

REINHOLD ENVIRONMENTAL Ltd.



**2018 APC & Wastewater Round Table
& Expo Presentation**

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HDR



Using Recirculated BATW Blowdown as Scrubber Makeup

Presenters: Dino Nanni
Chloe Grabowski



Outline

- Introduction
- Use of BATW Blowdown in a Dry Scrubber
– A Case Study
- Use of BATW Blowdown in a Wet Scrubber
- Conclusion – Is this Viable?

HDR Project Team

- John Schubert
- Nathan Kutil
- Dan Sampson
- Chloe Grabowski
- Dino Nanni



Introduction – Client Project Drivers

- Effluent Limitations Guidelines
 - November, 2015
 - Except when the BATW is used in the FGD scrubber, there shall be no discharge of pollutants in BATW.
 - When the BATW is used in the FGD scrubber, the quantity of pollutants in BATW shall not exceed the limitations for FGD wastewater.
 - Dischargers must meet these limitations between November 1, 2018 and December 31, 2023.
 - September, 2017
 - EPA postponed the earliest compliance dates for BATW and FGD wastewater for a period of two years.
 - EPA to potentially revise the BATW and FGD wastewater limitations.
- Coal Combustion Residuals Rule (secondary driver)
 - Implementing a mechanical bottom ash dewatering system.

Introduction – Project Overview

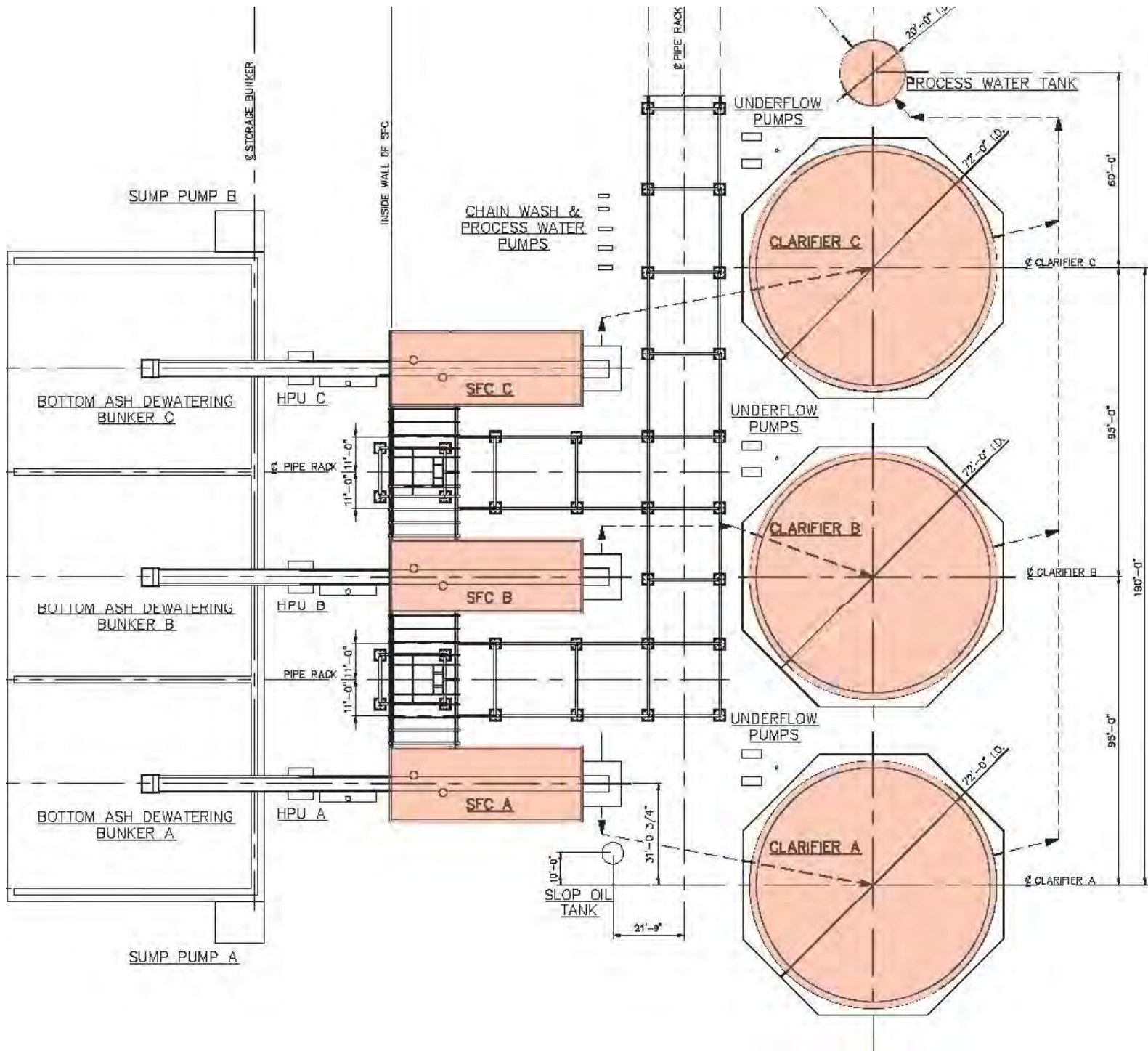
- Evaluate Options for Disposal of BATW Blowdown
 - FGD Makeup
 - Fly Ash / FGD Byproduct Conditioning
 - Zero Liquid Discharge:
 - Brine Concentrator / Brine Crystallizer
 - Deep Well Injection
 - Land Application
 - Treatment of Recirculated BATW
 - Vibratory Sheer Enhanced Processing (VSEP)
 - Pretreatment and Reverse Osmosis
 - Ion Exchange



Introduction – Plant Description

- Four Generating Units - ~1,000 MW Total Capacity
 - Sluice Bottom Ash once per shift
- Dry Flue Gas Desulfurization (FGD):
- Common Fly Ash / Dry FGD Byproduct collection/conveyance
- Currently Installing Bottom Ash Dewatering
 - Original: Once Through Operation
 - ELG Compliance: Recirculated

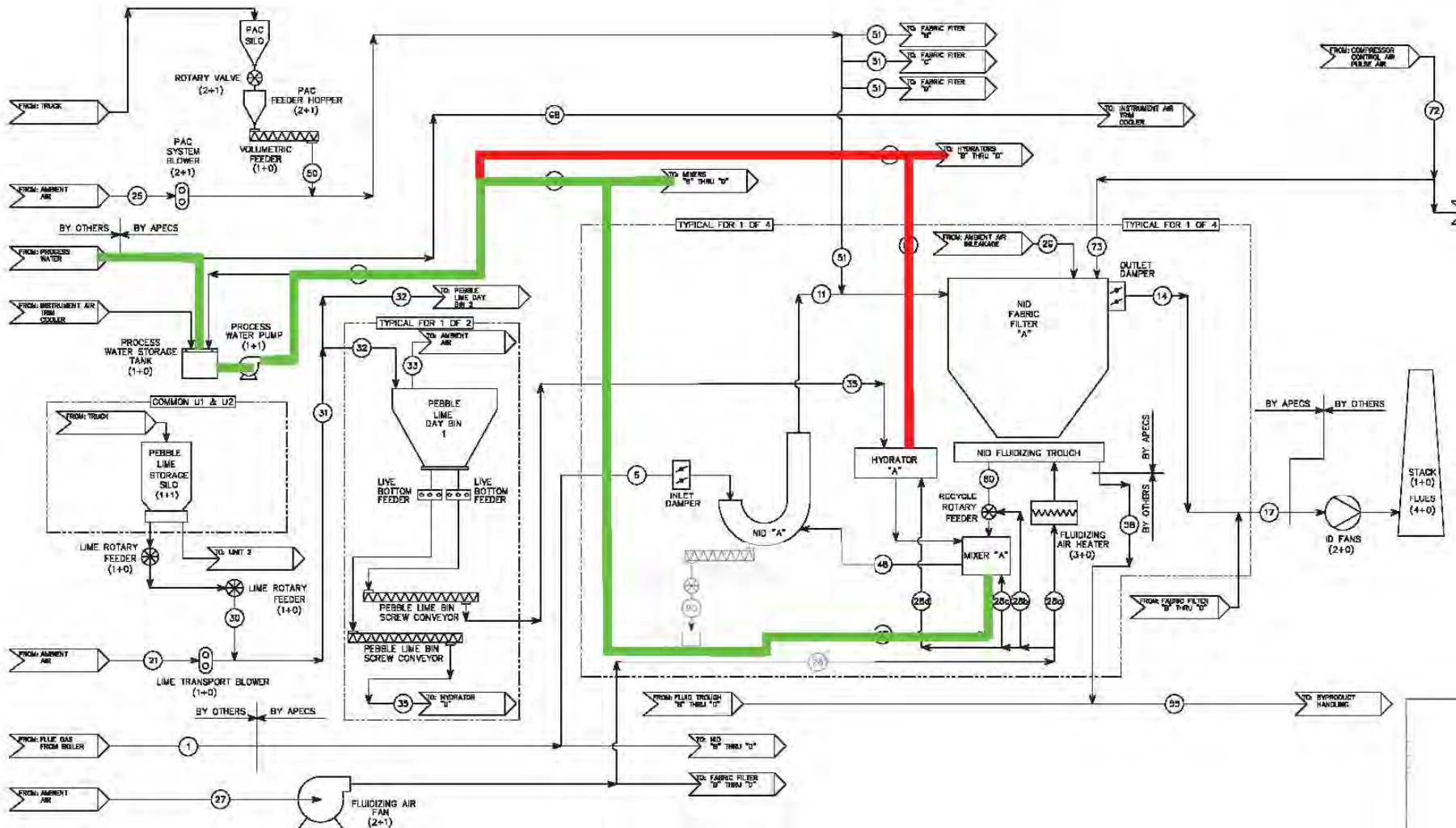




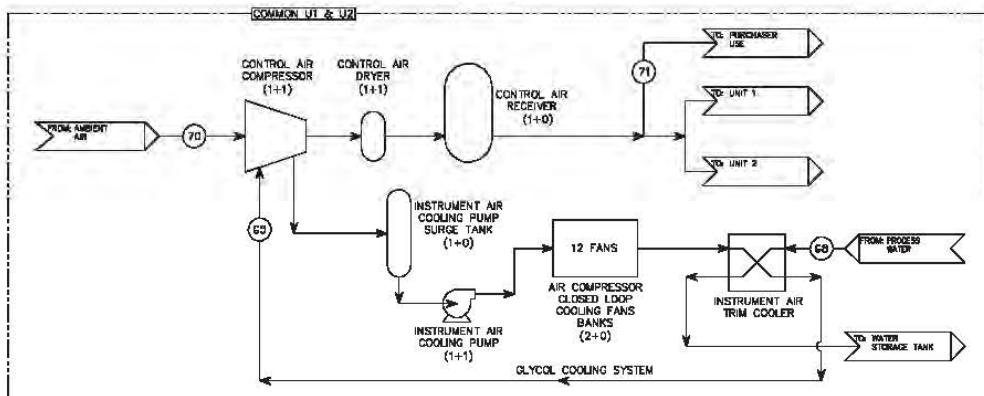


Use of BATW Blowdown in a Dry Scrubber

A Case Study



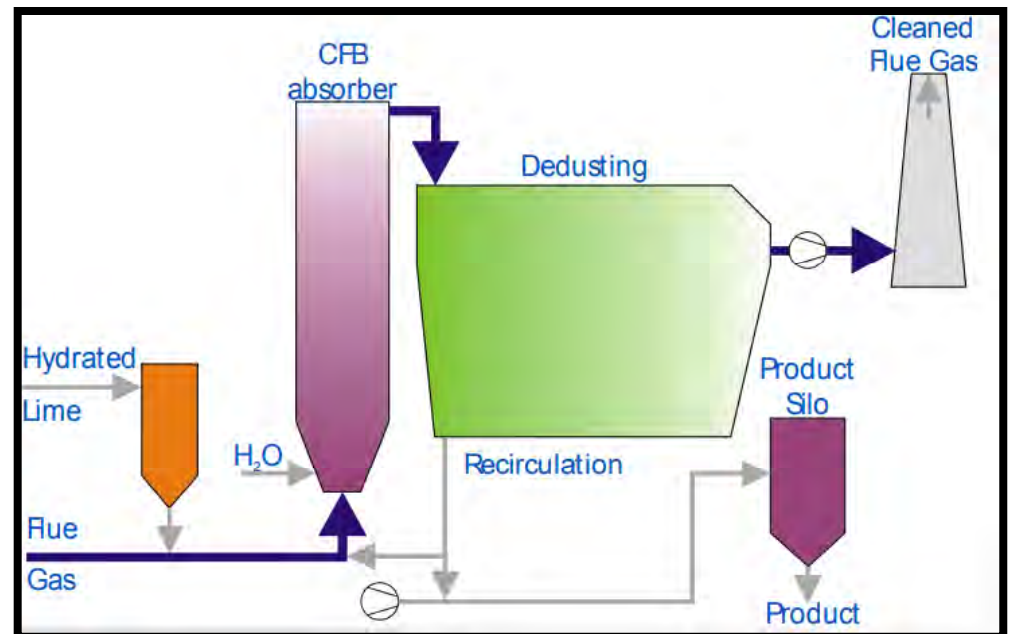
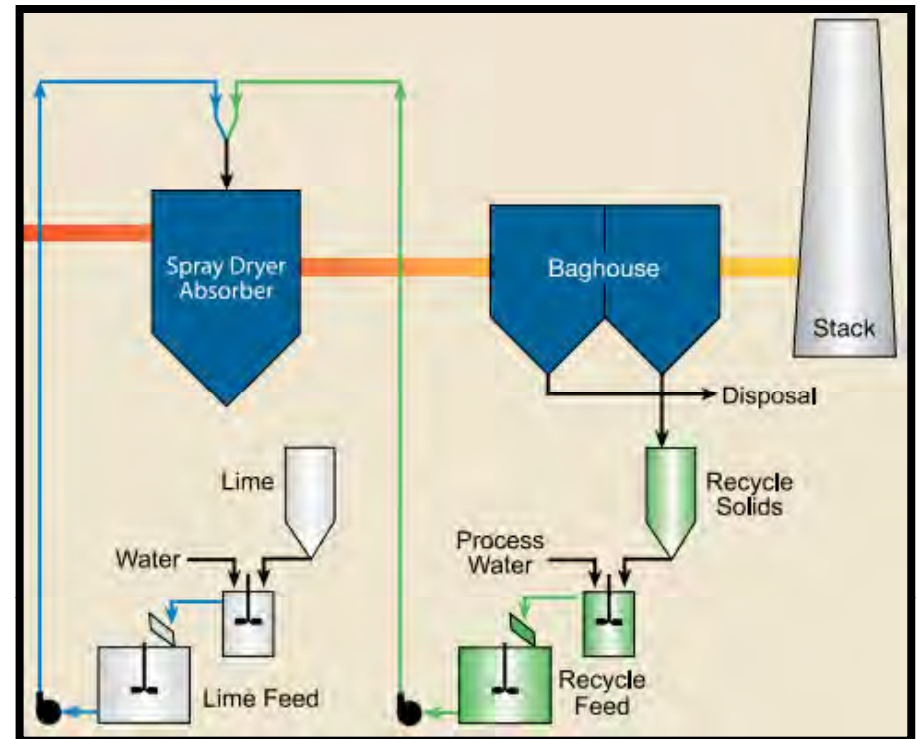
UNIT 1 SHOWN - UNIT 2, 3 & 4 SIMILAR



Mixer Water Usage		
	Unit Load	
	Minimum	Maximum
1 Unit	97	316
4 Units	387	1,265

Other Dry Scrubber Technologies

- Spray Dry Absorber (SDA)
- Sorbent Injection (with Reactor Vessel)
- Circulating Fluidized Bed
- Water Uses:
 - Sorbent (lime) Conditioning
 - Recycled Solids Conditioning
 - Flue Gas Conditioning



Developing a Water Mass Balance Model

- Developed a mass balance model to theoretically quantify the buildup of constituents in a recirculated bottom ash system
- Used to predict a blowdown flow rate that would keep constituent concentrations to acceptable levels
- Implemented a sampling plan:
 - Bottom Ash Transport Water with Mill Rejects
 - Bottom Ash Transport Water without Mill Rejects
 - Mill Reject Transport Water
 - Makeup Water



Developing a Water Mass Balance Model

- Comparing BATW samples to Raw Sluice Water, notable increase in:
 - Sulfate
 - Calcium
 - Total Dissolved Solids
 - Total Suspended Solids
 - Total and dissolved Barium, Aluminum, Boron, and Strontium
 - Total Iron
 - Total Silicon
 - pH
- No noticeable impact of mill rejects
- Results did not take into account changes in coal blend, only sampled when burning 100% PRB coal



Developing a Water Mass Balance Model

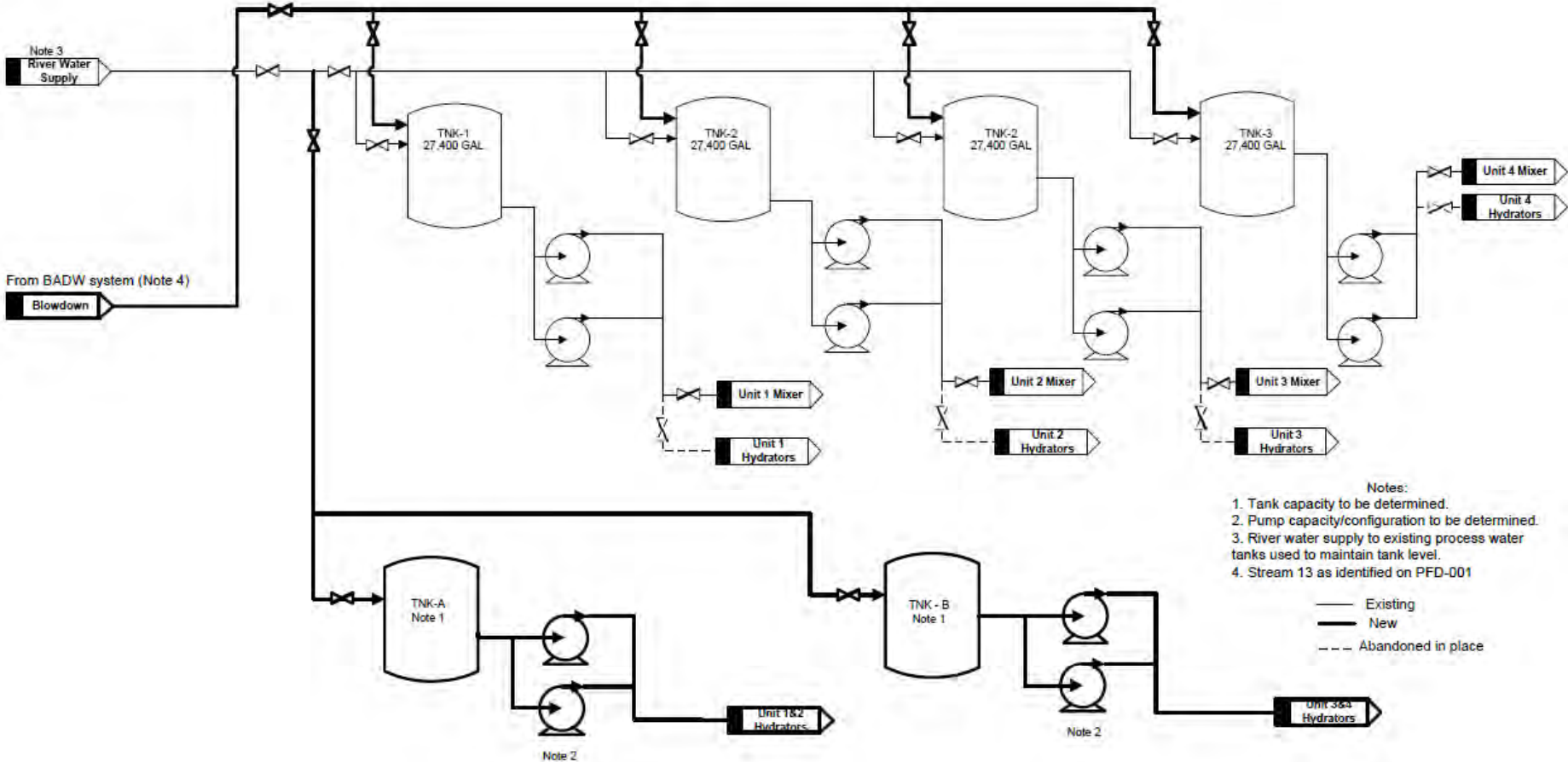
- Developed using a 10,000 gpm circulating water flow rate, to be continuously operated.
- A water loss rate of 90 gpm was used to account for:
 - Dewatered bottom ash
 - Water evaporated from the system
 - Leaks and other losses
- Controlling the blowdown is important to manage:
 - The concentration of sparingly soluble salts
 - Salts such as calcium will precipitate with sulfate resulting in scale formation
 - Corrosive ions upstream of the BADW clarifier
- Anti-scalants coupled with pH control may be used to minimize the potential for scale formation – to certain degrees of supersaturation
- The model assumes no precipitation occurs – the water is unstable; precipitation will occur to restore equilibrium

Water Mass Balance Model Findings – Predicted Blowdown

Parameter	Average at 150 gpm Blowdown (mg/L)	Maximum at 350 gpm Blowdown (mg/L)
TDS	4,412	4,028
pH (std. units) ²	8	8
Calcium as Ca, total	988	995
Calcium as Ca, soluble	720	489
Sodium as Na, total	18	44
Magnesium as Mg, total	43	50
Chloride as Cl, total ³	775	355
Sulfate as SO ₄ , total	1,257	1,845
Silicon as Si, total	80	86
Silicon as Si, soluble	6	15
Boron as B, total	7	17
Phosphorus as P, total	2	6
Iron as Fe, total	26	34
Iron as Fe, soluble	0	0
Aluminum as Al, total	334	393
Strontium as Sr, total	19	21
Manganese as Mn, total	45	191

- (1) Based on no chemical precipitation occurring in the system.
- (2) Assumed value based on adding hydrochloric acid (HCl) to neutralize the alkalinity picked up in bottom ash.
- (3) Based on adding 19.8 gal/hr of HCl for pH control, adding additional HCl will increase the chloride concentration.

Proposed Modification to Dry FGD

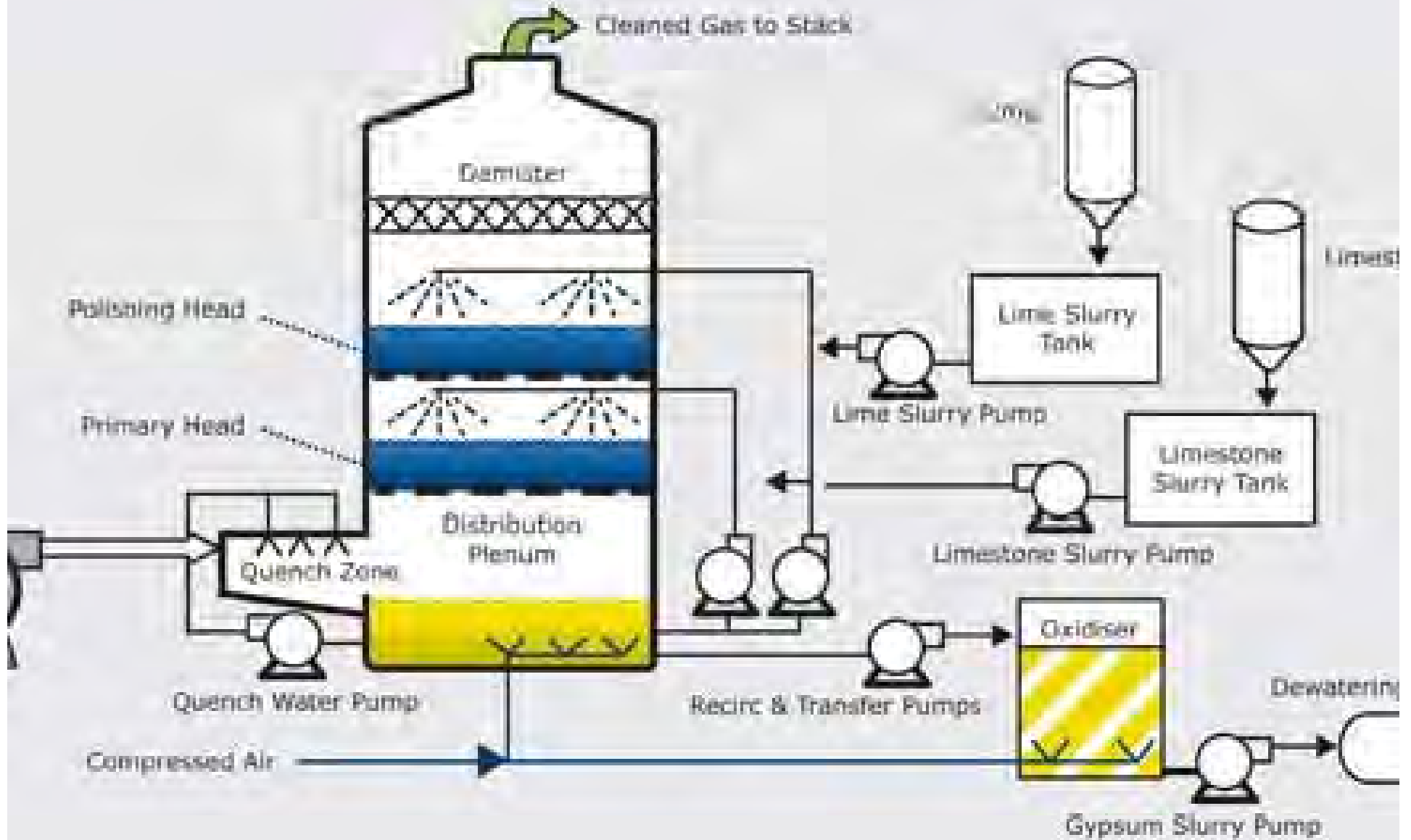




Use of BATW Blowdown in a Wet Scrubber

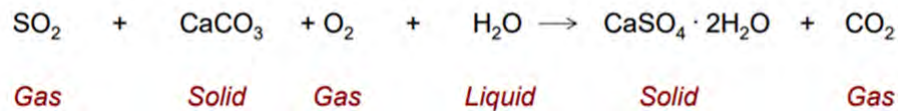
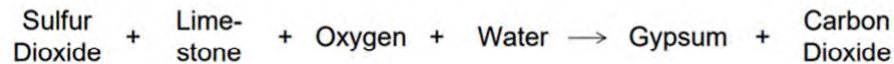
Potential Concerns

Basic Wet FGD Operation



Wet FGD Chemistry

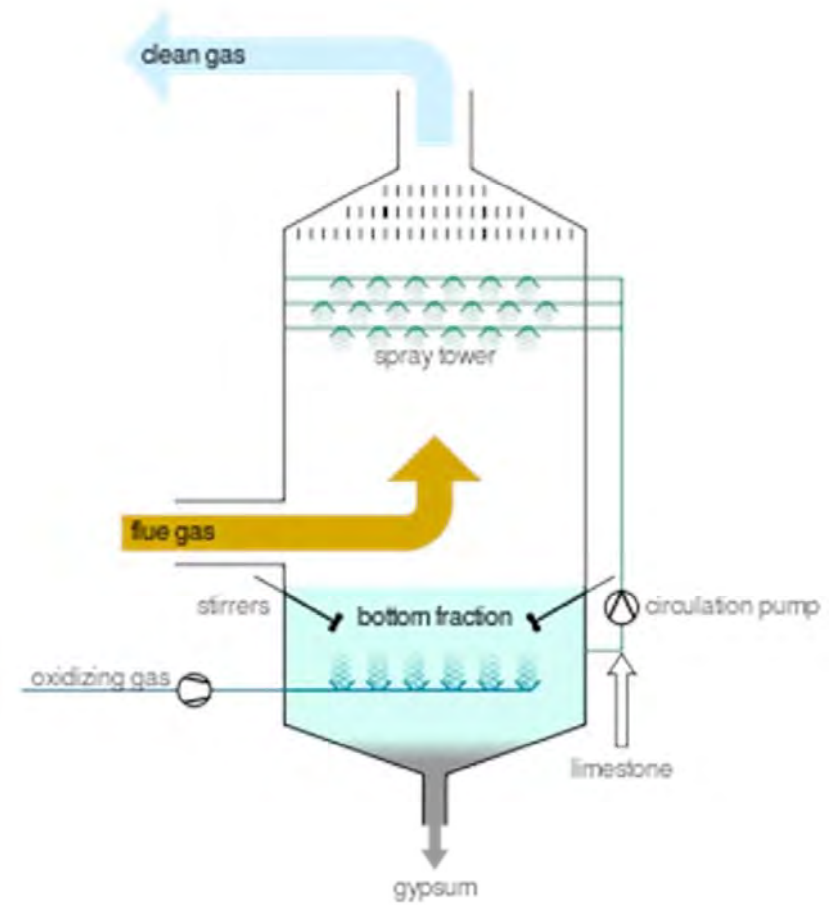
Basic reaction using a limestone reagent:



Primary reaction steps:

- SO₂ adsorption
- SO₂ neutralization – ensure that SO₂ can be absorbed
- Dissolution of limestone – a source of calcium and provides alkalinity for neutralization
- Oxidation of adsorbed SO₂ to form sulfate – may be achieved through forced oxidation
- Precipitation of calcium and sulfate or sulfite to form gypsum – solution must be supersaturated for precipitation to occur, solubility >1

Pic source: http://www.wikiwand.com/en/Flue-gas_desulfurization



Wet FGD Chemistry

Gypsum precipitation:

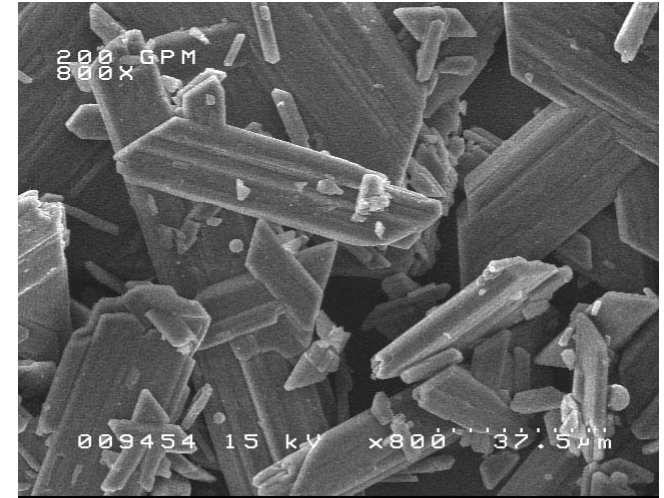
- Nucleation (spontaneous)
- Crystal growth (controlled) – assisted through seeding
- Crystal growth is preferred to minimize scale formation

Gypsum precipitate type depends on:

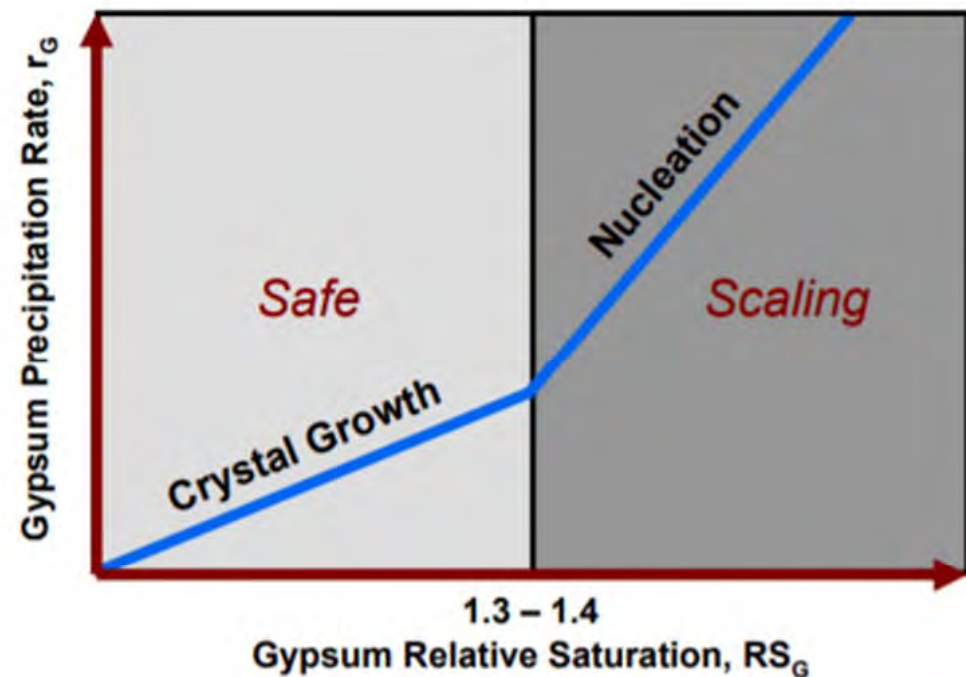
- The rate of precipitation
- Relative saturation
- Availability of seed solids

Crystal morphology (size, shape growth):

- Affects dewatering characteristics



Source: <http://www.caer.uky.edu/kyasheducation/gypsum.shtml>



Source: http://wpc.a.info/pdf/presentations/Orlando_Dec2008/6-FGD%20Chemistry%20Module.pdf

Wet FGD Chemistry

Performance factors:

- SO₂ removal efficiency
- Gypsum dewatering properties and quality
- Quantity of limestone used
- Scale formation

Performance issues include:

- Changes to mineral solubility
- Foaming – build up of bubbles at liquid gas-interface
- Increased gypsum moisture

Sources of performance issues:

- Impurities in makeup water, limestone source, and flue gas
- Flue gas conditions – cannot be controlled
- Insufficient limestone use – can be controlled
- Slurry density – can be controlled
- pH – can be controlled



Source: http://www.meningiegypsum.com.au/using_gypsum.html

Potential Effect of BATW on FGD Operations

Aluminum:

- Formation of aluminum fluoride complexes
- Causes limestone blinding (slowing or stopping of dissolution)
- Loss of pH control due to reduction in limestone dissolution – decreases scrubber performance
- Effects gypsum crystal formation – decreases the precipitation rate and increases supersaturation level

Possible concentration where problem occurs:

- Soluble aluminum >1-2 mg/L, total aluminum >5 mg/L (rule of thumb)

Aluminum in BATW:

Aluminum (mg/L)	Makeup Water	BATW (prior to reticulation)	Recirculated BATW (calculated) – no ppt.
Total	0.19	1.5 – 11.9	334 – 393
Soluble	<0.1	1.4 – 9.55	276 – 314

- Treatment step to remove aluminum through pH adjustment may be required

Potential Effect of BATW on FGD Operations

Fine solids:

- May be beneficial in providing seed sites for crystal growth
- Can cause foaming

Fine solids in BATW

- May enter scrubber – fine solids carryover from the BAD clarifier for example
- Filtration treatment for fine solids removal may be required
- Physical and chemical solution are available to prevent or minimize foam

Gypsum Discoloration:

- Gypsum must be <10% moisture, >95% purity, and not be discolored
- Primarily caused by limestone and fly ash addition

Gypsum Discoloration due to BATW:

- Not a significant concern



Source: <https://pubs.acs.org/doi/abs/10.1021/ie071660g?journalCode=iecred>

Potential Effect of BATW on FGD Operations

Mercury:

- Mercury re-emission
- Mercury in the scrubber may be re-emitted due to changes in scrubber solution chemistry

Mercury in BATW

- Re-emission of mercury due to changes in scrubber solution chemistry as a result of BATW
 - Not a major concern – possibly if changes to solution chemistry are significant
- Re-emissions of mercury in BATW (below detection)

Mercury (ng/L)	Makeup Water	BATW (prior to reticulation)	Recirculated BATW (calculated) – no ppt.
Total	<200	<200	Can't be determined
Soluble	<200	<200	

Potential Effect of BATW on FGD Operations

Chlorides:

- Cause corrosion – depends on material of construction tolerance
- High levels of dissolved chlorides can inhibit dissolution and calcium sulfate precipitation due to the common ion effect

Chlorides in BATW

- Not believed to be a significant concern

Chlorides (ng/L)	Makeup Water	BATW (prior to reticulation)	Recirculated BATW (calculated) – no ppt.
Total	3.7	3.8 – 4.3	355 – 775

Determining if this is a viable solution for your plant

Considerations:

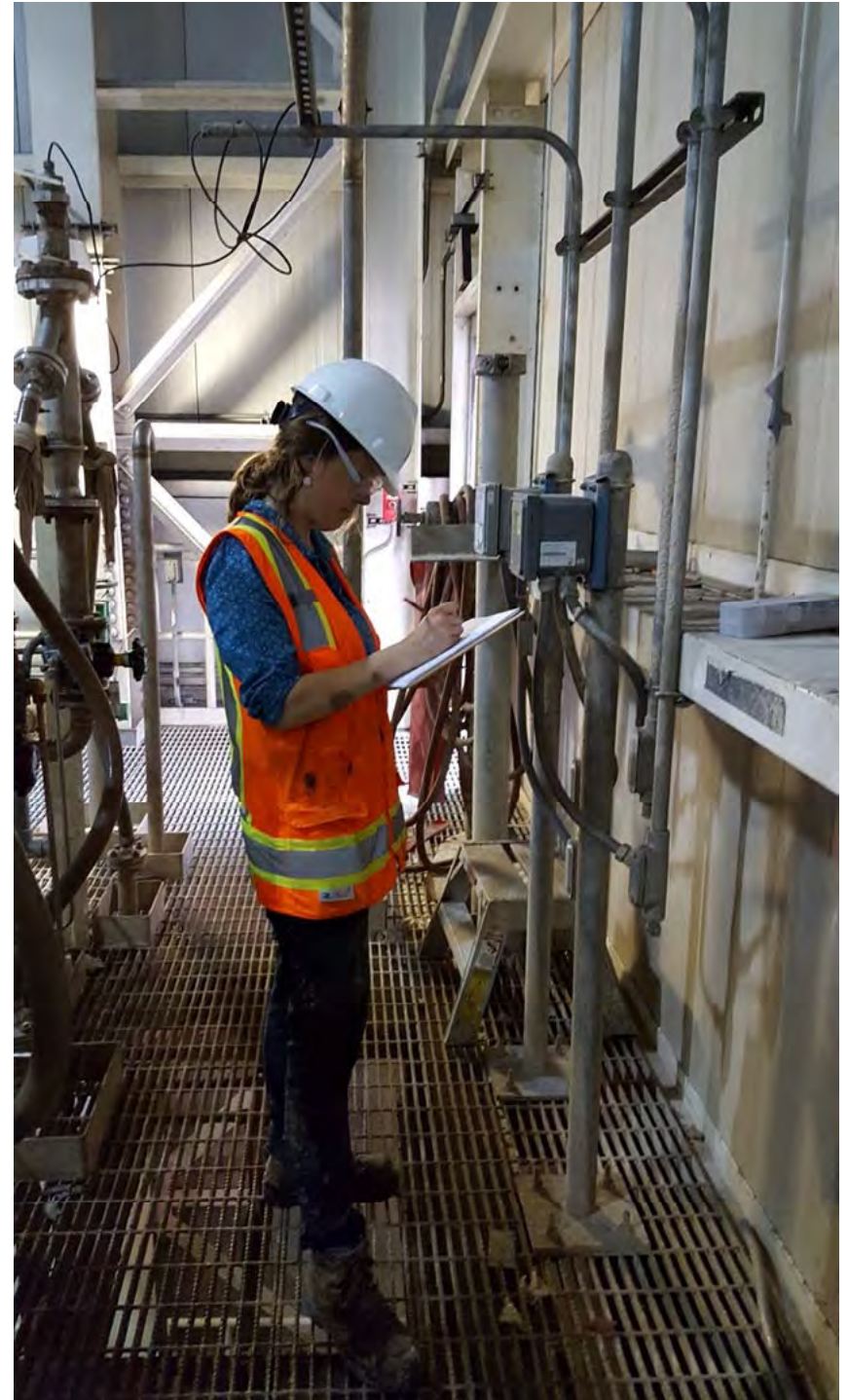
- How well the system is currently operating? Is it a robust system with a good operating history?
- What types of issues, if any, does the system experience?
- BATW blowdown flow rate and water quality – every plant is different
- How different is the BATW quality compared to the normal FGD makeup
- How significant is the blowdown flow rate compared to the makeup flow rate?
 - Maybe 5-20% when using blowdown from recirculated BAD facility
- Makeup water quality, are there constituents such as fluoride that may cause problems with the bottom ash blowdown?
- Limestone source, are there impurities that would cause problems with bottom ash blowdown?



Determining if this is a viable solution for your plant

Steps to take:

- Find similar plants that have look into or is using BATW as FGD makeup
- Characterize the blowdown quality from the BAD system
- Model chemistry affects using stream analyzer software such as OLI
- Determine what level of pre-treatment may be required
- Perform a bench scale study
- Start with a low flow and monitor FGD performance
 - May want to pre-treat BATW blowdown using a pilot system



A photograph of a nuclear power plant. In the foreground, a large body of water reflects the sky and the plant. A prominent cooling tower is on the right, and a large plume of white steam rises from the central part of the plant. The background shows a clear sky and some distant structures.

Questions?

References

- Mion, J.L, Hoydick, M.T., & Winter, S.C. (2014). A Root Cause Study to Determine the Source of High Gypsum Moisture. <
- Roby, C.,Muehlenkamp, R.,& Higgins, T.E. (2017). Closing the Bottom Ash Loop – Pilot Testing Treatment and Resue for FGD Makeup. International Water Conference. November, 2017.
- URS Corporation. Wet FGD Chemistry Performance Factors. Power Gen Conference, Orlando Florida. December 2008.

