Operational and Financial Studies of H_2O_2 vs. $Ca(OH)_2$ and H_2O_2 vs. NaOH at Two Pennsylvania Mine Drainage Treatment Sites

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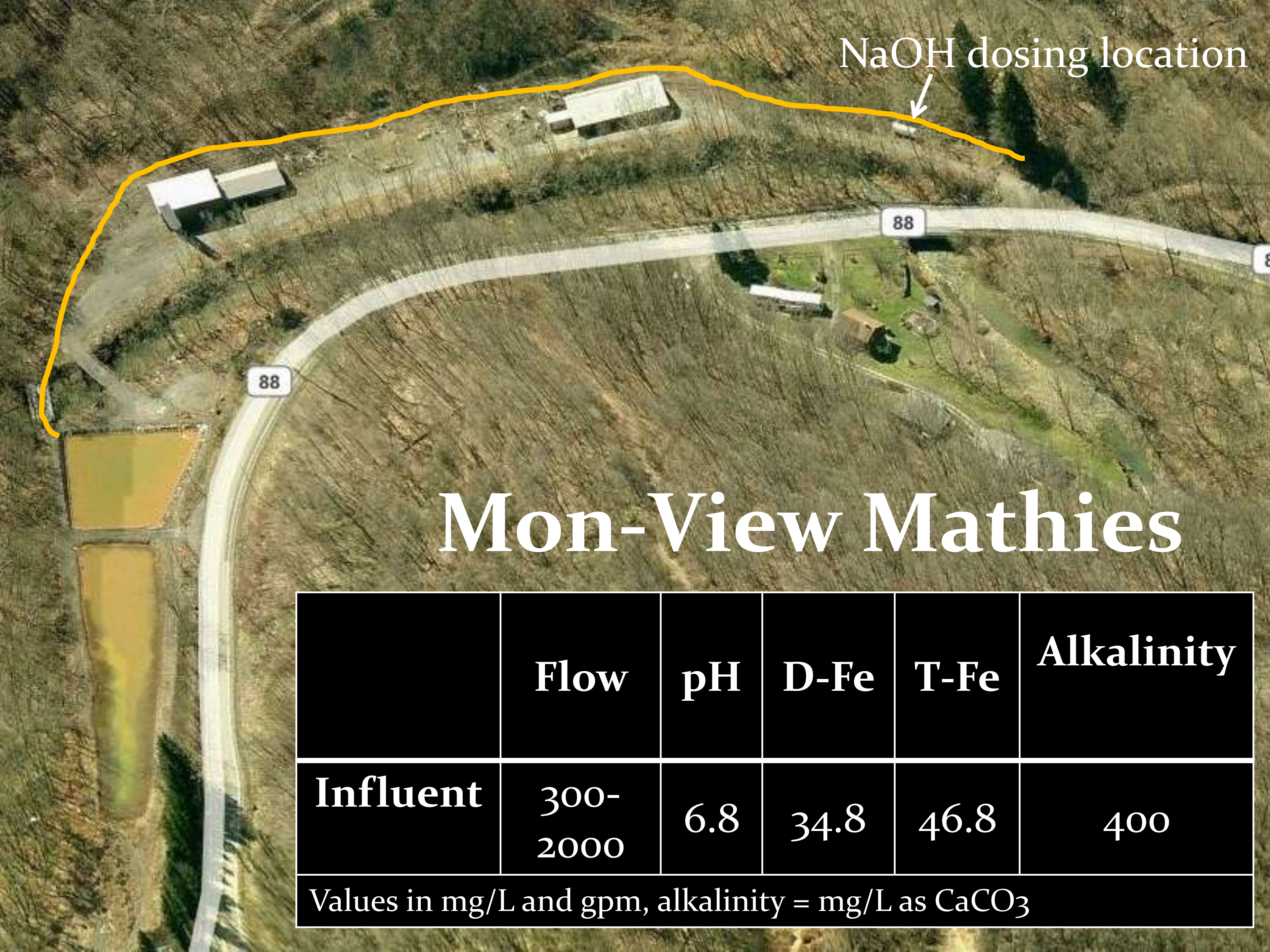


Mon-View Mathies

	Flow	pH	D-Fe	T-Fe	Alkalinity
Influent	300-2000	6.8	34.8	46.8	400

Values in mg/L and gpm, alkalinity = mg/L as $CaCO_3$

LTV Banning Treatment System

	Flow	pH	D-Fe	T-Fe	Alkalinity
Influent	2310	6.8	18	18	394

Values in mg/L and gpm, alkalinity = mg/L as $CaCO_3$



LTV Banning and Mon-View Mathies Cost-Reduction Evaluation

- Recent financial market condition has affected trust revenue generation
- PADEP with the assistance of OSM formed evaluation team to perform cost-reduction evaluations
- Evaluation team focused on reducing annual operation and chemical costs

Cost-Reduction Evaluation

- 5-Step Approach
  1. Determine current dosing rates;
  2. Quantify consumption of alkali chemical;
  3. Develop alternative treatment strategies;
  4. Pilot test alternative strategies;
  5. Perform cost and performance comparison evaluation

Step 1: Quantify original Mon-View NaOH Costs

Mon-View: Results of Original 20% Sodium Hydroxide (w/w) Treatment Configuation										
Sample Location	Flow (gpm)	Field pH	Field Alkalinity	Ca - D	Ca - T	Fe - D	Fe - T	Na - D	Na - T
Reaction tank Influent	396	6.86	400	96.5	100	34.8	46.3	448	468
Reaction tank Effluent	396	7.22	385	95.5	102	4.306	46.2	475	515
Final Effluent	396	7.48	375	94.3	97.2	1.1	1.09	454	502
All values in mg/L, Alkalinity = mg/L as $CaCO_3$, D = Dissolved, T = Total									

20% NaOH Dosing = 122 gal/day = $116/day = $42,340/yr

Step 1: Quantify Banning Hydrate Costs

Banning : Results of Original Hydrated Lime Treatment Configuation									
Sample Location	Flow (gpm)	Field pH	Field Alkalinity	Ca - D	Ca - T	Fe - D	Fe - T	Na - D	Na - T
Reaction tank Influent	2310	6.89	394	114	112	18	18.0	434	432
Reaction tank Effluent	2310	8.28	310	87.5	256	0.026	16.9	440	444
Final Effluent	2310	8.25	306	71.5	92	<.020	1.0	390	462
All values in mg/L, Alkalinity = mg/L as $CaCO_3$, D = Dissolved, T = Total									

Hydrated Lime Dosing = 3.77 tons/day = $603/day = $220,168/yr

STEP 2: Quantify Sources of Alkali Consumption

1. Fe(II) Removal
   - $Fe^{2+} + 2OH^{-} = Fe(OH)_2$
   - $Fe^{2+} + .5H_2O + .25O_2 + 2OH^{-} = Fe(OH)_3$

2. Calcite Formation
   - Dissolved-precipitate
     $Ca^{2+} + OH^{-} + CO_{2(aq)} = CaCO_{3(s)} + H^{+}$
   - Recarbonation
     $Ca(OH)_{2(s)} + CO_{2(aq)} = CaCO_{3(s)} + H_2O$

Step 2: Quantify Sources of Alkali Consumption

3. Hydroxylation - Reaction with OH^- ion with aqueous species to form H2O and other species

- Hydroxylation of anion

  $HCO_3^- + OH^- = CO_3^{2-} + H2O$

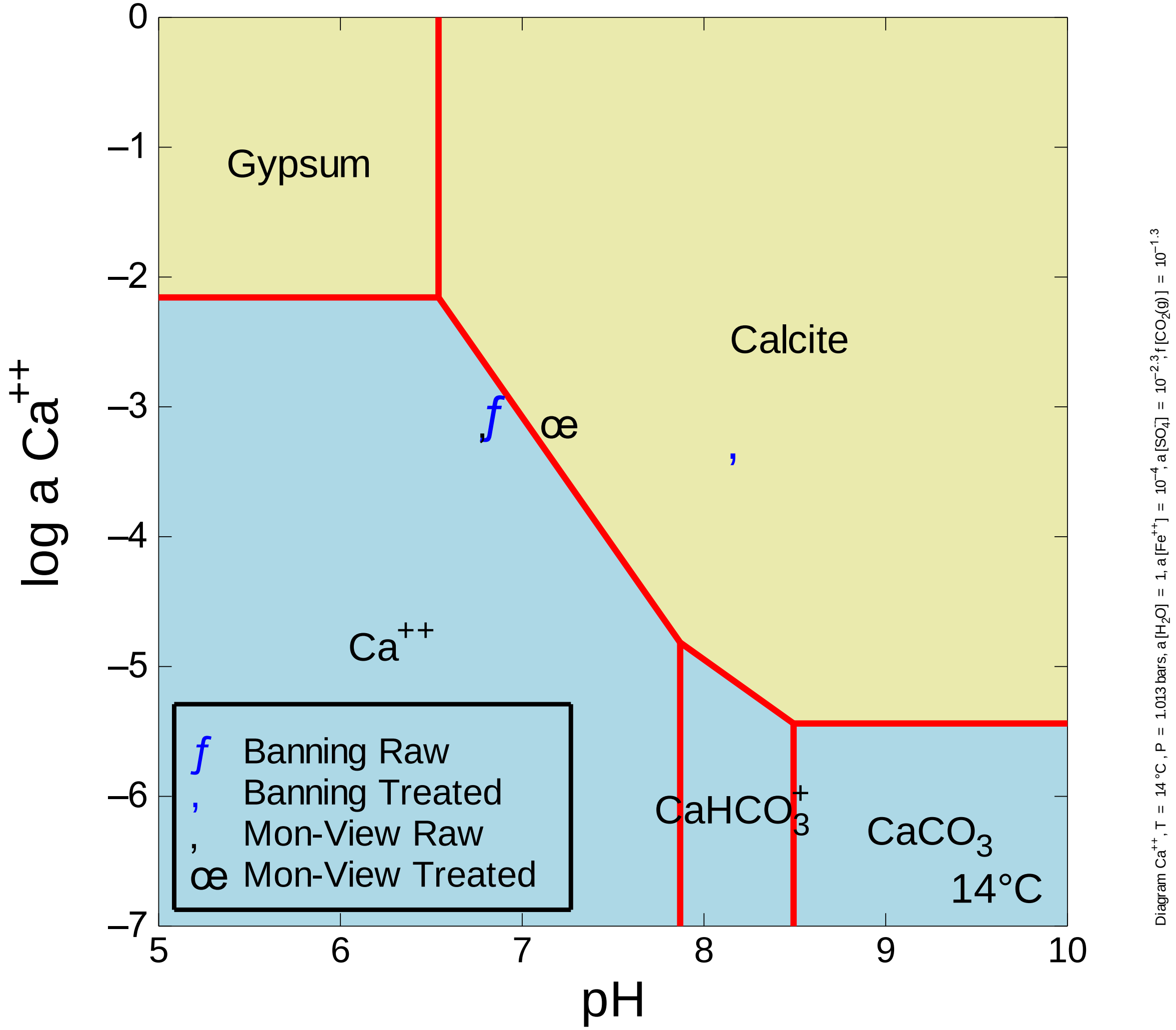
- Hydroxylation of cation

  $Mg^{2+} + OH^- = MgOH^+$

- Hydroxylation of Aqueous complexes

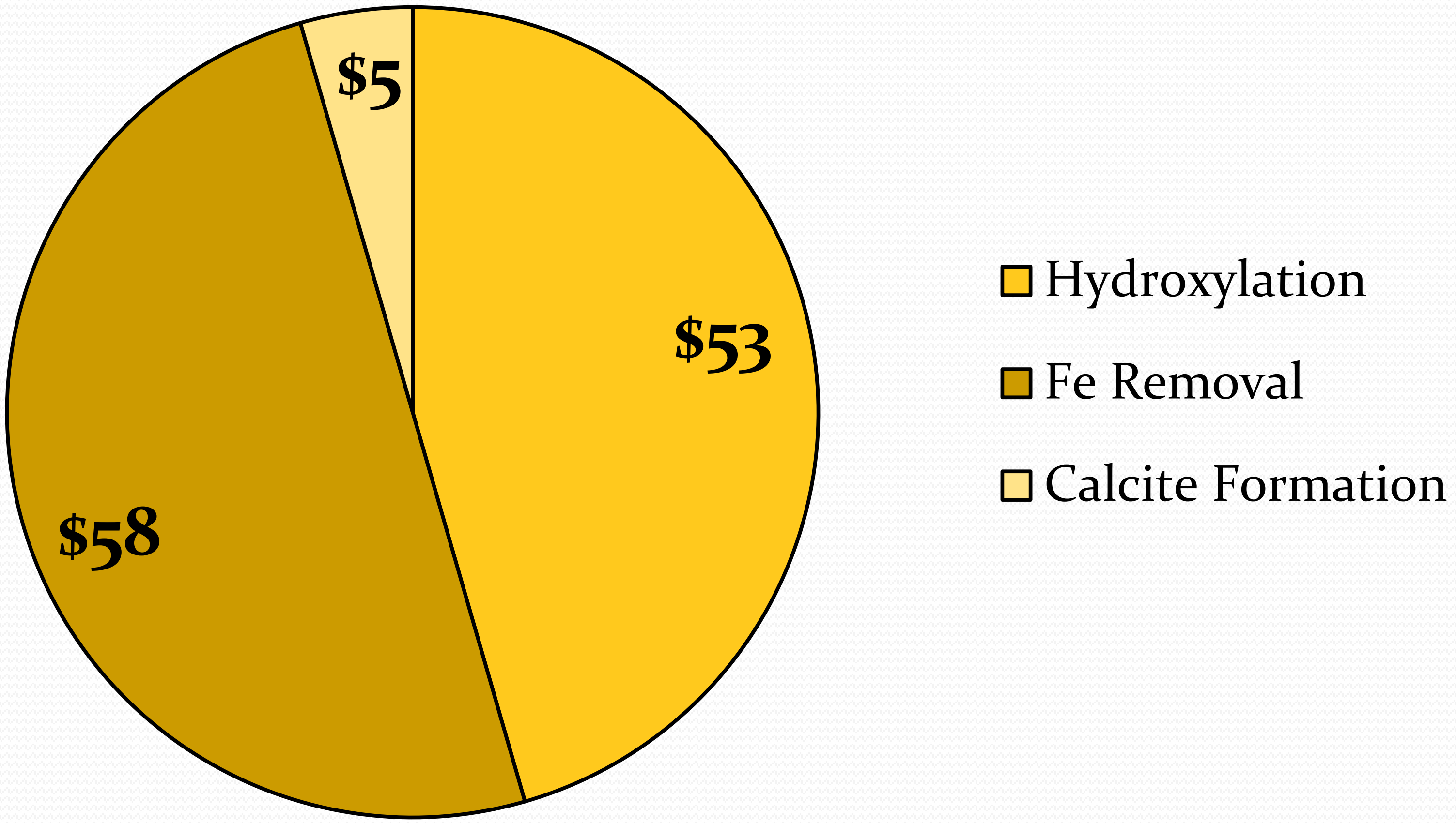
  $CaHCO_3^+ + OH^- = CaCO_{3(aq)} + H_2O$

Calcite Formation resulting from pH adjustment

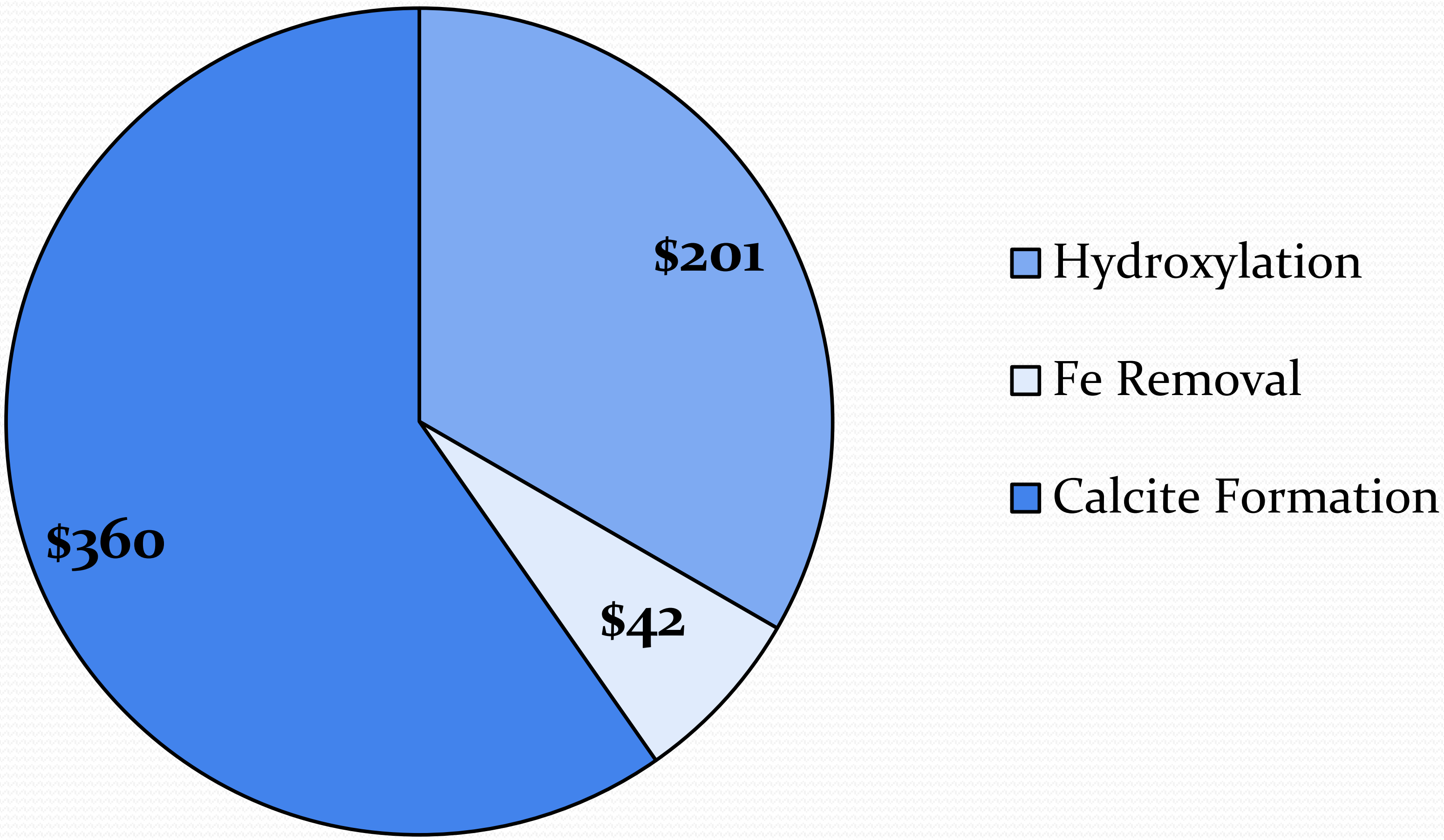


$$Ca^{2+} + OH^{-} + CO_2 = CaCO3 + H^{+}$$

Daily Consumption of NaOH at Mon-View



Daily Consumption of Hydrated Lime at Banning



Using pH adjustment as a treatment strategy is costing $561/day worth of nuisance consumption to treat 18 mg/L of Iron

Validation of Consumption Analysis

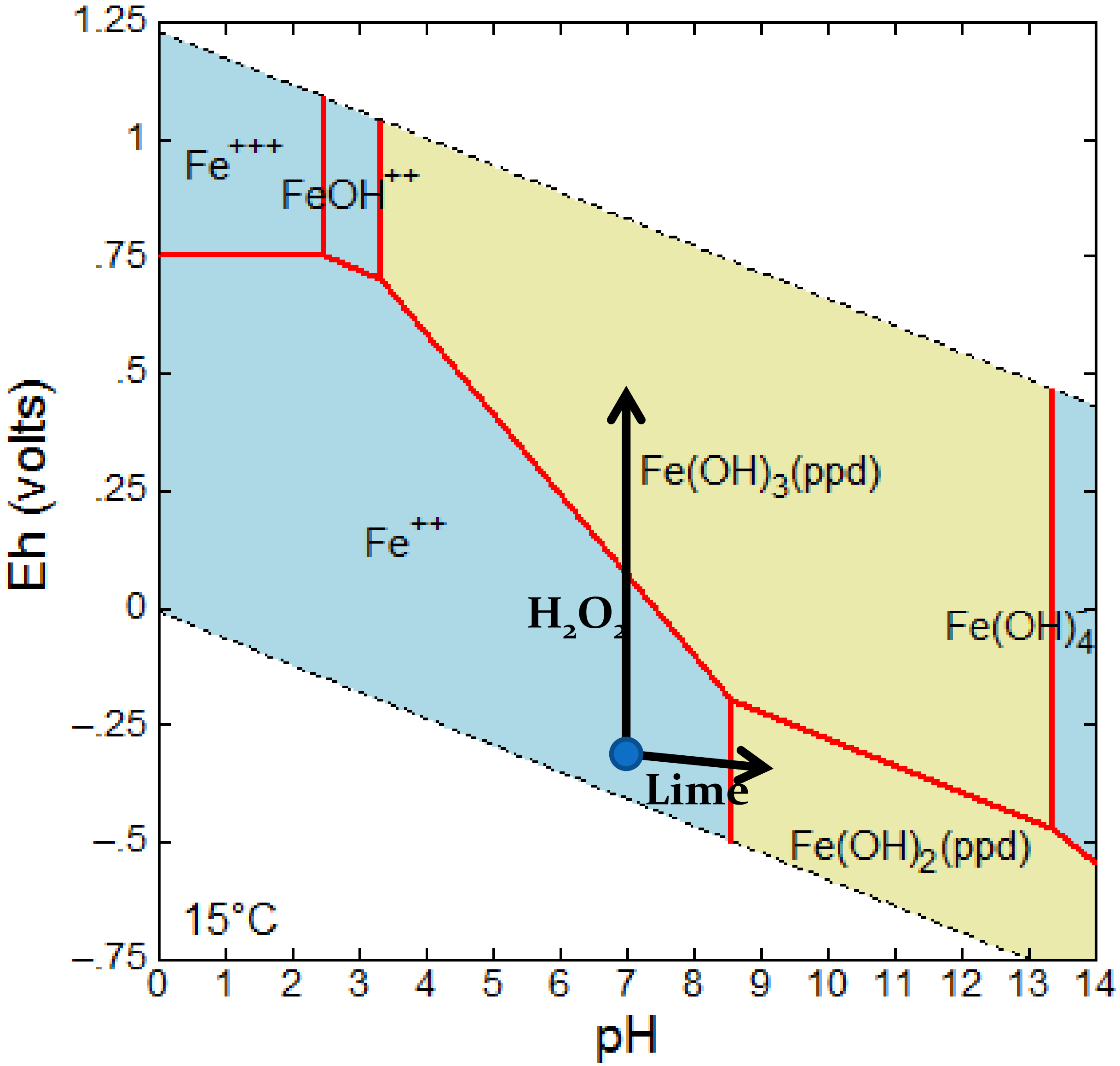
	Mon-View	Banning
Influent Alkalinity	400	394
Measured Alkali Dosing	65	252
Total Alkalinity Inputs	**465**	**646**
Computed Alkali Consumption	125	337
Calculated Effluent Alkalinity	**340**	**309**
Measured Effluent Alkalinity	375	310
Percent (%) Difference	-9%	-.3%

All values = mg/L as $CaCO_3$

Step 3: Develop alternative Treatment Strategy to reduce Cost

Pilot Test 50% H_2O_2

- Eh adjustment



Hydrogen Peroxide (H_2O_2)

- Benefits
  1. Avoids consumption due to hydroxylation and calcite formation;
  2. Targets iron;
  3. Low sludge production;
  4. Low Capital Cost and maintenance;
  5. Stable supply and pricing

- Drawbacks
  1. Safety – very strong oxidant;
  2. Containment and spill mitigation plan is required;
  3. Secure site facility

Step 4: Pilot test to gather performance and cost data

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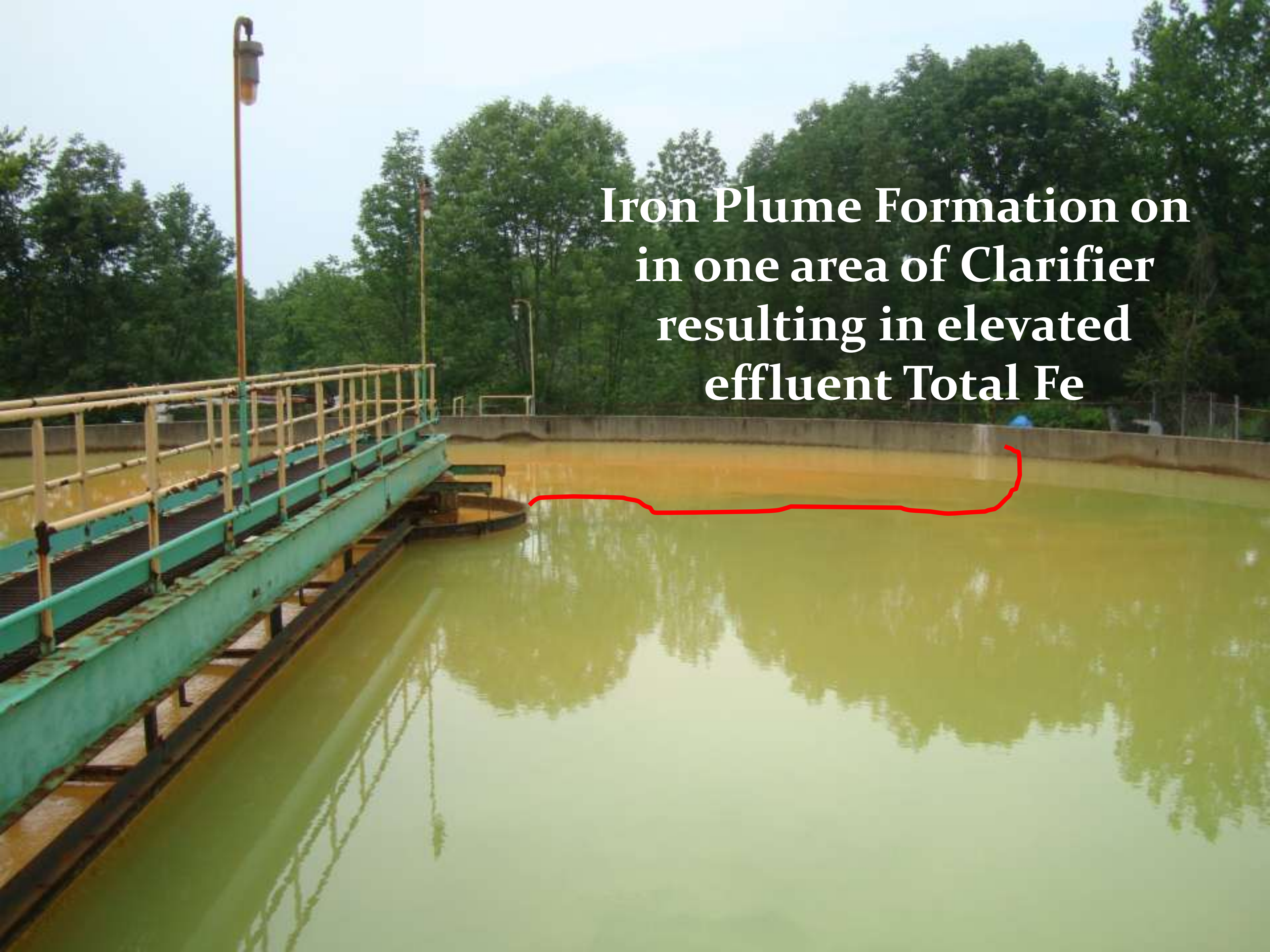
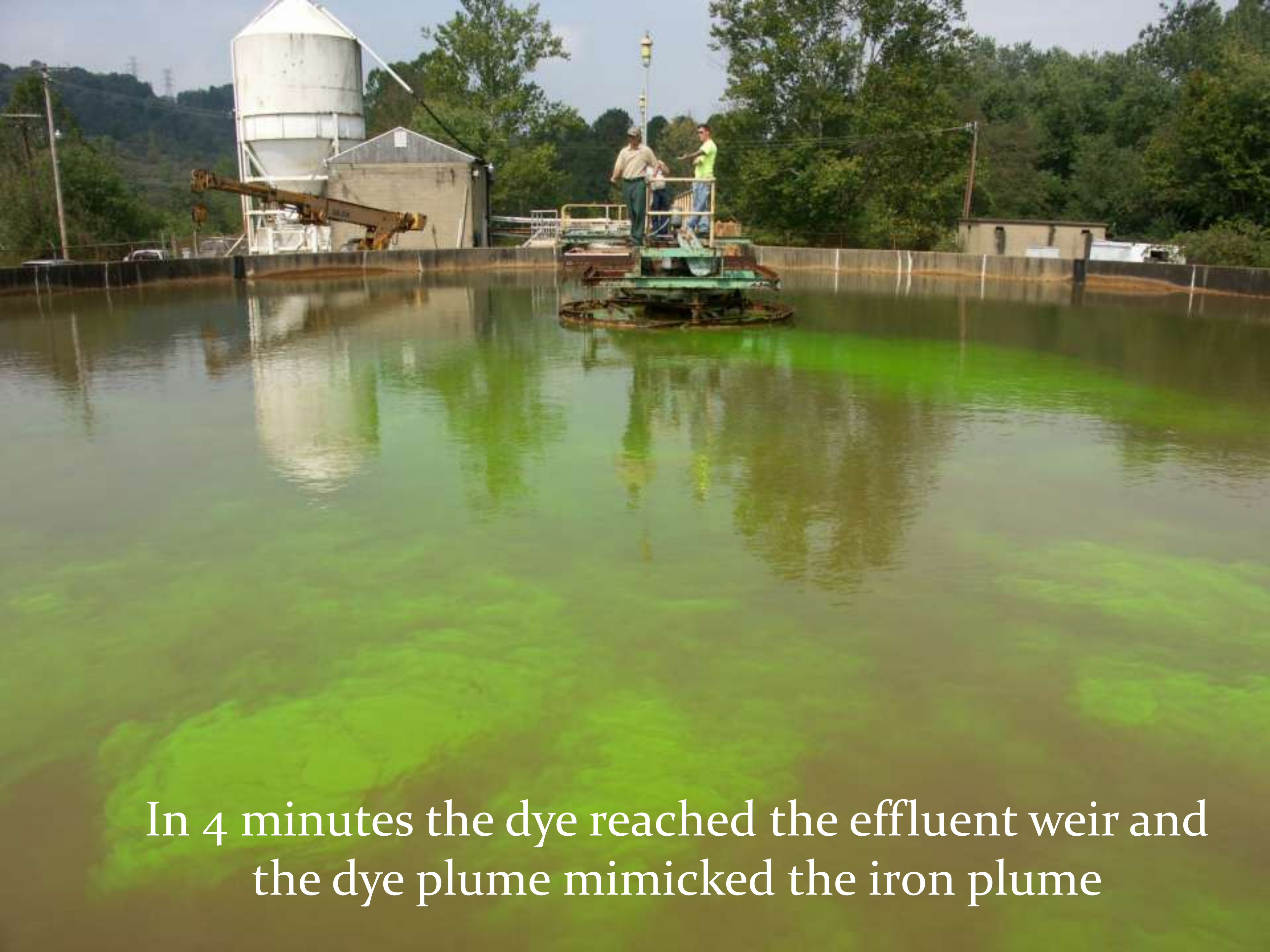
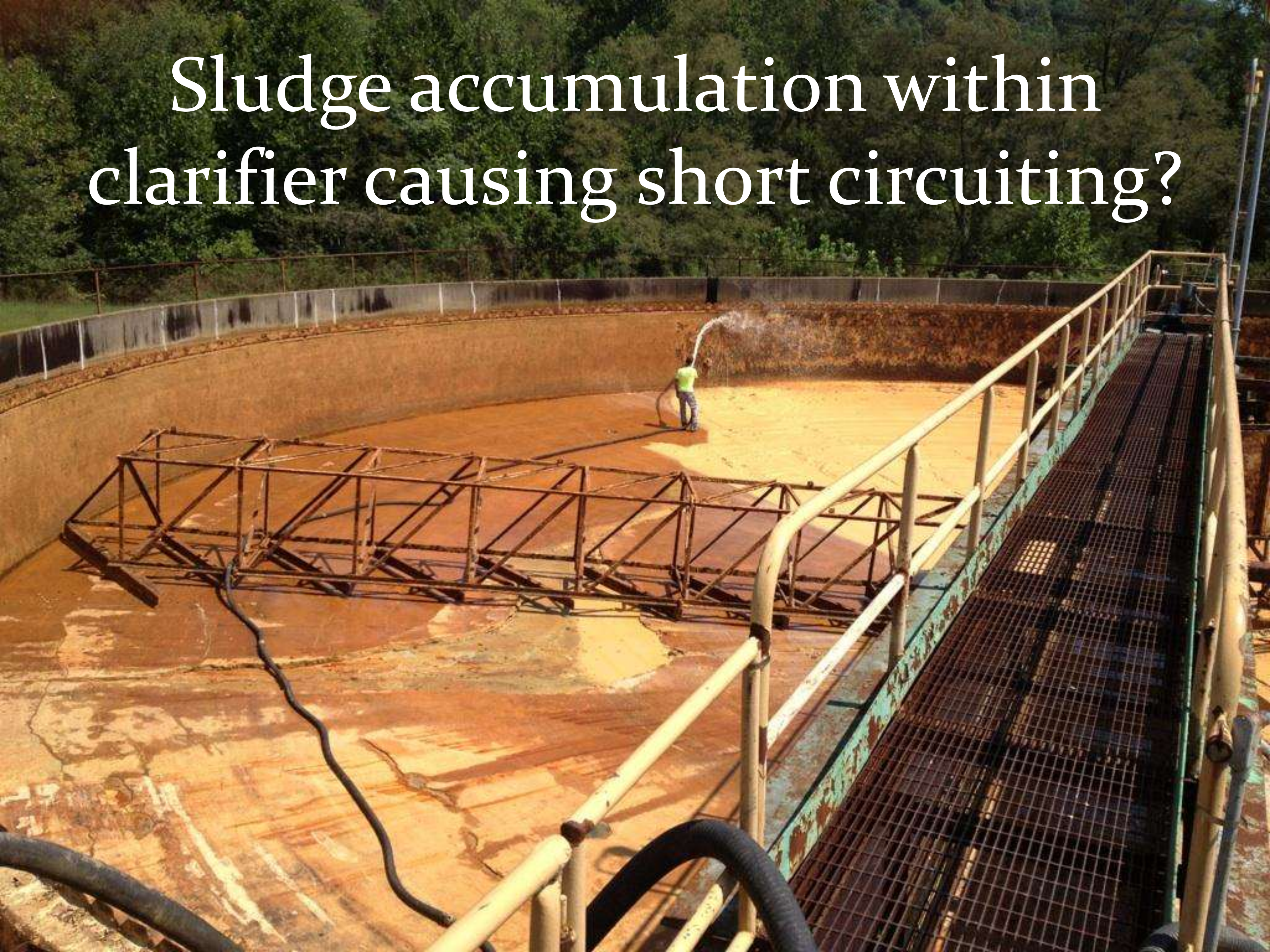

Iron Plume Formation on
in one area of Clarifier
resulting in elevated
effluent Total Fe

Tried to Chemically-Overcome Short Circuiting/settling issue

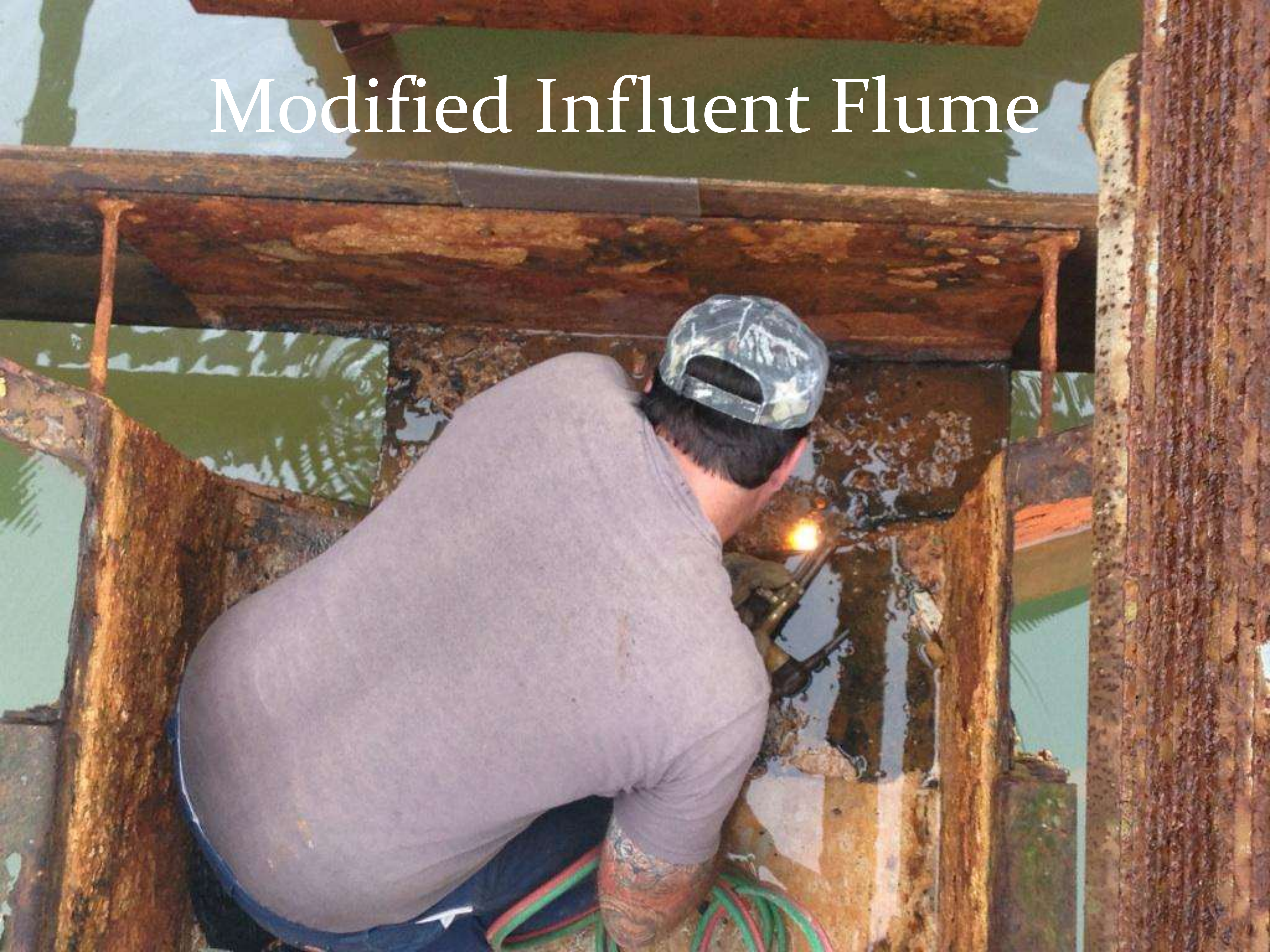
- 50% H_2O_2 & Alum
- 50% H_2O_2 & DelPAC 2020 (Polyaluminum Chloride)
- 50% H_2O_2 & Nalco Pol E-Z (Anionic Polymer)
- 50% H_2O_2 & $Ca(OH)_2$


In 4 minutes the dye reached the effluent weir and the dye plume mimicked the iron plume


Sludge accumulation within
clarifier causing short circuiting?


Unlevel Center Well or side wells causing preferential flow?

Modified Influent Flume



Fixed the Clarifier short circuit (no area-specific plume)!!!

Step 5: Cost & Performance Analysis between original and pilot systems

Monview Comparative Analysis					
	Reagent	**Dose (gal/day)**	**$/day**	**Effluent pH**	**Effluent T-Fe (mg/L)**
Original System	20% NaOH	122	$116	7.4	1.01
Pilot System	35% H2O2	14	$46	7.2	1.4
* NaOH = $.95/gal, H_2O_2 = $3.30/gal					

Step 5: Cost & Performance Analysis between original and pilot systems

Banning Comparative Analysis					
	Reagent	**Dose (gal/day)**	**$/day**	**Effluent pH**	**Effluent T-Fe (mg/L)**
Original System	$Ca(OH)_2$	3.77 ton/day	$603	8.25	1.0
Pilot System	50% H_2O_2 & $Ca(OH)_2$	25 gal/day & 1.2 ton/day	$275	7.5	1.0

* $Ca(OH)_2$ = $160/ton, H_2O_2 = $3.30/gal


2014


Conclusions

- Mon-View
  - Annual cost savings of $25,500
  - Implemented bulk H2O2 System for $25,000
- Banning
  - Annual cost savings of $120,000 could save the trust $1.1 million over the next decade
  - Plan to implement a bulk H_2O_2 system in 2013
- Conduct cost reduction evaluations at other LTV sites
  - Anticipated annual cost savings of $220,000