A Design & Build Active Treatment Plant for the Globe Mine High Strength Mine Drainage

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IOT IRON OXIDE TECHNOLOGIES

Globe Mine Location near Newell, WV

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Globe Mine Site (Clay Mine)

Raw Water Characteristics

Parameter	Units	Mine 1	Mine 2	Flow Weighted Average
Flow, Average	gpm	6.7	18.6	**25.3**
pH	S.U	4.5	3.5	**3.6**
Acidity	mg/L as $CaCO_3$	308	6,770	**5,060**
Iron, Total	mg/L	130	2,710	**2,030**
Manganese, Total	mg/L	5.0	45.	**34.4**
Aluminum, Total	mg/L	7.0	245.	**162.**
Sulfate	mg/L	840	10,500	**7,100**
Total Dissolved Solids	mg/L	1,150	18,900	**6,730**
Calcium, Total	mg/L	83	218	**163.**

At Low Flow:

Acidity = 8,000 mg/L
Iron = 3,900 mg/L

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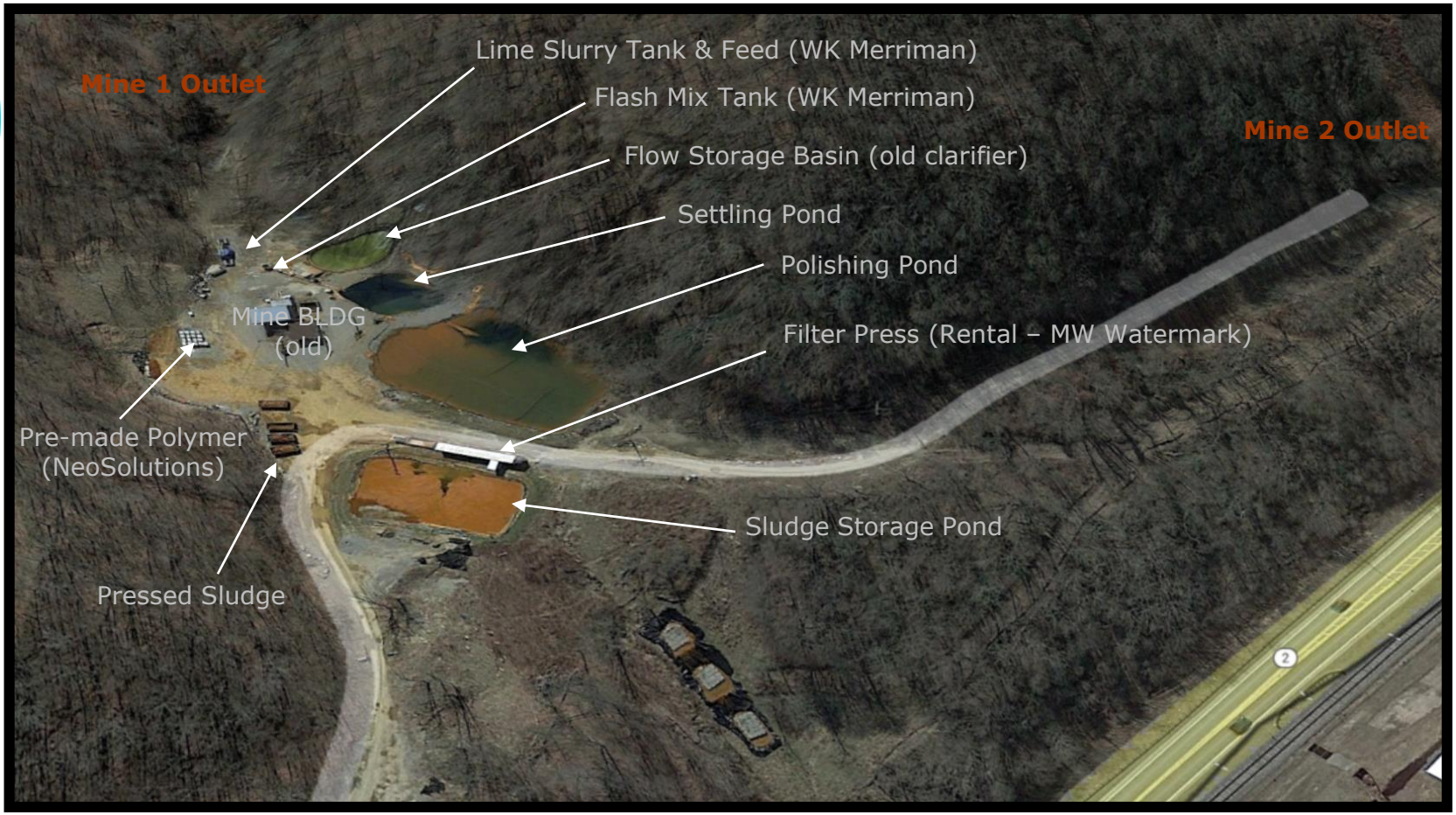
Globe Mine Site
Temporary Treatment



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Globe Mine Site

Treatability Investigation

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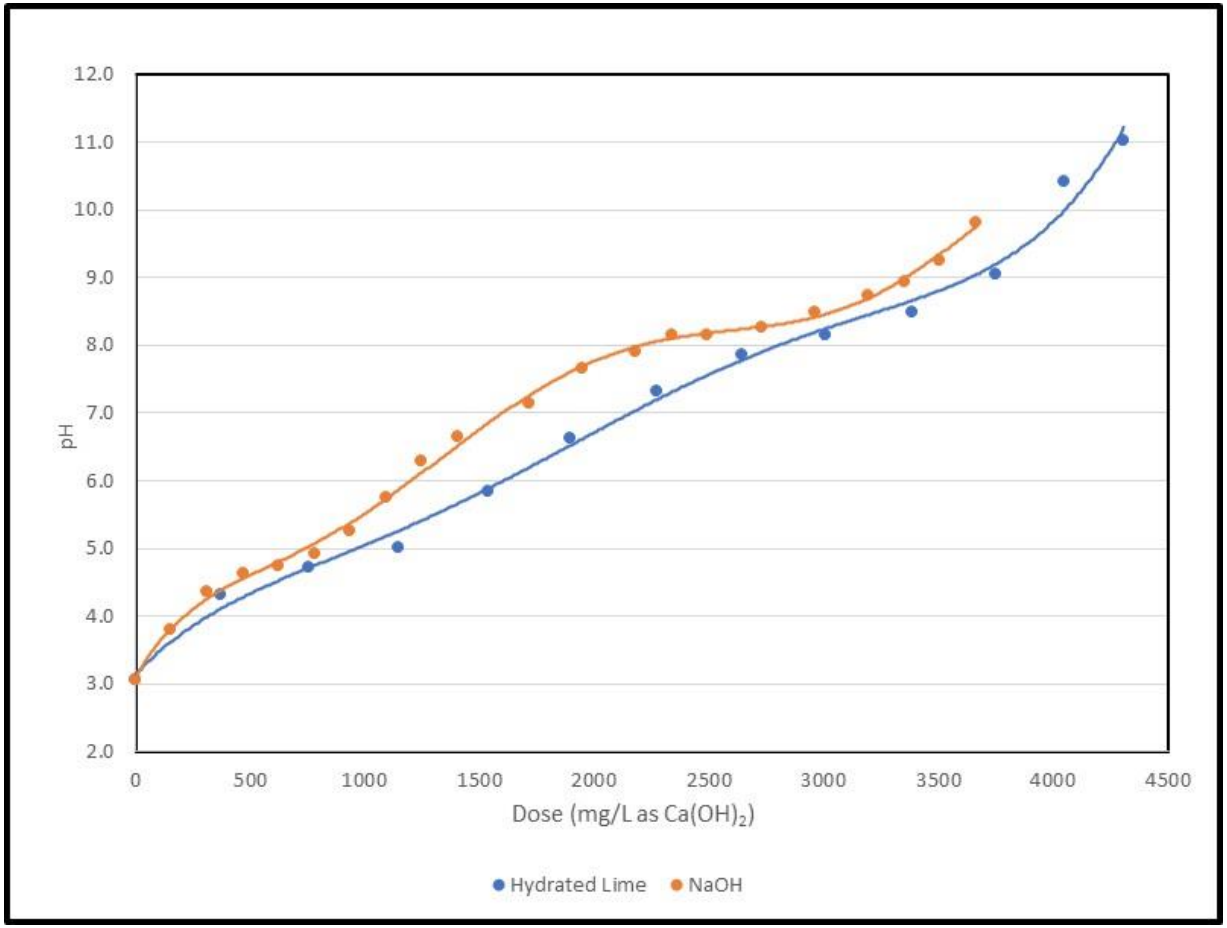
Neutralization Titration Evaluation



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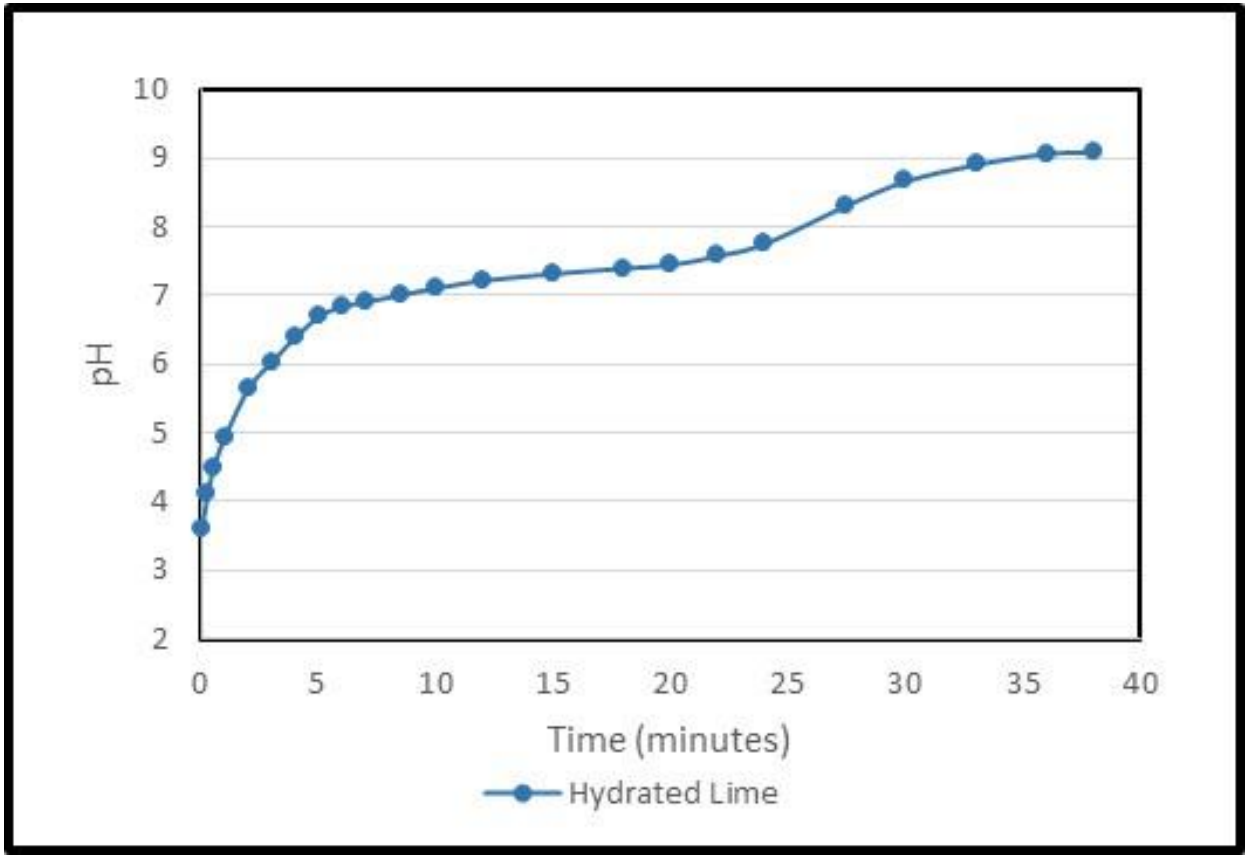
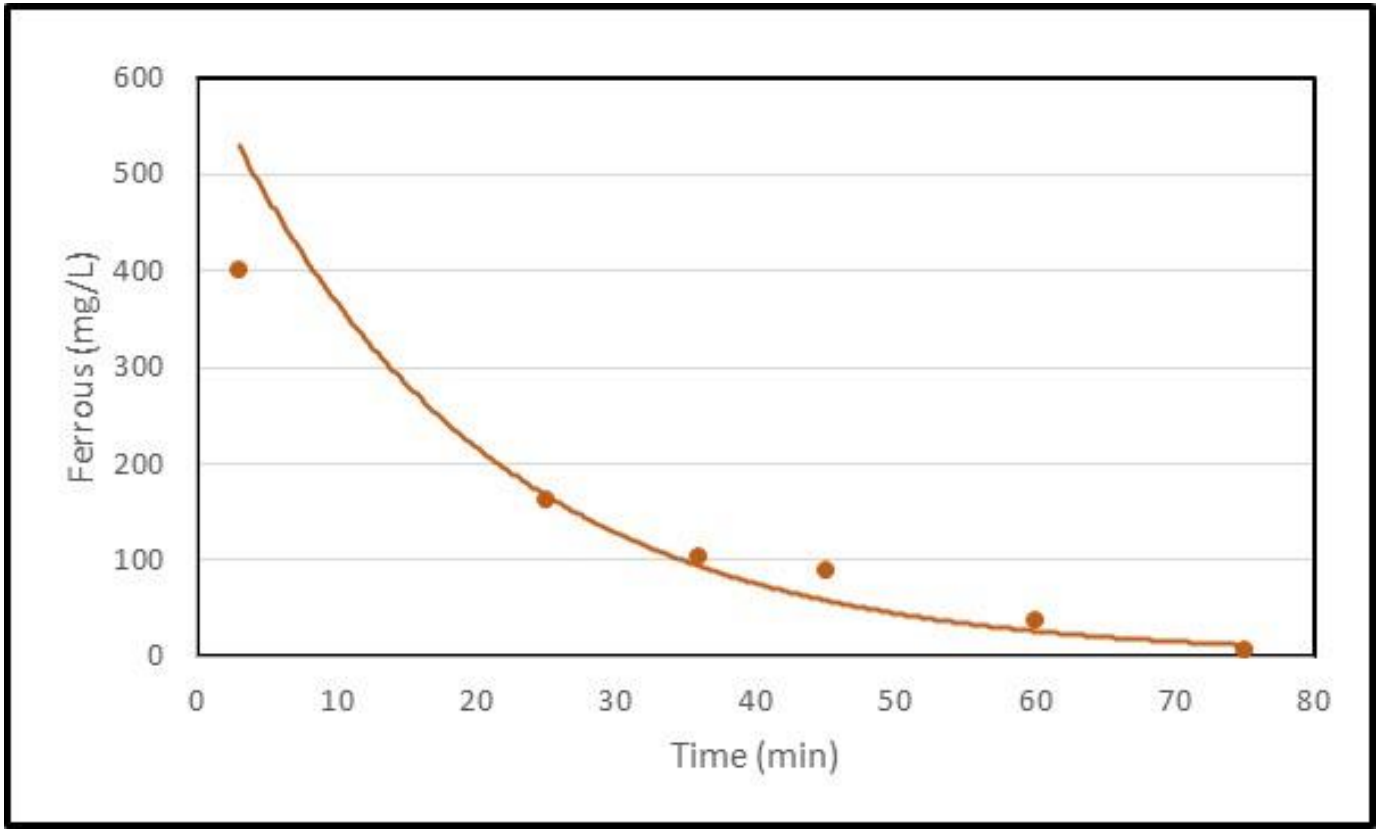
Lime Dissolution Kinetics



IRON OXIDE TECHNOLOGIES

Ferrous Oxidation Kinetics

pH = 7.0 to 7.5



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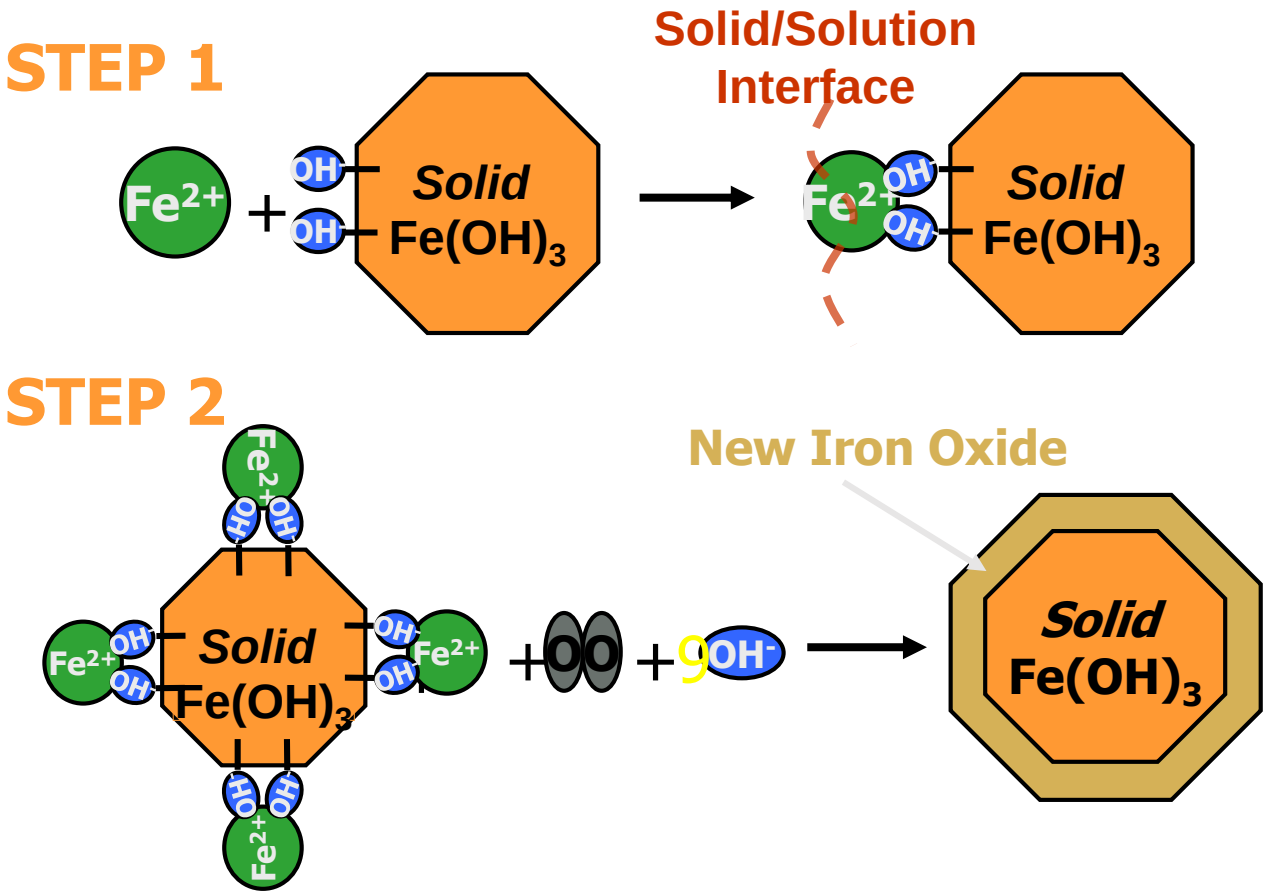
Heterogeneous Ferrous Iron Oxidation

Surface-based Oxidation & Precipitation



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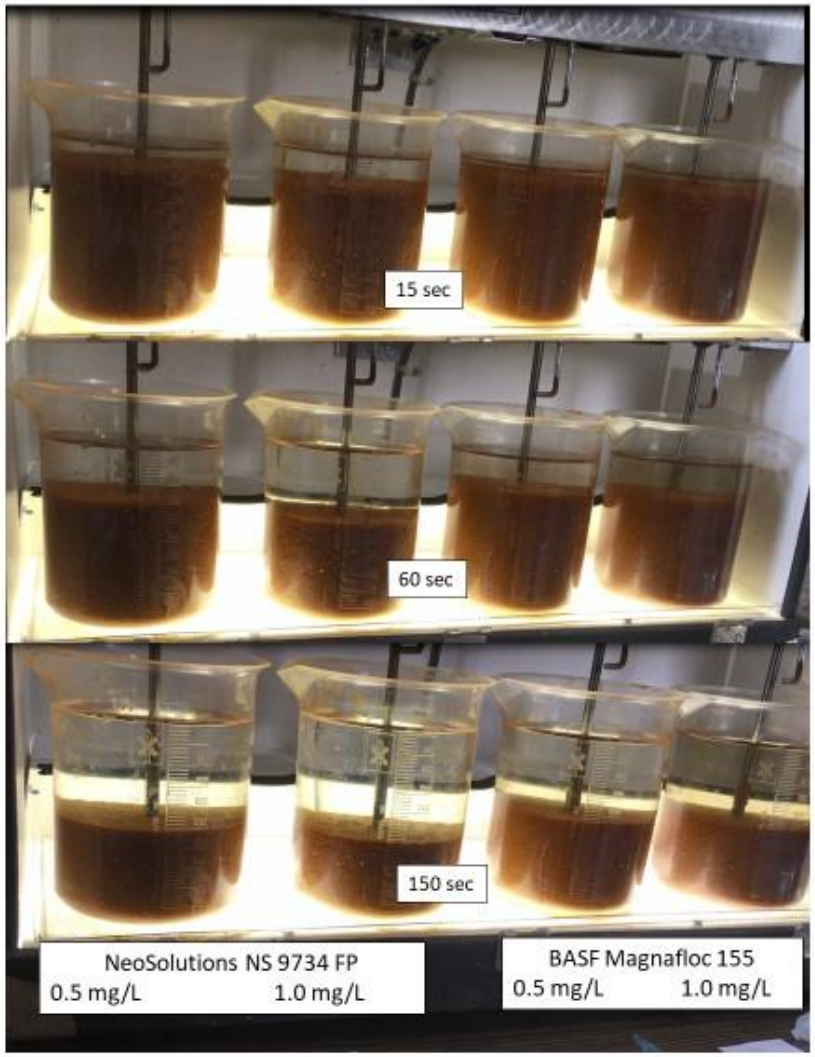
Polymer Testing



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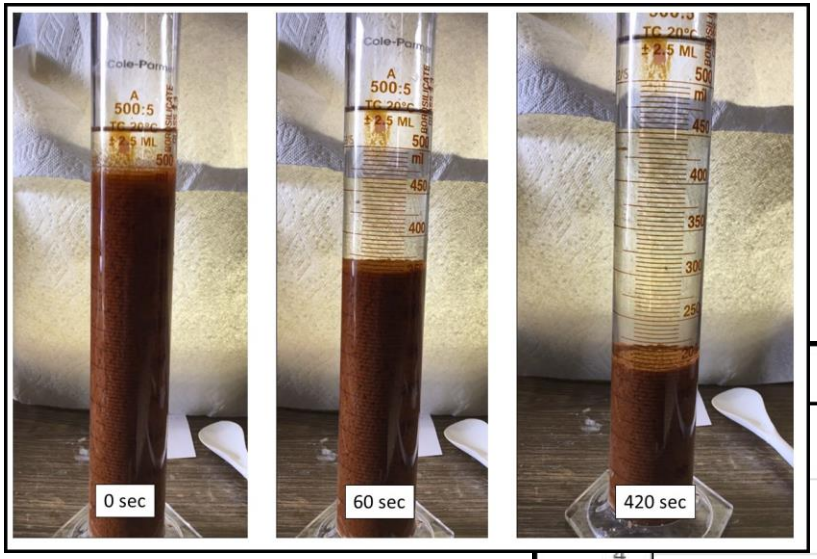
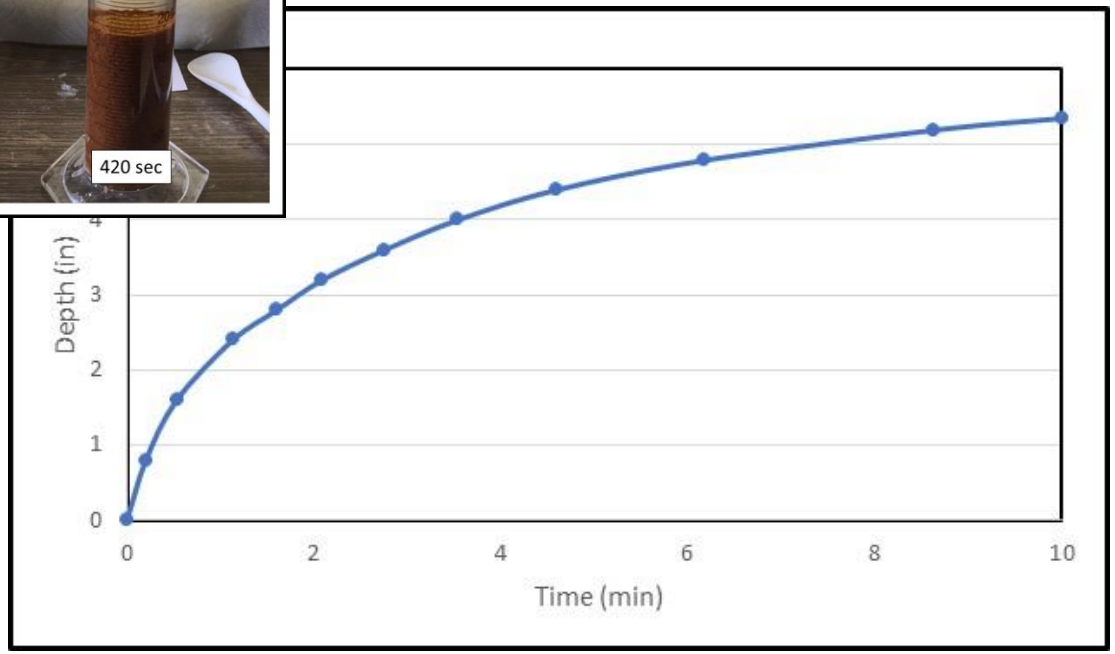
Solids Settling Tests





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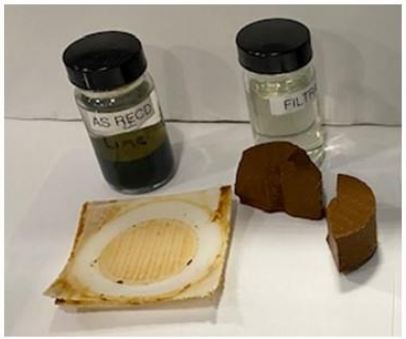
Solids Characteristics & Dewatering

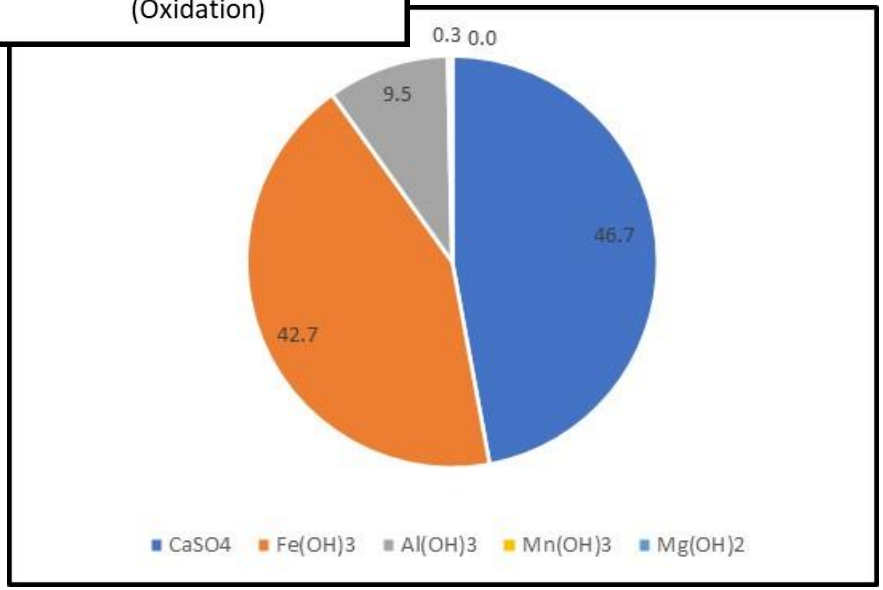
NaOH Sludge
(No Oxidation)



Lime Sludge
(No Oxidation)

Lime Sludge
(Oxidation)

Parameter	Units	Raw	TSS
Iron	mg/L	3,000	5,500
Aluminum	mg/L	250	750
$CaSO_4$	mg/L	NA	6,000
TSS	**mg/L**	**Total**	**12,250**



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Globe Mine Site

New Treatment Plant

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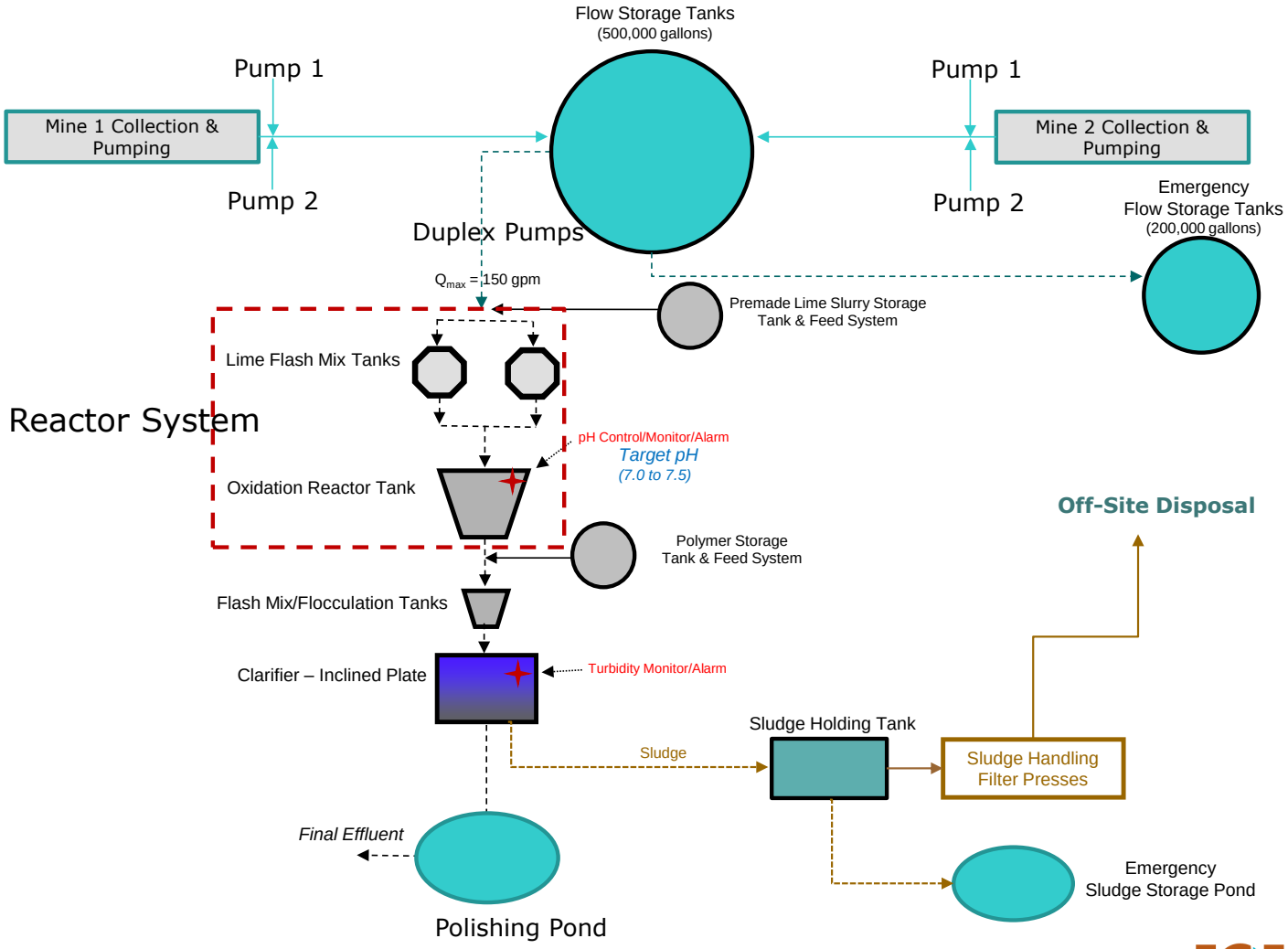
Globe Mine Site

Process Flow Diagram



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Globe Mine Site

Location & Plan View

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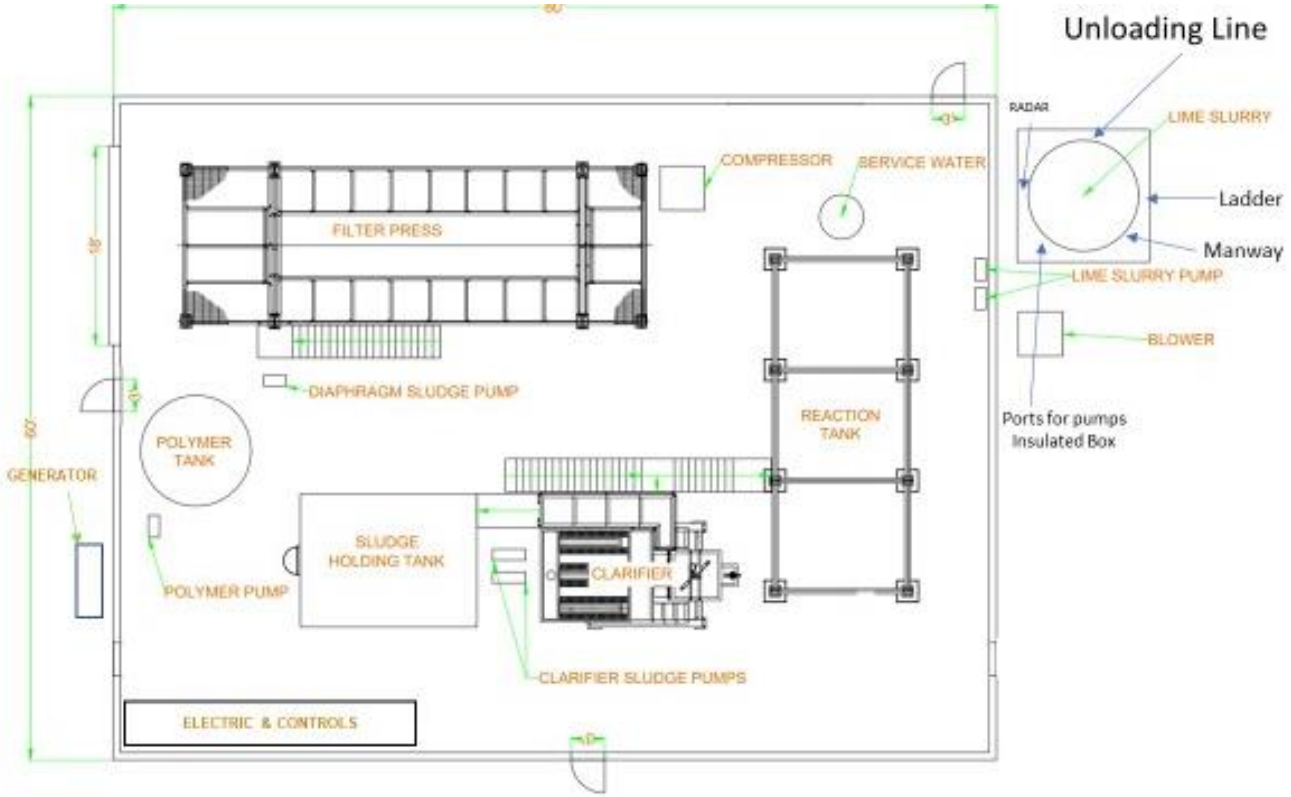
Globe Mine Site

Building & Treatment Plant Layout



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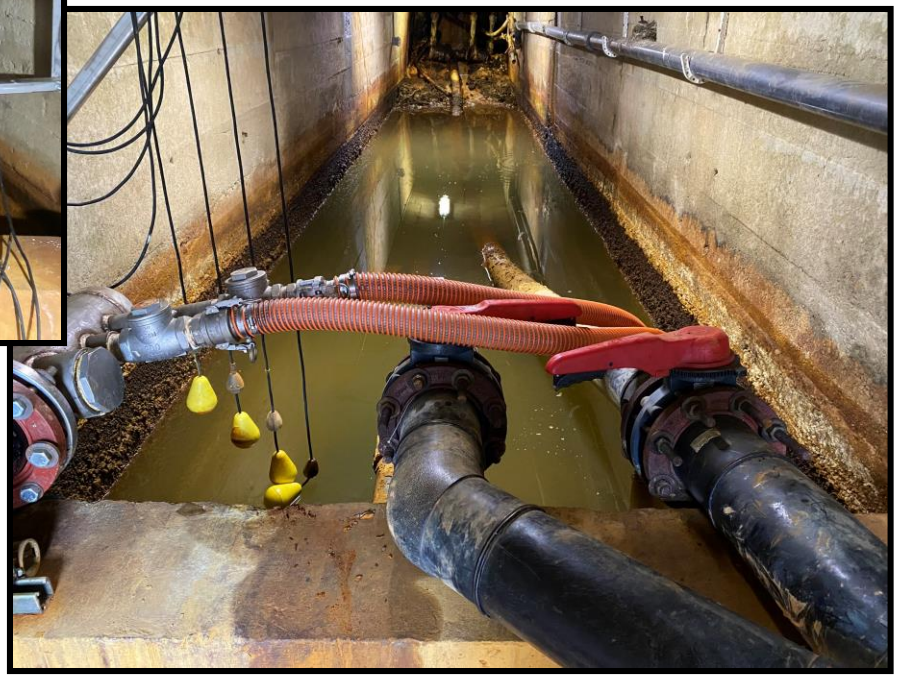
Mine Entry Pump Systems

Mines are gravity flow with water stored behind concrete walls near the entry



Duplex submersible SS pumps 1½ HP (~150 gpm) are operated by floats (also provide alarms)

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Above Ground Storage Tank

Above Ground Storage Tank (500k gals) stores pumped mine water to allow flexibility of operation & maintenance (AST level monitored)

Duplex submersible SS 1½ & ¾ HP pumps (50-150 gpm) deliver flow to treatment system

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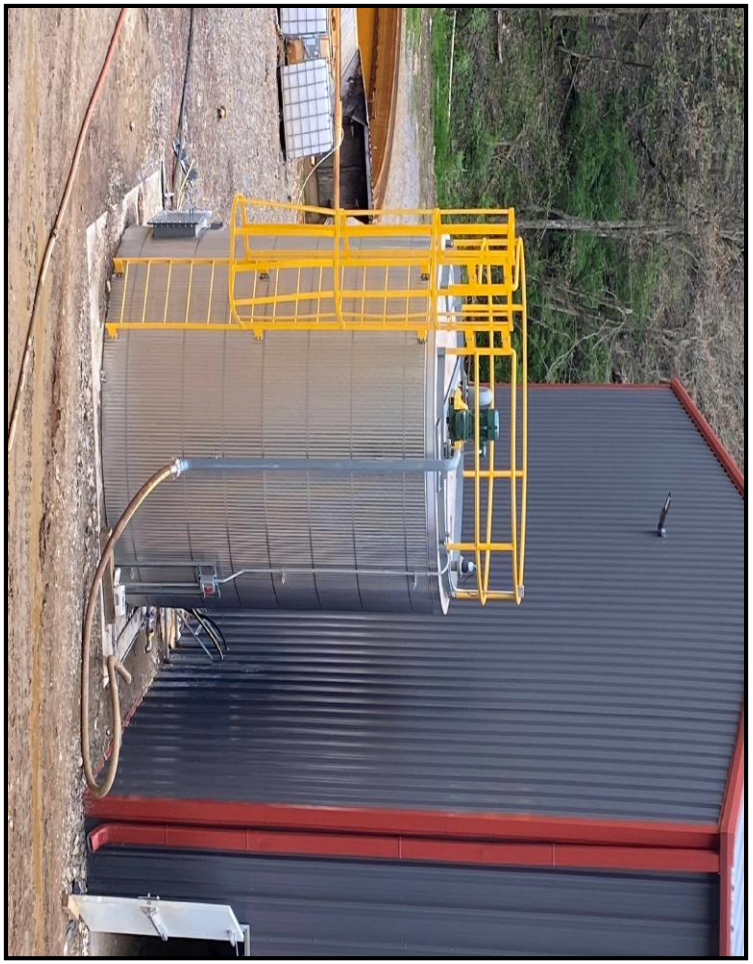
Lime Slurry Storage Tank & Feed System

WK Merriman, Inc.



Lime Slurry System Consists of:

1. Insulated & Heated Storage Tank
2. Level Monitoring
3. Mixer to Suspend Lime Slurry
4. Offloading Equipment
5. Duplex Hose Pumps (Manual or pH Controlled)

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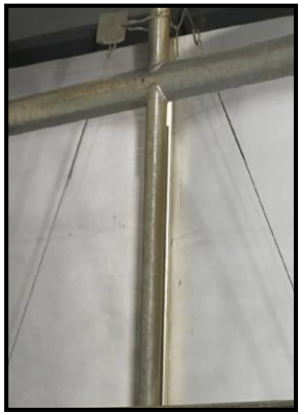
Reactor Tank System

Purestream, Inc. (Kentucky)

Reactor Tank System Consists of:

1. SS Inlet Flow Control Box
2. Lime Flash Mix Tanks (2 – only one operating)
3. Oxidation Reactor with Mixers and Diffused Air
4. PD Blower to Deliver Air
5. Outlet Trough

pH Monitoring & Control



Blower Unit

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Flocculation & Clarifier System

WESCO, Inc.

Clarifier System Consists of:

1. Polymer Flash Mix Tank
2. Flocculation Mix Tank
3. Inclined Plate (Lamella) Clarifier
4. SS Plates and Troughs

Turbidity Monitoring

IRON OXIDE TECHNOLOGIES

Polymer (Pre-Made) Storage & Feed System

Polymer System Consists of:

1. 6,0000 gal Storage Tank
2. Watson Marlow Qdos Pump
   (2 operating/backup)
1. Stores & Delivers Premade Polymer
   1. Neolsolutions 9734 Premade Polymer

IRON OXIDE TECHNOLOGIES

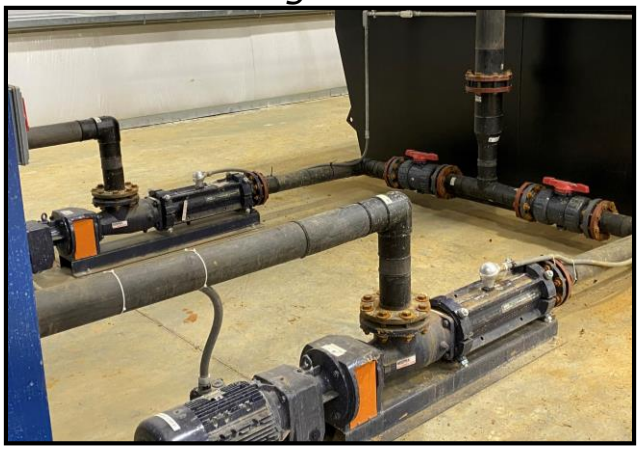
Sludge Pumps & Storage Tank

Sludge Storage Tank

Mixers provide Uniform Sludge

Progressive Cavity Sludge Pumps (2)

Pump Sludge from Clarifier to Storage Tanks



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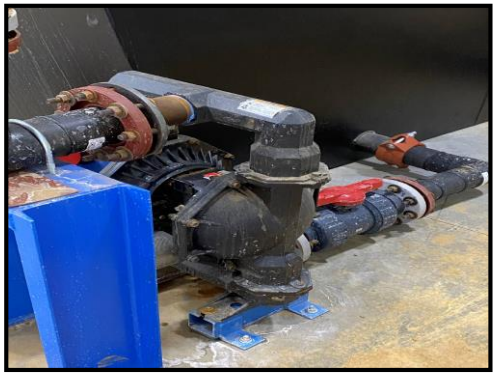
Sludge Filter Press System

M.W. Watermark, LLC

Plate & Frame
(65 CF) Filter Press

Diaphragm Pump



Screw Compressor
With Dryer

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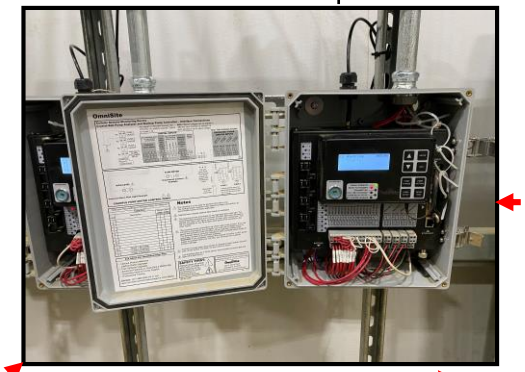
Control & Monitoring Systems

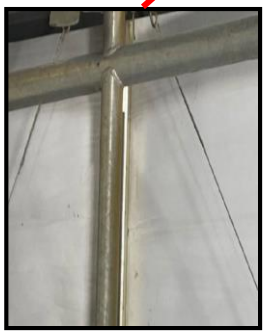
Cellular-Based
Internet System

Omnisite(s)
for System Monitoring &
Alarms



Control Panel
for System Components

pH & Turbidity



Tank Levels

1. AST
2. Lime
3. Sludge

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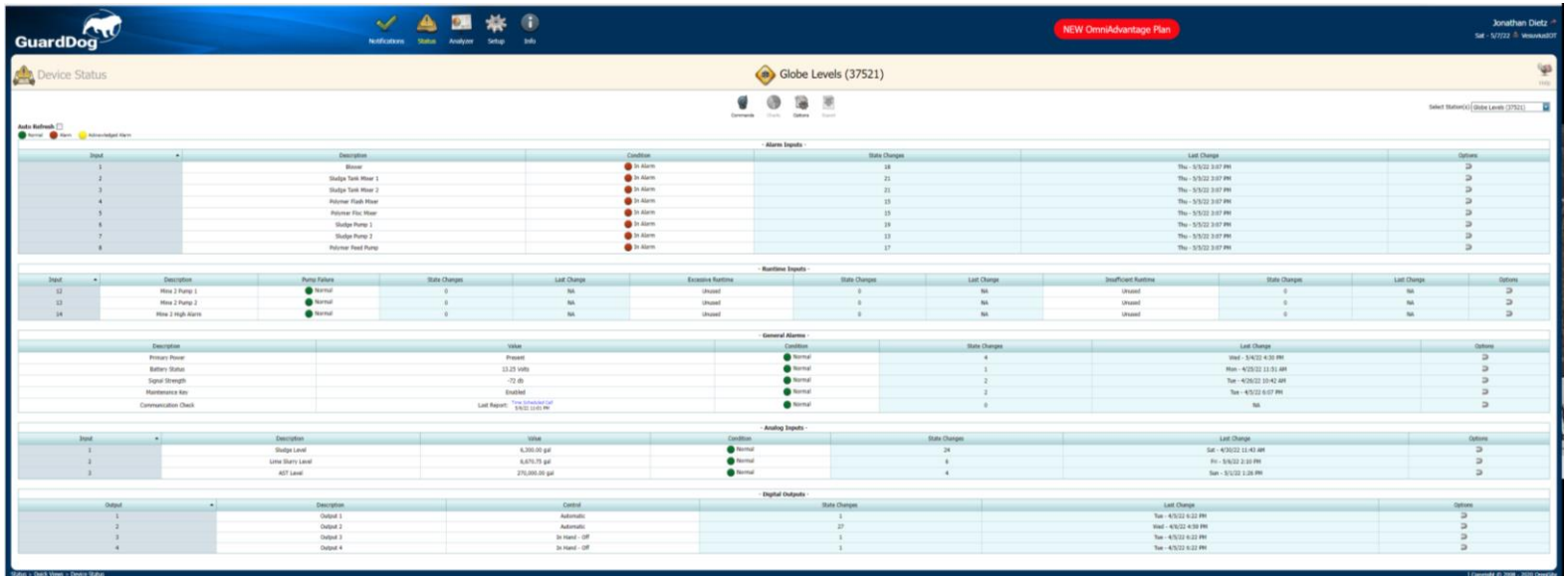

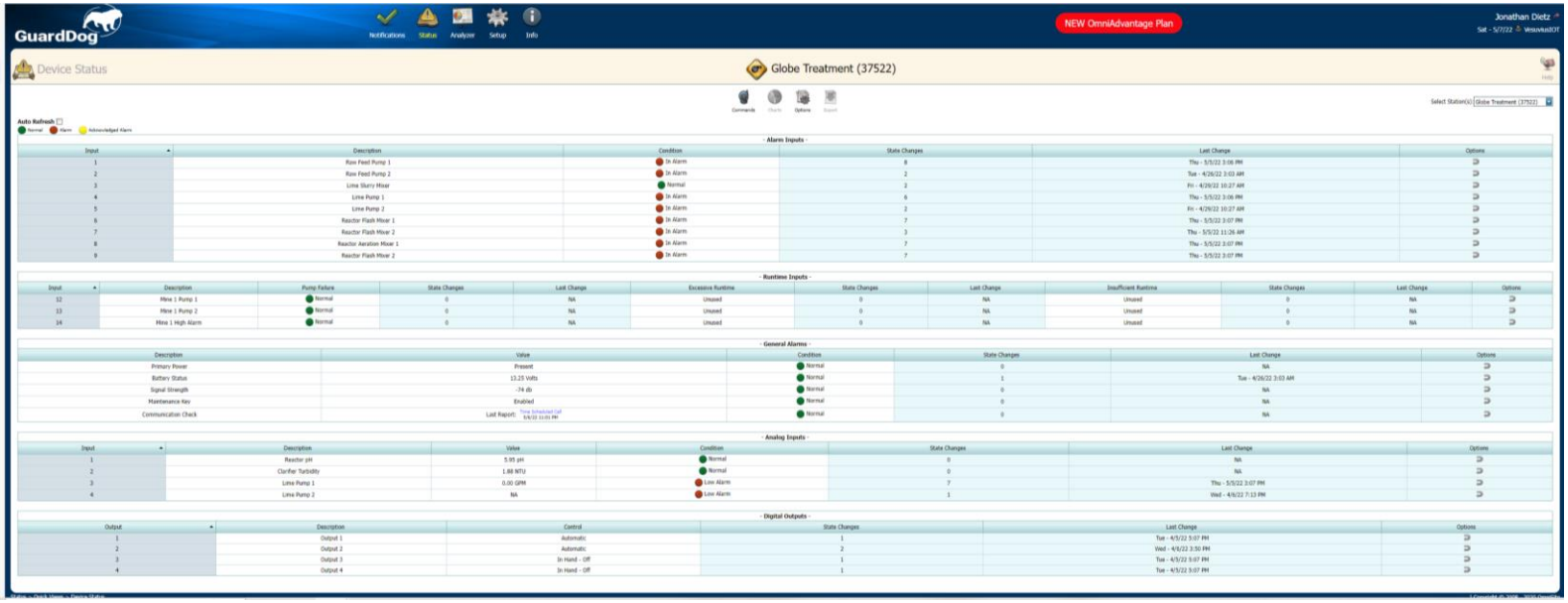

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Backup Power Supply (Propane)

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Globe Mine Plant Operation

1. Start-up April 2022
2. Initial operating pH of 9.0 (due to Mine 1 water in AST)
3. Decreased operating pH to 7.5
4. Expect to lower operating pH to ~7.0
5. Effluent Compliant with NPDES Effluent Limits Since Startup
6. Low flow operation has high solids (> 10,000 mg/L)
   a. Causes Hindered Settling vs. Slow Zone Settling
   b. Due to limited particle interaction

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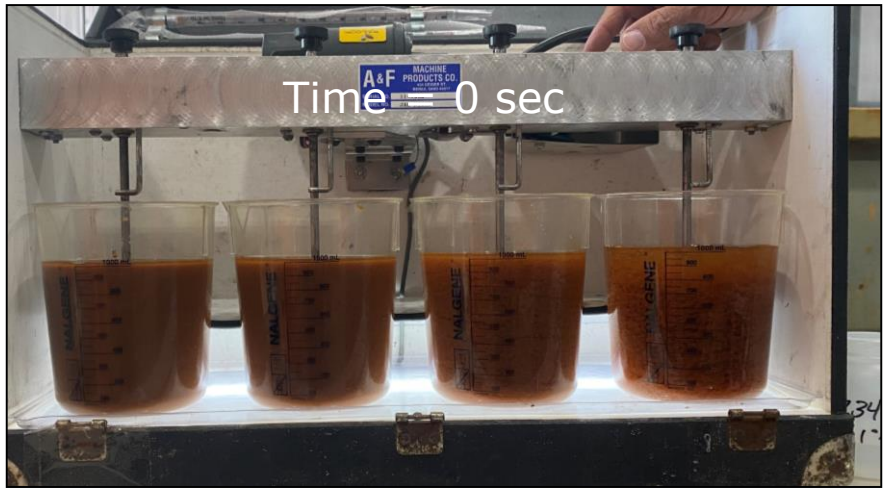
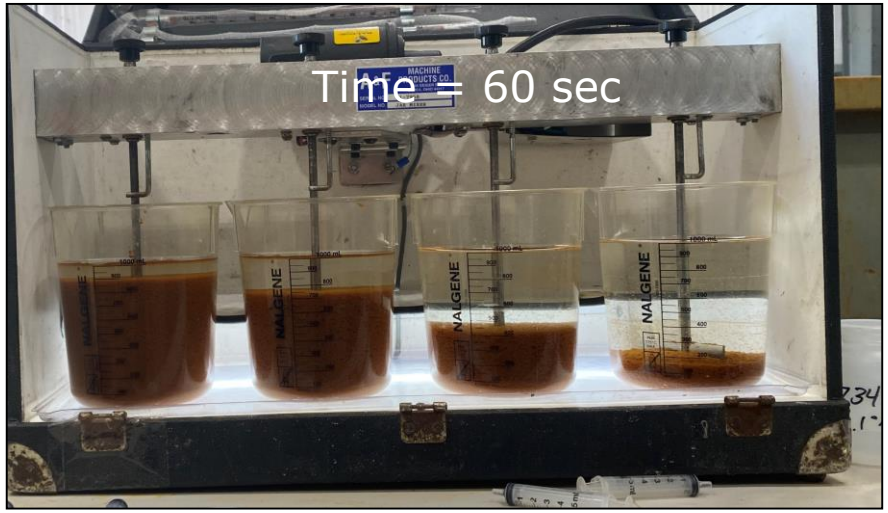
Planned Low Flow Operational Modification



Dilution Ratio 0 3:1 1:1 1:3



Based on IOT suggestions:

Dalton Derberry of Neosolutions conducted Jar Tests at various dilutions of neutralized/oxidized water containing solids (>15,000 mg/L) with clarified water (< 10 mg/L) using a 2 mg/L NS9734 pre-made polymer dose.

Jar Testing indicated that 1:1 dilution ration yielded settling rates 8x faster than without dilution.

Dilution allowed for increased particle interaction (i.e., flocculation) forming larger particles that settled faster, and is consistent with Stoke's Law.

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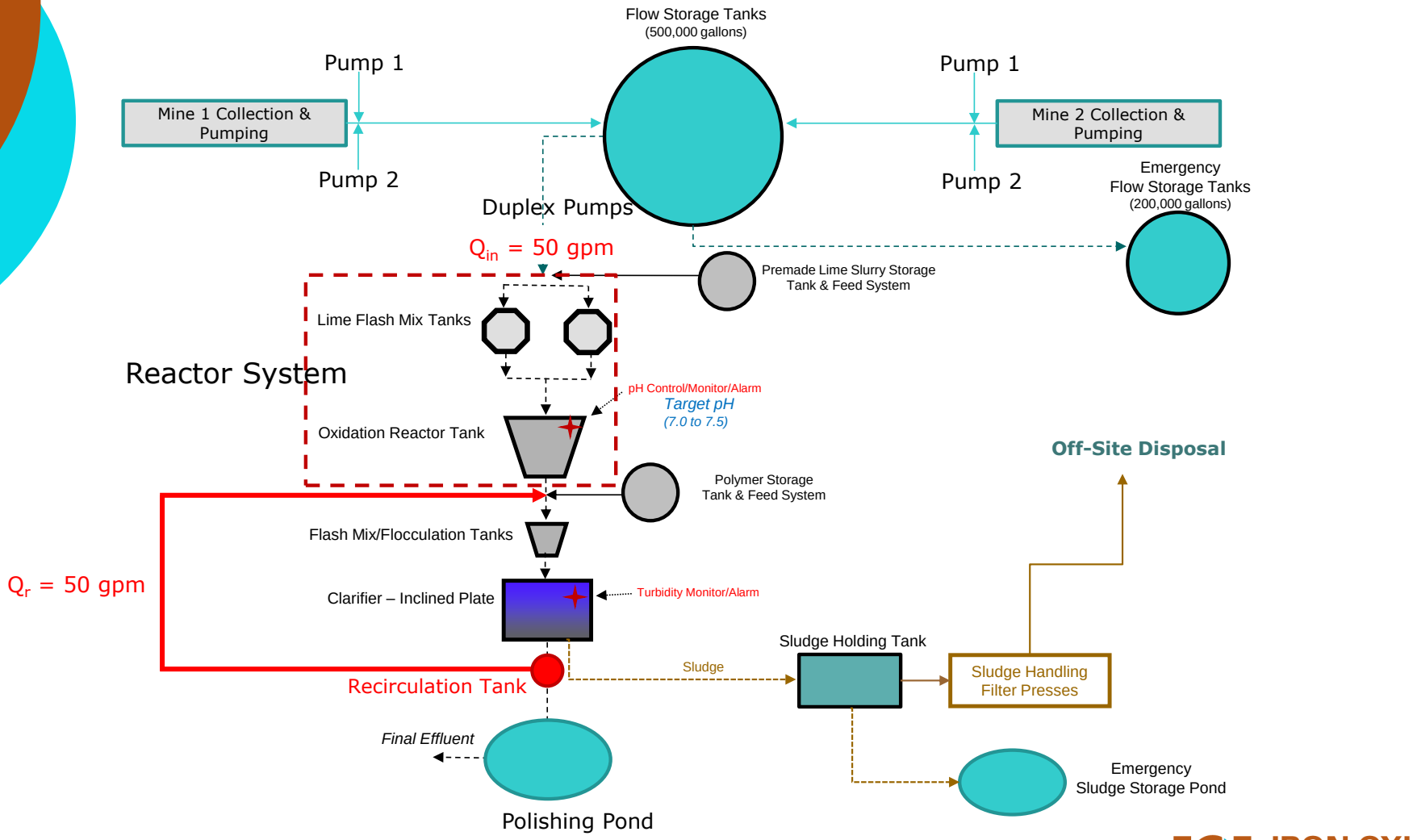
Globe Mine Site

Modified Process Flow Diagram for Low Flow



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