




Effluent Limitation Guidelines for Power Plants

Behrang (Ben) Pakzadeh, Ph.D., P.E.

Prepared for 24th Annual Midwest Section, Air and Waste Management Association Environmental Technical Conference | February 24, 2016

BUILDING

MINING

OIL AND GAS

POWER

TRANSPORTATION

WATER/WASTEWATER

Agenda

- ELG Regulation Overview
- ELG Action Items
- CCR Regulation Overview
- CCR Action Items
- CCR and ELG Compliance Timeline
- Forced Oxidation Limestone System Process
- FGD Wastewater Treatment Overview
  – Biological Treatment
  – Evaporation
  – Innovative Technologies
- Summary

Steam Electric Effluent Limitation Guidelines (ELG)

- The ELG Rule was finalized by the EPA on September 30, 2015 and published in the Federal Register November 3, 2015. It became effective on January 4, 2016
- Applicable to coal-fired steam electric power plants:
  - Primarily coal-fired power plants greater than 50 MW
  - National technology-based effluent limitation guidelines (ELGs) and new source performance standards (NSPS) for direct discharges into waters of the United States
  - Pretreatment standards for discharges from existing (PSES) and new sources (PSNS) to publicly owned treatment works (POTWs)
- Uses existing NPDES permit system

States incorporate ELG limits into the renewed NPDES permit

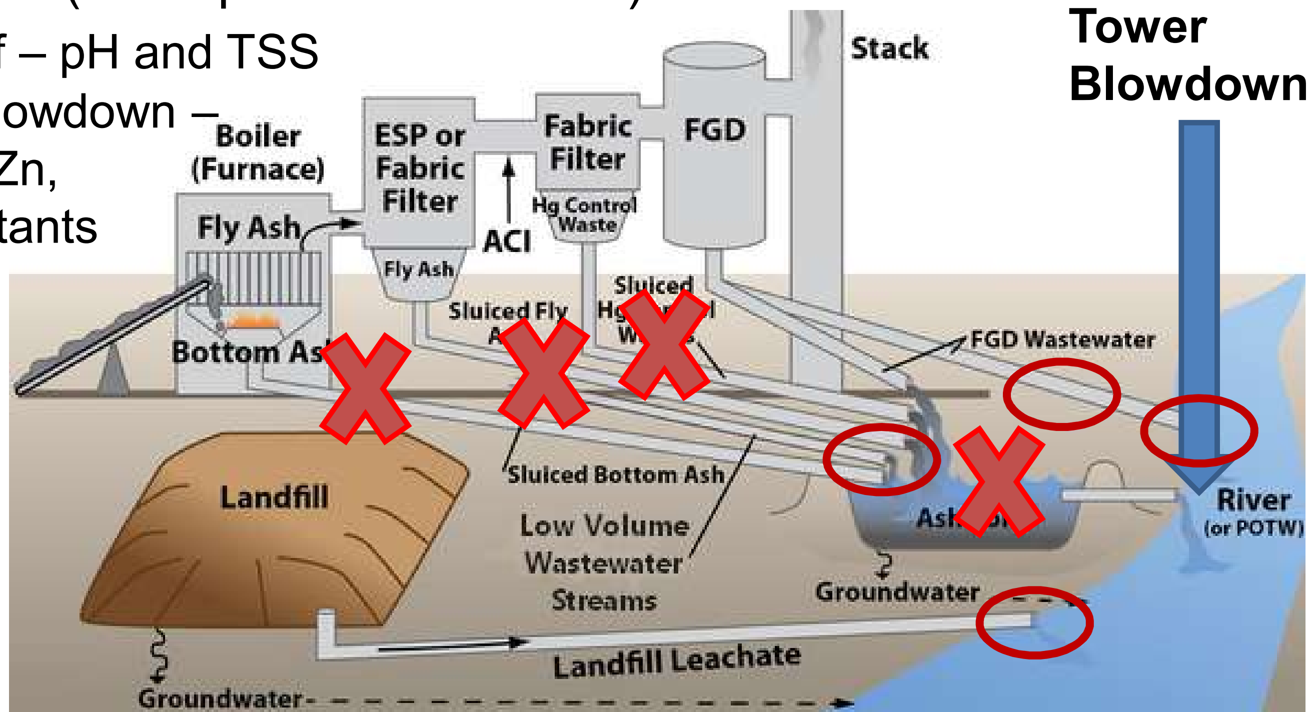
Steam Electric Effluent Limitation Guidelines (ELG)

- Compliance by 2018 to 2023
- Impacts the discharge flue gas desulfurization (FGD) wastewater, bottom ash transport water, and fly ash transport water
- Zero discharge of pollutants in ash transport water
- **Comingling of wastewater streams are not allowed:**
  - FGD Wastewater
  - Gasification Wastewater
  - Combustion Residual Landfill and Impoundment Leachate
  - Fly Ash Transport Water
  - Bottom Ash Transport Water

Compliance by 2018 to 2023 depends on renewal of NPDES permit

Power Plant Wastewater Streams

- Low Volume: pH, TSS, Oil and Grease
  - Water Treatment System – acid and alkali residuals
  - Plant Drains – oil; metal oxides; dissolved additives
  - Storm Water not in contact with ash and not isolated
  - Transformer Containments – oil
- Other Wastewaters (with specific ELG limits)
  - Coal Yard Runoff – pH and TSS
  - Cooling Tower Blowdown – pH, free Cl-, Cr, Zn, 126 priority pollutants



Bottom Ash SFC and ELG: Closed Loop

- Route sluice lines to new remote SFC (or recirculation bin system)
- SFC dewaters the ash in the ramped flights
- Bunker runoff water is pumped to the SFC
- If needed, used conveying water is clarified
- Conveying water is pumped back to the boiler sluicing system

Image from United Conveyor Corp.

Final Rule: Steam Electric Main Regulatory Options

Wastewater Type	Regulatory Options	
	Option D (Existing Sources)	Option F (New Sources)
FGD Wastewater	Chemical Precipitation + Biological Treatment	Evaporation
Fly Ash Transport Water	Dry handling	Dry handling
Bottom Ash Transport Water	Dry handling or closed loop	Dry handling or closed loop
FGMC Wastewater	Dry handling	Dry handling
Combustion Residual Leachate	Impoundment (Equal to BPT)	Chemical precipitation

Management of Wastewater Streams

1. Identify wastewater streams and their current discharge point
2. Collect data on flows and contaminants, including
   - Seasonal, load, and other variations (if possible)
   - Steady state, maximum and minimums
3. Develop water balances for current operations
4. Develop water balances alternatives for future operations (e.g., without discharge to ash ponds)
5. Determine water treatment requirements and system alternatives based on discharge limits
6. Economic evaluation of alternatives
7. Select best configuration
8. Detail Design, procurement, construction, start-up

Coal Combustion Residuals Final Rule

The Coal Combustion Residuals (CCR) Final Rule was published in the Federal Register on April 17, 2015 and became effective on October 19, 2015

- This rule establishes nationally applicable minimum criteria for the safe disposal of CCR in landfills and surface impoundments.

CCRs are designated as a RCRA Subtitle D Waste – non-hazardous

CCRs are generated from the combustion of coal for the purpose of generating steam for electric power or thermal energy.

CCRs include:

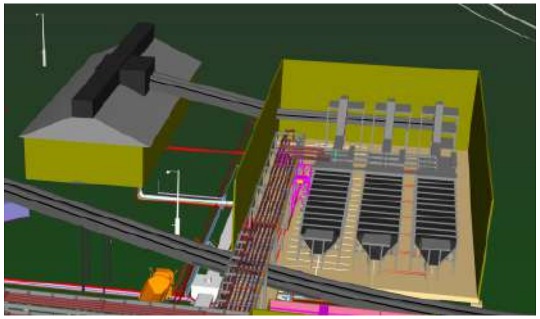
- Fly Ash
- Bottom Ash
- Boiler slag
- FGD solid wastes

Coal Combustion Residuals Final Rule

- Final Rule Applies to:
  - Existing CCR landfills
  - Existing CCR surface impoundments
  - New landfills and surface impoundments, including all lateral expansions
  - Inactive CCR surface impoundments
- Used for the disposal of CCR generated from the combustion of coal at electric utilities and independent power producers.

CCR Overall Impacts and Action Items

- Case assessment and economic analysis
  - Develop compliance schedule
- Impoundments and landfill closure
- Record keeping and Internet websites
- Develop sampling plans for groundwater monitoring
- CCR related design and construction
  - New landfills or impoundments
  - Run-on/off controls
  - Dust control
  - Equipment work: dry removal, conveying, dry Silos
  - Install groundwater monitoring wells

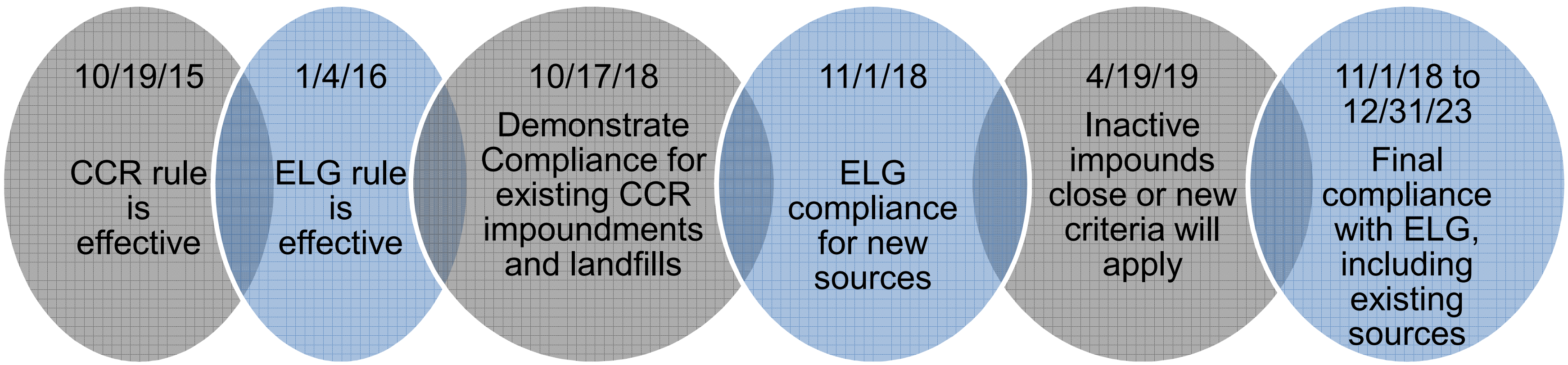


Bottom Ash Remote Submerged Flight Chain Conveyor

Pipe Conveyor

Slip Form Construction for Fly Ash Silos

CCR and ELG Combined Timeline



ELG: FGD Wastewater - Standards for Existing Units

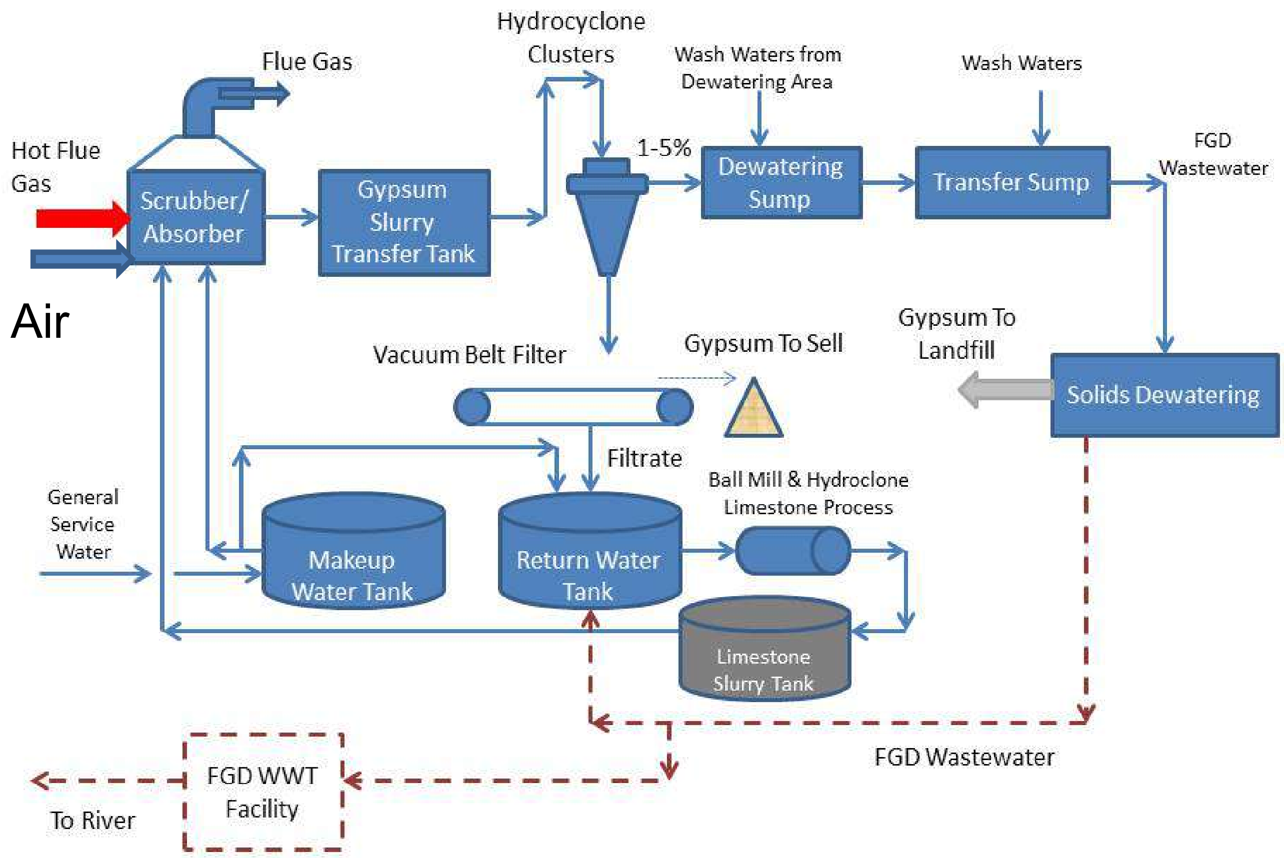
More stringent effluent limits for wastewater discharged from wet scrubber (FGD) systems into surface waters using BAT – Best Available Technology Economically Achievable

Pollutant	Daily Max	30-day Average
As	11 ug/L	8 ug/L
Hg	788 ng/L	356 ng/L
Se	23 ug/L	12 ug/L
NO3/NO2 as N	17 mg/L	4.4 mg/L

TECHNOLOGY: Physical / Chemical and Biological Treatment

Forced Oxidation Limestone System Process Overview

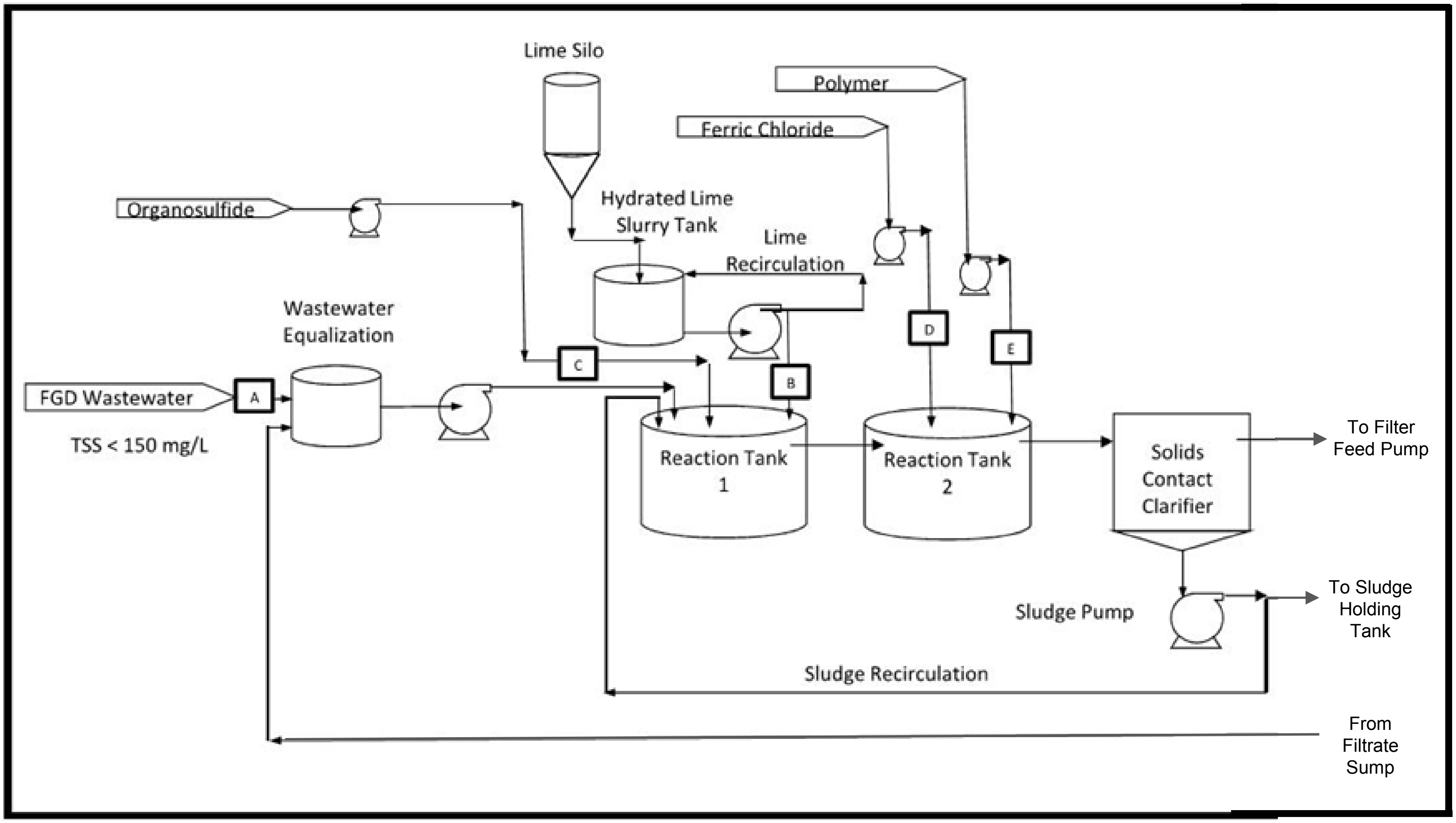
- ~116 U.S. plants have wet FGD systems (EPA/EIA)
- Some wet scrubbers utilize forced-air oxidation to convert the byproduct to gypsum, some employ inhibited oxidation
    - (70%) use limestone
    - 17% employ lime feed
    - Remainder other reagents



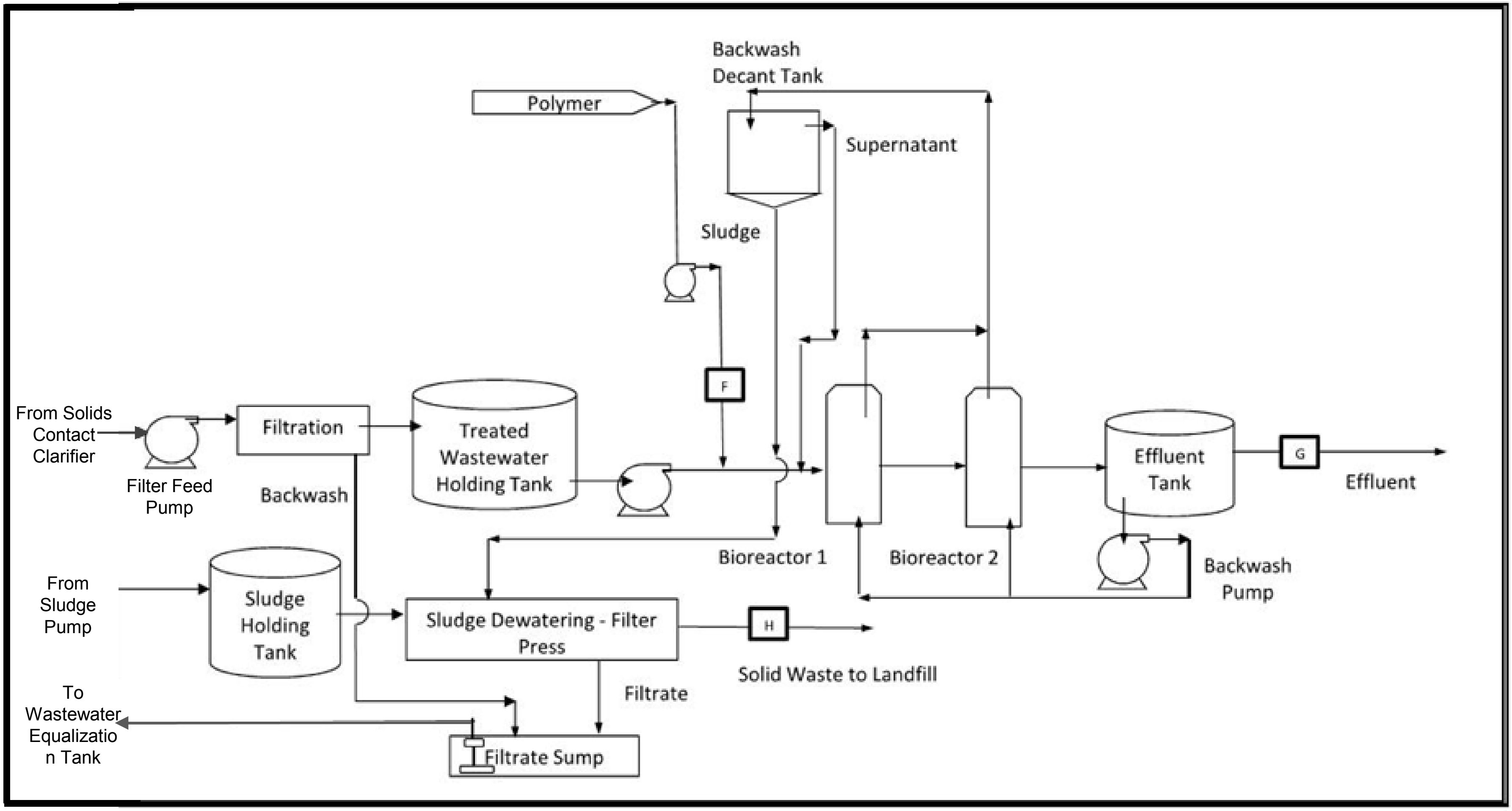
Wet FGD Wastewater Characteristics

Constituent	Units	Range	Monthly Average Limitation for Existing Sources	Required Removal
TDS	mg/L	10,000-50,000	N/A	N/A
Alkalinity as $CaCO_3$	mg/L	20-300	N/A	N/A
Calcium	mg/L	750 – 8700	N/A	N/A
Magnesium	mg/L	500 - 1800	N/A	N/A
Sodium	mg/L	30 - 600	N/A	N/A
Sulfate	mg/L	1300 -3600	N/A	N/A
Chloride	mg/L	800 - 37,000	N/A	N/A
Boron	mg/L	30 - 900	N/A	N/A
pH		5.5 – 8.0	6.0-9.0	N/A
TSS	**mg/L**	**10 - 40,000**	**30**	**0-99.9%**
Nitrate/Nitrite as N	**mg/L**	**10 - 100**	**4.4**	**56%-95.6%**
Arsenic	**µg/L**	**10 - 500**	**8**	**20%-98.4%**
Selenium	**µg/L**	**50 - 3900**	**12**	**76%-99.7%**
Mercury	**ng/L**	**100 – 20,000**	**356**	**0-98.2%**

Generic Block Flow Diagram for Chemical Precipitation and Biological Treatment (1 of 2)



Generic Block Flow Diagram for Chemical Precipitation and Biological Treatment (2 of 2)



Advantages and Disadvantages of Biological Treatment Processes

Advantages	Disadvantages
1. Proven technology 2. Automation is relatively simple and reliable 3. Low hydraulic retention times	1. Physical / chemical pretreatment required: biological treatment for polishing. 2. Sensitive to temperature changes, high chloride concentrations, scaling, high oxidation-reduction potential (ORP) 3. Microorganisms maintenance (nutrients are required) 4. Waste sludge can have a low settling rate

Evaporation

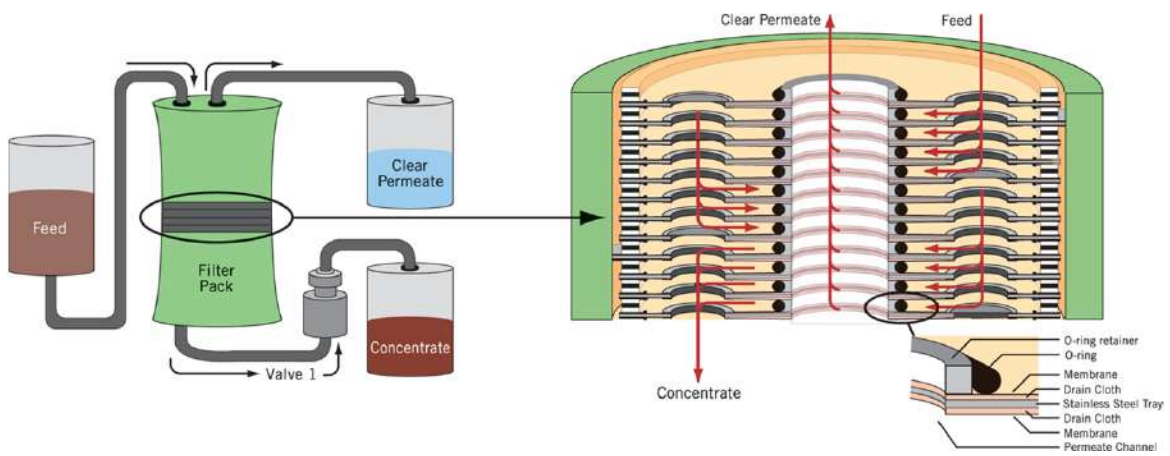
- EPA established BAT limitations for FGD wastewater recommend falling-film evaporation to produce a concentrated brine and a distillate stream.
  - Needs pretreatment by chemical precipitation to reduce scale formation in the evaporator.

- Zero Liquid Discharge
  - Evaporation and deep well injection
  - Evaporation and forced-circulation crystallization - exotic materials, high energy requirements, scale formation
  - Spray drying – using hot flue gas (≈ “free” energy source)
  - Evaporation/Spray drying and Solidification and stabilization – mix concentrate with fly-ash and lime in a pug mill to produce a solid product; Add reducing agents to fixate metals

Advantages and Disadvantages of ZLD Evaporation - Crystallization

Advantages	Disadvantages
1. Evaporation separates all dissolved species and forms a stable solid for landfill 2. Distilled water is high purity and can be reused 3. With crystallizers, no wastewater is produced.	1. Extensive physical / chemical pretreatment required. 2. Very high OPEX (high energy and reagent costs) and CAPEX (exotic alloys) 3. Hard to operate 4. Stringent maintenance requirements

Innovative Technologies – An Example Vibratory Sheer Enhanced Processing (VSEP) By NLR



- Membrane tray elements arrayed as parallel discs providing “open channel” flow arrangement.
- Shear cleaning action lifts the solids boundary layer off the membrane surface.

Summary

- FGD wastewater process chemistry is very complex.
- Good understanding of the FGD process to predict water chemistry changes and design variations in FGD wastewater treatment systems.
- The fuel source, makeup water chemistry, scrubbing process, and other plant processes should be studied in detail prior to FGD wastewater treatment design.
- Several technologies are proven to remove arsenic, mercury, nitrate/nitrite, and selenium from FGD wastewater.
- Process guarantees are very important when selecting technologies.
- Equipment availability and redundancy, effluent quality, leachability of sludge, and water reuse potential should be considered carefully.
- Solids stabilization is an important process to fixate metals within the solids and minimize leachability.

Questions?

Behrang (Ben) Pakzadeh, Ph.D., P.E.

Behrang.Pakzadeh@kiewit.com

(913) 689-4016