Effluent Limitation Guideline Analysis Update

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Solutions for Today | Options for Tomorrow

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Outline

1. Regulatory status update
2. Meeting FGD wastewater standard for different coal types
3. Ongoing work – Speciation of trace metals in wastewater
4. Research boundary conditions

Regulatory Status Update

Regulatory Status Update

Effluent Limitation Guideline

1. **Finalized in 2015, establishes emission limits for wastewater streams from coal-fired power plants**

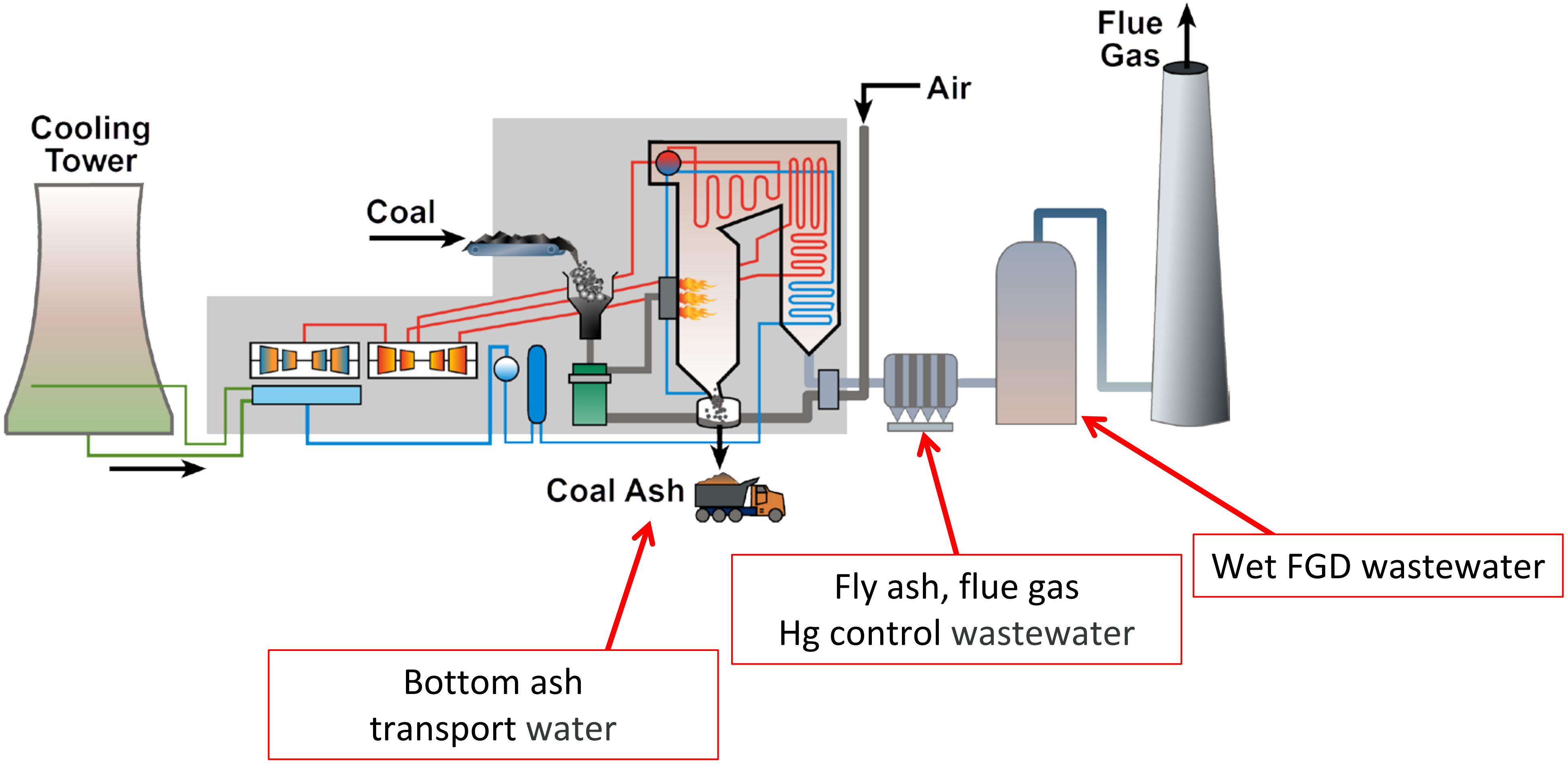
2. **Addresses heavy metals (Arsenic, Mercury, Selenium), nitrate/nitrite, and total dissolved solids**

3. **Compliance at permitting authority's discretion, but between 11-1-18 and 12-31-23**

4. **Two-year compliance extensions given for FGD wastewater and bottom ash transport water, *<u>for existing units only</u>***

Regulatory Status Update

Effluent Limitation Guideline Covered Streams



Regulatory Status Update

Effluent Limitation Guideline Best Available Technology (BAT)

Stream	Existing Source Standard	New Source Standard
FGD Wastewater		
Fly Ash Transport Water		
Bottom Ash Transport Water		
Flue Gas Hg Control Wastewater		
Gasification Wastewater		
Combustion Residual Leachate		

https://www.epa.gov/eg/steam-electric-power-generating-effluent-guidelines-2015-final-rule

Regulatory Status Update

Effluent Limitation Guideline Best Available Technology (BAT)

Stream	Standard (New Sources)*	New Source Performance Standard/Pretreatment Standard for New Sources (NSPS/PSNS)	Standard (Existing Sources)*	Best Available Technology/Pretreatment Standard for Existing Sources
Fly ash transport water	Zero liquid discharge (ZLD)	Dry handling	ZLD	Dry handling
Bottom ash transport water	ZLD	Dry handling/closed loop	ZLD	Dry handling/closed loop
Flue gas mercury control transport water	ZLD	Dry handling	ZLD	Dry handling
Coal combustion residual leachate	Arsenic, 5.98 μg/L Mercury, 159 ng/L	Chemical Precipitation	TSS, 100 mg/L	Impoundment
Wet FGD wastewater	Arsenic, 4.0 μg/L Mercury, 17.8 ng/L Selenium, 5.0 μg/L Total dissolved solids (TDS), 14.9 mg/L	Evaporation	Arsenic, 5.98 μg/L Mercury, 159 ng/L Selenium, 7.5 μg/L Nitrate/Nitrite, 1.3 mg/L Voluntary incentive program (same as new source numerical standard)	Chemical Precipitation, Biological Treatment
Gasification wastewater	Arsenic, 4.0 μg/L Mercury, 1.08 ng/L Selenium, 147 μg/L TDS, 15.2 mg/L	Evaporation	Arsenic, 4.0 μg/L Mercury, 1.08 ng/L Selenium, 147 μg/L TDS, 15.2 mg/L	Evaporation

**Numerical value are shown for long-term averages. Monthly average and daily maximum limits, which are both less stringent than the long-term average, are also presented in the final rule.*

Regulatory Status Update

Effluent Limitation Guideline Revisions

AUTHENTICATED U.S. GOVERNMENT INFORMATION GPO

43494 **Federal Register** / Vol. 82, No. 179 / Monday, September 18, 2017 / Rules and Regulations

SUMMARY: Under the Clean Water Act ("CWA"), The Environmental Protection Agency (EPA) intends to conduct a rulemaking to potentially revise certain best available technology economically achievable ("BAT") effluent limitations and pretreatment standards for existing sources ("PSES") for the steam electric power generating point source category, which were published in the **Federal Register** on November 3, 2015. EPA is, accordingly, postponing the associated compliance dates in the 2015 Rule. In particular, EPA is postponing the earliest compliance dates for the new, more stringent, BAT effluent limitations and PSES for flue gas desulfurization ("FGD") wastewater and bottom ash transport water in the 2015 Rule for a period of two years. At this time, EPA

- Compliance date for Wet FGD effluent, bottom ash transport water for existing sources postponed (by two years)
- Existing source standards for Hg control, fly ash handling, gasification wastewater NOT being reconsidered
- Wet FGD effluent, bottom ash transport water standards for existing sources may be revised

Meeting FGD Wastewater Standard for Different Coals

Meeting FGD Wastewater Standard for Different Coals

NATIONAL ENERGY TECHNOLOGY LABORATORY

Comparison of 4-Day Average FGDW Treatment After Chemical Precipitation at Allen, Belews Creek, and Pleasant Prairie[99]

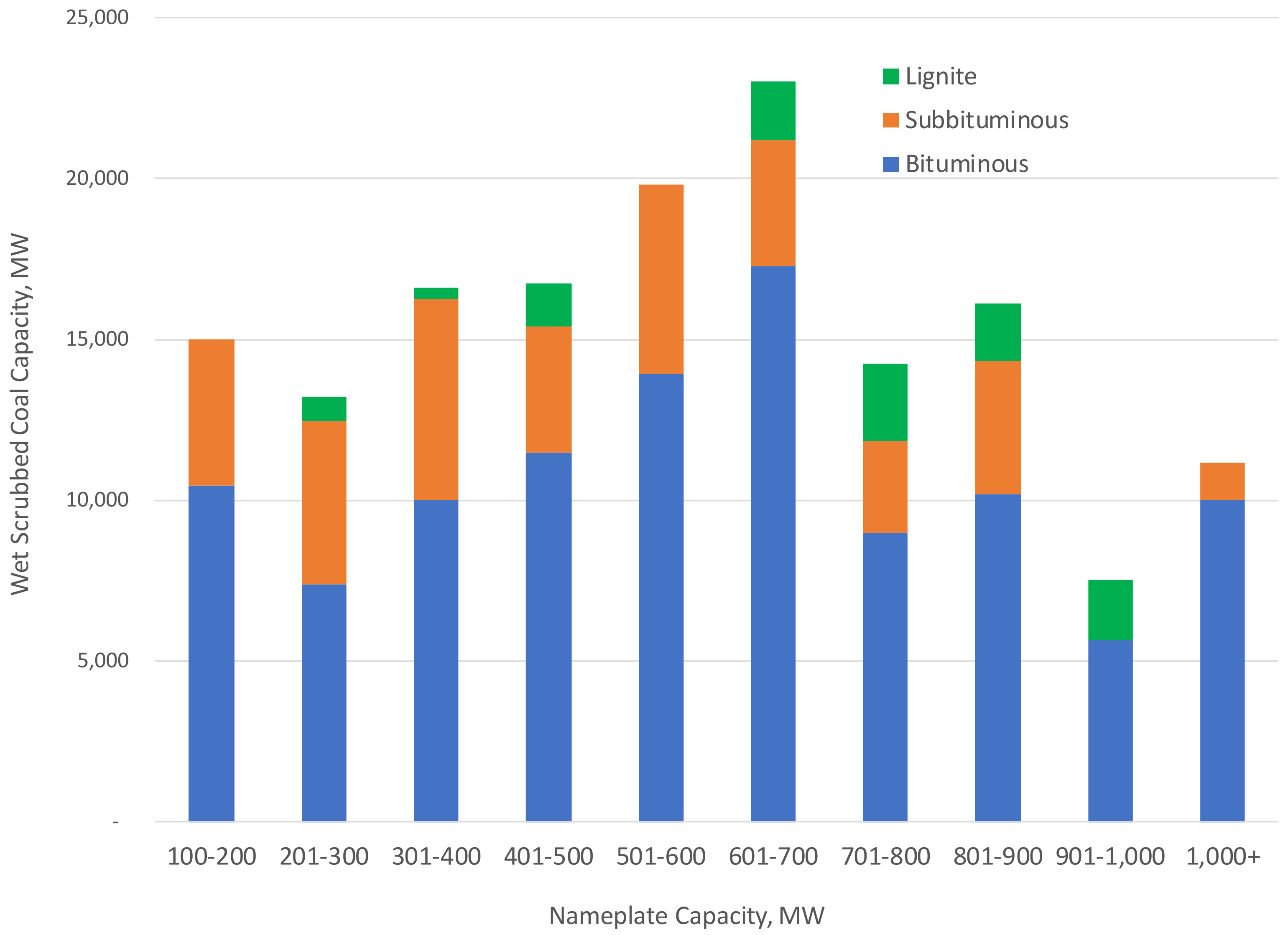
Analyte	Unit	4-Day Average Dissolved Effluent, Allen (E. Bituminous)	4-Day Average Dissolved Effluent, Belews Creek (E. Bituminous)	4-Day Average Dissolved Effluent, Pleasant Prairie (PRB)
Aluminum	(ug/l)	NQ[100]	ND	NQ
Arsenic*	(ug/l)	NQ	NQ	4.85
Boron	(ug/l)	58,600	150,000	9,930
Calcium	(ug/l)	1,750,000	3,490,000	639,000
Chloride	(mg/l)	3,300	7,780	1,950
Magnesium	(ug/l)	396,000	738,000	3,560,000
Manganese	(ug/l)	393	NQ	10,800
Mercury	(ng/l)	342	46,200	22.3
Nitrate/Nitrite	(mg/l)	13.3	19.8	160
Selenium	(ug/l)	91.1	1,210	2,080
Sodium	(ug/l)	31,300	48,900	518,000
Sulfate	(mg/l)	1,400	1,380	15,500
TDS	(mg/l)	7,560	20,100	22,400

*The pollutants highlighted are those for which EPA set new BAT limits.

- FGD wastewater for bituminous ≠ wastewater for PRB
- FGD wastewater from 2 bituminous units significantly different
- Current regulation requires 7.5 µg/L selenium, regardless of coal type – compliance technology needs to perform differently

"Utility Water Act Group Petition for Reconsideration of EPA's final rule titled "Effluent Limitation Guidelines and Standards for the Steam Electric Power Generating Point Source Category," 80 Fed. Reg. 67,838 (Nov. 3, 2015).

Meeting FGD Wastewater Standard for Different Coals



- **About a third of domestic scrubbed coal capacity does NOT burn bituminous!**

Meeting FGD Wastewater Standard for Different Coals

- **Technology need during reconsideration: ability of biological treatment to demonstrate consistent performance with changing FGD wastewater quality**
- **Factors that impact FGD wastewater quality:**
  - Coal quality
  - FGD cycles of concentration that affect Cl, TDS
  - Cl, Mg levels in limestone reagent
  - Various forms of Se in FGD wastewater
  - Coal plant cycling
  - FGD wastewater temperature swings

Speciation of Trace Metals in Coal Plant Wastewater

Speciation of Trace Metals in Coal Plant Wastewater

1. "EPA intends to fully evaluate all of the issues raised in the petitions, including concerns about: cost and impacts to steam electric facilities, public availability of information on which the rule is based, lack of data for plants that burn certain types of coal, and validity of certain pollutant data used in EPA's 2015 Rule analysis."*

2. Similar to Hg air emissions, need to characterize speciation of heavy metals in wastewater streams as functions of coal type, pollution controls

3. Ongoing NETL project (with funding from EPRI) that characterizes where trace metals partition (flue gas, solids, or water), and in what amounts (results expected later in 2019)

* https://www.epa.gov/sites/production/files/2017-09/documents/steam-electric-elg_final_postpone-compliance-dates_fr-prepub_09-12-2017.pdf

Research Boundary Conditions

Research Boundary Conditions

- **NETL systems analysis and research community should be a collaborative relationship**

- **NETL will provide "typical" operating conditions for researchers to consider:**
  i. FGD wastewater quality (incoming to treatment technology)
  ii. Flowrates and stream temperatures

- **Research results minimum reporting requirements**
  i. Cost and performance results needed by NETL to facilitate technology analysis
  ii. Technology development should serve FE strategic objectives (reduced water use in power systems, cost-effective water treatment systems)

Research Boundary Conditions

Techno-Economic Analysis and Evaluation of FGD Wastewater Treatment Processes

- Techno Economic Analysis Objectives – Characterize the estimated performance, capital costs, operating and maintenance (O&M) costs, applicability limitations, technical challenges, and research and development (R&D) opportunities for wet flue gas desulfurization (FGD) wastewater treatment systems for Effluent Limitation Guidelines (ELG) compliance at existing coal-fired power plants
- Systems evaluated
  - Chemical precipitation
  - Biological treatment
  - Zero valent iron
  - Brine concentration
  - Vapor compression crystallization
  - Fly ash conditioning

Research Boundary Conditions

Techno-Economic Analysis and Evaluation of FGD Wastewater Treatment Processes

Case	Description	Wastewater Solids Handling and Disposal (TPY)	Recovered Water Available for Reuse (gpm)	Fly Ash Disposal Auxiliary Load (kW)	Raw Water Withdrawal (gpm/MWnet)	Raw Water Consumption (gpm/MWnet)	Wastewater Treatment Auxiliary Load (kWe)	Net Power (MW)	HHV Net Plant Efficiency (%)
0	Reference Plant (Surface Water Discharge)	0	0	700	10.0	7.9	0	650	38.9
Compliance Options (Treat and Discharge)									
1	Chemical Precipitation + Biological Treatment	3,780	0	700	10.0	7.9	53	650	38.9
2	Chemical Precipitation + Zero Valent Iron	4,160	0	700	10.0	7.9	74	650	38.9
Over Compliance Options (ZLD)									
3	Chemical Precipitation + Brine Concentration + Fly Ash Conditioning	3,780	47	770	9.9	7.8	342	650	38.9
4	Chemical Precipitation + Vapor Compression Crystallization + Fly Ash Conditioning	3,780	52	730	9.9	7.8	1,060	649	38.8

Conclusions

1. Selenium limit in FGD wastewater for existing units expected to be updated soon

2. FGD wastewater is variable even among the same coal type; about a third of all scrubbed coal capacity is subbituminous or lignite, and uncertainty regarding treatment technology performance for these coal exists

3. The relationship between NETL analysts and research community should be an iterative and collaborative one

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Facilitated Discussion – ELG

1. Influence of coal type on FGD wastewater quality – diverse fleet that needs to be brought into compliance!

2. Techno Economic Analysis Requirements – Equipment list, capital cost, parasitic power load, overall cost of electricity

3. "Typical" FGD wastewater quality (see table)

Table 6- Design Basis FGD Wastewater Quality

Parameter	FGD Wastewater (Range)	FGD Wastewater (Average)	FGD Wastewater (Design Basis)
pH	5.5 – 7.4	6.6	7.2
Chemical oxygen demand, ppm	304 – 1,060	682	350
Biological oxygen demand, ppm	21 – 1,370	422	500
Specific Conductance, µS/cm	5,990 – 32,000	9,595	32,000
Suspended Solids, ppm	4,970 – 25,300	13,888	15,000
Total Dissolved Solids, ppm	4,740 – 44,600	21,310	43,494
Chloride as Cl, ppm	832 – 28,800	9,966	20,000
Sulfate as SO4, ppm	1,290 – 11,900	4,212	7,600
Calcium as Ca, ppm	751 – 5,370	2,791	5,370
Magnesium as Mg, ppm	176 – 7,000	2,728	6,000
Sodium as Na, ppm	59 – 5,340	998	2,900
Boron (total), ppm	3.0 – 626	220	430
Potassium as K, ppm	35 – 684	226	250
M-Alkalinity as CaCO3, ppm	131 – 625	275	200
Iron (total), ppm	3.4 – 824	200	290
Aluminum (total), ppm	1.0 – 289	93	150
Silica as SiO2, ppm	1 – 91	33	100
Manganese (total), ppm	1.58 – 225	32.1	60
Nitrate/Nitrite as N, ppm	1.0 – 54.5	20.5	30
Total Kjeldahl[22] Nitrogen, ppm	6.2 – 51.6	19.2	20
Ammonia as N, ppm	1.5 – 31.5	8.4	10
Phosphorus, ppm	0.05 – 10.5	4.61	7
Nickel (total), ppm	0.447 – 6.0	2.05	5
Selenium (total), ppm	0.651 – 8.66	2.75	5
Zinc (total), ppm	0.31 – 9.04	3.23	6
Barium (total), ppb	588 – 11,900	3,330	5,000
Titanium (total), ppm	0.377 – 8.18	2.57	4

Facilitated Discussion – Condensers

1. Ambient conditions and condenser performance used for techno economic analyses

2. Condenser performance and improvements specifically noted in EPA's Affordable Clean Energy Rule

3. What metrics or parameters should NETL be paying attention but are not?

Table 2 - Available Cooling Water Temperature Assumptions[7]

	Midwest (ISO)
Design Ambient Dry Bulb Temperature, ºF	59
Design Ambient Wet Bulb Temperature, ºF	51.5
Design Ambient Relative Humidity, %	60
Cooling Water Temperature, ºF8	60

Table 3 - Process Parameters for Surface Condensers[7]

	Parameter Value	Range	Notes
Operating Pressure, psia	0.982	0.43 – 5.8	Operating pressure depends on cooling water temperature. Design parameter is for ISO condition cooling water.
Terminal Temperature Difference, ºF	21	21 – 23	Terminal temperature difference is higher than typical to account for lack of a summer design condition
Design Cleanliness Factor	85%		85% is a typical value, although some EPC's use a more conservative 75%
Typical tube thickness	22-24 gauge		