Process Optimization for O&M Cost Savings

– A Case Study for Gold Mining Effluent Treatment

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One Team. Infinite Solutions.

Stantec

OUTLINES

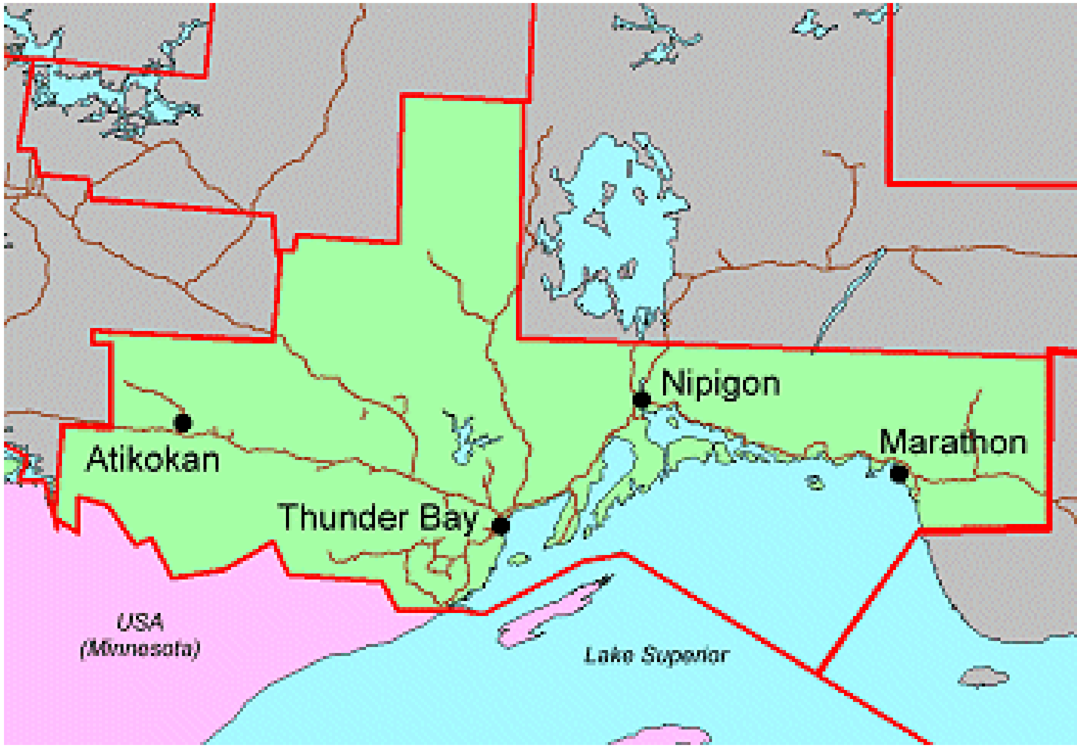
- **Project Background**
  - **Williams Operating Corporation (WOC) Introduction**
  - **Project Objectives**

- **Design Basis**
- **Methodology**
- **Results**
- **Conclusions**
- **Acknowledgements**

PROJECT BACKGROUND

Williams Operating Corporation Introduction

- **East Thunder Bay**
- **Gold Mining**
- **Cyanide Leaching Process**



PROJECT BACKGROUND

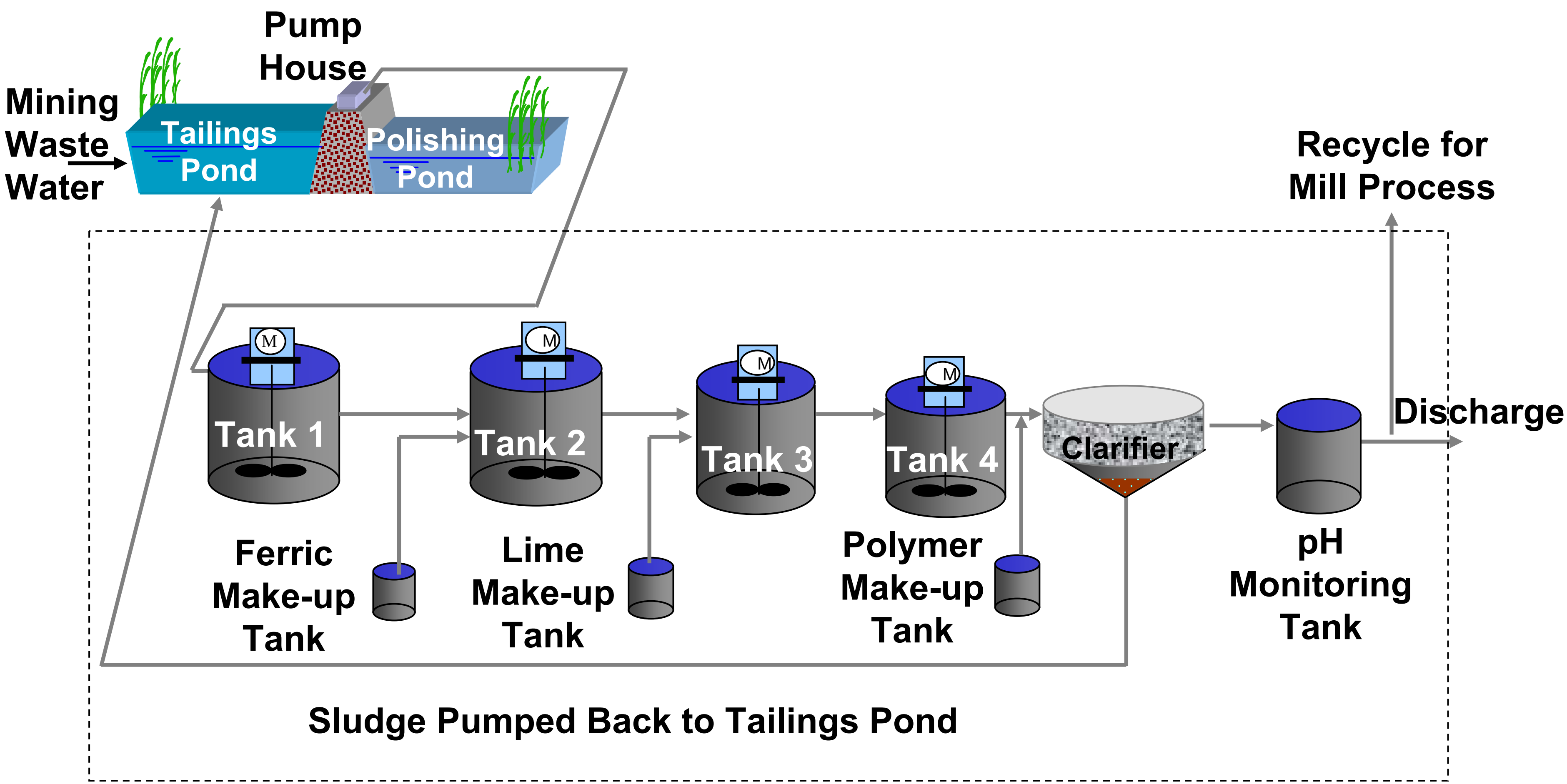
Williams Operating Corporation

Introduction

WILLIAMS MINE

PROJECT BACKGROUND

Williams Operating Corporation Introduction



PROJECT BACKGROUND
Williams Operating Corporation Introduction

- **Existing Problems**
  - **Hydraulic Capacity Upgrade**
    - **Current: 600 m^3/hr (8 month/yr)**
    - **Plan: 1,500 m^3/hr (12 month/yr)**
  - **Operation Only Based on Working Knowledge**
  - **High Chemical Consumption**
  - **High O&M Cost**

PROJECT BACKGROUND

Williams Operating Corporation Introduction

- **Project Objectives**
  - **Hydraulic Capacity Optimization (not included)**
  - **Contaminants Removal Mechanisms Identification**
  - **Chemical Dosing Optimization**
  - **O&M Cost Reduction**

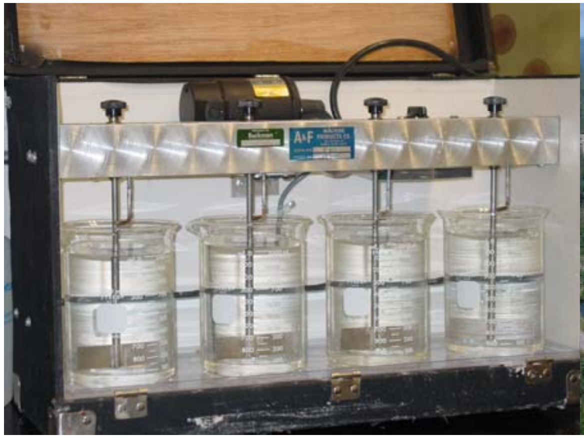
DESIGN BASIS

Parameter	ETP Feed, mg/L	Current C of A limits, mg/L	Design Basis, mg/L
Ammonia, total	8.1	20	10
Antimony, total	2.08	1.0	0.5
Arsenic, total	0.410	0.5	0.5
Copper, total	0.22	0.3	0.2
Cyanide, total	0.04	2.0	1.0
Iron, total	0.10	1.0	1.0
Lead, total	0.015	0.2	0.1
Molybdenum, total	1.60	1.0	0.5
Nickel, total	0.865	0.5	0.3
pH	7.8	5.5 – 10.6	5.5 – 9.0
TSS	2	15	10
Zinc, total	0.880	0.5	0.3
Effluent Toxicity		Non-Toxic	Non-Toxic

METHODOLOGY

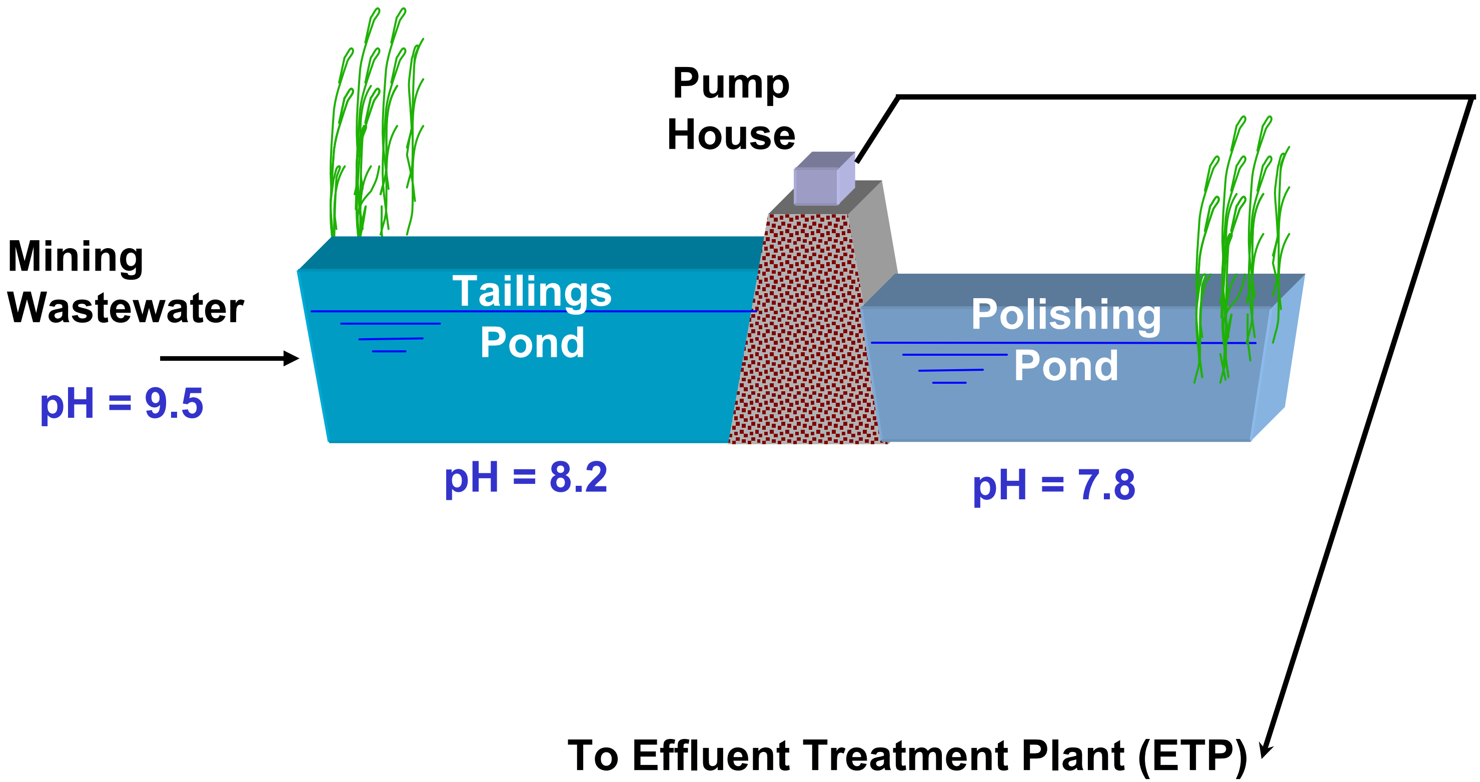
- **Problem Identification and Optimization Solution**

- **Treatability Test**
  - **Bench-Scale Testing**
  - **Full-Scale Testing**
  - **Toxicity Testing**



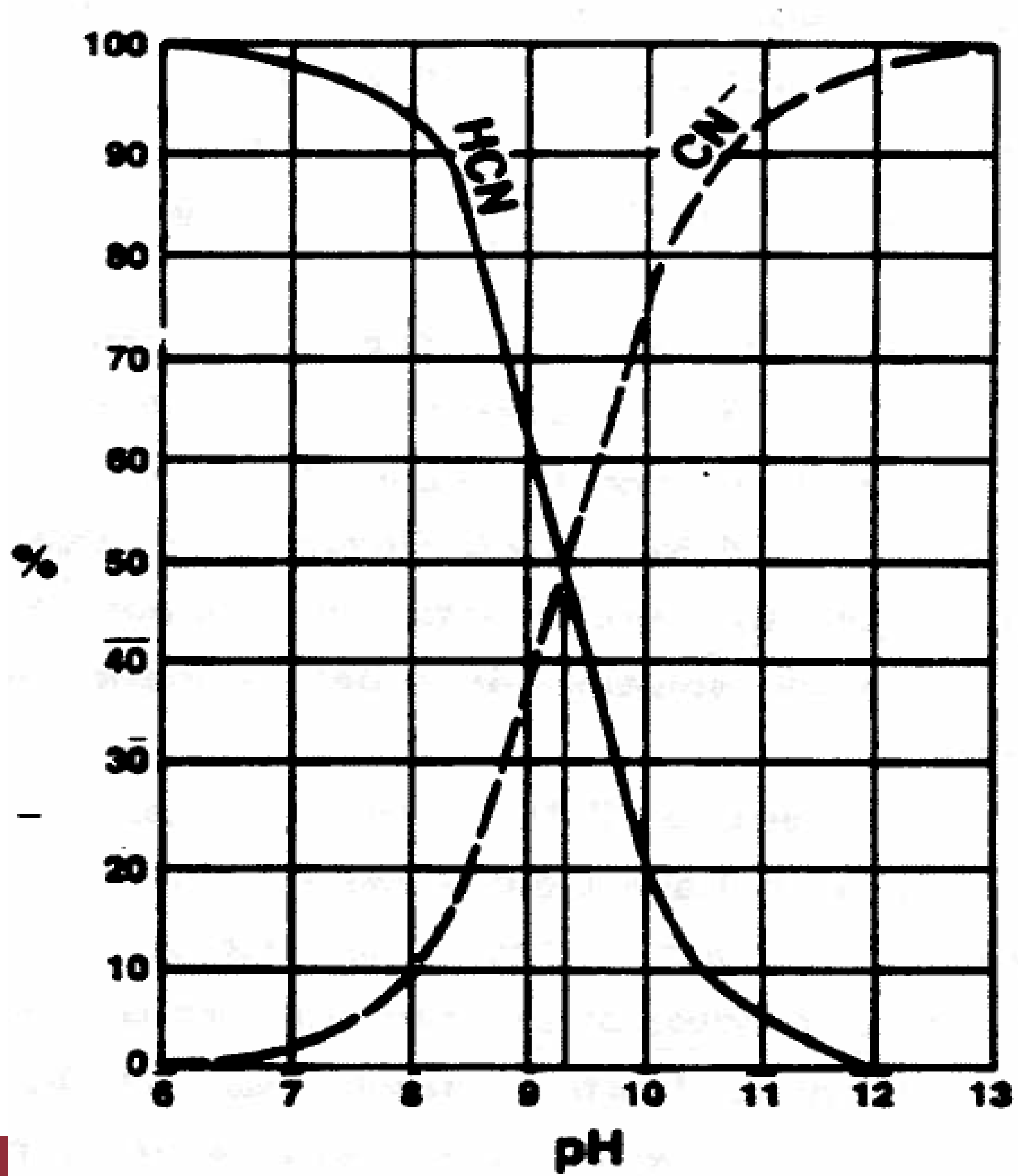
Problem Identification & Optimization Solutions

- **Tailings and Polishing Ponds:**
  - Satisfactory Removal: TSS, NH3-N, CN, As, Fe, Pb
  - HRT in Two Ponds: > 1 yr
  - Natural Degradation of CN (pH variation)



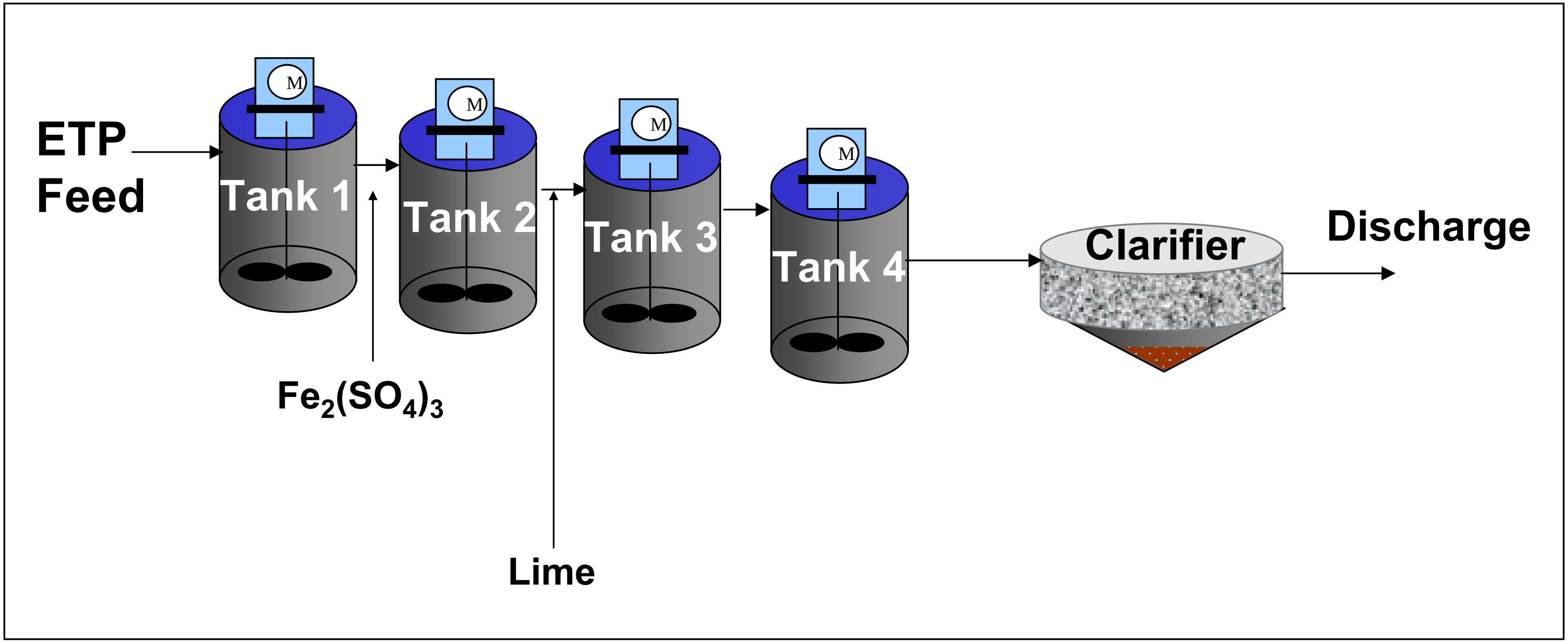
Problem Identification & Optimization Solutions

- **Degradation of CN:**
  - Tailings Solution: 53.4 mg/L (pH = 9.5)
  - Tailing Pond: 5.2 mg/L (pH = 8.2)
  - Polishing Pond: 0.036 mg/L (pH = 7.8)



Problem Identification & Optimization Solutions

- **ETP to Remove: Sb, Mo, Cu, Ni, and Zn**
- **Non-toxic effluent**
- **Coprecipitation: Sb and Mo**
- **pH adjustment: Cu, Ni, and Zn**



Optimization Solutions

- **Coprecipitation Process (CP) for Sb & Mo Removal**
  - Coprecipitation with iron hydroxide
  - Most common practice for Sb & Mo removal
  - Very limited available literature

- **Coprecipitation Process**
  - $Fe_2(SO_4)_3 + 6H_2O = 2Fe(OH)_3(s) + 6H^+ + 3SO_4^{2-}$
  - lower pH
  - Sb and Mo adsorbed onto $Fe(OH)_3$ surface
  - $FeCl_3$ also effective

Technical Challenges

- **Limited Literature for Sb and Mo Removal**
  - Determined by Fe Dosages
  - No design guideline
  - Low pH Value (<8.0)
- **Working Knowledge**
  - WOC: Fe/Sb = 43/1
- **High Optimal pH Value for Cu, Ni, and Zn (>9.0)**
- **Single Reactor for Multiple Metals Removal**
- **One pH Value Required**

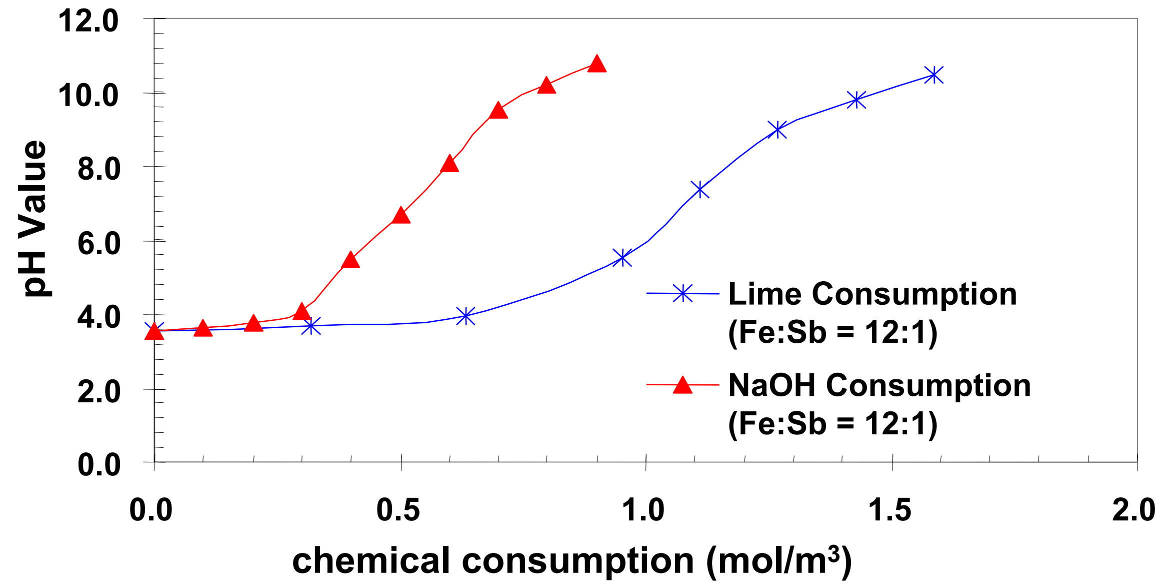
RESULTS
Bench-Scale Testing

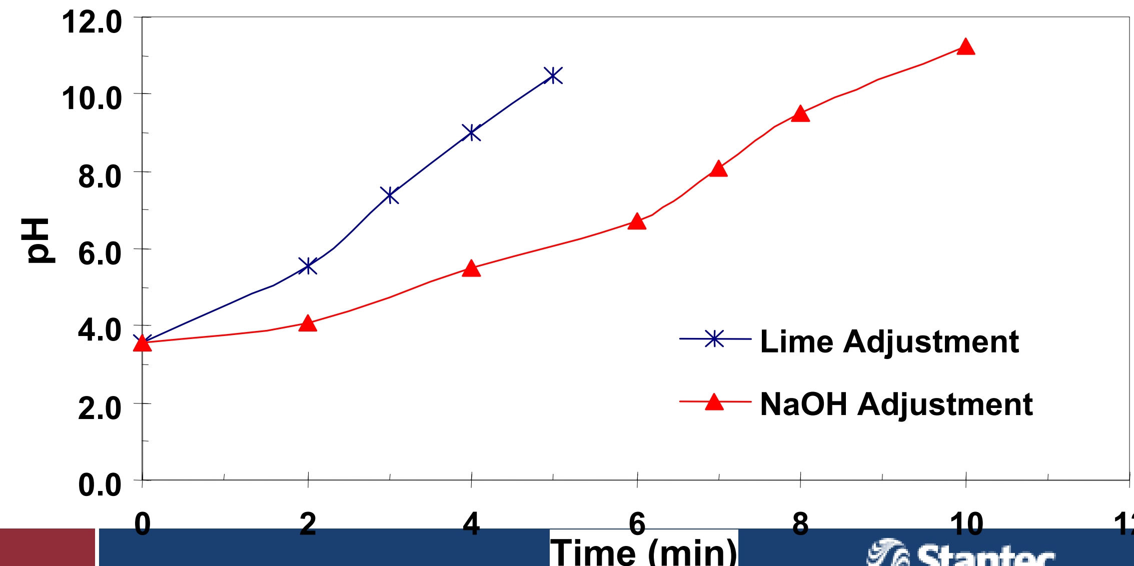
- **Objectives**
  - **Identify optimal alkali material (NaOH vs. Lime)**
  - **Identify optimal Fe^{3+} dosages**
  - **Identify optimal pH value for multi-metals removals**
- **Bench-Scale Setup**
  - **Jar-Test**

RESULTS

Bench-Scale Testing – Titration Test

- **NaOH vs. Lime**
  - **More lime than NaOH needed**
  - **Lime raises pH value faster than NaOH**
  - **Lime was recommended**

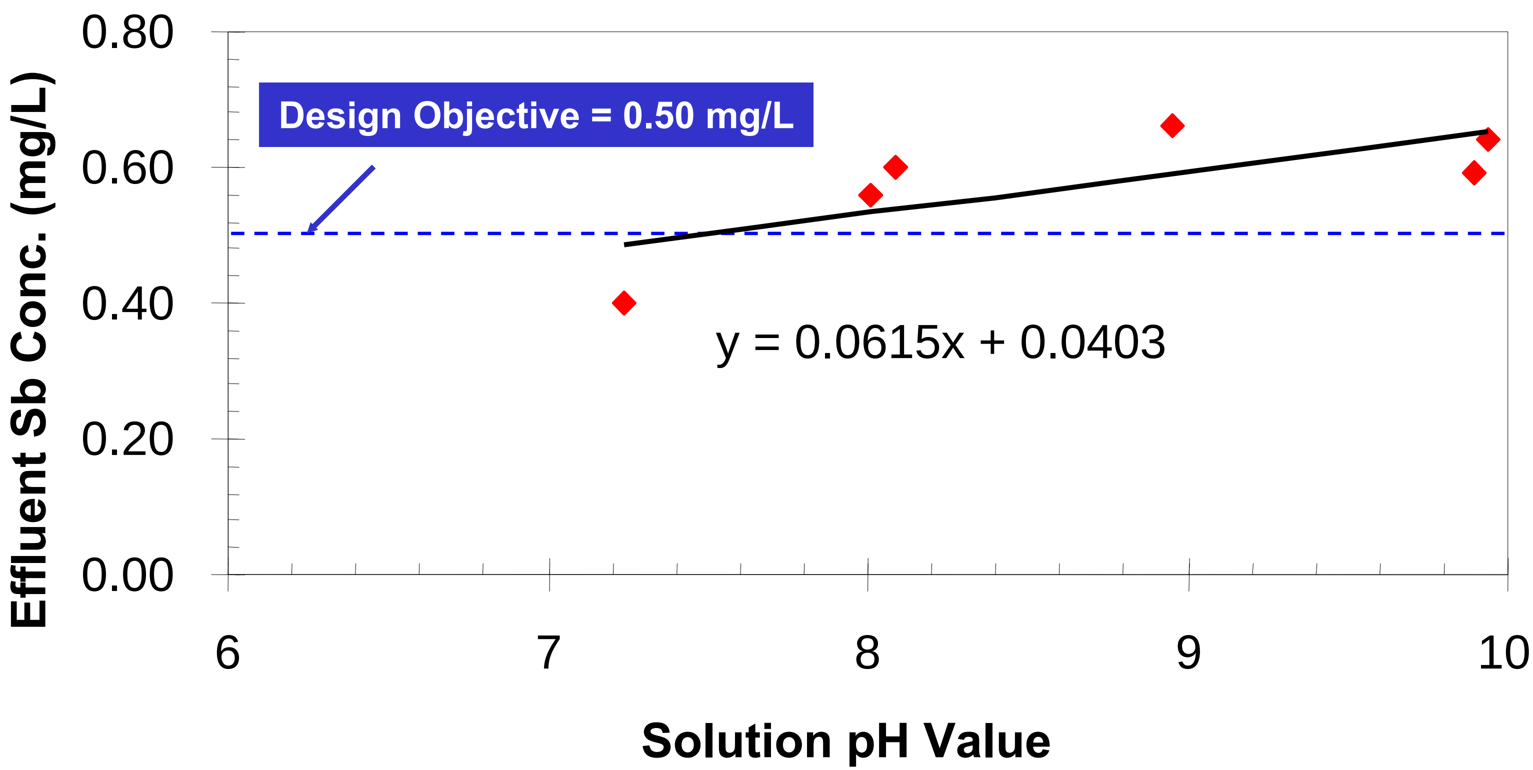




RESULTS

Bench-Scale Testing – Optimal pH in Single Reactor

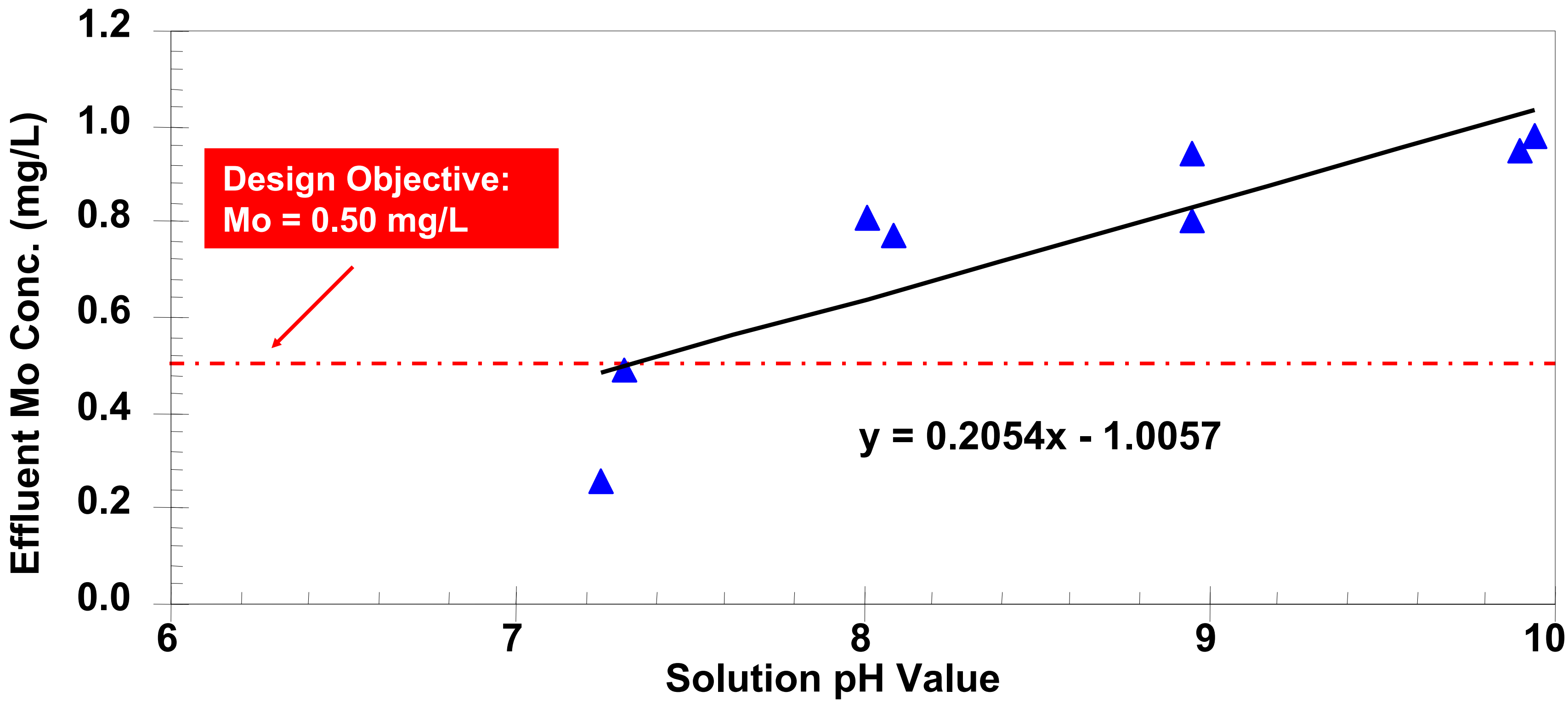
- **Optimal pH for Sb Removal**
  - **High pH resulted in higher effluent Sb**
  - **pH <8.0 more favorable for Sb Removal**



RESULTS

Bench-Scale Testing – Optimal pH in Single Reactor

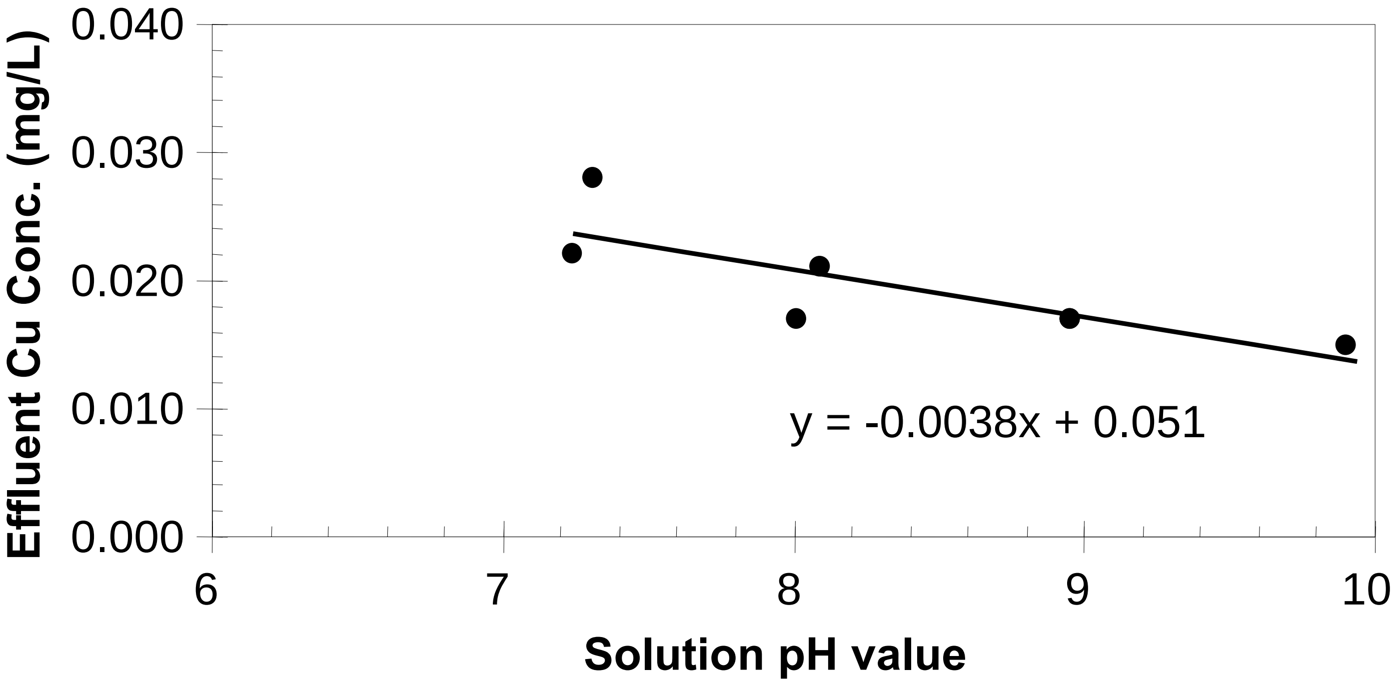
- **Optimal pH for Mo Removal**
  - **High pH values result in higher effluent Mo**
  - **pH ≈ 7.0 was more favorable for Mo removal**



RESULTS

Bench-Scale Testing – Optimal pH in Single Reactor

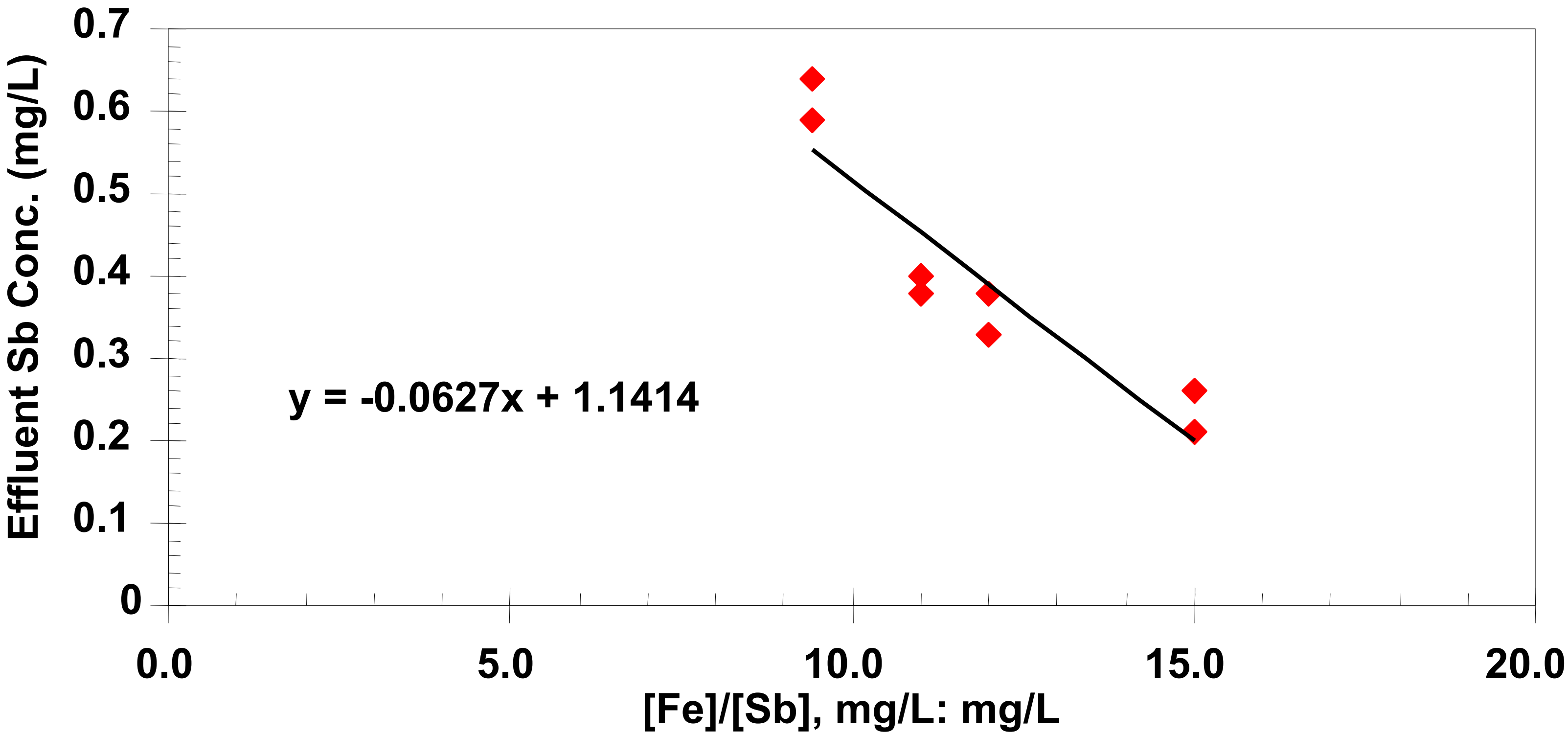
- **Optimal pH for Cu Removal**
  - **Higher solution pH result in lower effluent Cu**
- **Optimal pH for Ni and Zn Removal**
  - **Similar to Cu**



RESULTS

Bench-Scale Testing – Optimal Ferric Dosage

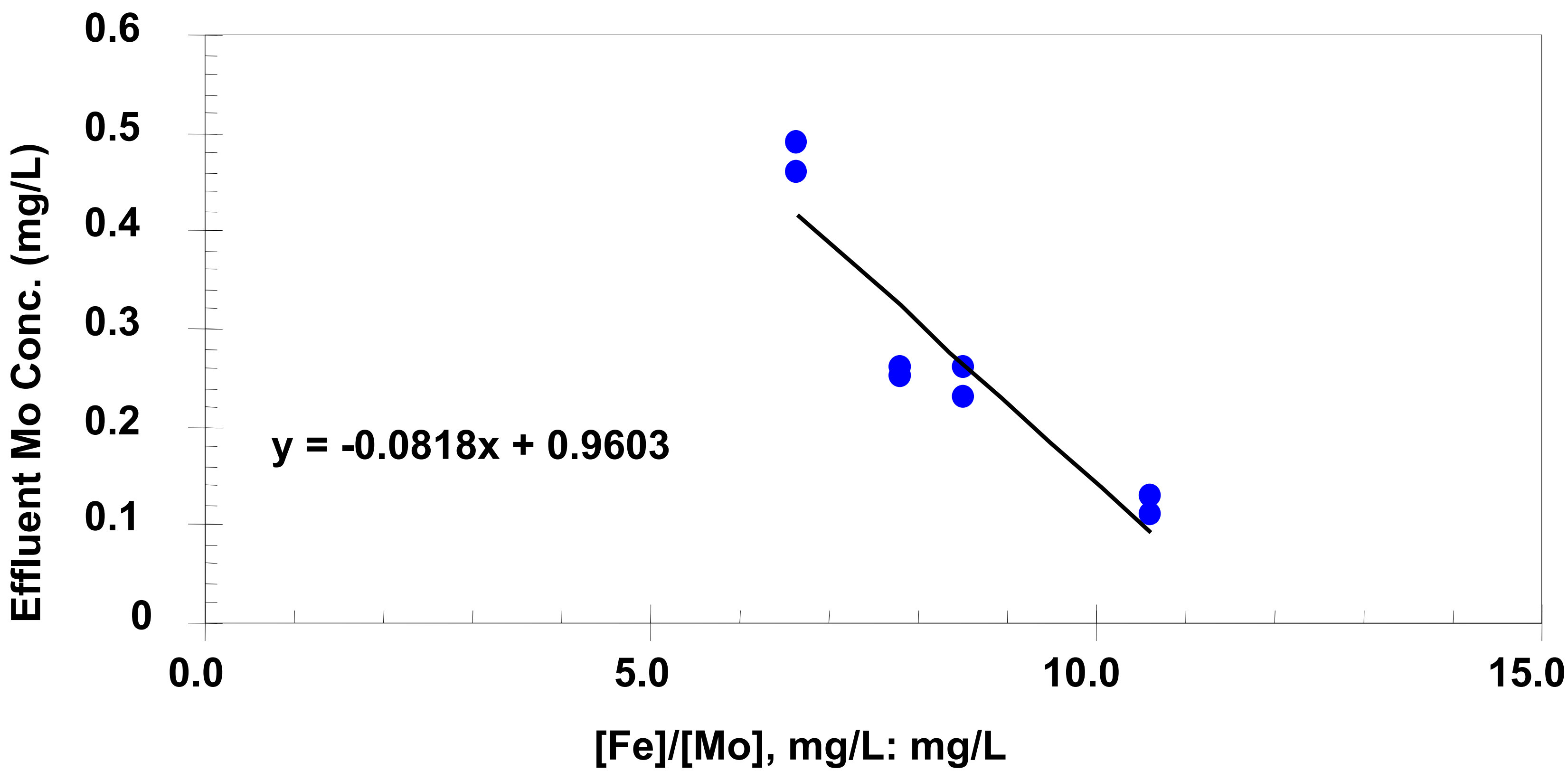
- **Fe Dosage for Sb Removal**
  - **Higher [Fe]/[Sb] resulted in higher Sb removal**
  - **[Fe]/[Sb] of 10/1 could result in Sb < 0.50 mg/L**



RESULTS

Bench-Scale Testing – Optimal Ferric Dosage

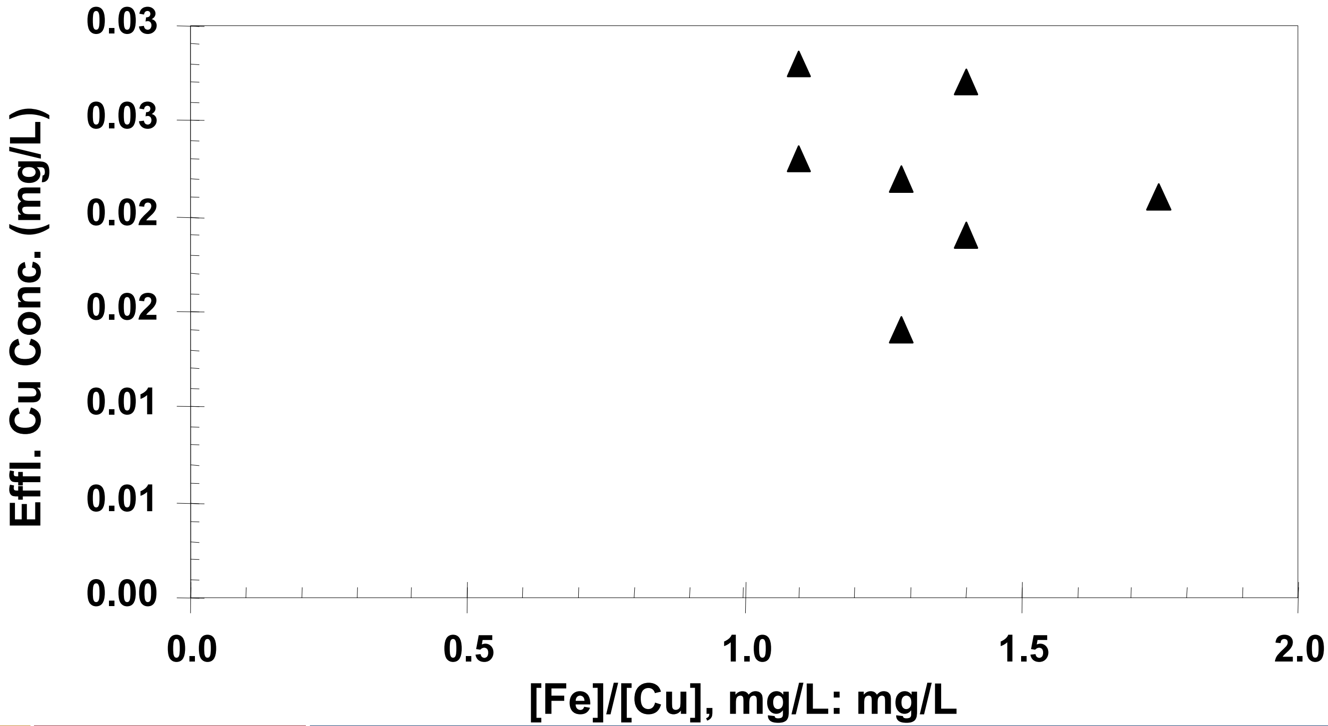
- **Optimal Fe Dosage for Mo Removal**
  - **Higher [Fe]/[Mo] resulted in higher Mo removal**
  - **[Fe]/[Mo] of 6/1 could result in Mo < 0.50 mg/L**



RESULTS

Bench-Scale Testing – Optimal Ferric Dosage

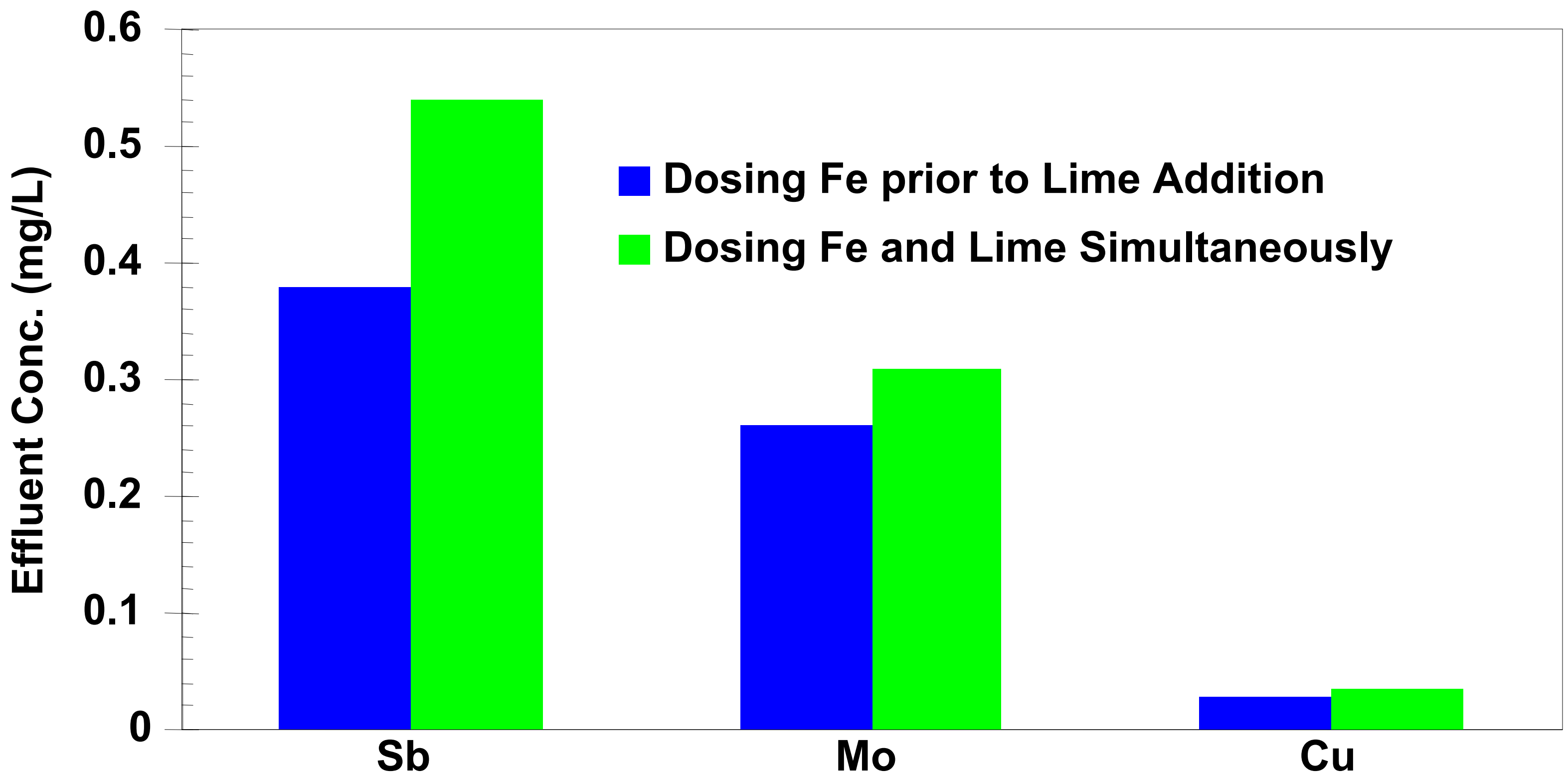
- **Fe Dosage for Cu Removal**
  - **Fe dosage did not impact Cu removal**
  - **Cu removal determined by pH**
- **Fe Dosage for Ni and Zn Removal**
  - **Similar to Cu**



RESULTS

Bench-Scale Testing – Dosing Sequence of Ferric and Lime

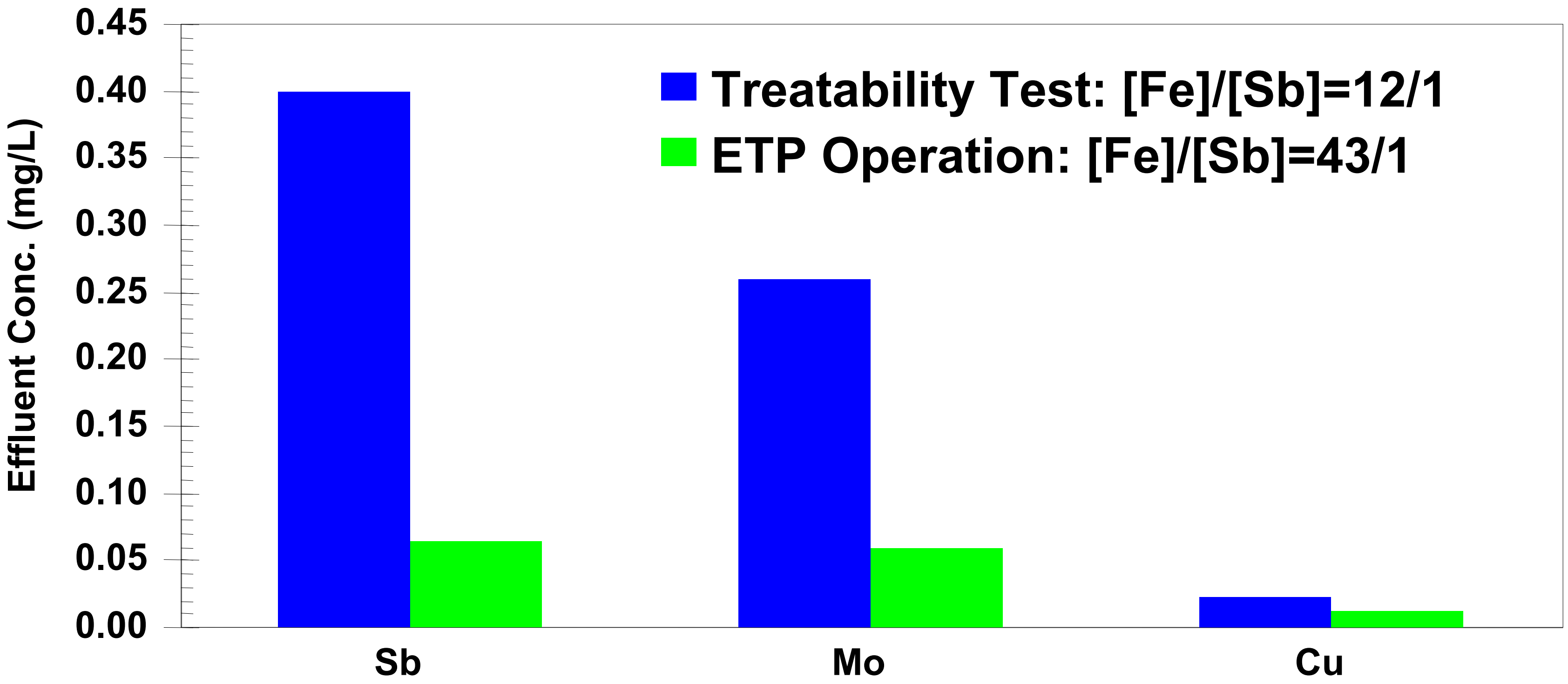
- **Results**
  - **Dosing simultaneously reduced removal rates**
  - **Dosing simultaneously did not meet the design Sb objective**
  - **Ferric should be dosed prior to lime addition**



RESULTS

Bench-Scale Testing - Comparison w/ Operation at ETP

- **Results**
  - **Both met CofA and Design Objectives**
  - **Less chemicals required (treatability test)**
  - **Less sludge generated (treatability test)**



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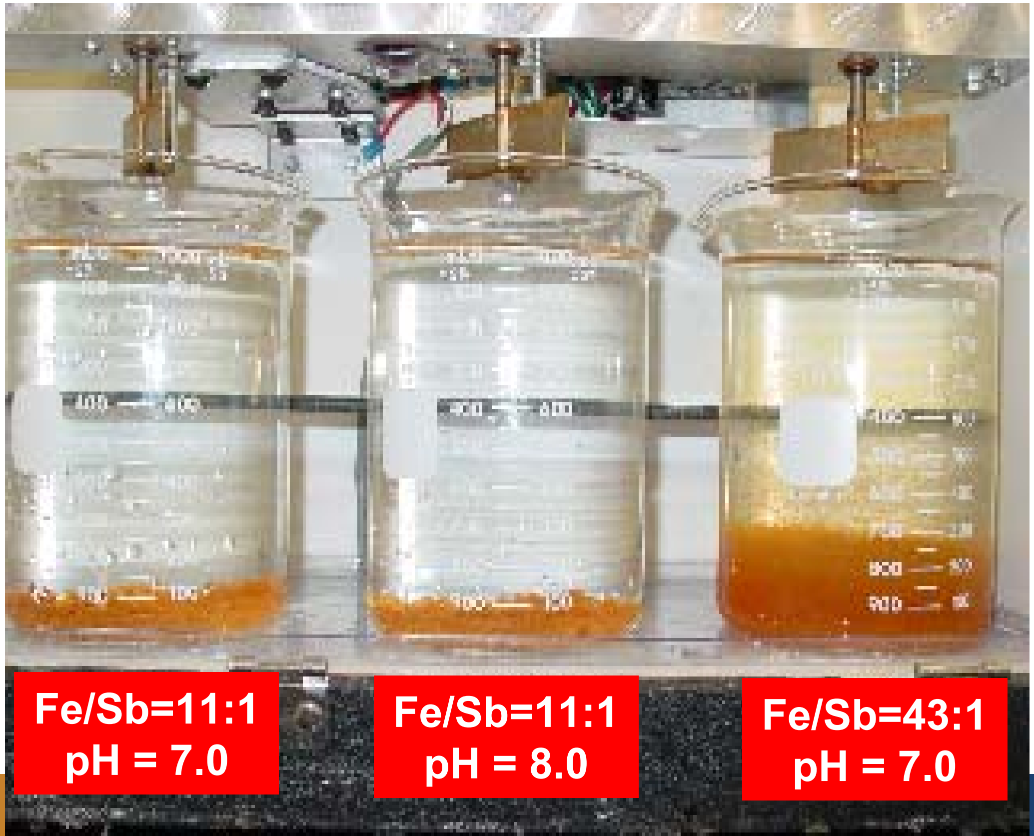


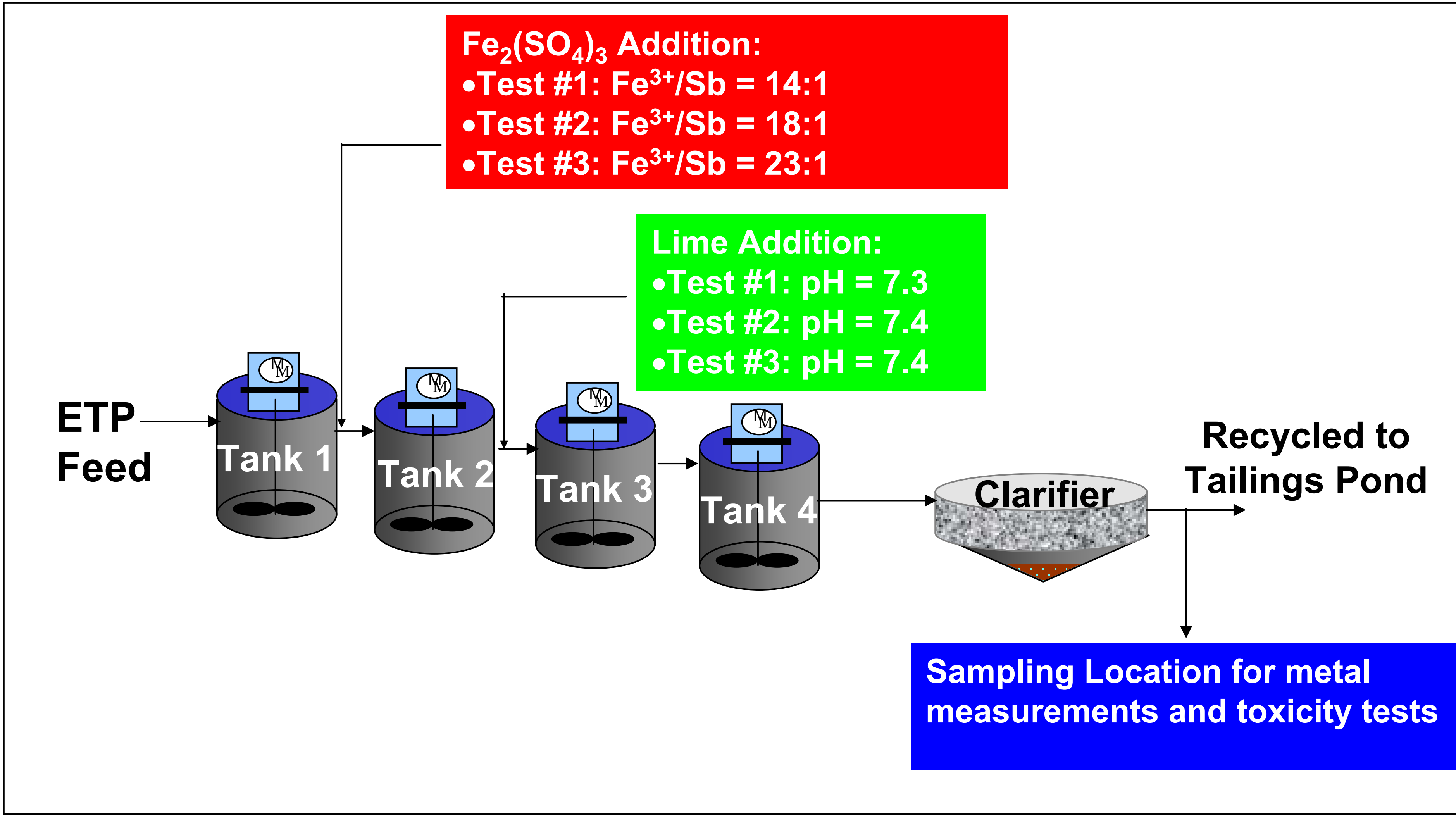
RESULTS

Bench-Scale Testing – Toxicity Test with *Daphnia Magna*

- **Jar Test Setup**
  - **$[Fe^{3+}]/[Sb] \approx 11/1$**
  - **pH = 7.0**
  - **Polymer = 1.1 mg/L**
- **Results**
  - **0% mortality in all exposure concentrations(100, 50, 25, 13 ,6%)**

RESULTS

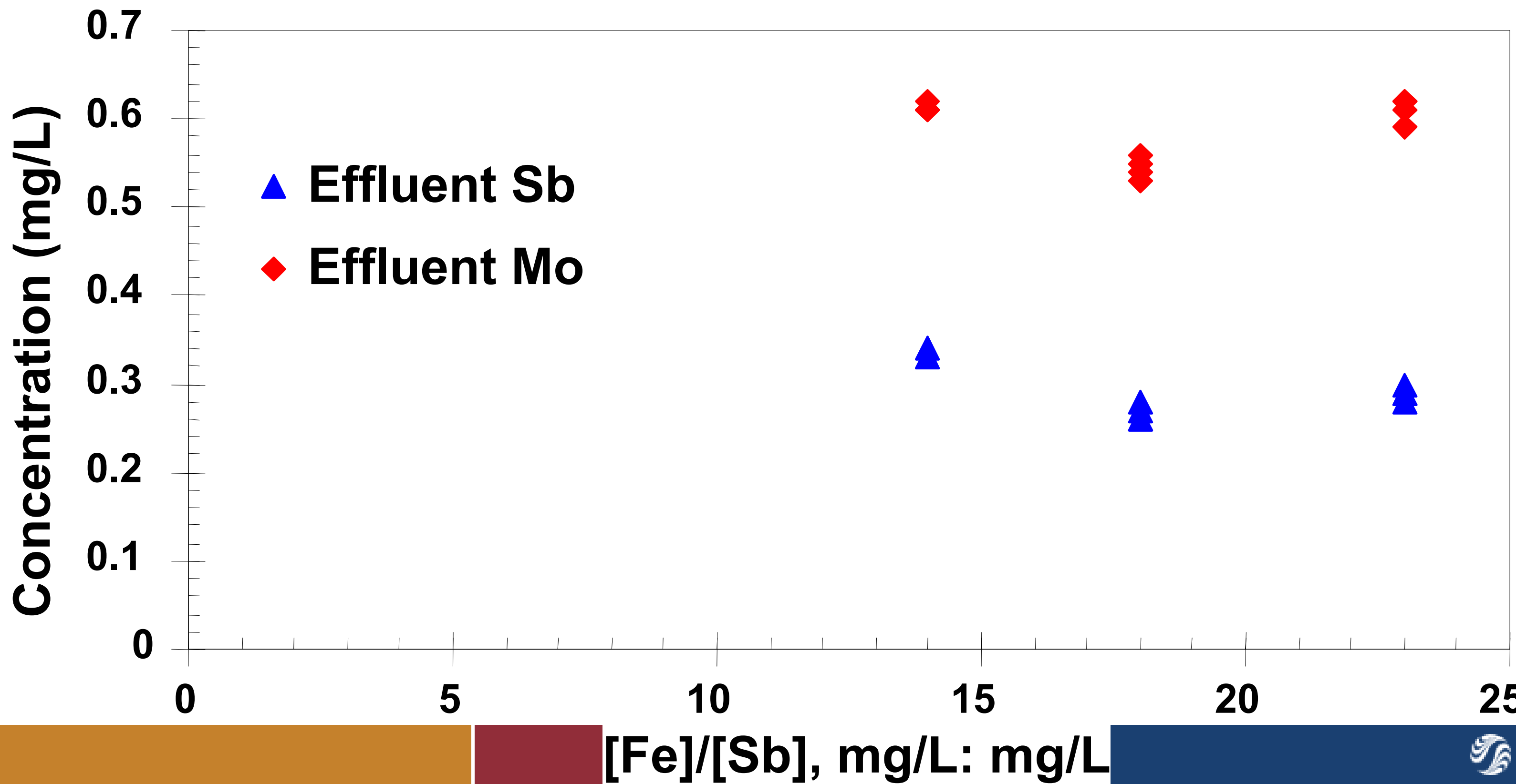
Onsite Full-Testing



RESULTS

Onsite Full-Scale Testing – Effluent Quality

- **Results**
  - **Met design objective for Sb (0.50 mg/L);**
  - **Not meet design objective for Mo (0.5 mg/L)**
  - **pH of 7.4 was not favorable for Mo removal**



RESULTS

Onsite Full-Scale Testing – Effluent Toxicity Test

Fe^{3+} / Sb	Onsite Full-Scale	
	Daphnia magna	**Rainbow trout**
14	**0%**	**50%**
18	**3.3%**	**0%**
23	**0%**	**0%**

- **[Fe]/[Sb] = 14/1**
  - **ETP Feed Cu = 0.41 mg/L**
  - **Effluent Cu = 0.080 mg/L**
- **ETP Historical Operation**
  - **ETP Feed Cu = 0.22 mg/L**
  - **Effluent Cu = 0.026 mg/L**

CONCLUSIONS

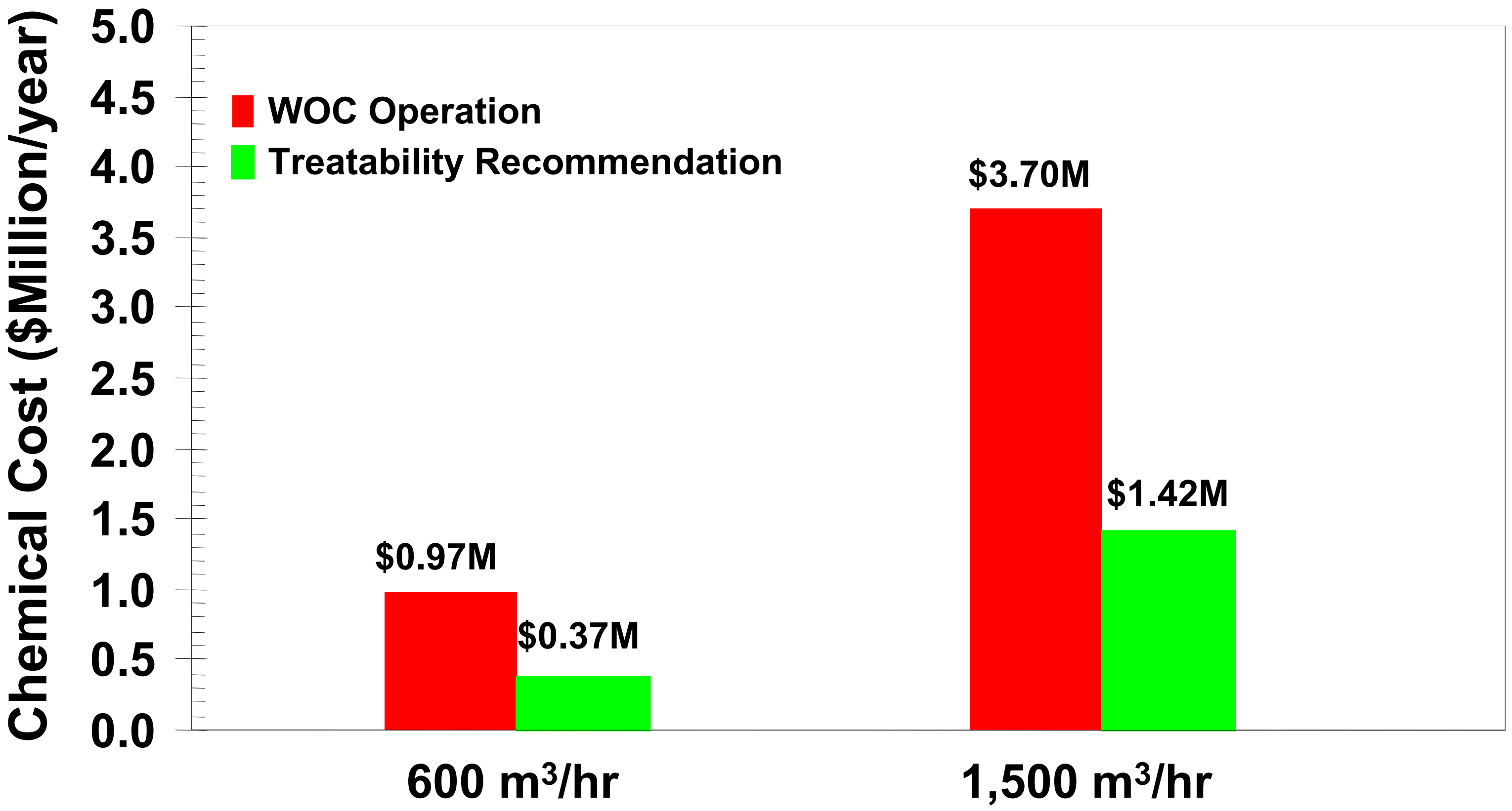
- **Contaminants Removal Mechanisms**
  - Coprecipitation is efficient for Sb and Mo removal
  - Sb and Mo removal rates determined by ferric dosages
  - Ferric dosage prior to pH adjustment
  - Coprecipitation did not impact Cu, Ni, and Zn removal
  - An optimal pH identified

CONCLUSIONS

- **Chemical Dosing Optimization**
  - **Lime selected for less reaction time**
  - **Fe/Sb of 14/1 recommended to WOC**
  - **Treatability test to optimize chemical dosing**

CONCLUSIONS

- **O&M Cost Reduction**
- **Economically Significant to Conduct Treatability Study**



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Questions and Answers