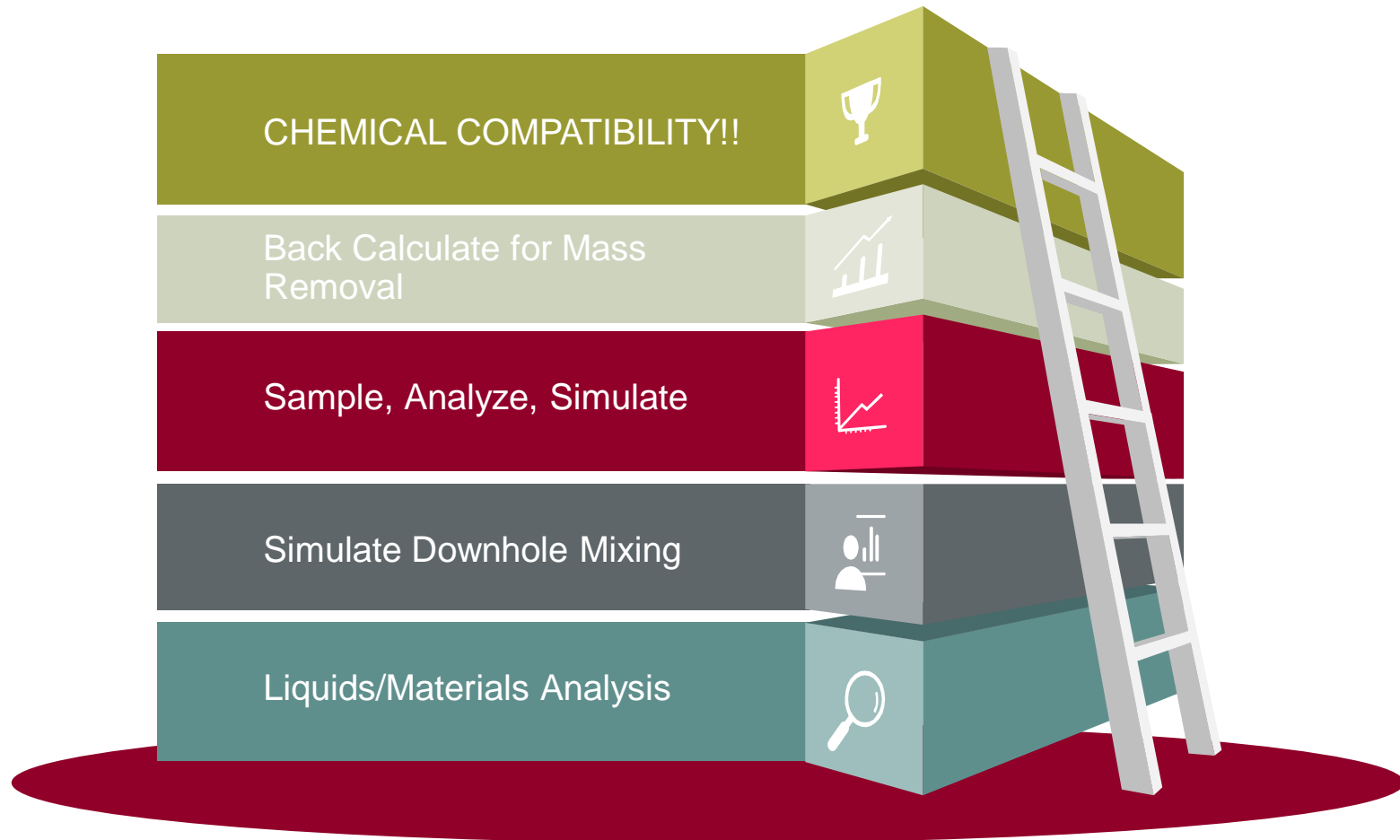
# OUR SOLUTION

- Continue Leachate Analysis
- Continue Simulation Revisions
- Watch for Changes to Liquids Handling

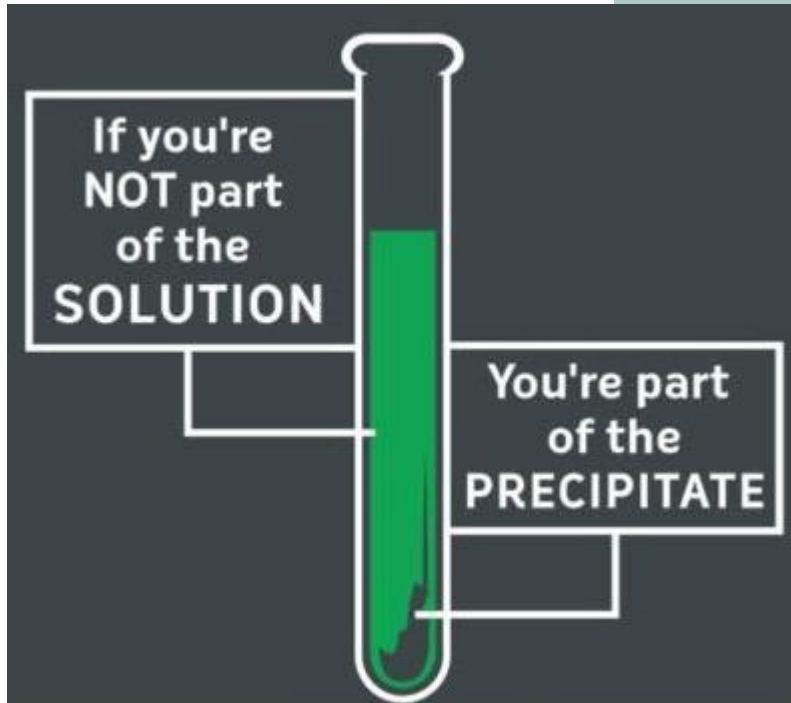




# SUMMARY



# Thank you



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