REINHOLD ENVIRONMENTAL Ltd.

2019 REINHOLD Round Table Presentation

June 24 & 25, 2019, in Birmingham, Alabama / Hosted by Southern Company

UNITED CONVEYOR CORPORATION

Treating Bottom Ash Transport Water with Enhanced Wastewater Technologies

Prepared for: 2019 Reinhold Round Table

Presented By: Kevin L. McDonough & David Donkin

25 June 2019

Safety Moment

Bottom Ash Transport Water Treatment

UCC Remote Submerged Flight Conveyor (R-SFC) & Clarifier System

Presentation Prepared For:

UNITED CONVEYOR CORPORATION

Discussion Overview

- Regulatory Considerations
- Overview of R-SFC / Clarifier Technology
- Design Approach and Performance Results
- Additional Water Management Considerations

Discussion Overview

Presentation Prepared For:

- **Regulatory Considerations**
- Overview of R-SFC / Clarifier Technology
- Design Approach and Performance Results
- Additional Water Management Considerations

Key Regulatory Actions

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
- CFR Publication: November 03, 2015
- Goals
  - ✓ Strengthen Steam Electric Power Plant Discharge Controls
  - ✓ Reduce Surface Water Pollutant Discharges

ELG Ruling

EPA Stay on FGD Wastewater and Bottom Ash Transport Water

Wastestreams	Technology Basis
FGD Wastewater	Chemical Precipitation + Biological Treatment
Fly Ash Transport Water	Dry Handling / Closed-loop for units >50W; Impoundment (equal to BPT) for units <50MW
Bottom Ash Transport Water	Dry Handling / Closed-loop for units >50W; Impoundment (equal to BPT) for units <50MW
Combustion Residual Leachate	Impoundment (equal to BPT)
FGMC Wastewater	Dry Handling
Gasification Wastewater	Evaporation
Nonchemical Metal Cleaning Wastes	Chemical Precipitation

ELG Ruling

Final Rule Basis

Wastestreams	Technology Basis
FGD Wastewater	Chemical Precipitation + Biological Treatment
Fly Ash Transport Water	Dry Handling / Closed-loop for units >50W; Impoundment (equal to BPT) for units <50MW
Bottom Ash Transport Water	**Dry Handling / Closed-loop for units >50W; Impoundment (equal to BPT) for units <50MW**
Combustion Residual Leachate	Impoundment (equal to BPT)
FGMC Wastewater	Dry Handling
Gasification Wastewater	Evaporation
Nonchemical Metal Cleaning Wastes	Chemical Precipitation

ELG Ruling

Specialized Definitions

- **Transport Water**
  - Any wastewater that is used to convey fly ash, bottom ash, or economizer ash from the ash collection or storage equipment, or boiler, and has direct contact with the ash.
  - Transport water does not include low volume, short duration discharges of wastewater from minor leaks (e.g. leaks from valve packing, pipe flanges, or piping) or minor maintenance events (e.g., replacement of valves or pipe sections).
- **Low Volume Waste Sources include:**
  - Boiler blowdown
  - Floor drains
  - Recirculating house service water systems

Bottom Ash Transport Water Management

Technical Options

- **Dry Ash Handling System**
  - Submerged Drag Chain System
  - Dry Pneumatic System
  - Dry Mechanical System
- **Closed-loop Recirculation System**
  - Conventional Dewatering Bin / Settling / Surge Tanks
  - Continuous Dewatering & Recirculation System with Remotely-located Submerged Flight Conveyors (CDR)
  - Dewatering Basin Recirculation System
- **FGD Source or Make-Up Water Feed System**
  - Viability based on Bottom Ash & FGD Water Requirements
  - Must Investigate BA System vs. FGD System Water Balances

Bottom Ash Transport Water as FGD Water Source

ELG Requirements

- "When the bottom ash transport water is used in the FGD scrubber, the quantity of pollutants in bottom ash transport water shall not exceed the quantity determined by multiplying the flow of bottom ash transport water times the concentration listed in the table in paragraph (g)(1)(i) of this section."

Pollutant or Pollutant Property	BAT Effluent Limitations	
	Maximum for any 1 day	Average of daily values for 30 consecutive days shall not exceed
Arsenic, total (ug/L)	11	8
Mercury, total (ng/L)	788	356
Selenium, total (ug/L)	23	12
Nitrate/Nitrite as N, total (mg/L)	17	4.4

Discussion Overview

- Regulatory Considerations
- **Overview of R-SFC / Clarifier Technology**
- Design Approach and Performance Results
- Additional Water Management Considerations

Bottom Ash WTD Conversion Alternatives

Conventional Dewatering & Recirculation System

Presentation Prepared For:

- **Multiple Tank Arrangement**
- **Greater Foundation Design Requirements**
- **Inconsistent Bottom Ash Dewatering**
- **Limited Clarification Capability**

UCC R-SFC & Clarifier System

For Bottom Ash Transport Water Treatment

Presentation Prepared For:

- Remote Submerged Flight Conveyor (R-SFC)
- Combines R-SFC Technology with Bottom Ash Transport Water Clarifiers

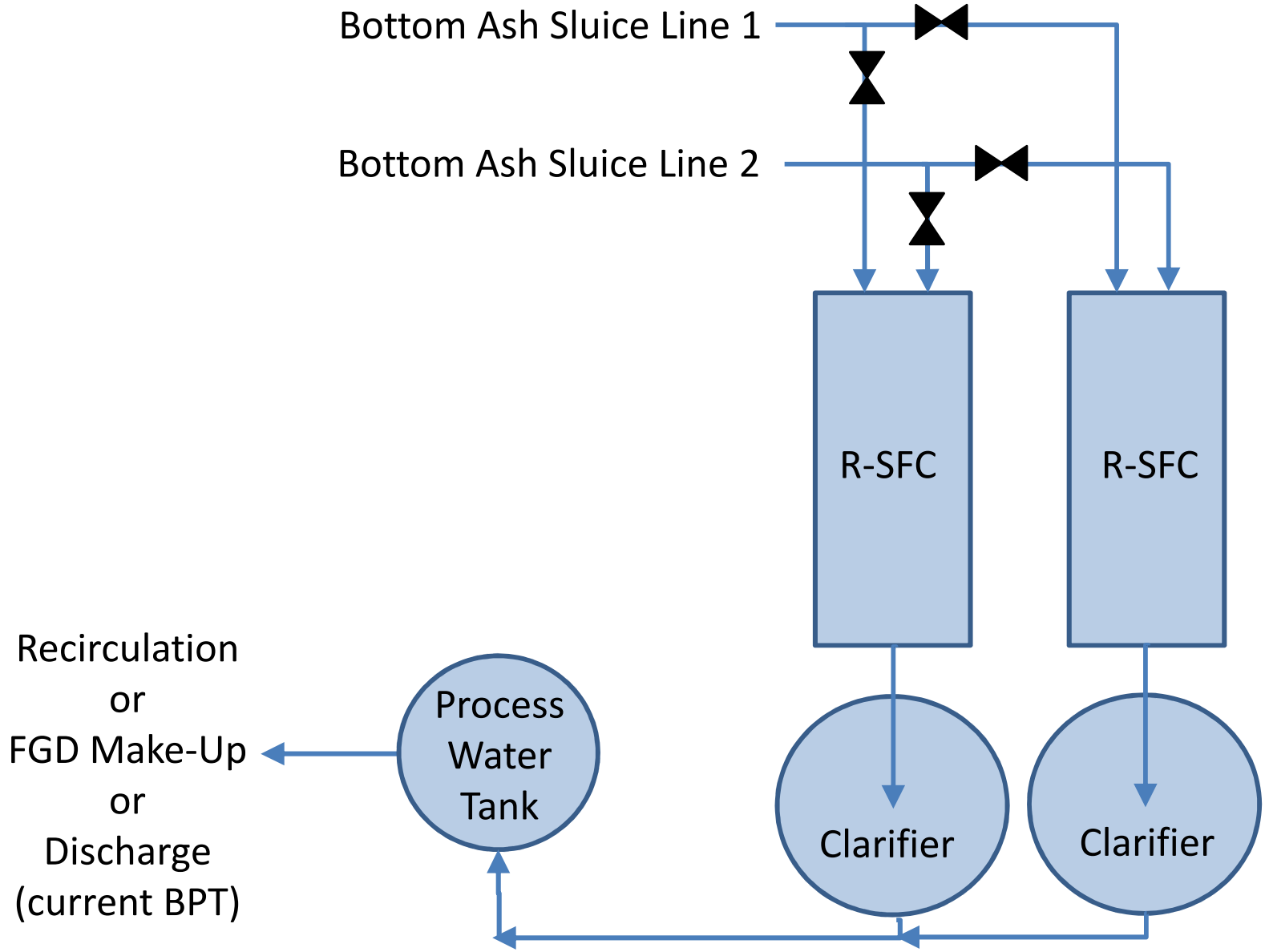
UNITED CONVEYOR CORPORATION

Remote SFC & Clarifier System

Bottom Ash WTD Conversion Alternatives

UCC R-SFC & Clarifier System

Presentation Prepared For:



UNITED CONVEYOR CORPORATION

UCC R-SFC & Clarifier System

For Bottom Ash Transport Water Treatment

Presentation Prepared For:

UNITED CONVEYOR CORPORATION

UCC R-SFC & Clarifier System

For Bottom Ash Transport Water Treatment

Technical Design Features

- Optimized 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 R-SFC Incline Section
  - Dewaters Bottom Ash to Moisture Levels Suitable for Landfill Disposal or Beneficial Use

UCC R-SFC & Clarifier System

For Bottom Ash Transport Water Treatment

Presentation Prepared For:

UNITED CONVEYOR CORPORATION

UCC R-SFC & Clarifier System

For Bottom Ash Transport Water Treatment

Presentation Prepared For:

UNITED CONVEYOR CORPORATION

UCC R-SFC & Clarifier System

For Bottom Ash Transport Water Treatment

Presentation Prepared For:

UNITED CONVEYOR CORPORATION

UCC R-SFC & Clarifier System

For Bottom Ash Transport Water Treatment

Presentation Prepared For:

UNITED CONVEYOR CORPORATION

UCC R-SFC & Clarifier System

For Bottom Ash Transport Water Treatment

Presentation Prepared For:

UNITED CONVEYOR CORPORATION

UCC R-SFC & Clarifier System

For Bottom Ash Transport Water Treatment

Presentation Prepared For:

UNITED CONVEYOR CORPORATION

UCC R-SFC & Clarifier System

For Bottom Ash Transport Water Treatment

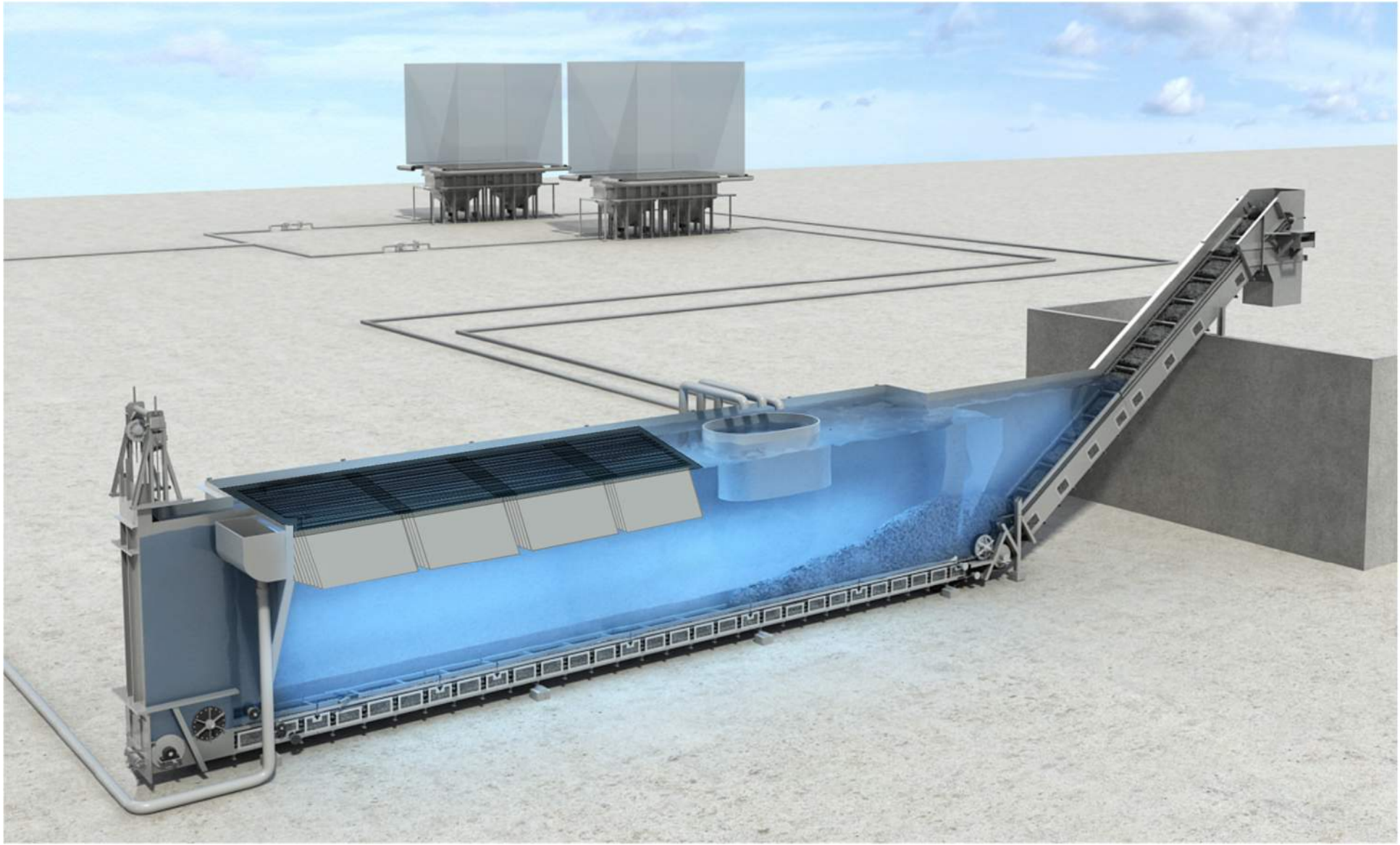
Presentation Prepared For:

- **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 a make-up water source for FGD System (per Effluent Limitations Guidelines)
    - Can be designed for TSS levels suitable for Recirculation Pumps

UCC R-SFC & Clarifier System

TSS Control: UCC Lamella Design

Presentation Prepared For:

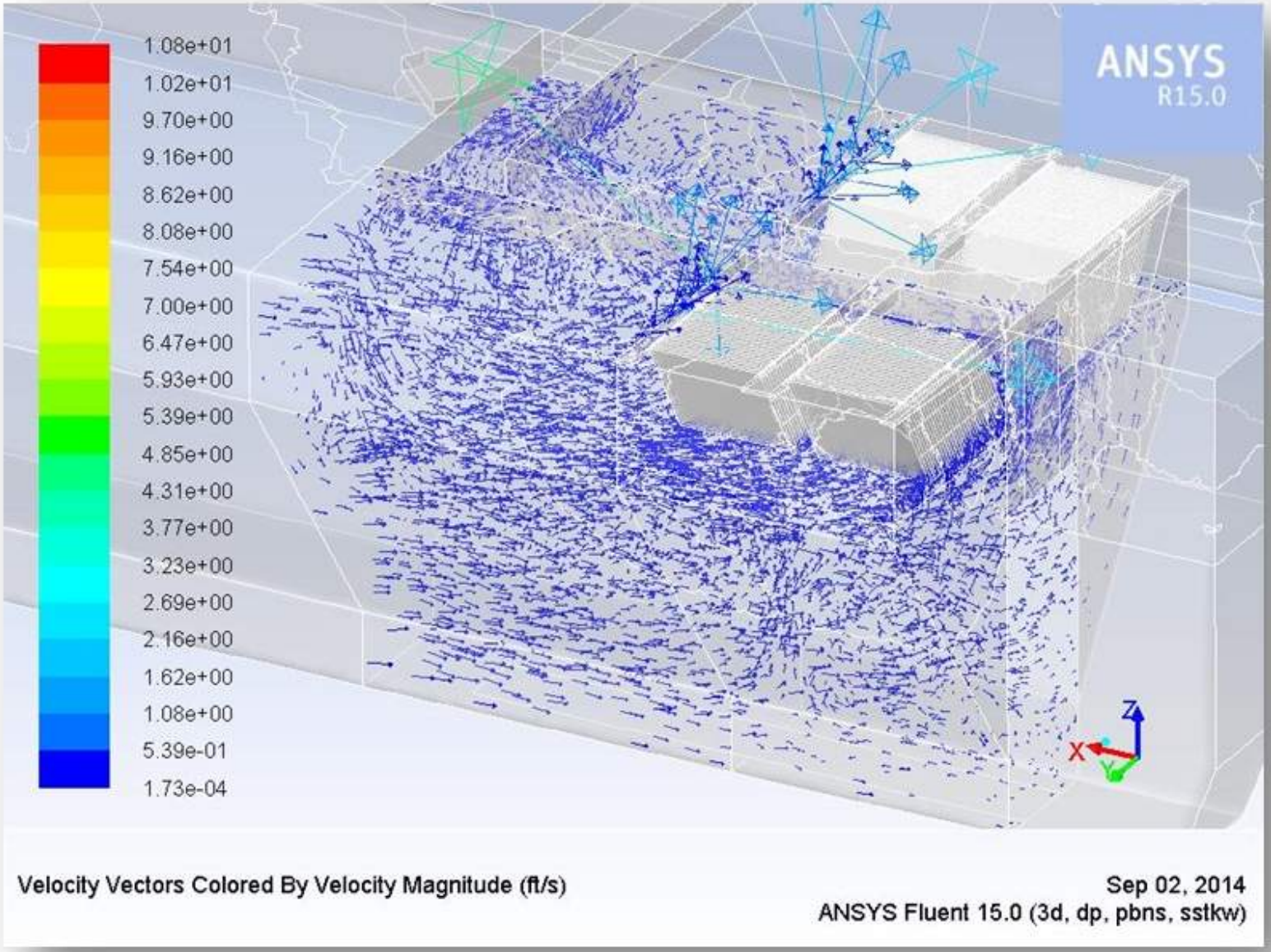


UNITED CONVEYOR CORPORATION

UCC R-SFC & Clarifier System

TSS Control: UCC Lamella Design

Presentation Prepared For:



UCC R-SFC & Clarifier System

TSS Control: UCC Lamella Design

Presentation Prepared For:

UCC R-SFC & Clarifier System

TSS Control: UCC Lamella Design

Presentation Prepared For:

UNITED CONVEYOR CORPORATION

Design Basis Requirements

Bottom Ash Sluice Water Demands for R-SFC & Clarifier 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

Design Basis Requirements

Typical Performance Guarantees

Presentation Prepared For:

Parameter	Performance Requirement
TSS (in R-SFC Overflow)	400 ppm (24-hour average)
TSS (in Clarifier Overflow)	100 ppm (daily maximum) 30 ppm (monthly average)
Moisture % (Bottom Ash)	20% in bunker after 24 hours or Paint Filter Test

Discussion Overview

Presentation Prepared For:

RE

- Regulatory Considerations
- Overview of R-SFC / Clarifier Technology
- **Design Approach and Performance Results**
- Additional Water Management Considerations

UCC Wastewater Treatment Design Approach

UCC Typical Approach Prior to System Design

Presentation Prepared For: RE

- **Secure Solids Samples**
  - Test for Particle Size Distribution, Bulk Density, Specific Gravity, Chemical Constituency, Dewatering Potential
- **Secure Water Samples**
  - Test for Total Suspended Solids (TSS), Total Dissolved Solids (TDS) and pH
- **Confirmation of Incoming Flows**
  - Confirm all continuous flow sources and rates
  - Confirm all intermittent flow sources and rates
- **Laboratory Testing**
  - TSS and TDS Removal/Settling
- **Equipment Sizing**
  - Utilize sample testing data to confirm required size of clarifiers, tanks, filters, etc.
- **CFD Modeling**
  - Model performance of clarifiers with confirmed flow and particle data

UCC Research & Development Capabilities

Advanced Technology and Test Lab

Presentation Prepared For:

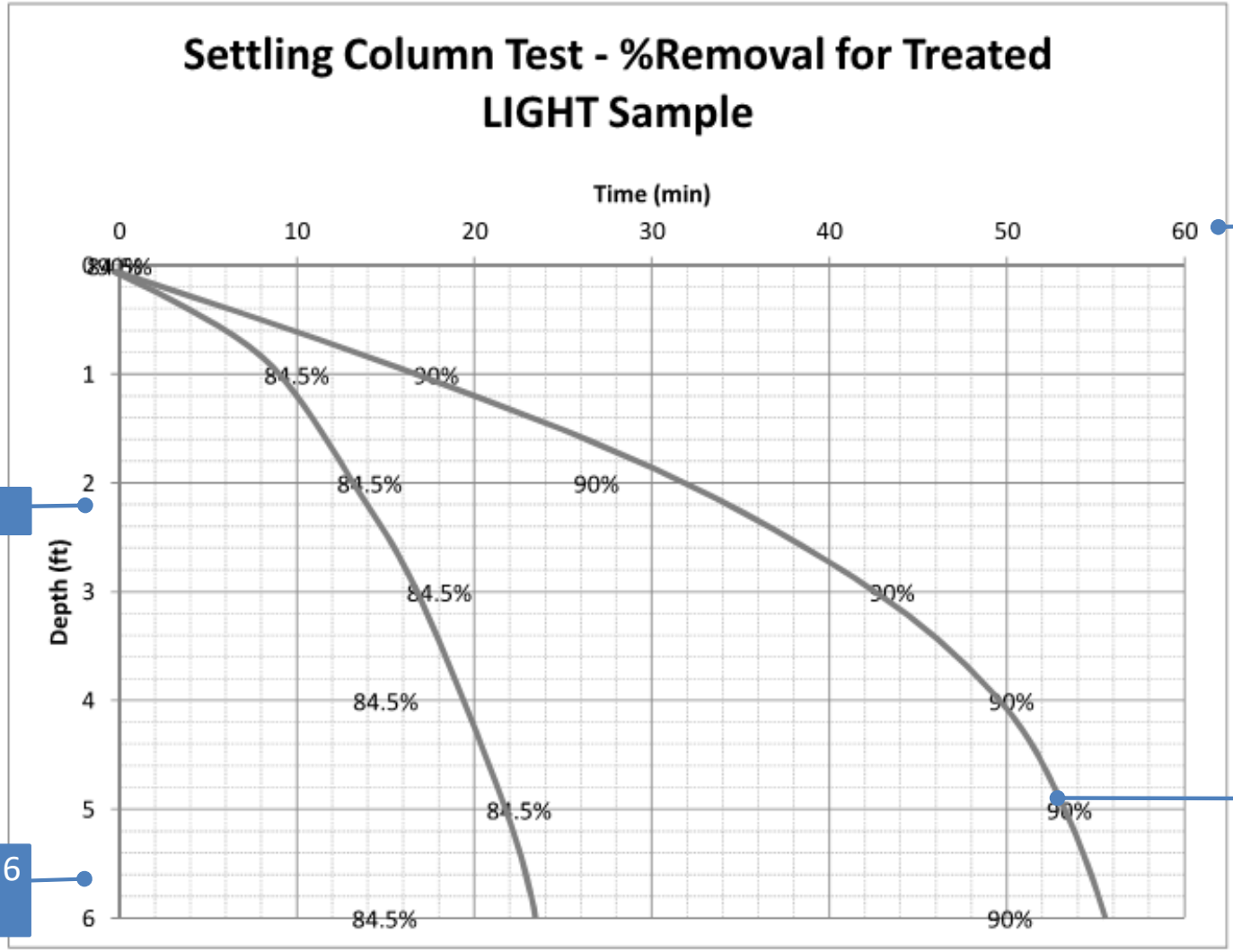
The UCC commitment to quality is backed by thousands of hours of development, testing and evaluation. UCC works closely with customers to test and verify conveying performance before deployment at the plant to effectively manage risk.

- State of the art 11,000 ft^2 research laboratory
- In-house product development and testing
- Material testing capabilities
- Numerous test loops and settling tanks/settling column tests to determine predictive system performance prior to final design

Bottom Ash Clarifier

Clarifier Diameter Design Basis – Settling Column Test

Presentation Prepared For:



Time

Water Depth

85% of Particles Drop 6 Feet in 24 Minutes

90% of Particles Drop 6 Feet in 56 Minutes

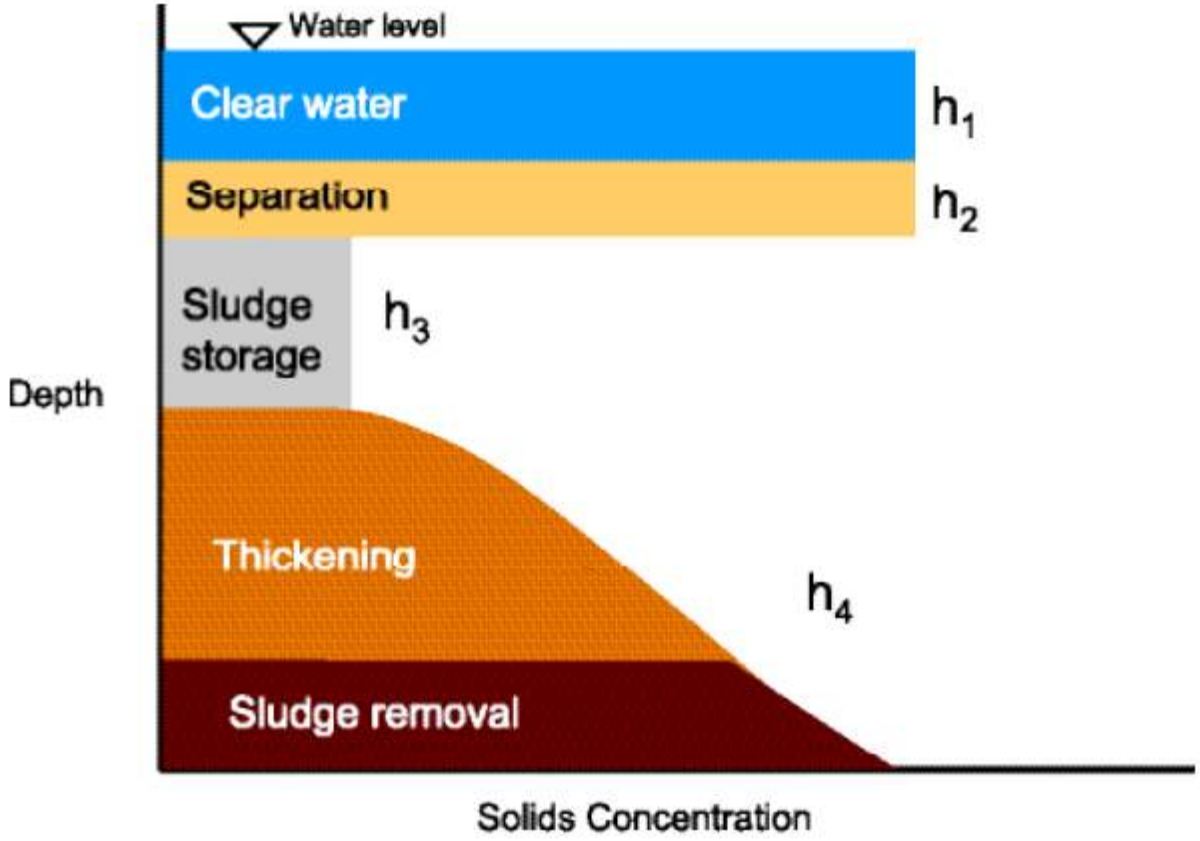
UNITED CONVEYOR CORPORATION

Bottom Ash Clarifier

CFD Model – Saturation Example; Settling Zones

According to the International Water Association model (Figure 2), the clarifier solids concentration profile consists of four zones: a clear water zone (h_1) a separation zone (h_2), a sludge storage zone (h_3), and a thickening/sludge removal zone (h_4). When the SLR exceeds the limiting flux, the sludge storage zone (h_3) expands to accumulate the sludge and limits its conveyance to the bottom of the tank. The continued expansion of h_3 will result in the sludge interface reaching the effluent weir, causing a loss of solids (clarification failure).

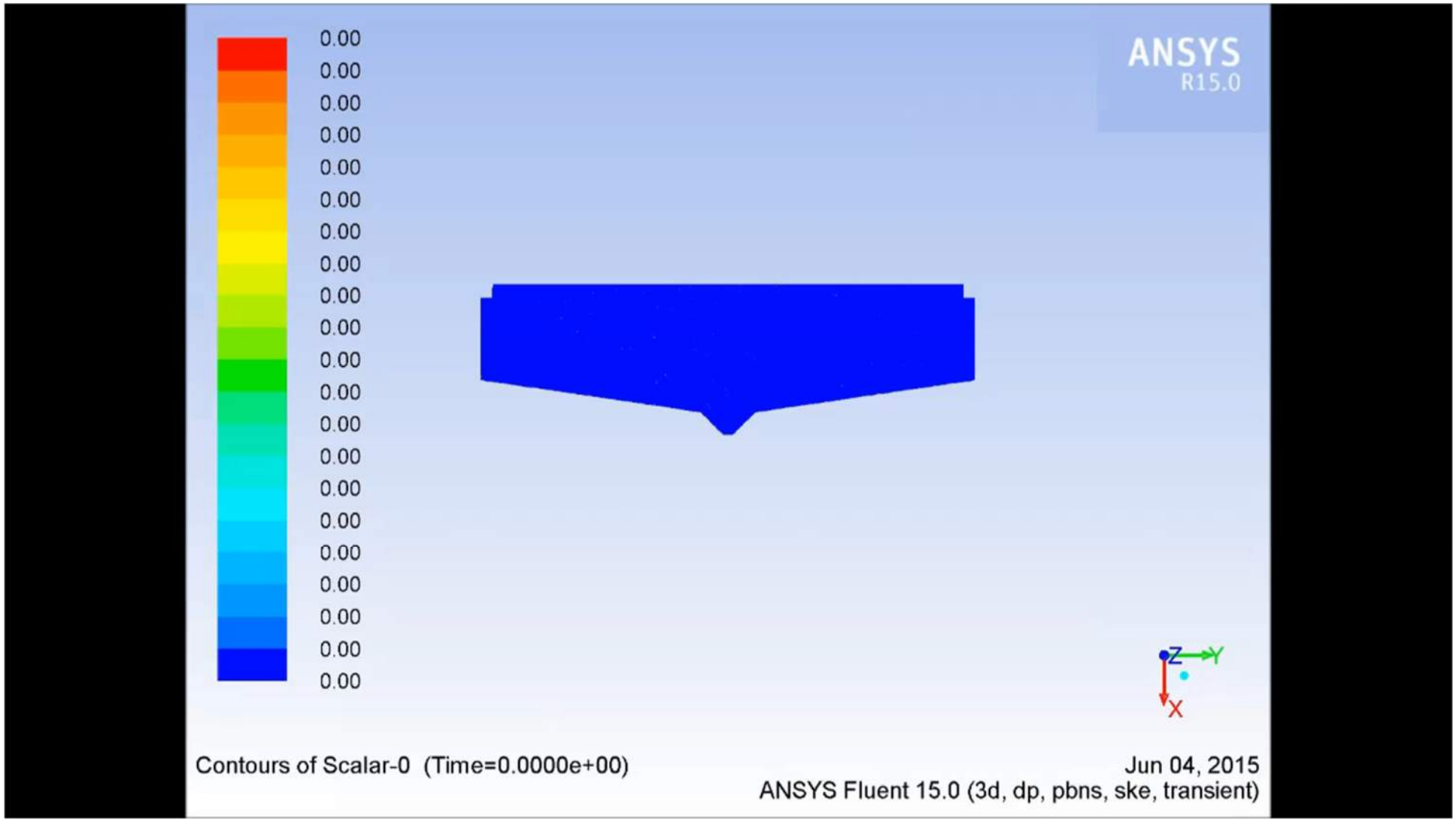
(Figure 2)



Bottom Ash Clarifier

CFD Model – Recovery Example; 2000 PPM In/1.5 Hrs. : 500 PPM In/After

Presentation Prepared For:



Stop Conveying at 5400 seconds (1:47)

UCC R-SFC & Clarifier System

For Bottom Ash Transport Water Treatment

Presentation Prepared For:

UNITED CONVEYOR CORPORATION

UCC R-SFC & Clarifier System

For Bottom Ash Transport Water Treatment

Presentation Prepared For:

UNITED CONVEYOR CORPORATION

UCC R-SFC & Clarifier System

Design Requirements and Operating Results

Presentation Prepared For:

	Specified Design		Actual
	Maximum for any 1 day (mg/l)	Average of daily values for 30 consecutive days shall not exceed (mg/l)	Typical Daily Sample
TSS	100.0 ppm	30.0 ppm	<15ppm
Oil and Grease	20.0 ppm	15.0 ppm	<15ppm
pH	6-9		7.5

Discussion Overview

Presentation Prepared For:

RE

- Regulatory Considerations
- Overview of R-SFC / Clarifier Technology
- Design Approach and Performance Results
- **Additional Water Management Considerations**

Existing System Outage Wash Capability

Current and Potential Arrangement

- **Typical Outage Wash Operations**
  - Non-Chemical and Chemical Water Outage Wash of Boiler, Air Preheater, and ESPs
  - Outage Wash Wastewater Stream Directed to Low Volume Waste or Pond Systems
- **Potential Arrangement for Outage Wash Water**
  - Provide WWT to Mitigate TSS, Iron, and Copper
  - Utilize Existing Bottom Ash Dewatering System Equipment
  - Leverage R-SFC / Clarifier to capture Fine Particulate from Outage Wash Operations
  - Minimize the Requirement for additional WWT Equipment
  - Augment with additional Chemical Injection Equipment if necessary

Existing System Outage Wash Capability

Review of Existing Equipment & Instrumentation

Presentation Prepared For: RE

- **Existing Equipment Utilized in Wash Operations**
  - Remote Submerged Flight Conveyor (with Lamellas)
  - Clarifier
  - Clarifier Underflow Pumps
  - Process Water Tanks and Pumps
  - BA Hopper JETPULSION Pumps
  - Caustic, Coagulant, and Flocculant Skids at R-SFC Island
  - Clarifier Discharge Flow, pH, and Turbidity Meters

Existing System Outage Wash Capability

Key Considerations and Likely Discharge Requirements

Key Design Considerations

- Fully Understand Outage Wash Flow Rates
- Sludge Management
- R-SFC Conveyance Capabilities
- Chemical Injection Locations and Rates
- pH Adjustment Requirements

Likely Outage Wash Wastewater Treatment Targets

pH	Copper (mg/L)	Iron (mg/L)	TSS (mg/L)
6-9	Less than 30	Less than 30	Less than 30 Monthly Average Less than 100 Daily Max

Existing System Outage Wash Capability

Pre-Outage Wash Preparation Considerations

Presentation Prepared For:

- **Remote Submerged Flight Conveyor (R-SFC)**
  - Adjust Shimming to Lower Head Shaft Centerline for improved fines sludge removal
  - Turn Off R-SFC Chain Wash Nozzles
  - Ensure Proper R-SFC and HPU Settings
  - Water in R-SFC should be at a pH of 8
- **Other Items**
  - Ensure Ash Hoppers are Emptied as much as Possible
  - Ensure Proper Clarifier Rake Torque Settings
  - Complete Piping Tie-Ins

Existing System Outage Wash Capability

Potential Flow Rates (Typical Example)

Presentation Prepared For:

RE

Outage Wash Water Flows (per Unit)									
Area to be Washed	Wash Time (Hrs)	Flow per Hose (GPM)	Number of Hoses	Number of Flush Nozzles used	Flush Nozzle Flow per Nozzle (GPM)	Push Water Pump Type	Push Water flow (GPM)	Total Flow (GPM)	Total Wash Volume (Gallons)
Boiler Wash Internal	72	95	2	-	-	Jetpump	1,770	1,960	8,467,200
Boiler Wash External	12	95	6	-	-	Jetpump	1,770	2,340	1,684,800
Air Preheater	40	95	2	2	100	Jetpump	1,770	2,160	5,184,000
Precipitator Wash (Option)	96	95	6	-	-	Centrifugal	1,000	1,570	9,043,200

Existing System Outage Wash Capability

Potential Range of Water Influent Properties & Potential Sludge Loading

Presentation Prepared For:

Boiler Wash		
	Units	**Range**
Total Suspend Solids	mg/L	100 – 20,000
pH	SU	3 - 8

Air Preheater Wash		
	Units	**Range**
Total Suspend Solids	mg/L	100 – 20,000
pH	SU	2 - 8

Precipitator Wash		
	Units	**Range**
Total Suspend Solids	mg/L	100 – 65,000
pH	SU	2- 7.5

- Calculated Maximum Solids Loading Rate at SFC based on 60,000 Assumed TSS (Preliminary):
  - 14 tons/hour (SFC rated for 30 ton/hour)

Existing System Outage Wash Capability

Suggested Chemical Treatment Plan

Presentation Prepared For: RE

Chemical Addition Primer

- Caustic – pH Adjustment to Precipitate Dissolved Iron and Copper
- Coagulant – Particle Neutralization
- Flocculant – Polymer that Gather Particles Together and Aids in Settling

- High Density Sludge
- Dewaters More Readily
- Lower Carryover Rates

- Lower Density Sludge
- Runny, Harder to Dewater
- Fines/Floaters

Existing System Outage Wash Capability

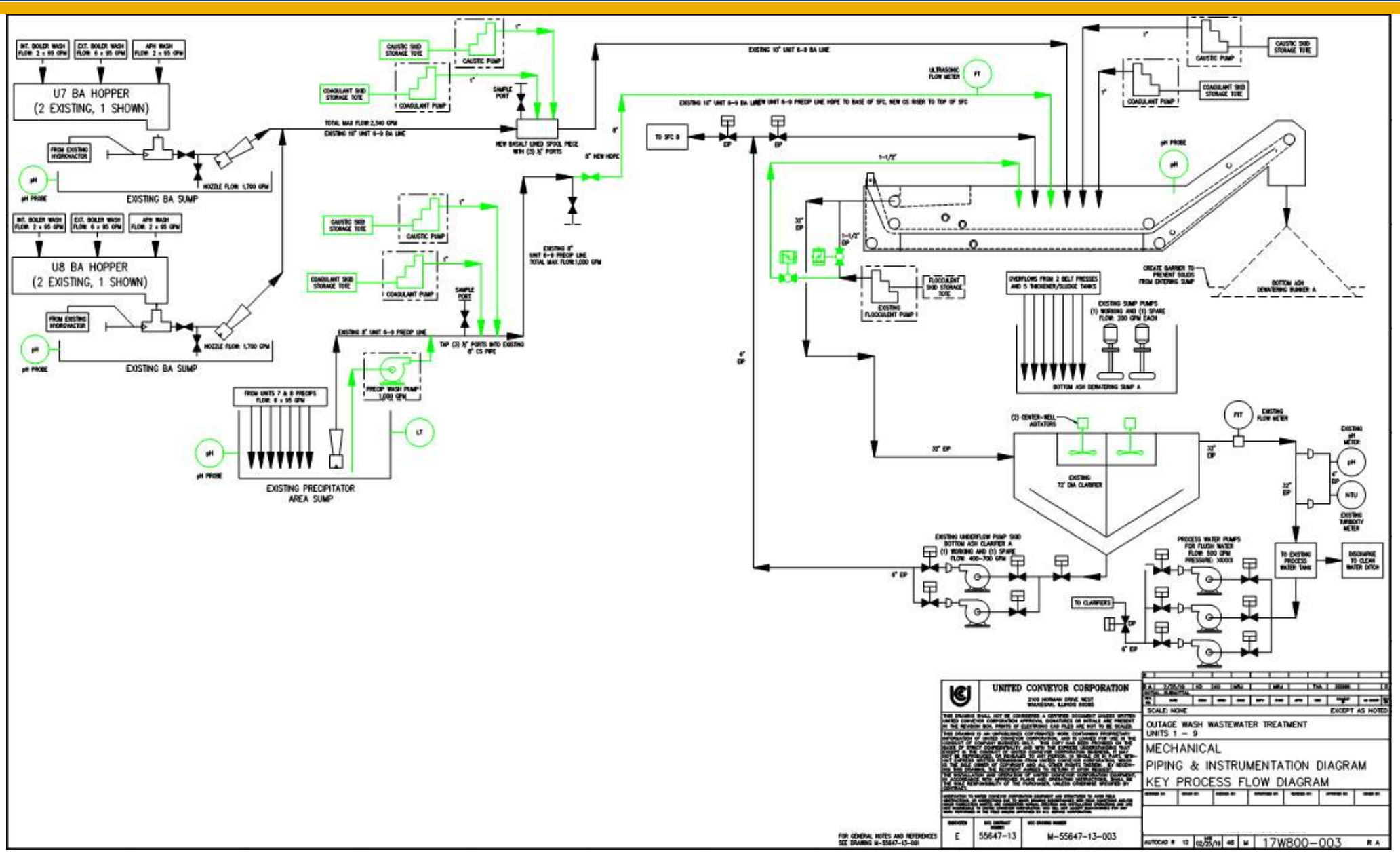
Chemical Injection Flexibility: Injection & pH Measurement Locations

Presentation Prepared For:

- **Injection Locations**
  - Caustic Injection (pH Adjustment)
    - Upstream - at the SFC
  - Coagulant Injection
    - Upstream - at the SFC
  - Flocculant Injection
    - SFC Overflow to Clarifier - at the SFC
- **pH Measurement Locations**
  - Bottom Ash Hopper Sump
  - Precipitator Sump
  - Submerged Flight Conveyor
  - Clarifier Discharge (Effluent)

Existing System Outage Wash Capability

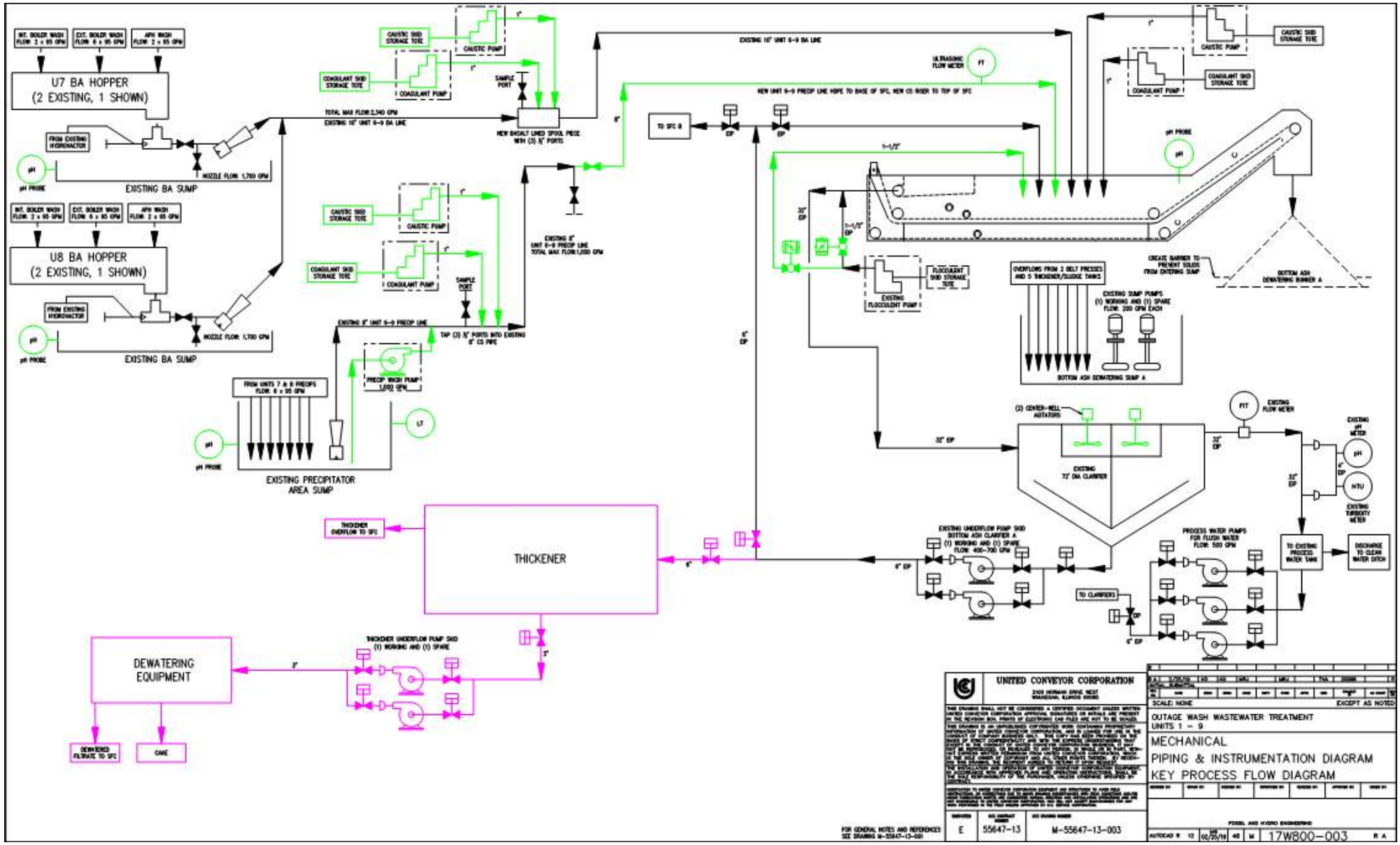
Equipment, Instrumentation, and System Operation Plan



Presentation Prepared For:

Existing System Outage Wash Capability

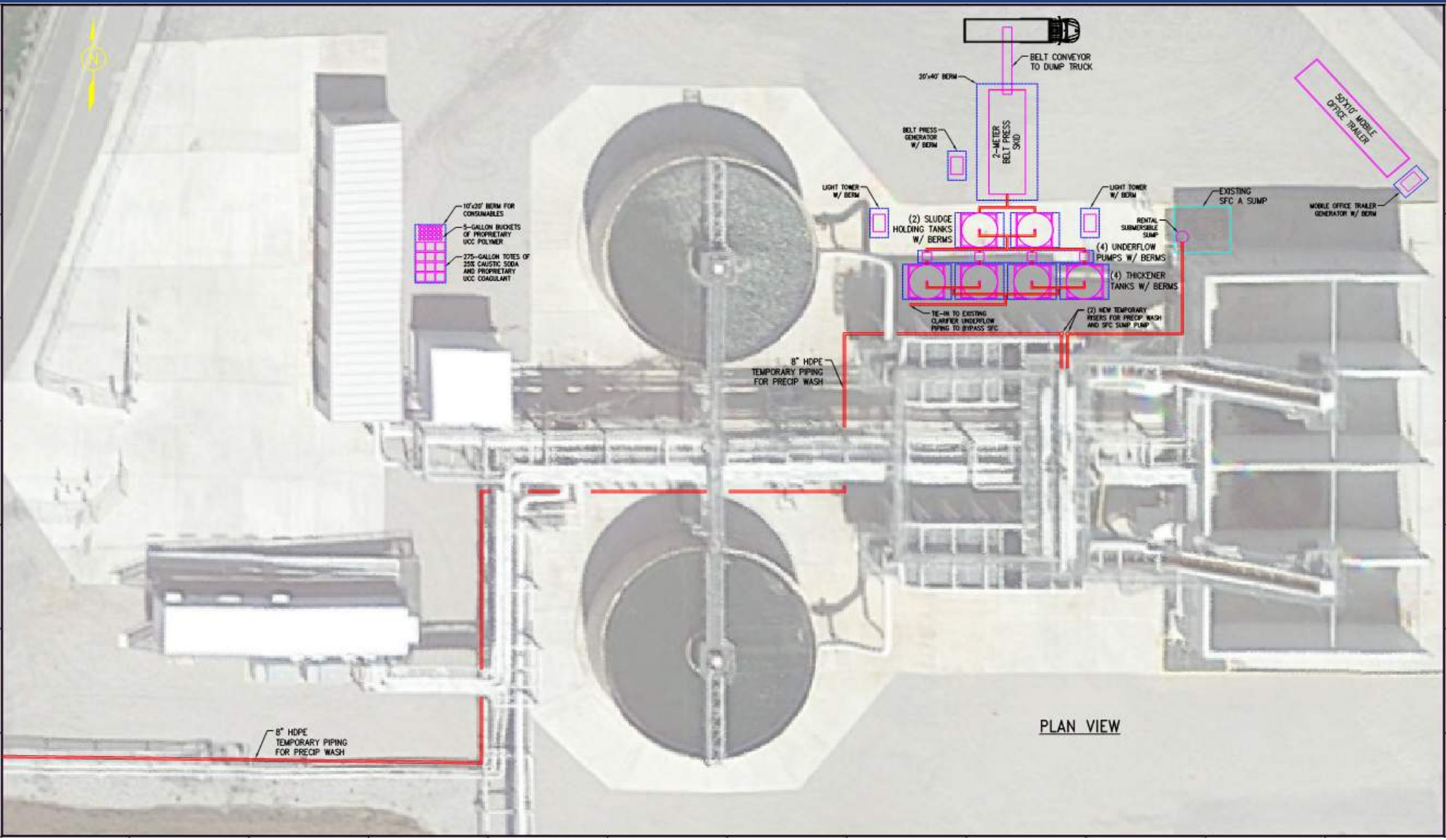
Potential Sludge Removal Arrangement



Presentation Prepared For:

Existing System Outage Wash Capability

Equipment, Instrumentation, and System Operation Plan



UCC R-SFC & Clarifier System

For Bottom Ash Transport Water Treatment

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 a make-up water source for FGD System (per Effluent Limitations Guidelines)
- Can be designed for TSS levels suitable for Recirculation Pumps

Outage Wash Capabilities

- Can be utilized (with minor modifications) to process Outage Wash Water during boiler cleanout operations

Questions ?