

REINHOLD ENVIRONMENTAL Ltd.



2015 Wastewater-Ash Round Table Presentation

September 22, 2015, in Charlotte, NC / Hosted by Duke Energy

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Options, Considerations and Implications of Wet-to-Dry Ash Conversions

Prepared for: WASTEWATER-ASH/PCUG CONFERENCE

Presented By: Kevin McDonough

22 September 2015



Regulatory Update & Implications

Activity Summary & Technology Selection Criteria

Ash Wet-to-Dry Conversion Technologies

Water Balance & Wastewater Considerations



Safety Moment

Coal Combustion Residuals (CCR)

- Issued December 19, 2014
- CFR Publication: April 17, 2015
- Goals
 - ✓ Groundwater Protection Benefits
 - ✓ Preventing Future CCR Impoundment Catastrophic Failures



Effluent Limitations Guidelines (ELG)

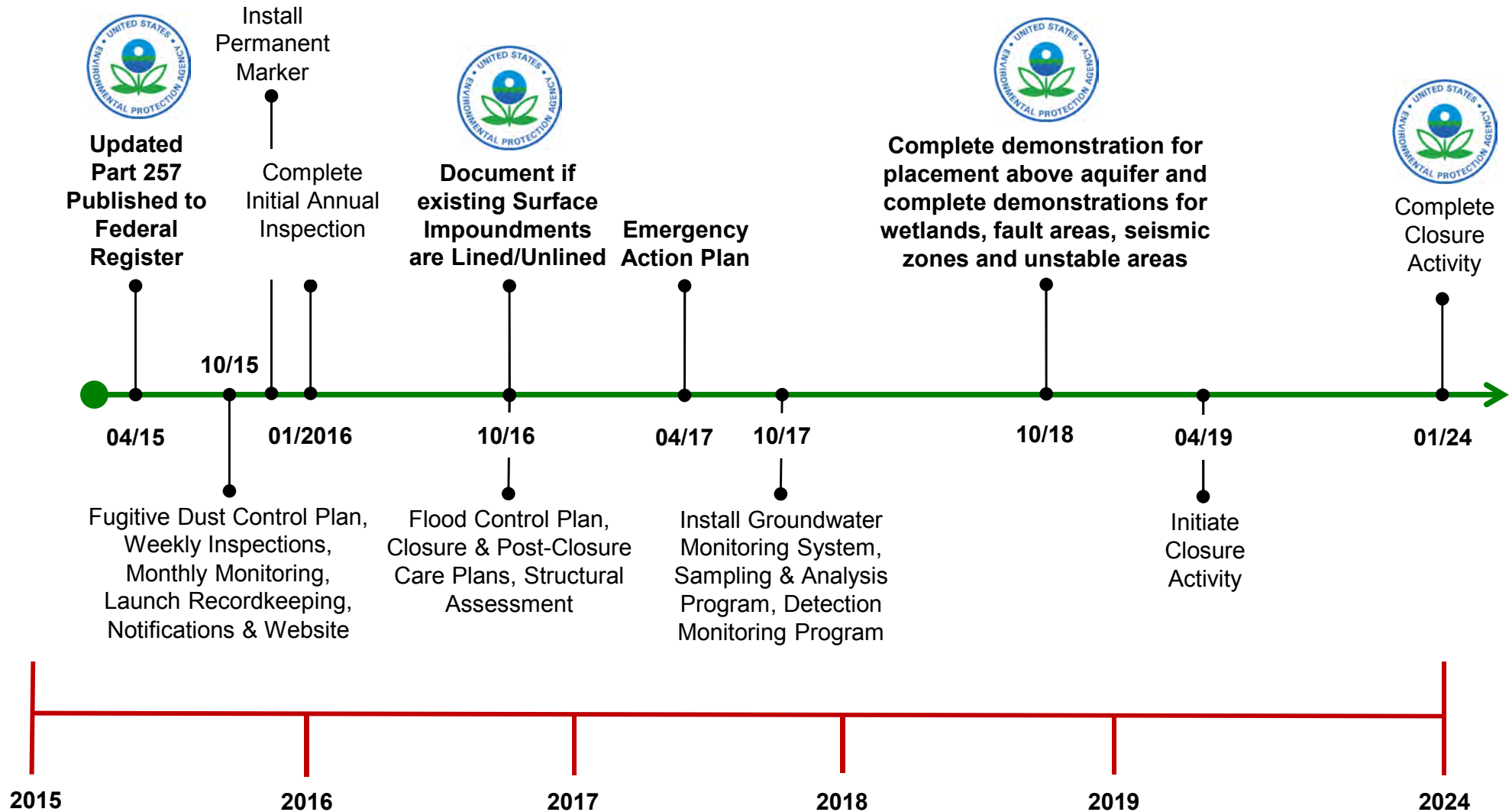
- Proposed Rules Issued April 2013
- Final Rules: Consent Decree = September 30, 2015
- Goals
 - ✓ Strengthen Steam Electric Power Plant Discharge Controls
 - ✓ Reduce Surface Water Pollutant Discharges



- **Regulation Focus Areas:**
 - Location Restrictions: Aquifer, Wetlands, Fault Zones, Seismic Zones, Unstable Areas
 - Design Criteria: Lined/Unlined, Leaking/Not Leaking, Structural Integrity
 - Operating Criteria: Flood Control, Fugitive Dust Control, Inspections (Weekly/Monthly/Annual)
 - Groundwater Monitoring and Corrective Action
 - Closure Requirements and Post-closure Care
 - Recordkeeping, Notification, and Internet Posting

Coal Combustion Residuals (CCR) Ruling

Regulatory Timeline – Existing CCR Surface Impoundments



ELG Ruling

Steam Electric Main Regulatory Options



Wastestreams	Technology Basis for the Main Regulatory Options			
	3a	3b	3	4a
FGM		Chemical Precipitation + Biological Treatment for units		ation + ment
Fly				g
Bottom				losed- 00W; equal to 00MW
Comb				nt (T)
FGMC Wastewater	Dry Handling	Dry Handling	Dry Handling	Dry Handling
Gasification Wastewater	Evaporation	Evaporation	Evaporation	Evaporation
Nonchemical Metal Cleaning Wastes	Chemical Precipitation	Chemical Precipitation	Chemical Precipitation	Chemical Precipitation

EPA will choose the preferred option and issue as final on 30 September 2015

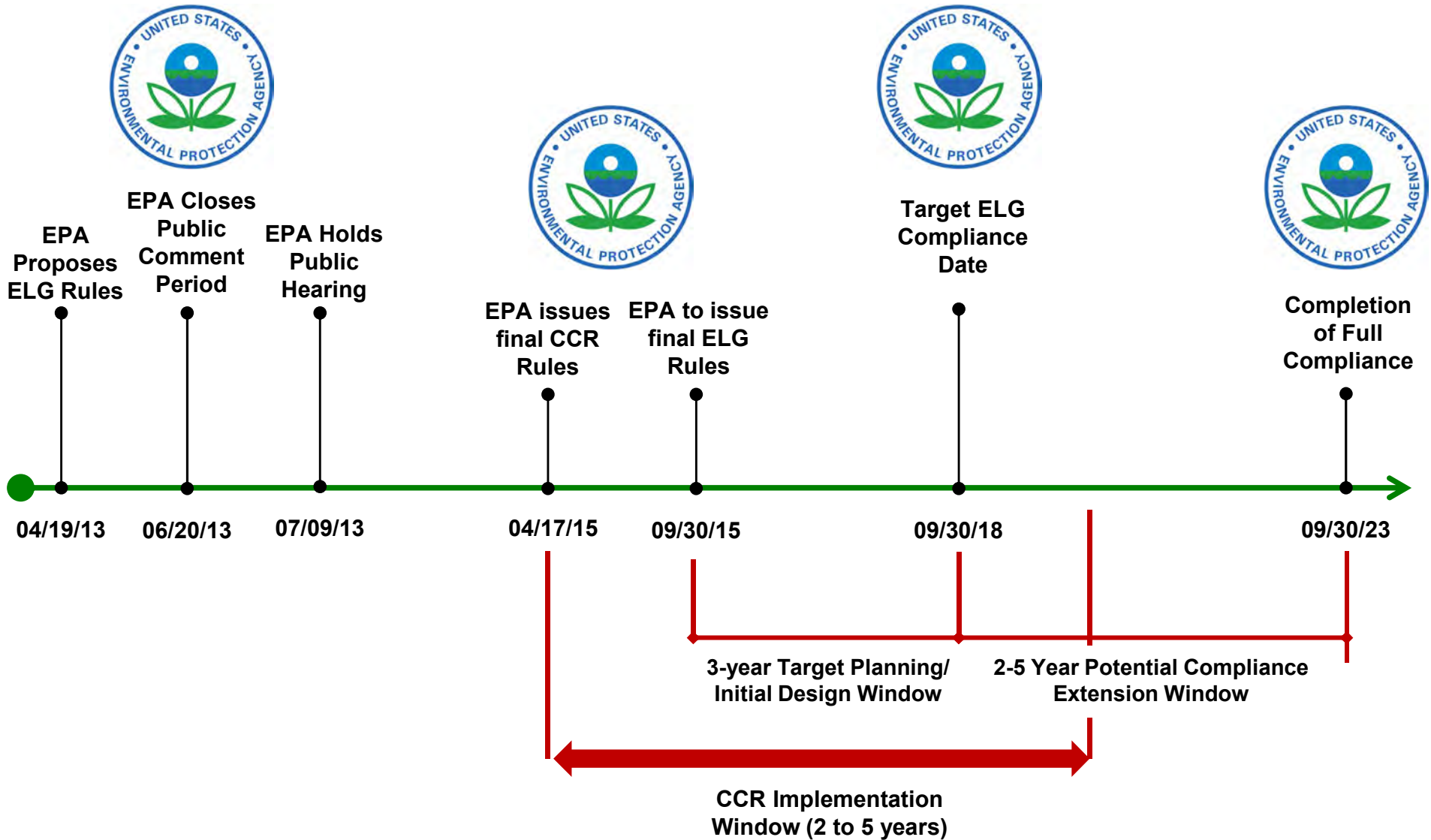


Bottom Ash BPT Requirements

Pollutant or Pollutant Property	BPT Standard Options 3a, 3b, 3 and 4a (<400 MW)	
	Maximum for any 1 day (mg/l)	Average of daily values for 30 consecutive days shall not exceed (mg/l)
TSS	100.0	30.0
Oil and Grease	20.0	15.0

ELG & CCR Ruling

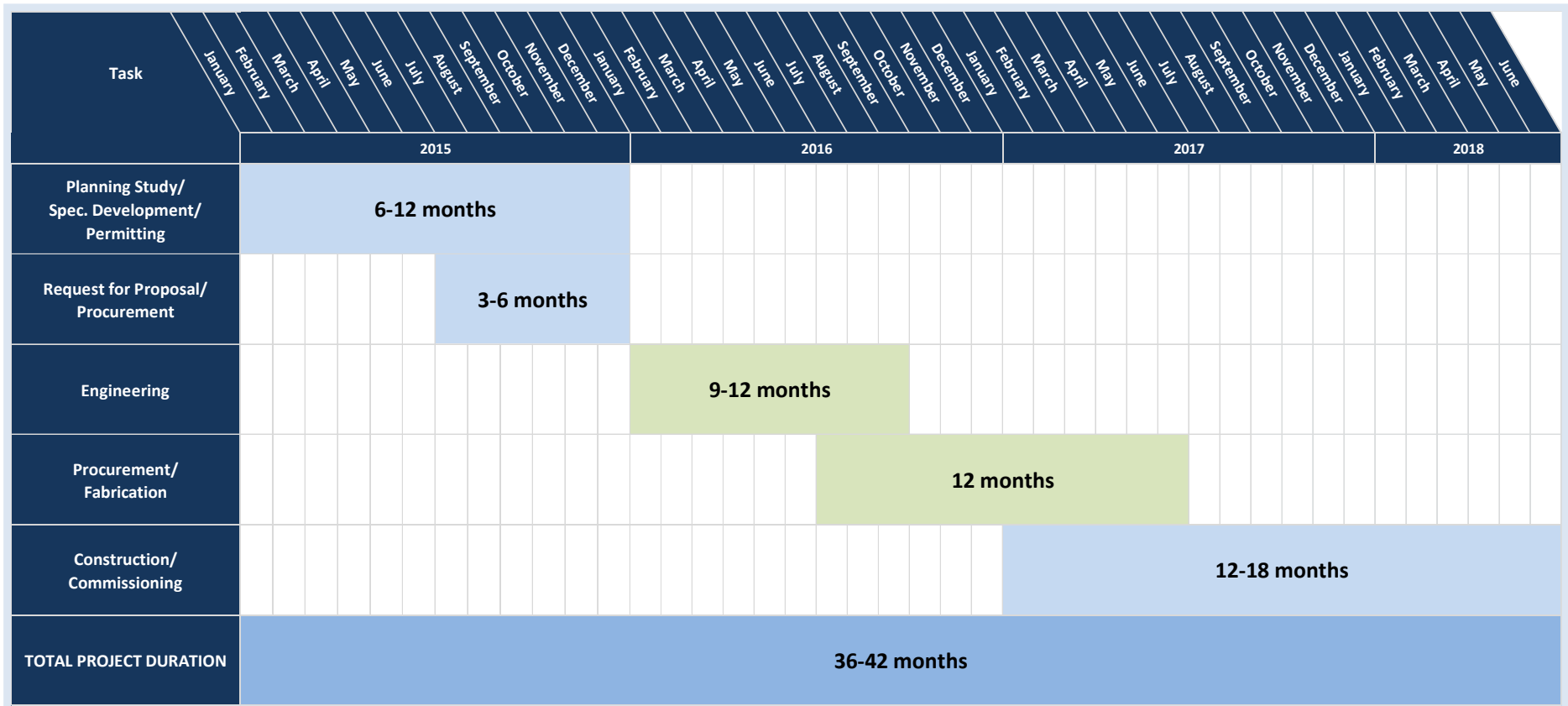
Regulatory Timeline



ELG & CCR Ruling



Typical Wet-to-Dry Ash Conversion Project Durations



- Rules will likely drive dozens of WTD ash conversion, pond closure, dry landfill and wastewater treatment projects
- Potential to test the capacity of Utilities, AE Firms, Technology Providers & Installation Contractors



Fly Ash Wet-to-Dry Conversions (All 4 Options)

- Remaining wet fly ash systems will likely be converted to dry systems
- Existing wet back-up systems will likely be decommissioned and may require additional redundancy for primary dry systems

Bottom Ash Wet-to-Dry Conversions

- Under 3 of 4 preferred regulatory options, utilities will have to determine if existing impoundments can meet BPT requirements (TSS, oil and grease)
- Utilities will also have to weigh BA WTD conversion costs against CCR Subtitle D requirements for existing Surface Impoundments
- For Option 4a, all generating units >400 MW will have to implement BA WTD conversions (ZLD); generating units <400 MW will have to evaluate BA WTD conversion costs against BPT requirements
- For Option 4, same as above for units >50 MW



Regulatory Update & Implications

Activity Summary & Technology Selection Criteria

Ash Wet-to-Dry Conversion Technologies

Water Balance & Wastewater Considerations

UCC Wet-to-Dry Summary of Activity

Recently Completed Projects (prior 3-5 years)



Owner/Plant	Scope	Technology
Eastern Plant	Fly Ash WTD	Dilute Phase Vacuum System
Eastern Plant	Fly Ash WTD	Dilute Phase Vacuum System
Midwestern Plant	Bottom Ash WTD	Submerged Flight Conveyor (SFC)
Midwestern Plant	Fly Ash WTD	Dilute Phase Vacuum/Pressure System
Midwestern Plant	Fly Ash WTD	Dilute Phase Vacuum/Pressure System
Eastern Plant	Fly Ash WTD	Dilute Phase Vacuum/Pressure System
Eastern Plant	Fly Ash WTD	Dilute Phase Vacuum System
Midwestern Plant	Fly Ash WTD	Dense Phase Vacuum/Pressure System
Eastern Plant	Fly Ash WTD	Dilute Phase Vacuum/Pressure System
Midwestern Plant	Fly Ash WTD	Dilute Phase Vacuum System
Western Plant	Bottom Ash WTD	Submerged Flight Conveyor (SFC)
Midwestern Plant	Fly Ash WTD	Dilute Phase Vacuum/Pressure System
Midwestern Plant	Fly Ash WTD	Dilute Phase Vacuum System
Midwestern Plant	Fly Ash WTD	Dilute Phase Vacuum/Pressure System

UCC Wet-to-Dry Summary of Activity

Recently Completed / Active Projects (3 years to present)



Owner/Plant	Scope	Technology
Eastern Plant	Fly Ash WTD	Dilute Phase Vacuum/Pressure System
Eastern Plant	Fly & Bottom Ash WTD	Dilute Phase V/P (FA) & CDR (BA) System
Midwestern Plant	Fly Ash WTD	Dilute Phase Vacuum System
Eastern Plant	Fly Ash WTD	Dilute Phase Vacuum System
Eastern Plant	Bottom Ash WTD	Pneumatic Ash Extractor (PAX) / Vacuum
Eastern Plant	Bottom Ash WTD	Dewatering Bin/Settling Tank/Surge Tank
Midwestern Plant	Bottom Ash WTD	CDR System with Remote SFC's
Midwestern Plant	Bottom Ash WTD	Submerged Flight Conveyor (SFC)
Eastern Plant	Bottom Ash WTD	Remote SFC Dewatering System
Eastern Plant	Bottom Ash WTD	CDR System with Remote SFC
Western Plant	Bottom Ash WTD	Submerged Flight Conveyor (SFC)
Eastern Plant	Bottom Ash WTD	CDR System with Remote SFC's
Midwestern Plant	Bottom Ash WTD	CDR System with Remote SFC's/Clarifiers
Midwestern Plant	Bottom Ash WTD	Remote SFC / Clarifier System
Western Plant	Fly Ash WTD	Dilute Phase Vacuum/Pressure System

Technical Design Considerations



Wet-To-Dry Ash Conversion Project Design Criteria

Budget	Plant Water Balance Considerations
Outage Requirements	Ash Conveying Capacities
Physical Parameters	Conveying Distance Considerations
Site Environmental Considerations	Operations & Maintenance Issues
Ash Characteristics	Multiple Unit Synergies
Ash Marketability/Beneficiation	Unburned Carbon Concerns

- Evaluate Criteria Against Multiple Alternatives
- Determine Optimal Solution for each Plant
- “One Size Does Not Fit All”



Regulatory Update & Implications

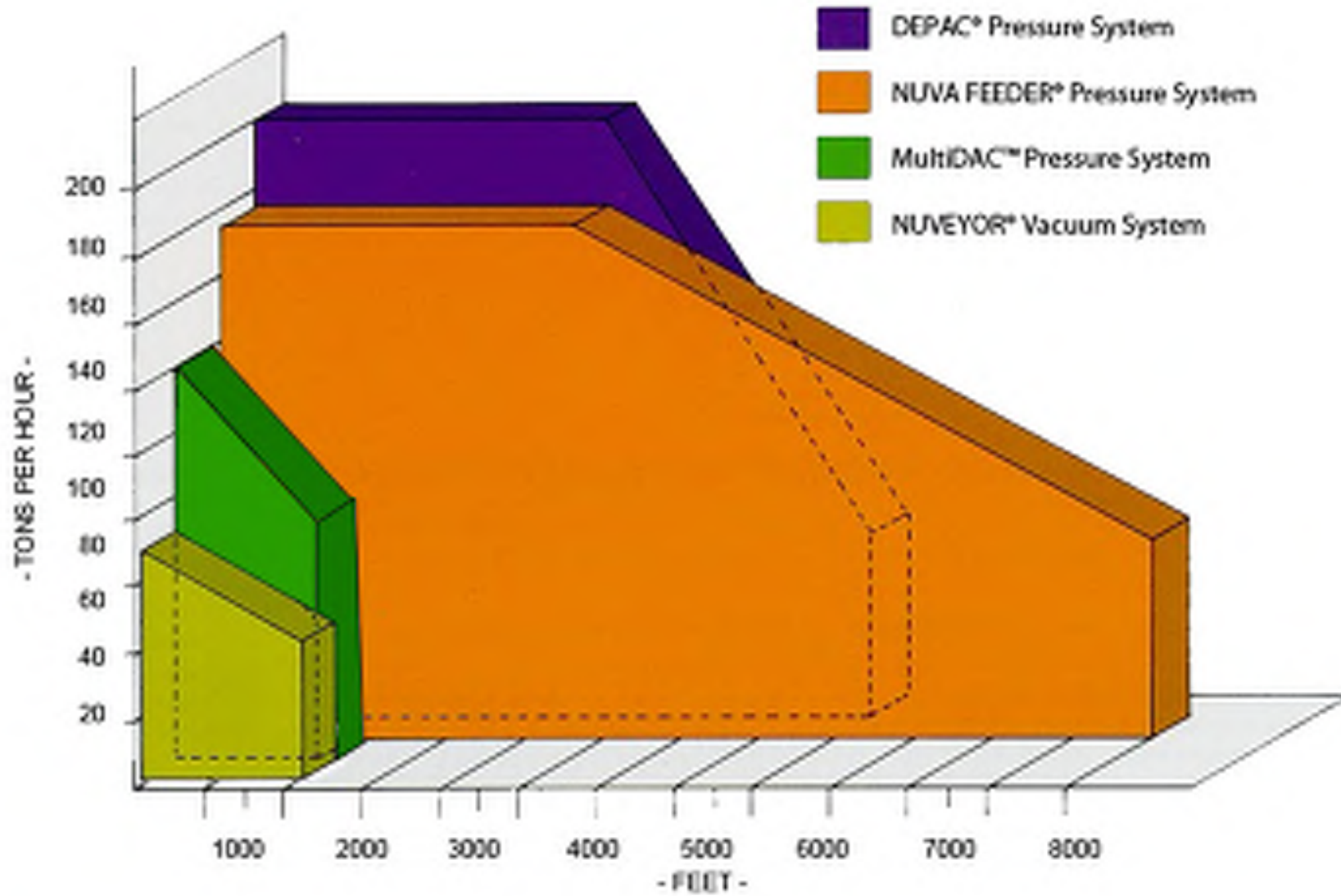
Activity Summary & Technology Selection Criteria

Ash Wet-to-Dry Conversion Technologies

Water Balance & Wastewater Considerations

Pneumatic Fly Ash System

Performance Considerations



Material Handling Options



A to B = 5500 feet

- Pnuematic conveying from A to wet unloaders at B
- Belt Conveyors from A to wet unloaders at B
- Tubular belt from A wet unloaders at B
- Wet unloaders at A truck to B
- HDSS A to B



High Density Conditioned Conveyance (HDCC)



High Density Conditioned Conveyance (HDCC)



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High Density Conditioned Conveyance (HDCC)



High Density Conditioned Conveyance (HDCC)



October 2000



High Density Conditioned Conveyance (HDCC)



October 2000



High Density Conditioned Conveyance (HDCC)



October 2007

Bottom Ash Wet-To-Dry Conversions

Technical Alternatives



Submerged Flight Conveyor – SFC™

- Long-Term Economical Choice (Low O&M Costs)
- Simple Solution if Space is Available



Re-Circulating Hydraulic System (3 Options)

- No Changes Under Boiler, Uses Existing Hopper
- Minimizes Outage Requirements



Clarifying Hydraulic System

- No Changes Under Boiler, Uses Existing Hopper
- Minimizes Outage Requirements
- Allows for Water Reuse (subject to final ELG rules)



Dry Hopper Pneumatic Conveying – PAX™

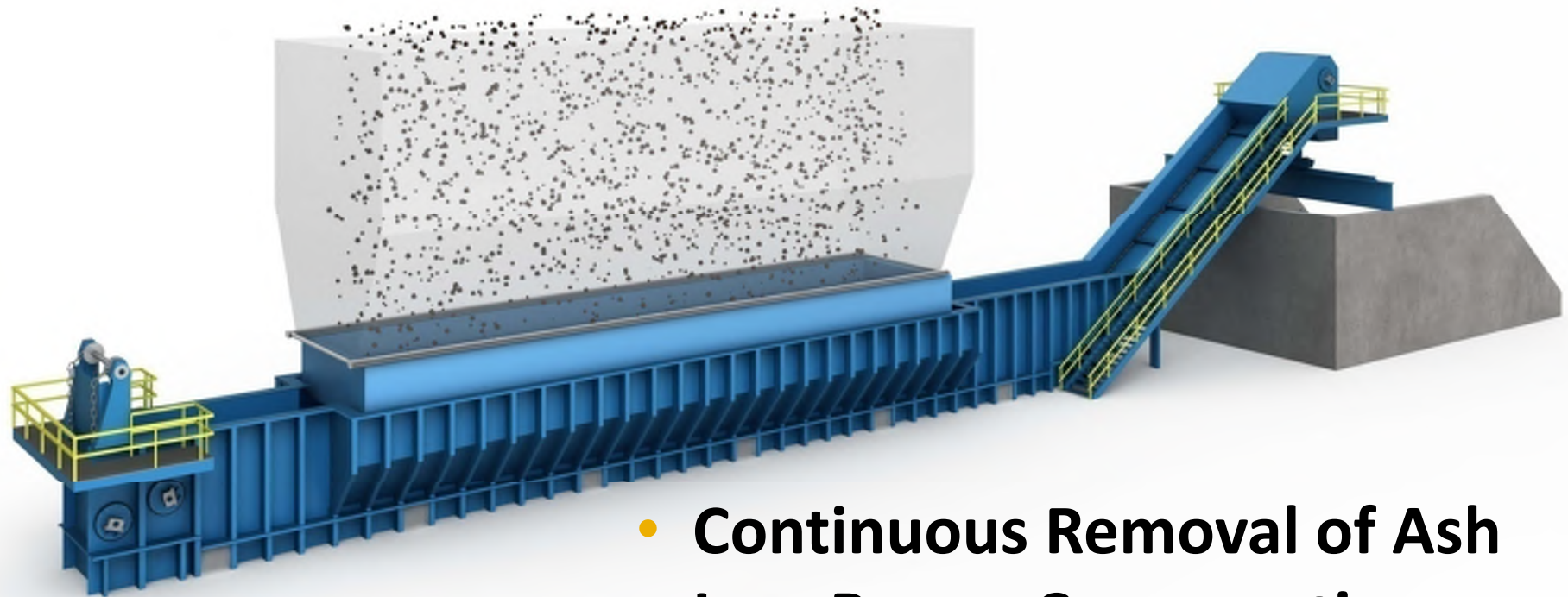
- No Water, Returns Heat Back to Boiler
- Easiest 100% Dry Option to Move Ash Out of Boiler Building



Submerged Flight Conveyor (SFC) System

Bottom Ash WTD Conversion Alternatives

Submerged Flight Conveyor (SFC)



- **Continuous Removal of Ash**
- **Low Power Consumption**
- **Easily Incorporates Mill Rejects**
- **Industry Standard on New Units for past 30 years**

Bottom Ash WTD Conversion Alternatives

Submerged Flight Conveyor (SFC)



Decision Analysis Favors SFC™ System



1 = Worst, 5 = Best	Technology Alternatives								
	Scale	SFC		Re-Circ System		R-SFC/Clarifier		PAX	
	1-5	(Mechanical)		(Hydraulic)		(Hydraulic)		(Pneumatic)	
Criteria for Determining									
<p>Decision Analysis Favors SFC™ System if criteria are weighted for:</p> <ul style="list-style-type: none"> • Total Installed Cost • Reduced O&M Costs • Reduced Wastewater Profile 									
Unburned Carbon / Boiler Efficiency	1	1	1	1	1	1	1	5	5
Weighted Total Score			90		85		69		72



Conventional Dewatering Bin System

Bottom Ash WTD Conversion Alternatives

Conventional Dewatering & Recirculation System



- **Minimal Outage Time for Conversion**
- **Continue to Use Existing Bottom Ash Hoppers**
- **Easily Incorporates Mill Rejects**

Bottom Ash WTD Conversion Alternatives

Settling and Surge Tanks



Bottom Ash WTD Conversion Alternatives

Settling and Surge Tanks



Bottom Ash WTD Conversion Alternatives

Conventional Dewatering & Recirculation System



- **Large Equipment Scope**
- **Greater Foundation Design Requirements**
- **Inconsistent Bottom Ash Dewatering**
- **Higher Maintenance**



Continuous Dewatering & Recirculation (CDR) System

Bottom Ash WTD Conversion Alternatives

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's



UCC Wet-to-Dry Summary of Activity

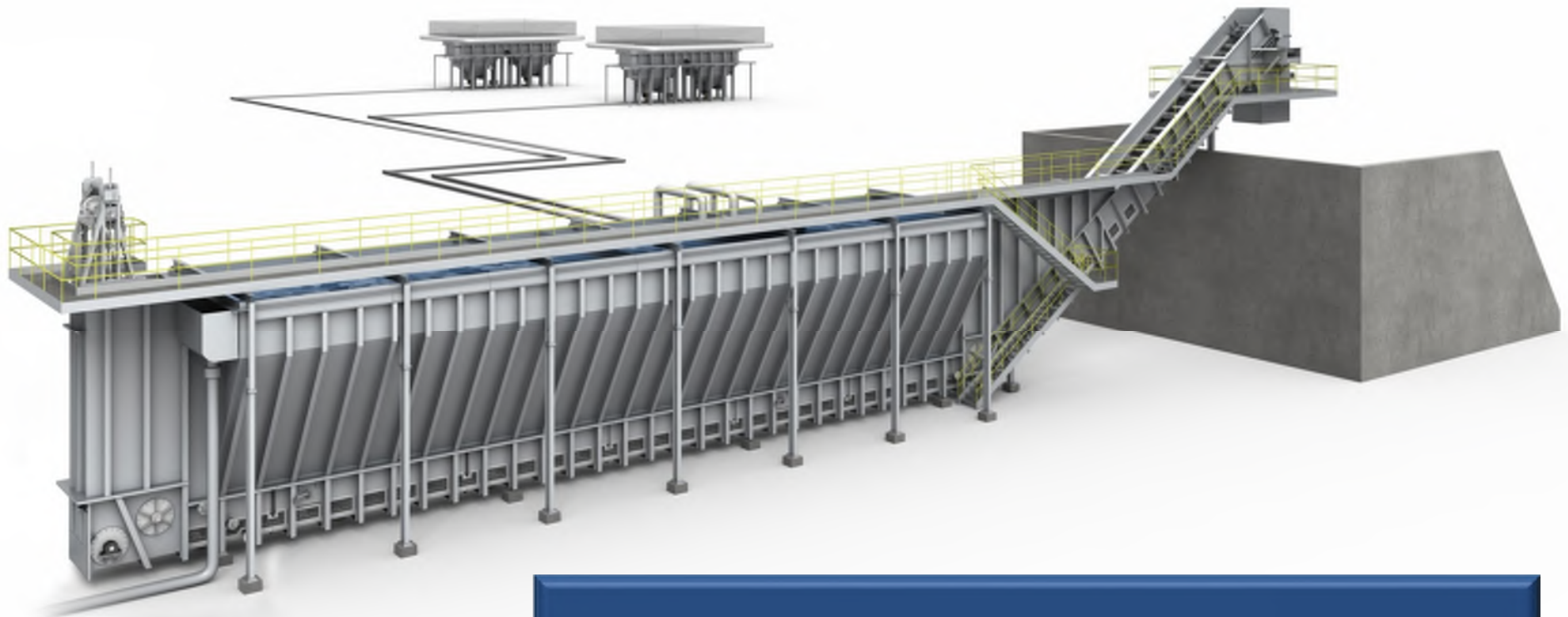
CDR / Remote SFC Systems for Bottom Ash WTD Conversion



Owner/Plant	Technology	Status
Virginia	CDR System with Remote SFC's (4), (2) for Bottom Ash, (2) for Pyrites	Engineering
Kentucky	CDR System with Remote SFC's (2)	Installation
Virginia	Remote SFC (1) Dewatering System	Engineering
Pennsylvania	CDR System with Remote SFC (1)	Engineering
Romania	Remote SFC (2) Dewatering System	Engineering/ Fabrication
South Carolina	CDR System with Remote SFC's (2)	In Service
Tennessee	CDR System with Remote SFC's (2) & Clarifiers	In Service
Tennessee	Remote SFC (2) / Clarifier System	Engineering

Bottom Ash WTD Conversion Alternatives

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's



- CDR System with Remote SFC's
- Combines SFC Technology with Conventional Recirculation System

Bottom Ash WTD Conversions

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's



Bottom Ash WTD Conversions

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's



Bottom Ash WTD Conversions

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's



Bottom Ash WTD Conversions

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's



■ Technical Design Features

■ Reduced Equipment Scope

- Combines Dewatering and Particulate Settling into Single Unit

■ Provides Multiple Unit Synergies

- Can Receive Sluice Lines from Multiple Units

■ Reduced Foundation Design Requirements

- Smaller Footprint than Traditional BA WTD Systems
- Reduced Construction Costs

■ Consistent Bottom Ash Dewatering

- Continuous Dewatering Up SFC Incline Section
- Dewateres Bottom Ash to Moisture Levels Suitable for Landfill Disposal or Beneficial Use

Bottom Ash WTD Conversions

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's



Bottom Ash WTD Conversions

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's



Bottom Ash WTD Conversions

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's





■ Technical Design Features

■ Uses Proven SFC Technology

- Robust Design Suitable for Utility Applications
- Standard Sections with Flexibility for Varying Sizes/Flows

■ Closed-Loop System

- Sluice Water is Recirculated to Powerhouse
- Runoff Water from Bunker is Returned to SFC
- Zero Discharge to the Environment

Bottom Ash WTD Conversion Alternatives

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's



■ Technical Design Features

- Achieves Particulate Removal Suitable for Closed-Loop System
 - 400 ppm (24-hour average)



Water Balance/Wastewater Considerations

Bottom Ash Sluice Water Demands for CDR & Dewatering Bin Systems



Typical Water Requirements:

- High Pressure Sluice Conveying Water = 2,500-3,500 gpm
- Low Pressure Cooling Water/Seal Trough Flushing/Make-Up Water Supply = 150-300 gpm/unit





Water Balance Key Considerations

- **Losses**

- Evaporation
- Water Retention in Ash
- Hopper Leakage
- Seal Trough Flushing

- **Gains**

- Chain Sprays – SFC (for CDR System)
- Seal Water from Pumps
- Rain

- **Will Have Net Loss of Water from System**

- **Water Balance can be complex**



Freeze Protection / Cold Weather Considerations

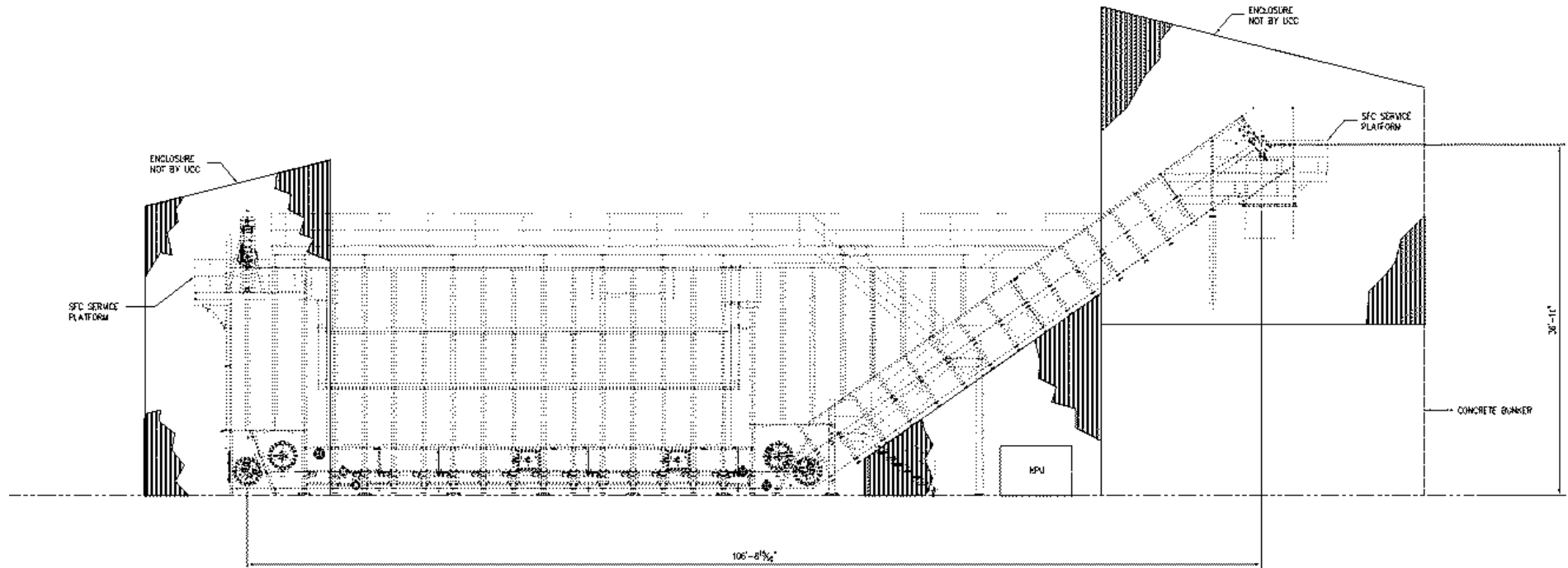
- Continuous Water Flow from Existing BA Hopper Overflows
- Heat Trace/Insulation for Service Water Piping
- Potential Enclosures/Buildings





Freeze Protection / Cold Weather Considerations

- Potential Enclosures/Buildings





Freeze Protection / Cold Weather Considerations

- Potential Enclosures/Buildings



Bottom Ash WTD Conversion Alternatives

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's



		Technology Alternatives							
1 = Worst, 5 = Best		Scale 1-5	SFC (Mechanical)	Re-Circ System (Hydraulic)	R-SFC/Clarifier (Hydraulic)	PAX (Pneumatic)			
Criteria for Determining									
W	<h2>Decision Analysis Favors CDR™ System if criteria are weighted for:</h2> <ul style="list-style-type: none"> • Reduced Outage Requirements • Physical Space Limitations • Multiple Unit Synergies 								
O									
T									
O									
P									
B									
M									
N									
U									
Weighted Total Score				69	103		97		75



Remote SFC & Clarifier System

Bottom Ash WTD Conversion Alternatives

Bottom Ash Dewatering and Clarification System with Remote SFC's



ELG Ruling

Steam Electric Main Regulatory Options



Wastestreams	Technology Basis for the Main Regulatory Options			
	3a	3b	3	4a
FGM		Chemical Precipitation + Biological Treatment for units		ation + ment
Fly				g
Bottom				losed- 00W; equal to 00MW
Comb				nt (T)
FGMC Wastewater	Dry Handling	Dry Handling	Dry Handling	Dry Handling
Gasification Wastewater	Evaporation	Evaporation	Evaporation	Evaporation
Nonchemical Metal Cleaning Wastes	Chemical Precipitation	Chemical Precipitation	Chemical Precipitation	Chemical Precipitation

EPA will choose the preferred option and issue as final on 30 September 2015



Bottom Ash BPT Requirements

Pollutant or Pollutant Property	BPT Standard Options 3a, 3b, 3 and 4a (<400 MW)	
	Maximum for any 1 day (mg/l)	Average of daily values for 30 consecutive days shall not exceed (mg/l)
TSS	100.0	30.0
Oil and Grease	20.0	15.0



■ Technical Design Features

■ Uses Proven SFC & Clarifier Technologies

- Similar features/benefits of CDR System
- Additional Clarification Phase to reduce particulate carryover (TSS)
- Can be recycled or designed for once-through system

■ Once-Through System

- Bottom Ash Sluice Water may be used as medium to manage other wastewater streams (subject to Effluent Limitations Guidelines)
- Can be designed for BPT standards for discharge
 - ◆ 30 day running average < 30 ppm
 - ◆ Daily maximum < 100 ppm

Bottom Ash WTD Conversion Alternatives

Bottom Ash Dewatering and Clarification System with Remote SFC's



Bottom Ash WTD Conversion Alternatives

Bottom Ash Dewatering and Clarification System with Remote SFC's



Bottom Ash WTD Conversion Alternatives

Bottom Ash Dewatering and Clarification System with Remote SFC's



1 = Worst, 5 = Best	Technology Alternatives					Total	
	Scale	SFC	Re-Circ System	R-SFC/Clarifier	PAX		
	1-5	(Mechanical)	(Hydraulic)	(Hydraulic)	(Pneumatic)		
Wa						10	
Out						5	
Tot						6	
Op						8	
Pov						6	
Bo						20	
Mu						15	
Ne						0	
Unburned Carbon/ Boiler Efficiency						5	
Weighted Total Score			69		103	117	75

Decision Analysis Favors Clarification System if criteria are weighted for:

- Need Clarified water for Plant Water Balance (Make-up Water Source)
- Prefer Ability to Discharge Water



Pneumatic Ash Extractor (PAX) System

Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX)

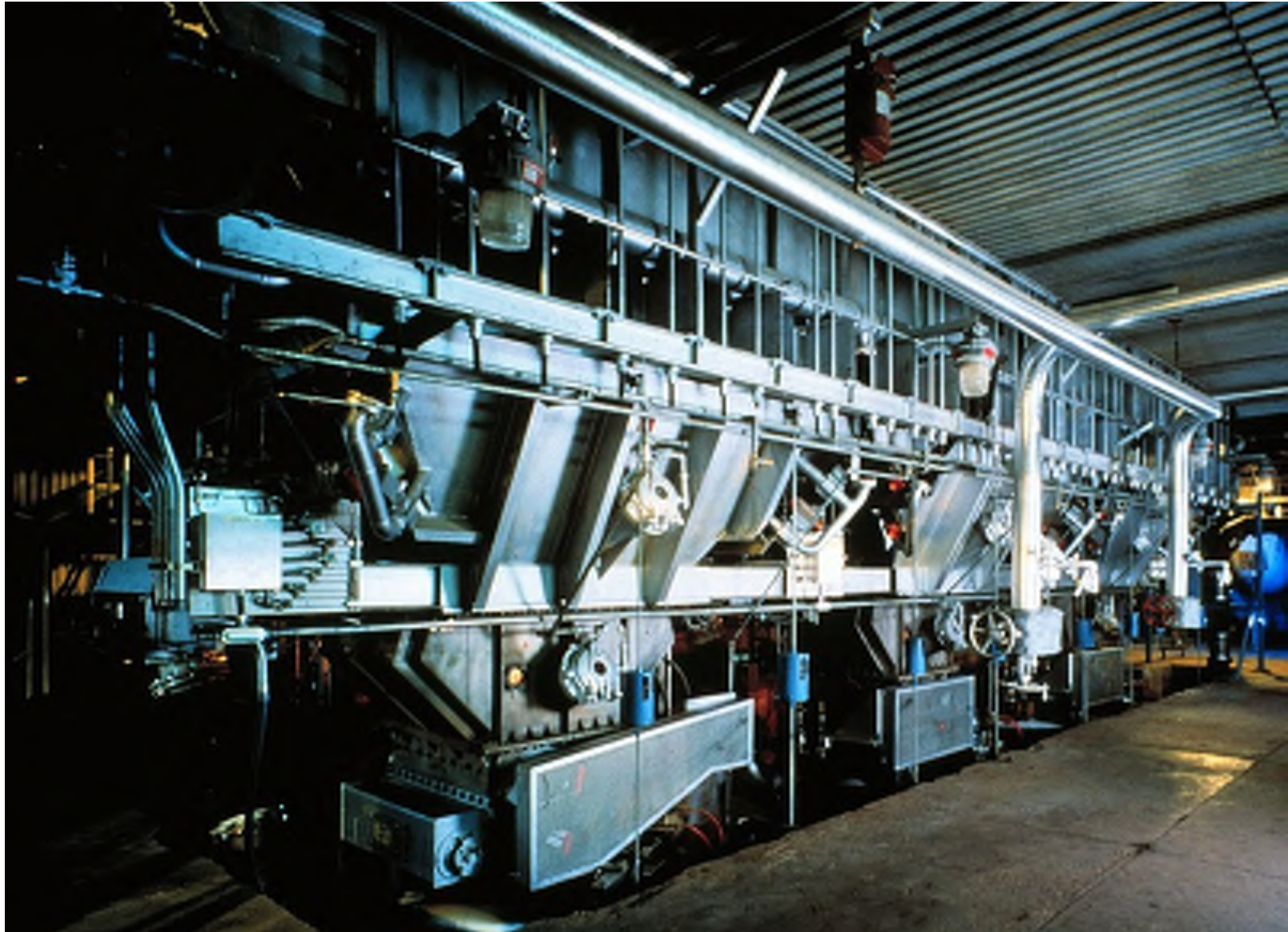


- **Easily Retrofitted Around Structural Barriers**
- **Provides Improved Heat Recovery and Boiler Efficiency**
- **Does Not Require Water**



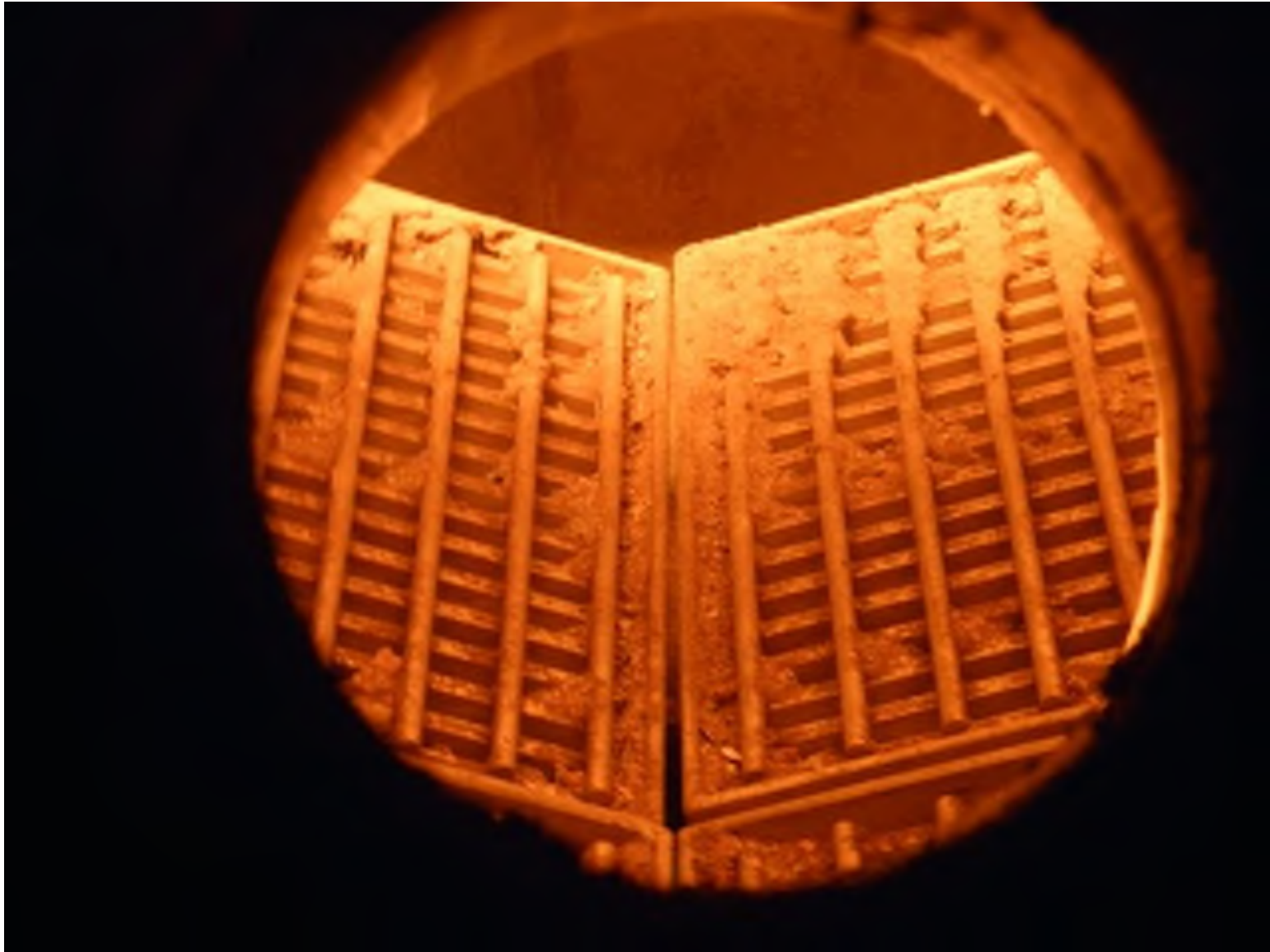
Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX)



Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX)



Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX)



Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX)



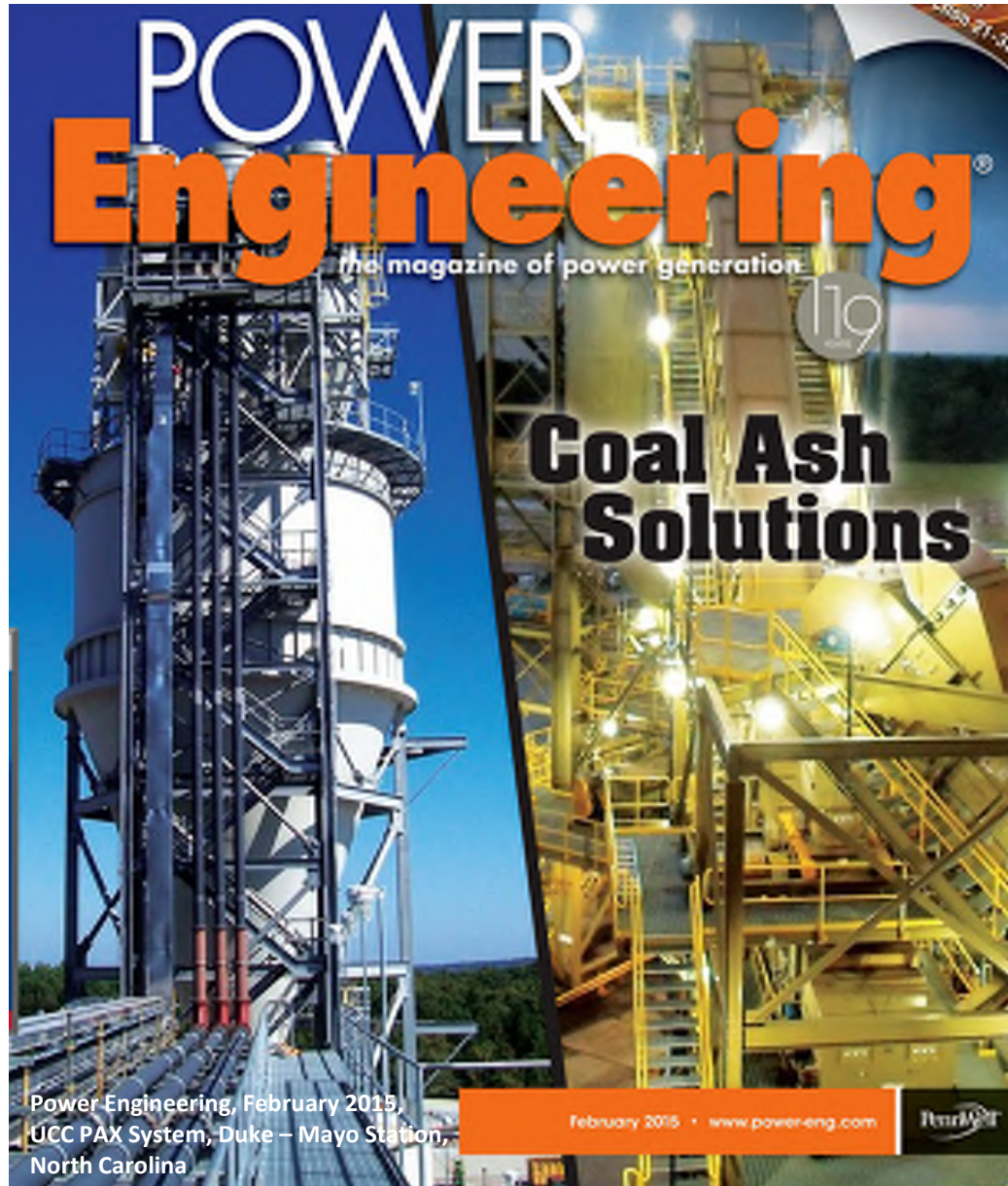
Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX)



Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX)



Power Engineering, February 2015,
UCC PAX System, Duke – Mayo Station,
North Carolina

Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX)



		Technology Alternatives								
1 = Worst, 5 = Best		Scale 1-5	SFC (Mechanical)	Re-Circ System (Hydraulic)	R-SFC/Clarifier (Hydraulic)	PAX (Pneumatic)				
W	O	T	O	P	B	M	N	Decision Analysis Favors PAX™ System if criteria are weighted for:		tal
								<ul style="list-style-type: none"> • 100% Dry Solution • Physical Space Limitations • Unburned Carbon / Boiler Efficiency 		5
Unburned Carbon / Boiler Efficiency		4	0	0	0	0	0	0	5	20
Weighted Total Score				82		99		83		108

Discussion Overview



Regulatory Update & Implications

Activity Summary & Technology Selection Criteria

Ash Wet-to-Dry Conversion Technologies

Water Balance & Wastewater Considerations



Additional Water Balance & Wastewater Considerations



Existing Systems:

- Most Mill Reject (Pyrites) removal systems use sluice conveying
- Most are connected to the Bottom Ash Sluice Conveying System and ponds, while some are independent sluice systems that discharge to separate ponds
- Some plants have Pyrites Dewatering Bins
- 100% Dry Solutions require separate systems



Key Considerations:

- Not clearly defined in proposed ELG
- Many plants are now requesting separation of Bottom Ash and Mill Rejects to ensure Bottom Ash Marketability
- 100% Dry Systems can be difficult retrofits (physical space, cost)
- Can be readily connected to CDR or SFC systems
- Can have an independent pyrites dewatering system



Pyrites Dewatering Bins





Existing Systems:

- Over half of Economizer Ash removal systems use sluice conveying
- Of these wet systems, most are connected to the Bottom Ash Sluice Conveying System or SFC's
- Some systems collect Economizer Ash with Dry Flight Conveyors (DFC) and transfer to Vacuum System or Sluice Conveying System
- Balance are typically connected to Dry Fly Ash Vacuum System



Key Considerations:

- Not clearly defined in proposed ELG
 - Economizer Ash = Fly Ash (when collected with Fly Ash System)
 - Economizer Ash = Bottom Ash (when collected with Bottom Ash System)
- 100% Dry Solutions can likely be tied into existing Fly Ash Systems
- Dry collection eliminates potential concern for fines concentrations in closed-loop dewatering systems



Define Criteria As Early As Possible

Evaluate Criteria Against Multiple Alternatives

Determine Optimal Solution for each Plant

“One Size Does Not Fit All”

Determine Fleetwide Synergies

Begin Schedule Planning ASAP



Questions ?

Wet-to-Dry Conversions

