REINHOLD ENVIRONMENTAL ®

2026 Reinhold/PCUG Round Table Presentation

Hosted by TVA, Southern Company and Vistra

in the Sonesta Nashville Airport Hotel, Nashville, TN

on June 22-23, 2026

FGD Wastewater Treatment For Coal-Fired Power Generation

Dexter Farmer
Technical Supervisor – Wastewater
Santee Cooper (Winyah Generating Station)

Michael Zumstein
Technical Supervisor – Wastewater
Santee Cooper (Cross Generating Station)

Why Treat FGD Wastewater

- Deadline to Comply With ELG was December 31st, 2025

- Santee Cooper responded by building FGD wastewater treatment plants at Cross And Winyah Generating Stations.

- To remove Arsenic, Mercury, Nitrates, & Selenium.

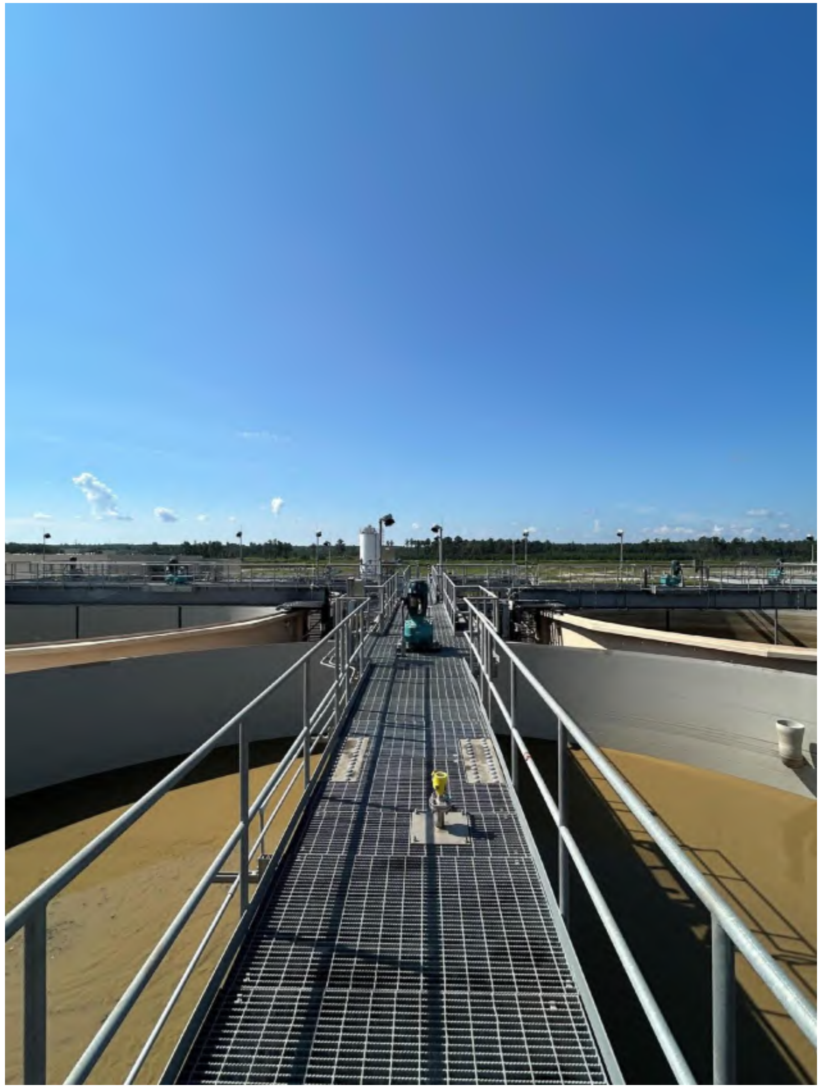
ELG Treatment Processes

- Physical/Chemical
- Biological
- Tertiary Filtration
- 360-800 GPM Flow Rate (Forwarding pumps)
- 600 GMP (Effluent Pumps)
- Requires SC A Licensed Physical/Chemical Wastewater Operator.

Physical/Chemical Treatment

- EQ Tanks
- Reaction Tanks
- Coagulation/Splitter
- Flocculating Clarifier
- Sludge Holding Tanks
- Plate Presses
- Sand Filters (Continuous Backwash)

EQ Tanks



- Three EQ tanks.
- 1.33 MG each. 15% Solids max
- Hyperbolic mixers
- 1-2 GPM flush waster per mixer.

EQ Tanks

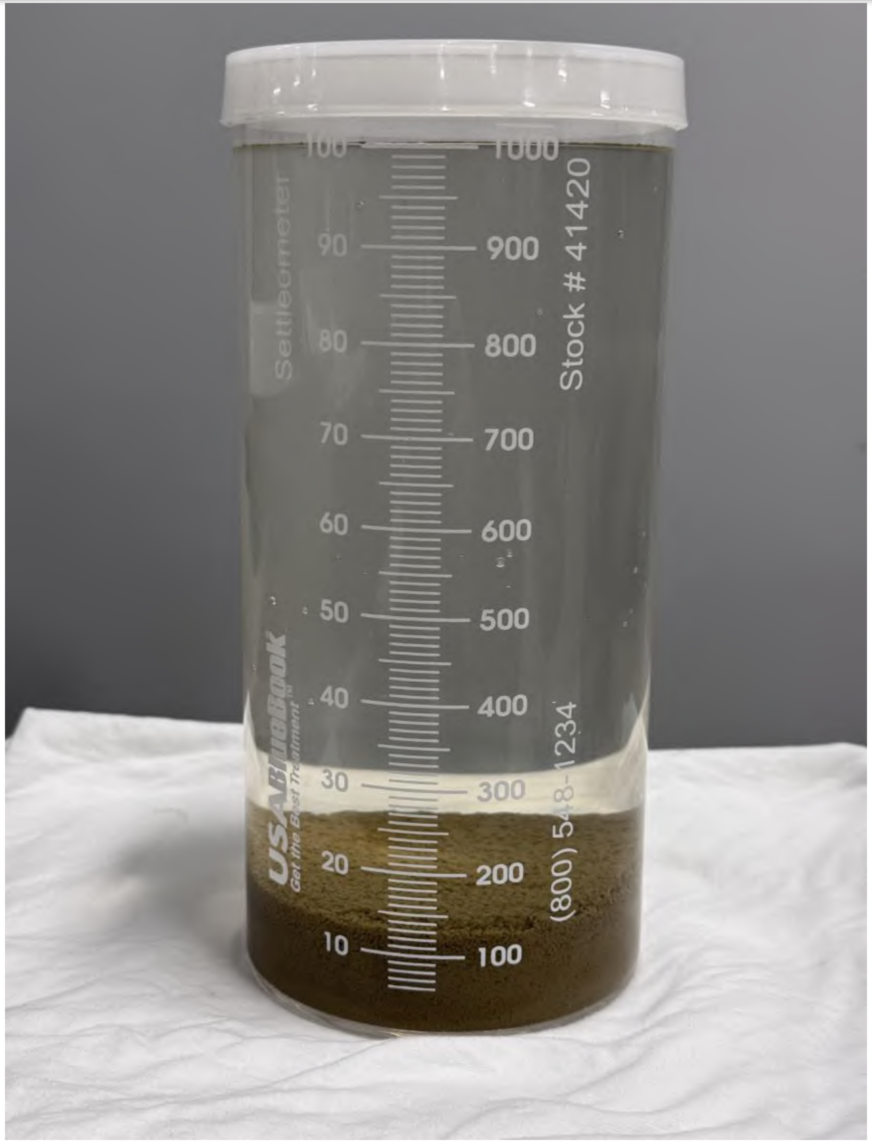
Reaction Tanks

- Three 71,672-gallon tanks.
- Two tanks in series.
- Tank (1,2) Tank (2,3) Tank (1,3)
- 1st tank in series (Lime, Organosulfide)
- 2nd tank in series (Ferric)
- pH monitors in each tank.

Reaction Tank Chemistry

- Lime pH control around 8.7
- Organo Sulfide 20 ppm negative charge to attract mercury
- Ferric 25 ppm positive charge to attract Arsenic and Elemental Selenium

Coagulation/Splitter Box



- 2600-gallon tank
- Polymer injection
- Too slow builds up clumps of solids
- Too Fast shears the floc.
- Acts as Splitter box between both clarifiers

Coagulation Chemistry

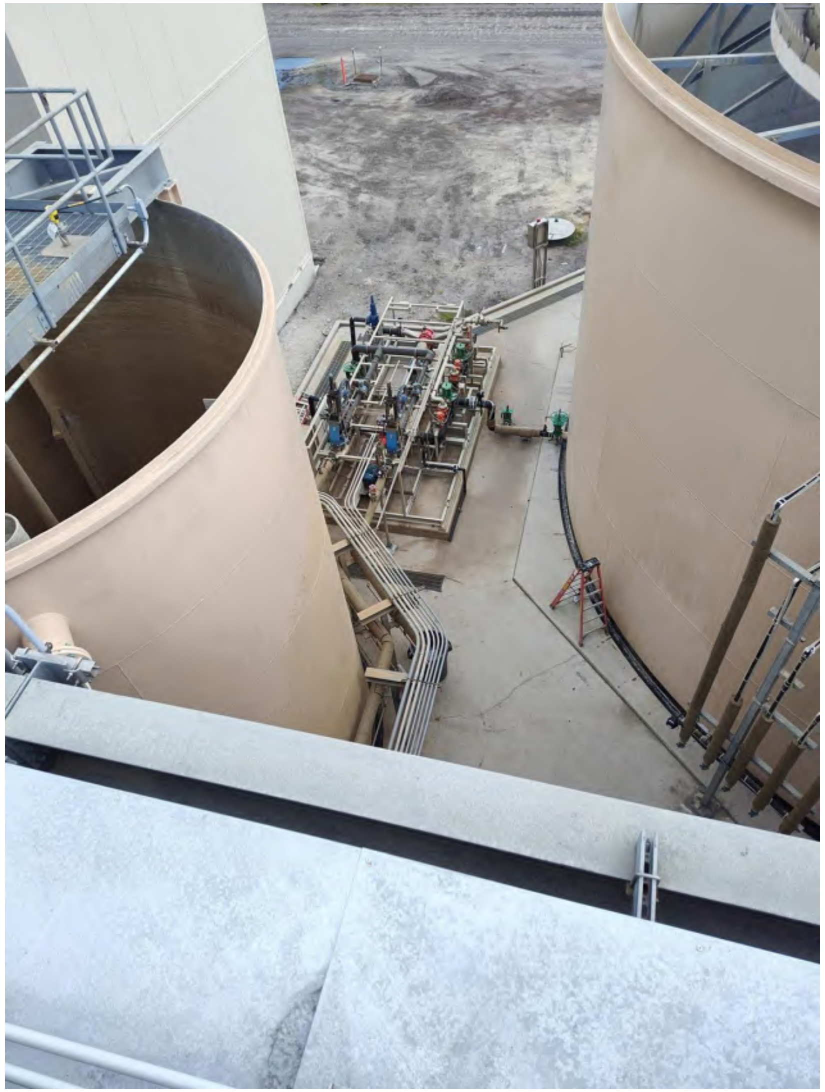
- Jar test performed for initial polymer dosage.
- Cationic Polymer.
- Typically, 6-8 PPM.
- Consistent solids concentration.

Flocculating Clarifiers

santee cooper®

- Two 549,000-gallon flocculating Clarifiers
- Each clarifier has two flocculators
- Center well acts as the flocculation basin
- Maintain between 10-20% solids blanket
- Operational Factors include density, Torque and clarifier turbidity.
- Settled sludge returns to reaction tanks/ waste to dewatering
- Supernate to sand filtration (Hydrochloric Acid)

Flocculating Clarifiers



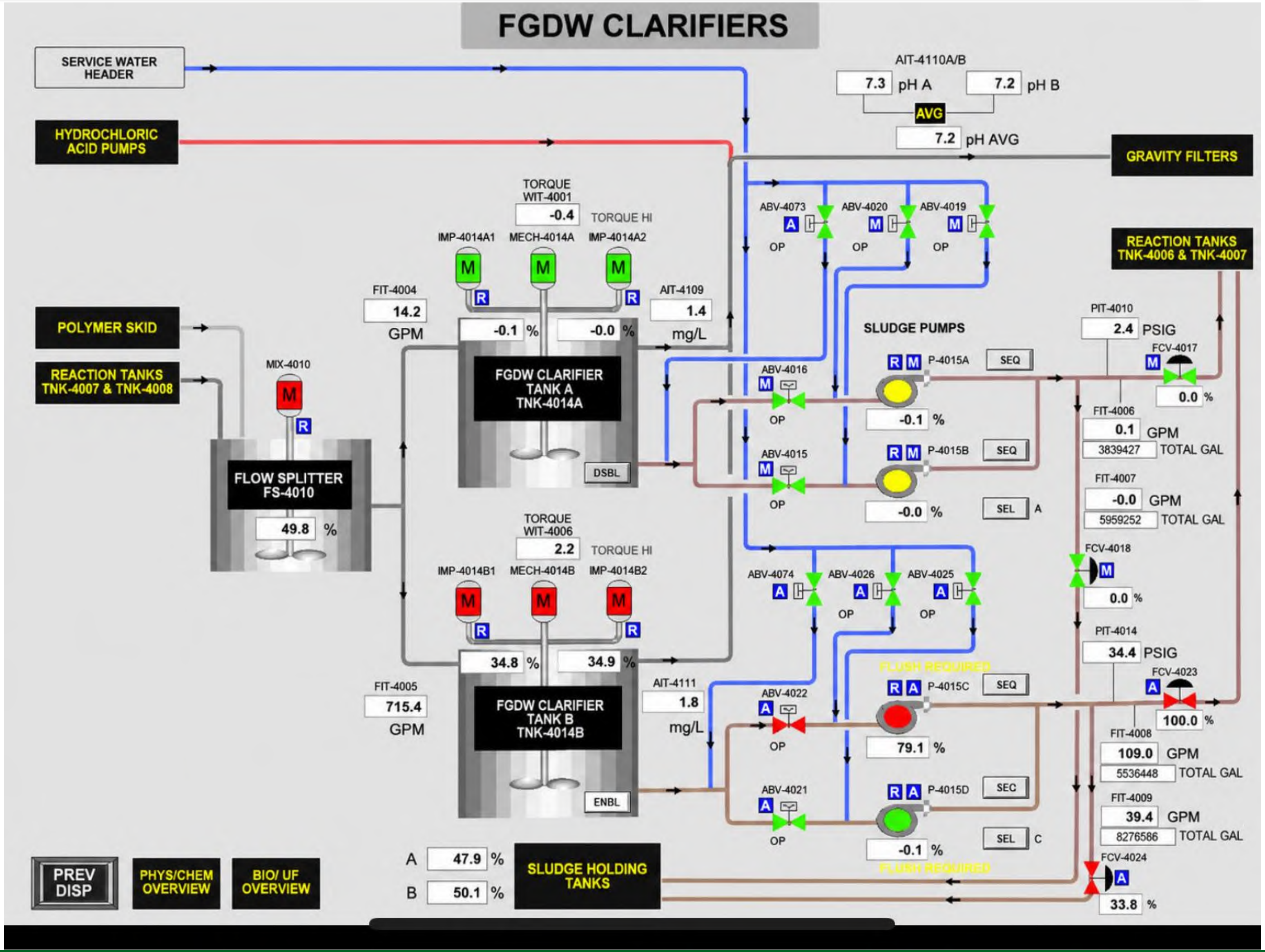
Sludge Holding Tanks/Dewatering

- Two 56,000 Gallon Sludge Holding Tanks
- Maintain minimum of 10% Solids
- Waste is piped off the return sludge pump line
- Sludge is pumped from the sludge holding tanks to plate presses for dewatering

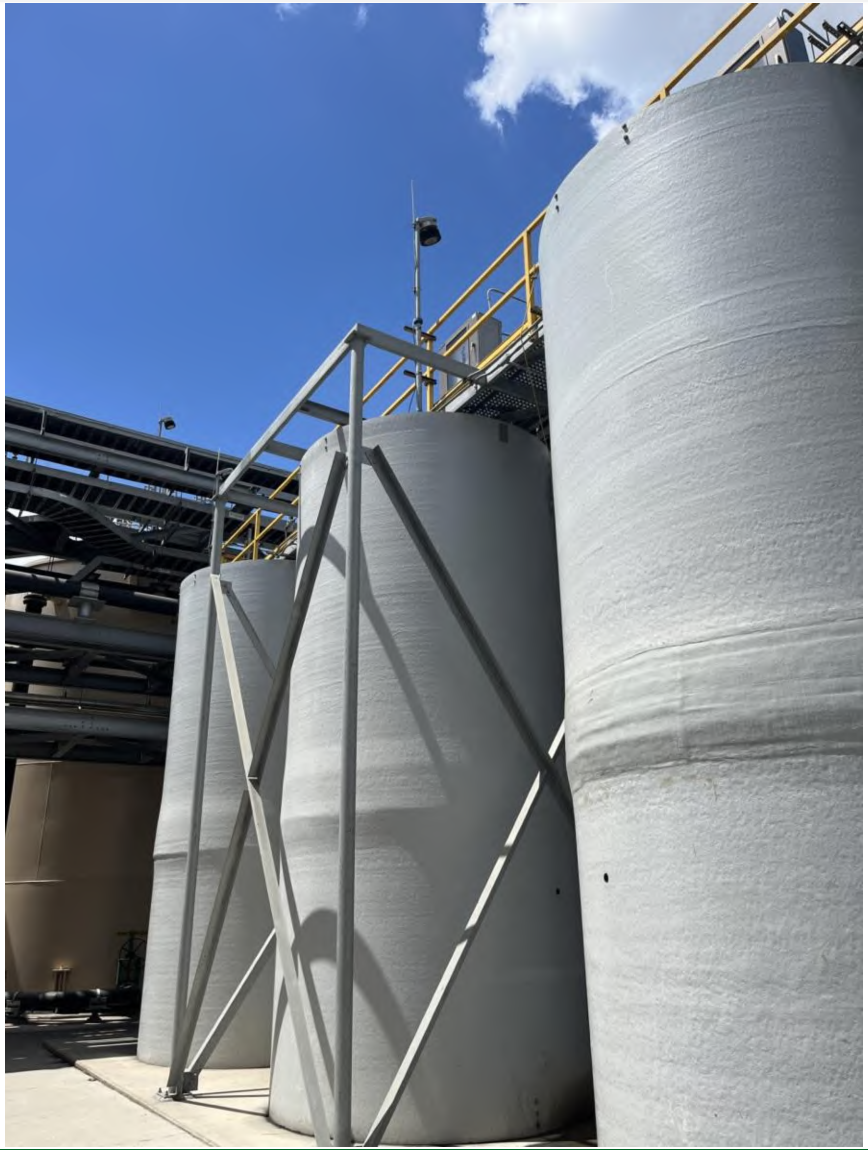
Sludge Holding Tanks/Dewatering

Sludge Return/Waste Logic

santee cooper®

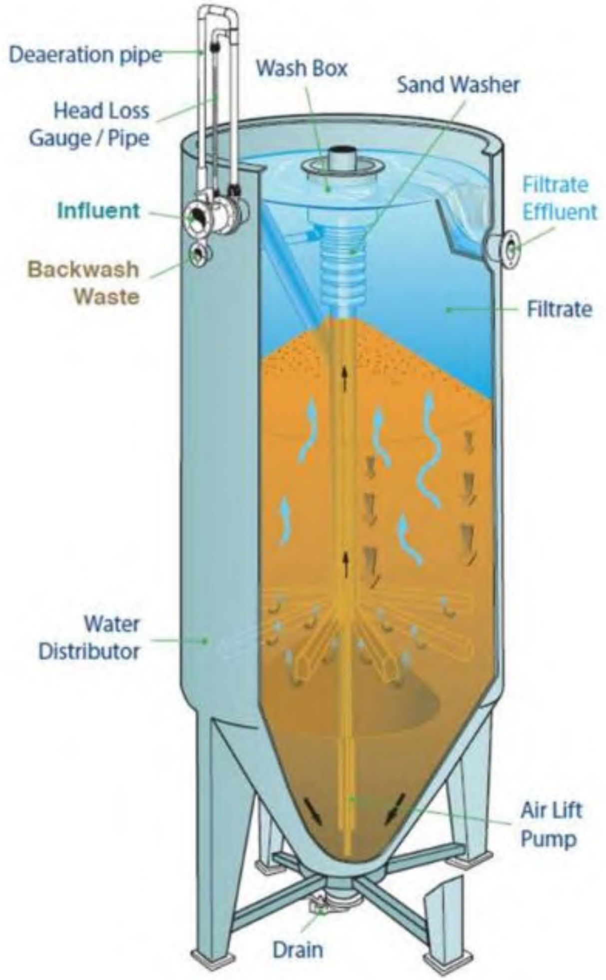


Continuous Backwash Sand Filters



- Three Sand Filters
- Run two at a time.
- Upward flow.
- Uses rotameter adjusted air flow to pull sand from the bottom to the top continuously while washing the sand.
- Reject water goes back to the EQ Tanks
- Filtered water goes to the Clear wells (Bio EQ Tanks)

Continuous Backwash Sandfilters



Clearwells (Bio EQ)

- P/C Effluent
- Two 23,030 Gallon tanks
- Bio Pumps pump to bio system.

Biological Treatment

- Strainers
- Heat Exchangers (When Needed)
- Stage 1 Bio
- Stage 2 Bio
- NO3 Removal
- Selenium Reduction/Removal

Strainers/Heat Exchangers

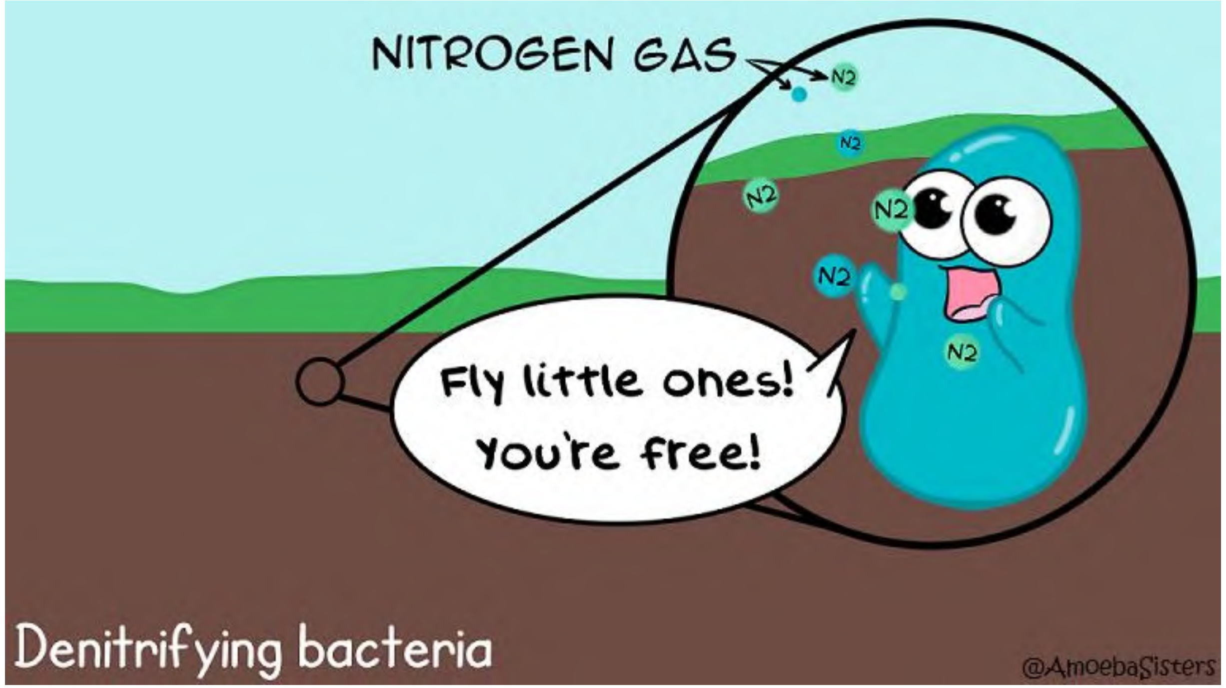
Bio Stage 1

- Five 6,000 Gallon Reactors
- ORP & pH readings
- NO3 Removal -250 to -350 mv
- Nutrient feed prior to stage 1
- COD to Nitrogen ratio
- Filled with Activated Carbon as Media (not used as Carbon Source)
- Upward Flow
- Air Scour / Backwash (Forward Flush)

Stage 1 Denitrification

- Denitrification NO3 - N2 (Heterotrophic Bacteria)
- Low DO, Media, Carbon source, Detention Time
- Heterotrophic Bacteria pseudomonas

- Control methods Flow Rate and Nutrient feed.
- Indicators are total nitrogen, ORP, pH and sulfides.



Bio Stage 1 Nozzle Clogging

- Biomass overgrowth in nozzles.
- Air scour would not correct the high pressure
- We took three different approaches.
- First Approach Sodium Hypo with air scour. (Reseed)
- 2nd Approach Sodium hypo just above nozzle (Needs recovery)
- 3rd approach using static head from stage 1 to drain through nozzles. (Needs multiple flushes over days)

Biomass

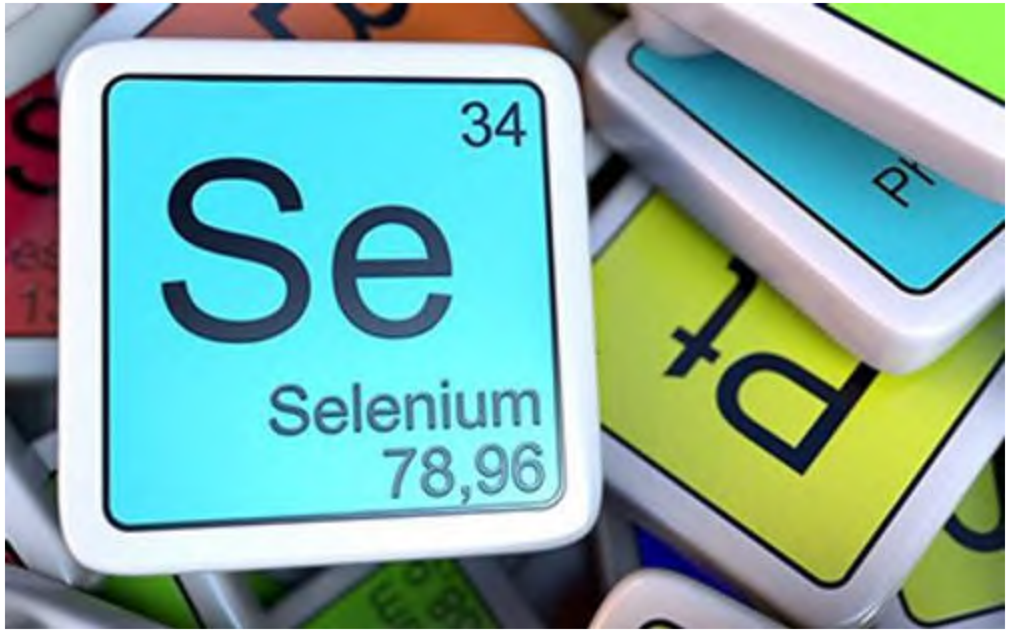
Bio Stage 2

- Fourteen 10,500 Gallon Reactors
- Activated Carbon used as media
- Remaining Nitrate removal
- Selenium Removal -250 to -400 mv
- Backwash cycle
- Degas cycle based on head loss from H_2S.
- Selenium is converted when sulfides are present.
- Backwash is critical for selenium removal.

Stage 2 Selenium Bio Reduction

santee cooper®

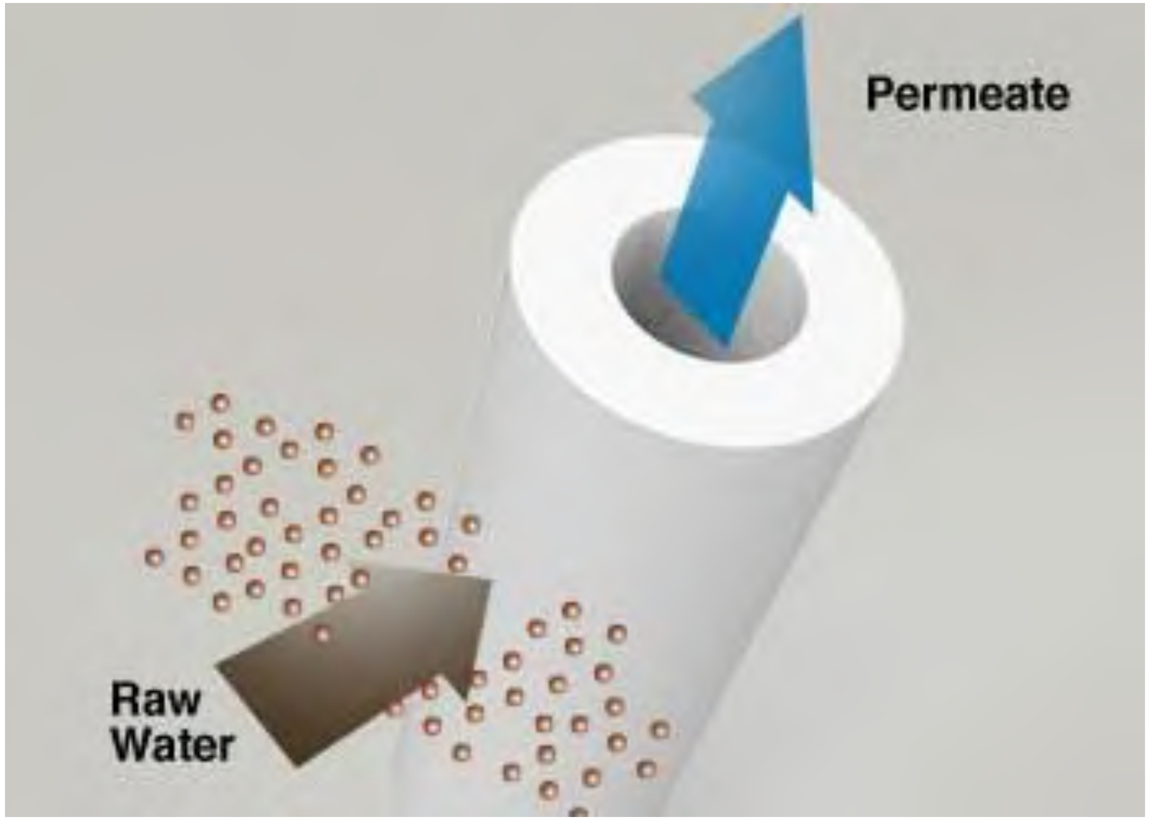
- Selenium is broken down by selenium reducing bacteria pseudomonas
- Selenate (Soluble)
- Selenite (Soluble)
- Elemental Selenium (Insoluble)
- Insoluble selenium removed through backwashing Bioreactors and UF.

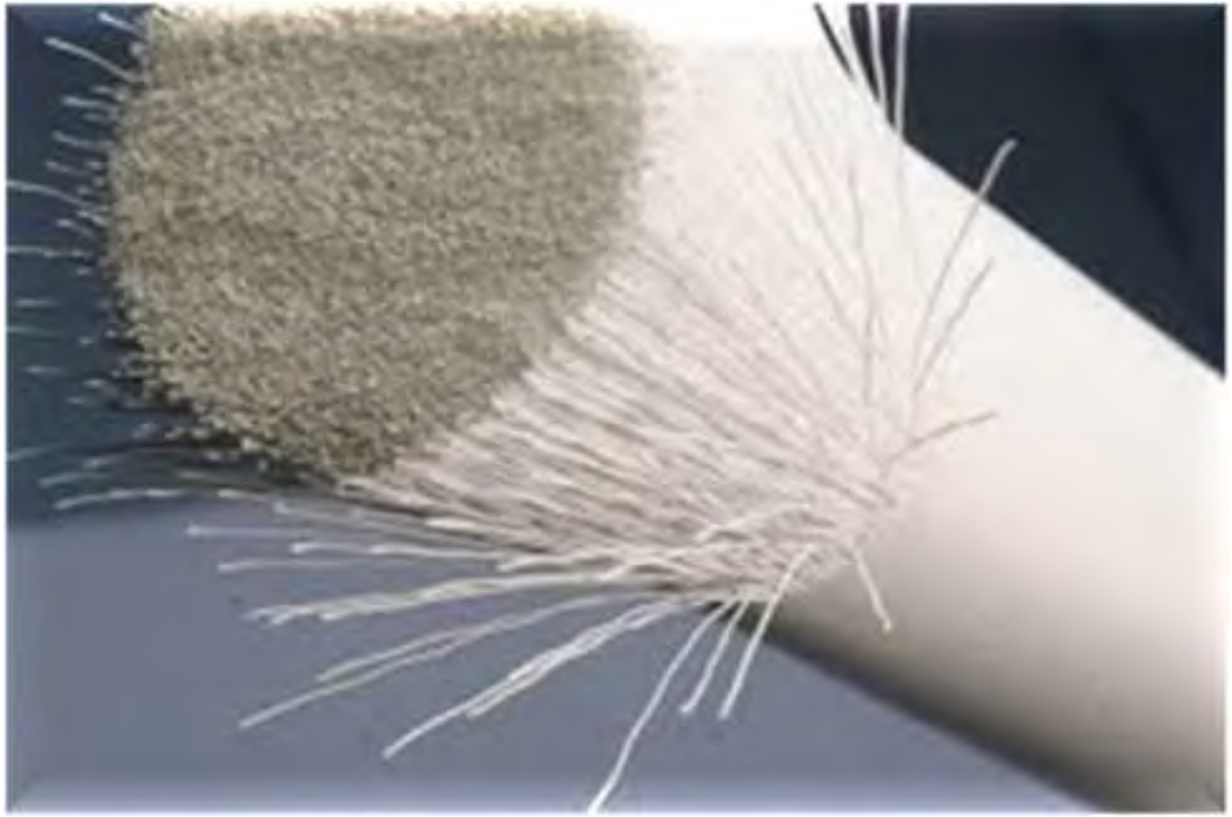


Tertiary Filtration UF

- Ultra Filters
- CIP System (Bleach, Citric)
- Backwashes to EQ
- Effluent used for UF and Bio Backwash.
- Removes remaining Se, Ar, Hg

Tertiary Filtration UF





Effluent & Backwash pumps

Chemicals

- Lime (pH Adjustment to 8.5 - 9.0)
- Organosulfide (coprecipitate)
- Ferric (coprecipitate)
- Polymer (Coagulation)
- HCL (pH Adjustment to 7.0)
- Nutrient (Carbon Source)
- Sodium Hypo (CEB/CIP System)
- Citric Acid (CIP System)
- Hydrogen Peroxide (Odor)

Cross Generating Station Differences

santee cooper®

- Cross Generating Station's FGD Wastewater Treatment system differs from WGS's in three ways

- 1. Size
- 2. Unit 2 Equipment
- 3. Chemical Use

CGS Difference #1

- CGS’s flow can handle up to 900 GPM
- 4 Continuous Backwash Filters
- 7 Stage 1 Bio Reactors
- 20 Stage 2 Bio Reactors

CGS Difference #2

- Our Unit #2 System
- Designed for up to 300 gpm flow
- Cross Generating Station Unit 2's scrubber design results in the wastewater having the presence of reduced selenium species
  - $SeSO_3$, SeCN.
- A specific treatment process has been developed to help address the selenium species found in the Unit 2 wastewater.

Unit 2 Equipment

- EQ Tank C
- Reaction Tank
- Lamella Clarifier
- Clearwell Tank
- Sludge Holding Tanks

U2 Reaction Tank

- 7050 gal tank
- Lime adjustment to 9.5 pH
- FeCl2 feed currently at 600 mg/L
- OrganoSulfide feed at 25 mg/L

Lamella Pumps/Bypass Path

- Can direct flow from the U2 Reaction Tank to the U2 Lamella Clarifier or to the main system splitter box
- Redirection would depend on if selenium speciation results showed that the equipment was not needed.

U2 Lamella Clarifier

- 44,000 gal
- Polymer injection
- Settled sludge is pumped to main system sludge holding tanks.

U2 Clearwell Tank

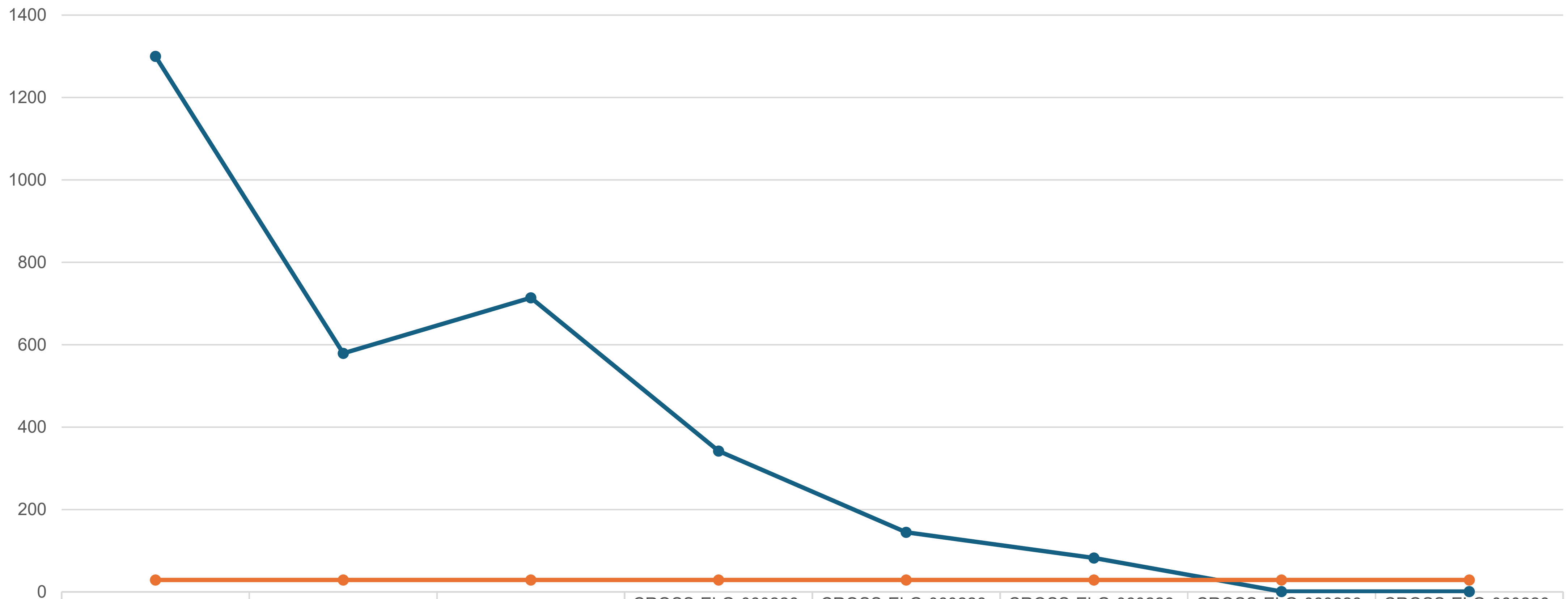
- 4712 gal tank
- HCl adjustment to 6.5 pH
- H2O2 feed at 200 mg/L
- Secondary ferrous dose at 100 mg/L

Fenton Reaction

- The Fenton reaction involves the reaction of **ferrous iron (Fe^{2+}) with hydrogen peroxide (H_2O_2)** to generate **hydroxyl radicals (•OH)** and ferric iron (Fe^{3+}), which then participates in a catalytic cycle to sustain radical production
  - ($Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + OH^- + \bullet OH$)
- **Initiation:** Fe^{2+} reacts with H_2O_2 to form Fe^{3+}, hydroxide ions, and hydroxyl radicals.
- **Propagation:** Fe^{3+} is reduced back to Fe^{2+} by another H_2O_2 molecule, producing hydroperoxyl radicals (HOO•) and protons.
- **Oxidation:** The generated radicals attack organic molecules through hydrogen abstraction, electrophilic addition, or electron transfer, leading to their breakdown.
  This cycle allows continuous radical generation, making the Fenton reaction highly effective for oxidizing complex organic compounds.

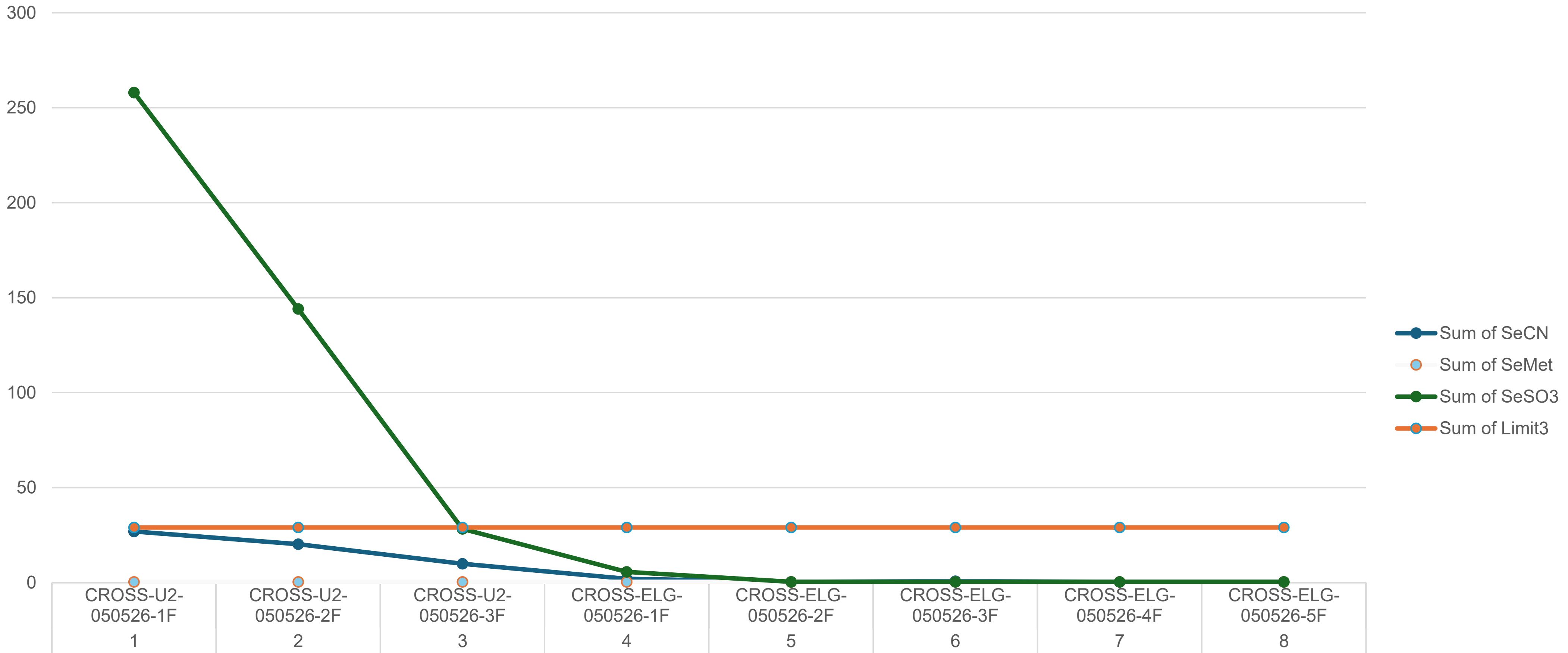
Selenium Removal Through Process (ppb)

santee cooper®



	CROSS-U2-060226-1	CROSS-U2-060226-2	CROSS-U2-060226-3	CROSS-ELG-060226-1	CROSS-ELG-060226-2	CROSS-ELG-060226-3	CROSS-ELG-060226-4	CROSS-ELG-060226-5
	1	2	3	4	5	6	7	8
Sum of Result	1300	579	714	342	145	82.4	1.18	0.91
Sum of Limit	29	29	29	29	29	29	29	29
	U2 FRWD Pumps	U2 Lamella Clarifier Eff.	U2 Clearwell	FRWD Pumps	Bio Feed Pumps	Stage 1 Bio Eff	Stage 2 Bio Eff	Effluent Pumps

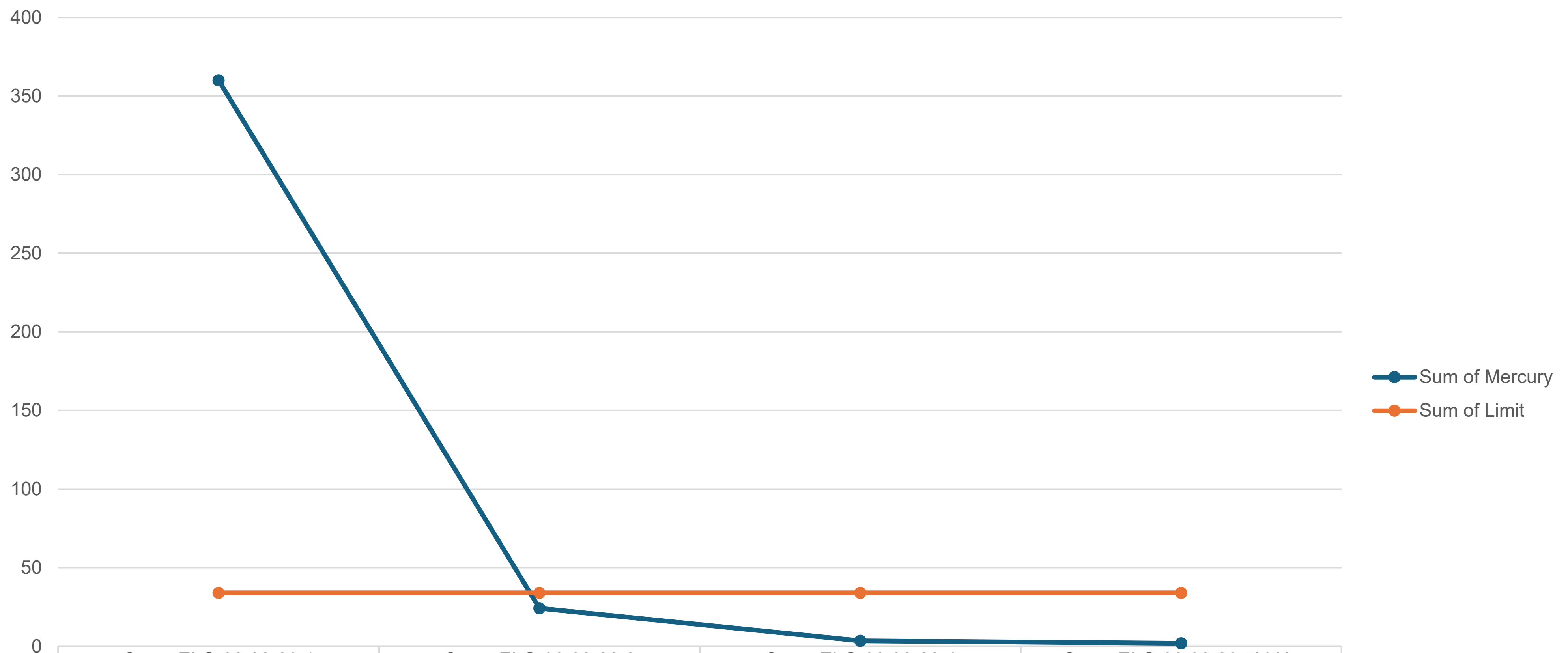
Speciated Selenium Removal (ppb)



	CROSS-U2-050526-1F 1	CROSS-U2-050526-2F 2	CROSS-U2-050526-3F 3	CROSS-ELG-050526-1F 4	CROSS-ELG-050526-2F 5	CROSS-ELG-050526-3F 6	CROSS-ELG-050526-4F 7	CROSS-ELG-050526-5F 8
Sum of SeCN	26.9	20.2	9.94	1.96	0.4	0.664	0.4	0.4
Sum of SeMet	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Sum of SeSO3	258	144	28.3	5.65	0.4	0.4	0.4	0.4
Sum of Limit3	29	29	29	29	29	29	29	29

U2 FRWD Pumps	U2 Lamella Clarifier Eff.	U2 Clearwell	FRWD Pumps	Bio Feed Pumps	Stage 1 Bio Eff	Stage 2 Bio Eff	Effluent Pumps

Mercury Removal (ng/L)



	Cross-ELG-06-02-26-1 1	Cross-ELG-06-02-26-2 2	Cross-ELG-06-02-26-4 4	Cross-ELG-06-02-26-5LLHg 5
	6/2/2026			
Sum of Mercury	360	24.2	3.46	1.9
Sum of Limit	34	34	34	34

FRWD Pumps | Bio Feed Pumps | Stage 2 Bio Eff | Effluent Pumps

pH Challenges

santee cooper®

- Effluent pH band between 6-9 pH
- We have seen pH drop to around 6.1 and lower depending on pH adjustment following the clarifiers.
- We have been targeting a pH of 7.2, and our final effluent pH can end up being as low as 6.10-6.20.
- Other waste streams have alarm conditions tied to this pH band, and are all comingled in our Effluent Mix Tank.

Toxicity issues

- We have had toxicity issues related to H_2S formation and low DO coming out of the effluent stream.
- We have dosed H_2O_2 to prevent excess H_2S at our effluent mix tank. We dose at a ratio of 4:1 for H_2O_2 to measured sulfides coming out of our stage 2 bio. This has helped with odor and toxicity.
- Aeration from our other waste streams helps with DO at our sample locations downstream. H_2O_2 has helped, but there is always a concern when it is the only waste stream running.

Questions?

santee cooper®