REINHOLD ENVIRONMENTAL Ltd.

2018 APC & Wastewater Round Table & Expo Presentation

July 23 & 24, 2018 in Lexington, KY / Hosted by East Kentucky Power Coop

ONE SOURCE. MANY SOLUTIONS.

Vogt Power International
Babcock Power SERVICES
Babcock Power ENVIRONMENTAL
TEi
Riley Power
Boiler Tube Company of America
TEiC | CONSTRUCTION SERVICES
TEiC | HEAT EXCHANGER SERVICES
GSI
Struthers Wells

Integrated Approach to Plant Water and ELG

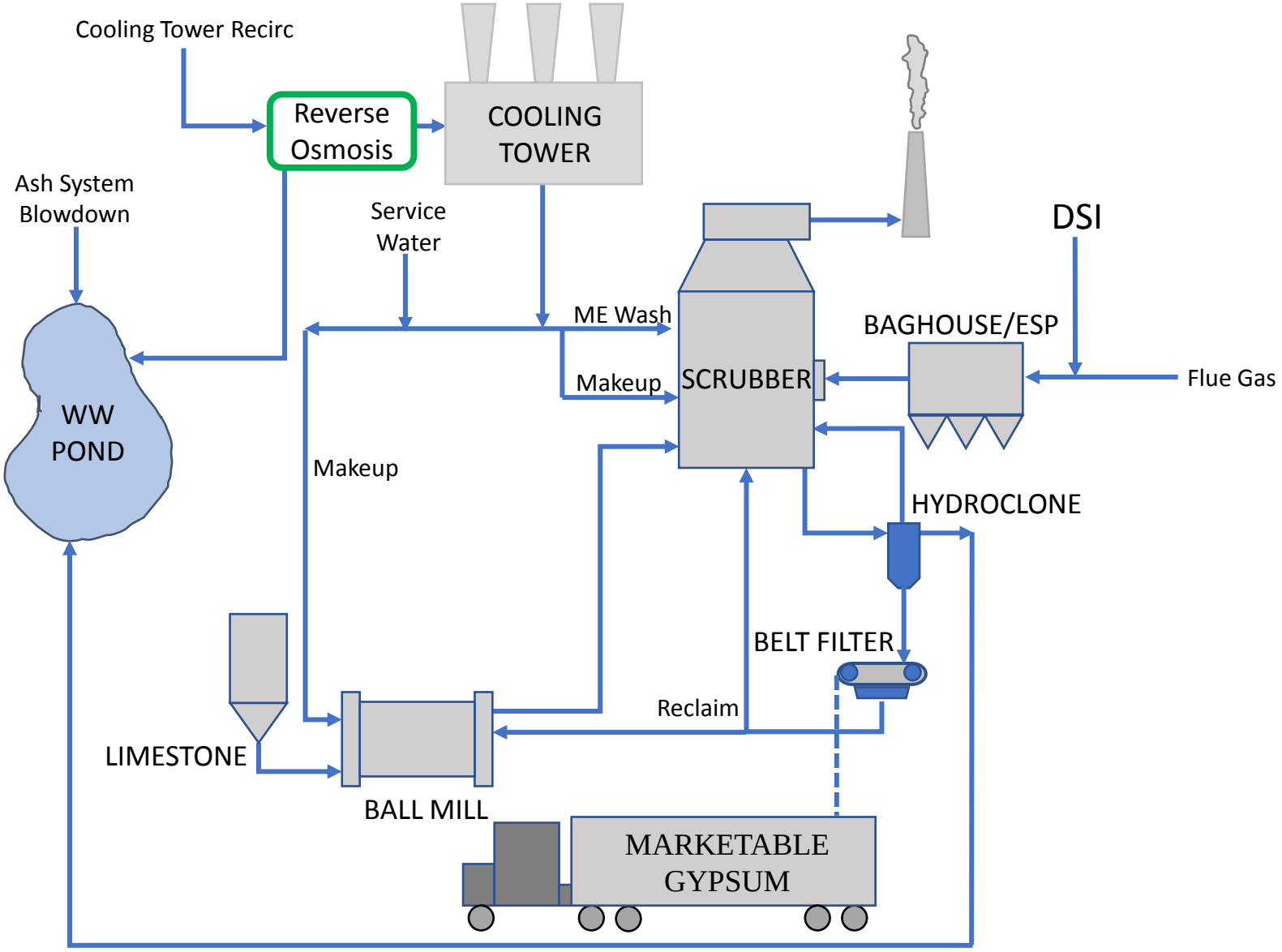
Intro

- **Status of ELG Rule**
- **Incumbent Technologies**
  - Falling Film Evaporators
  - Chemical/Biological Treatment
- **Integrated Solutions**
  - Site Specific Applications
- **System Integration**
  - UV Water Treatment
  - Micro/Nano Filtration
  - Reverse Osmosis
  - Dry Sorbent Injection
  - Evaporation
  - Wastewater Dewatering
  - Pond Lining
  - Scrubber Retrofits
  - Aftermarket support

Zero Liquid Discharge (ZLD)

- Permit concerns
- Variable makeup
- Variable output flow
- Treating Selenium
- Offline capability
- Consider option to maintain ELG Compliant discharge

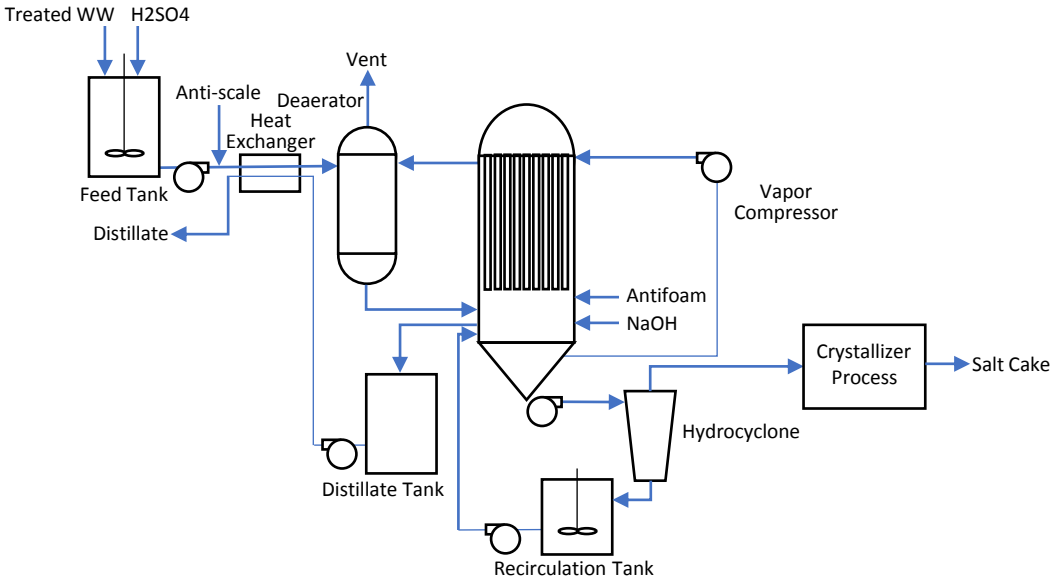
Wastewater PFD



Incumbent Wastewater Treatment Technologies

Chemical &
Biological Treatment

Falling Film Reactor
& Crystallizer



Incumbent Wastewater Treatment Technologies

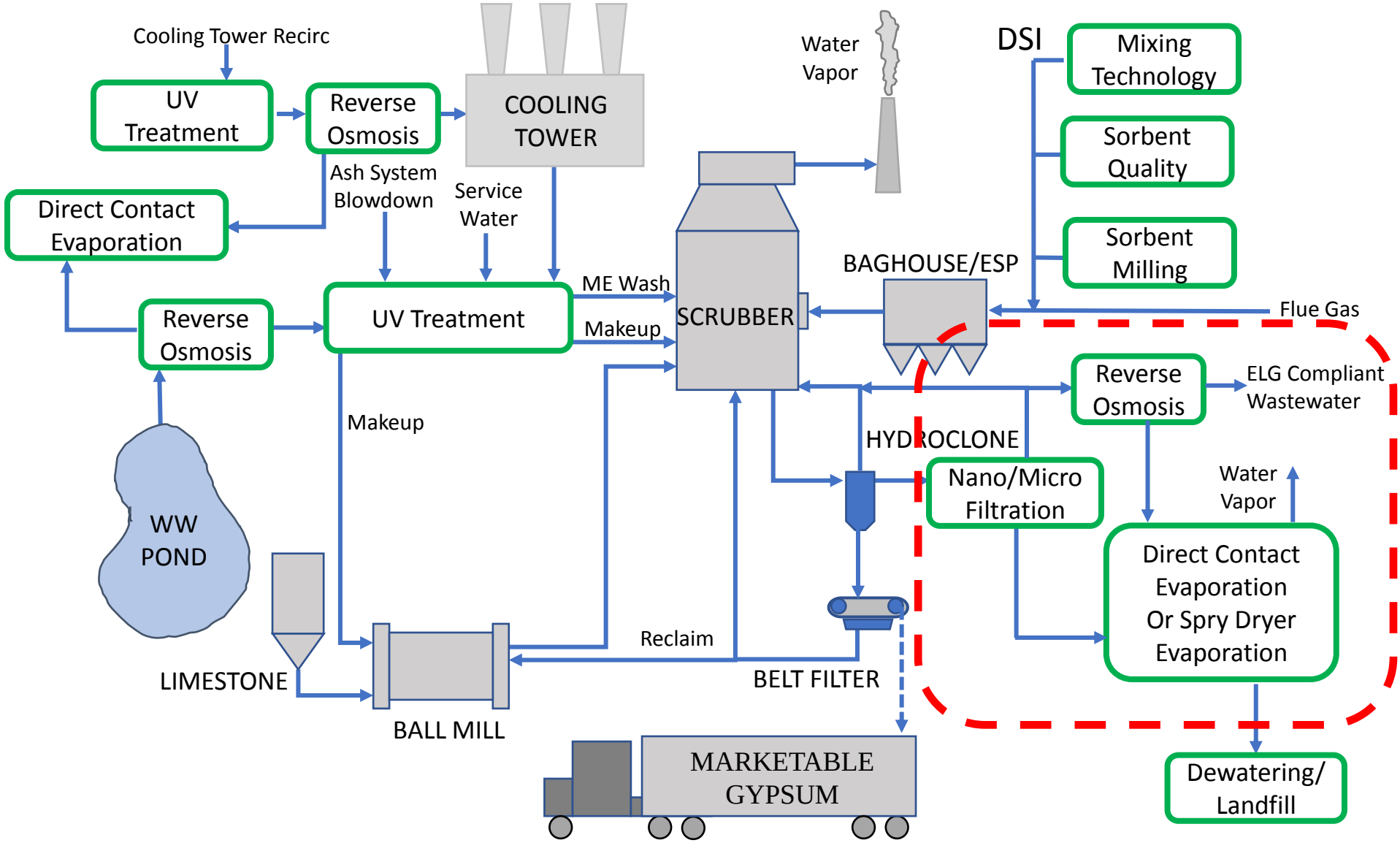
- High capital and O&M cost
- Large footprint
- Fixed chemistry (less flexible with process upsets)
- Fixed flow rate (less flexible with flow fluctuations)
- High scaling factor
- Additional manpower required

Utility OEM Suppliers Provide Optimal Solutions

One Source – Many Solutions

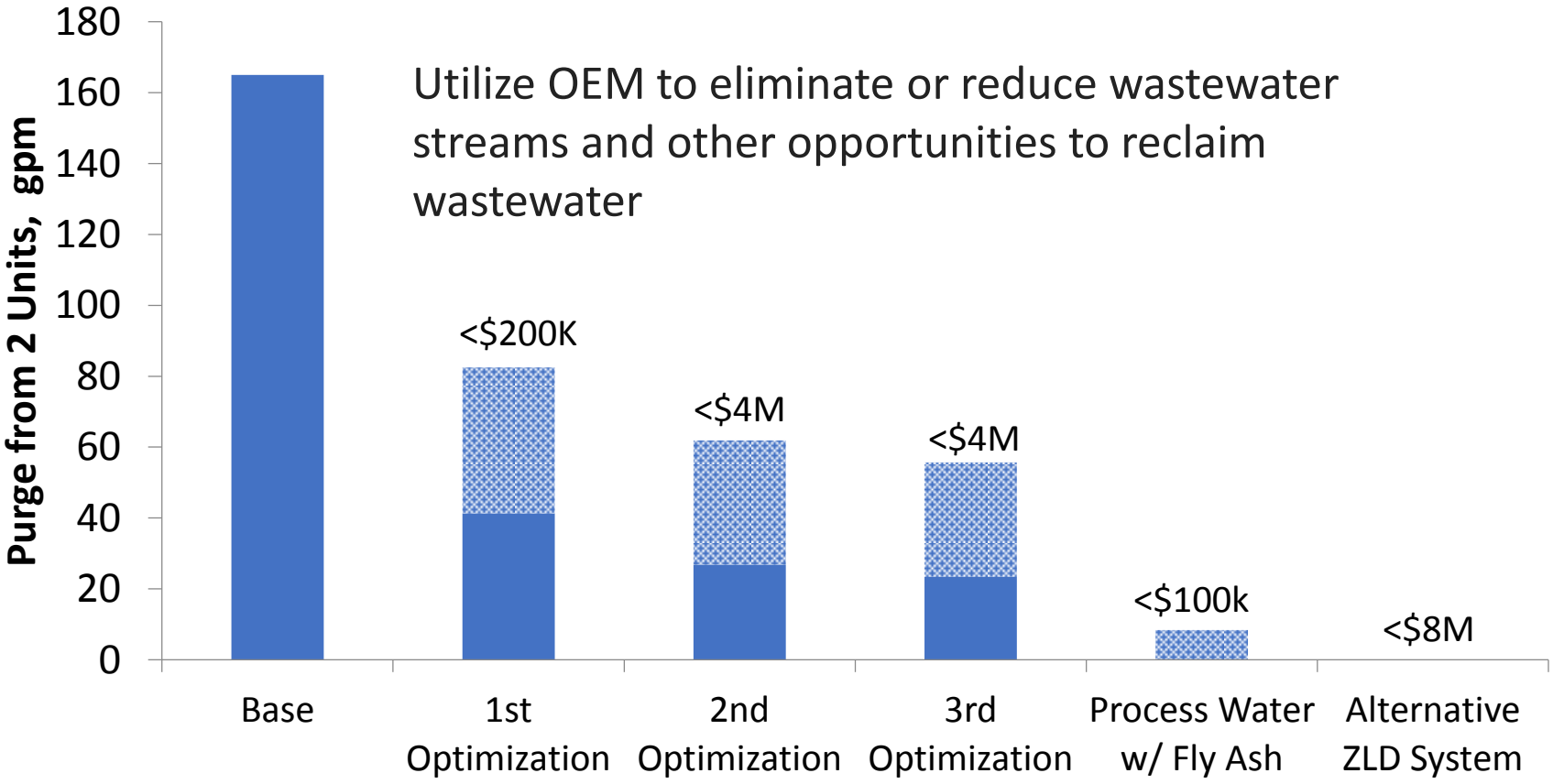
- Utility OEM suppliers provide engineering, equipment, solutions, and aftermarket support to the utility industry from chute-to-stack
- Utility OEM teaming up with sub-suppliers to provide an optimized solution for each customer that meets utility requirements
- Utility OEM provide aftermarket support

ZLD PFD w/ Utility OEM Integration



The Big Picture - OEM's Plant & AQCS Experience

BPE's expertise across the entire system provides the optimum solution to reduce purge and $/gal treated as first step



Water Pre-treatment

Cooling To
UV Treatment
Direct Contact Evaporation
Water Vapor
DSI
Mixing Technology
Sorbent Quality
Sorbent Milling
BAGHOUSE/ESP
Flue Gas
ME Wash
Makeup
SCRUBBER
Reverse Osmosis
ELG Compliant Wastewater
HYDROCLONE
Nano/Micro Filtration
Water Vapor
Direct Contact Evaporation Or Spry Dryer Evaporation
Dewatering/ Landfill
Reclaim
LIMESTONE
BALL MILL
BELT FILTER
MARKETABLE GYPSUM

UV Technology

Non-Chemical Dechlorination/Disinfection Solution w/ UVC Ultraviolet light

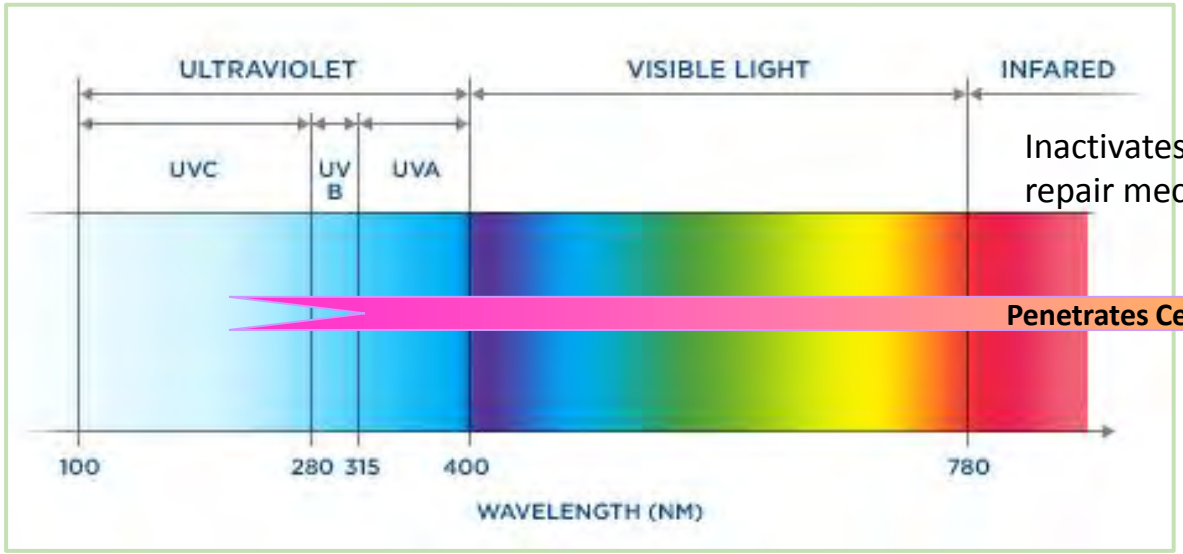
Treat incoming cooling and service water

- Well water
- River water

Treat reclaim water

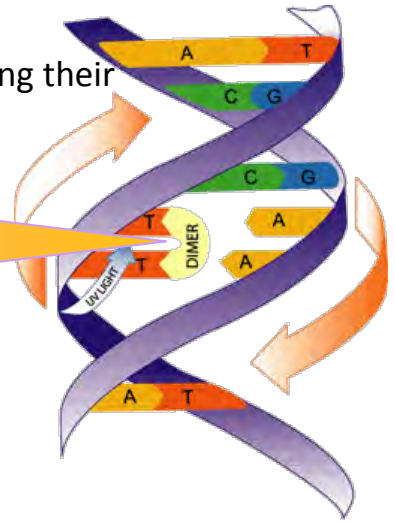
- Waste water pond
- Cooling tower recirculation
- Boiler water

UV ➔ Electricity ➔ Germicidal Power + Photochemistry Power

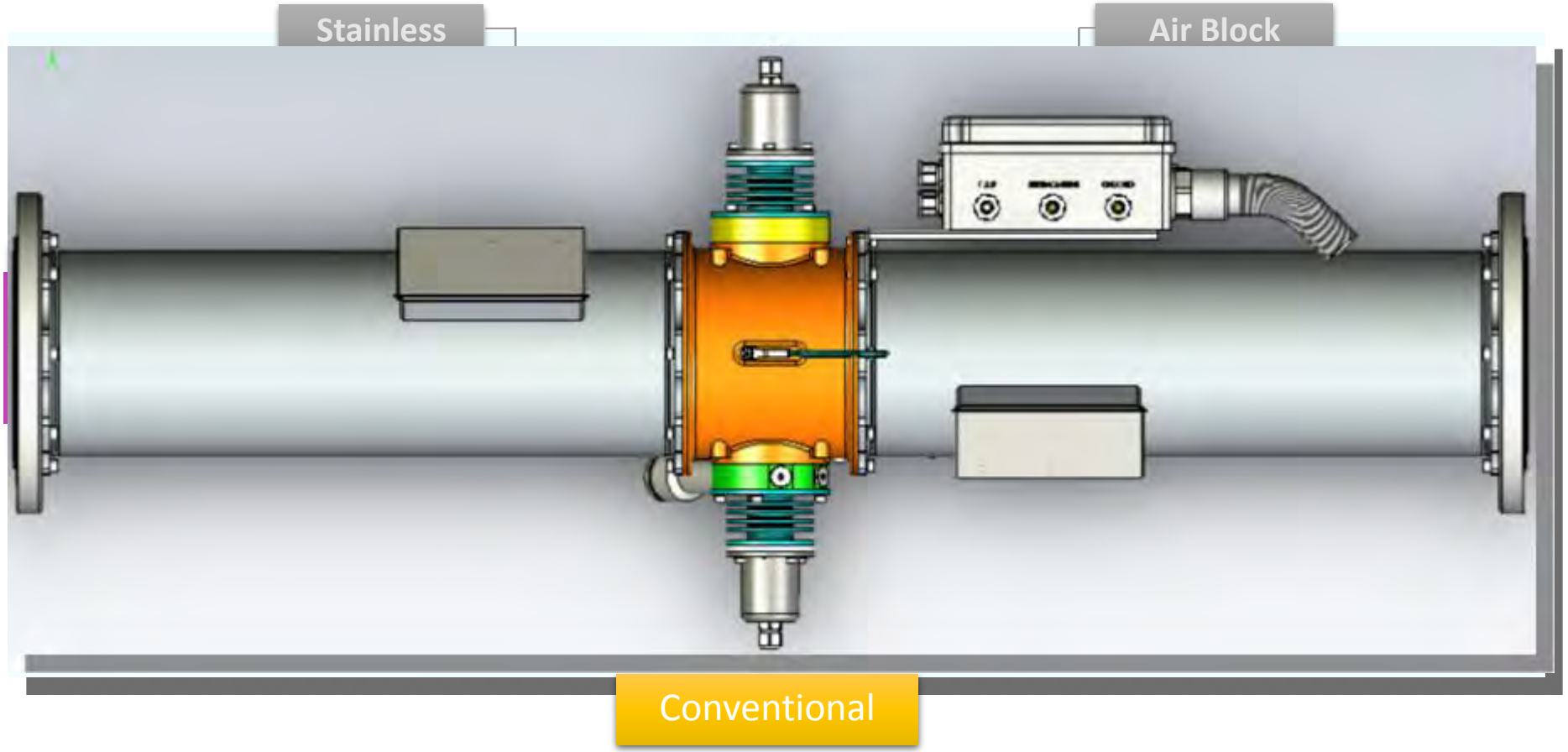


Inactivates cells by damaging their repair mechanism

Penetrates Cell Membrane



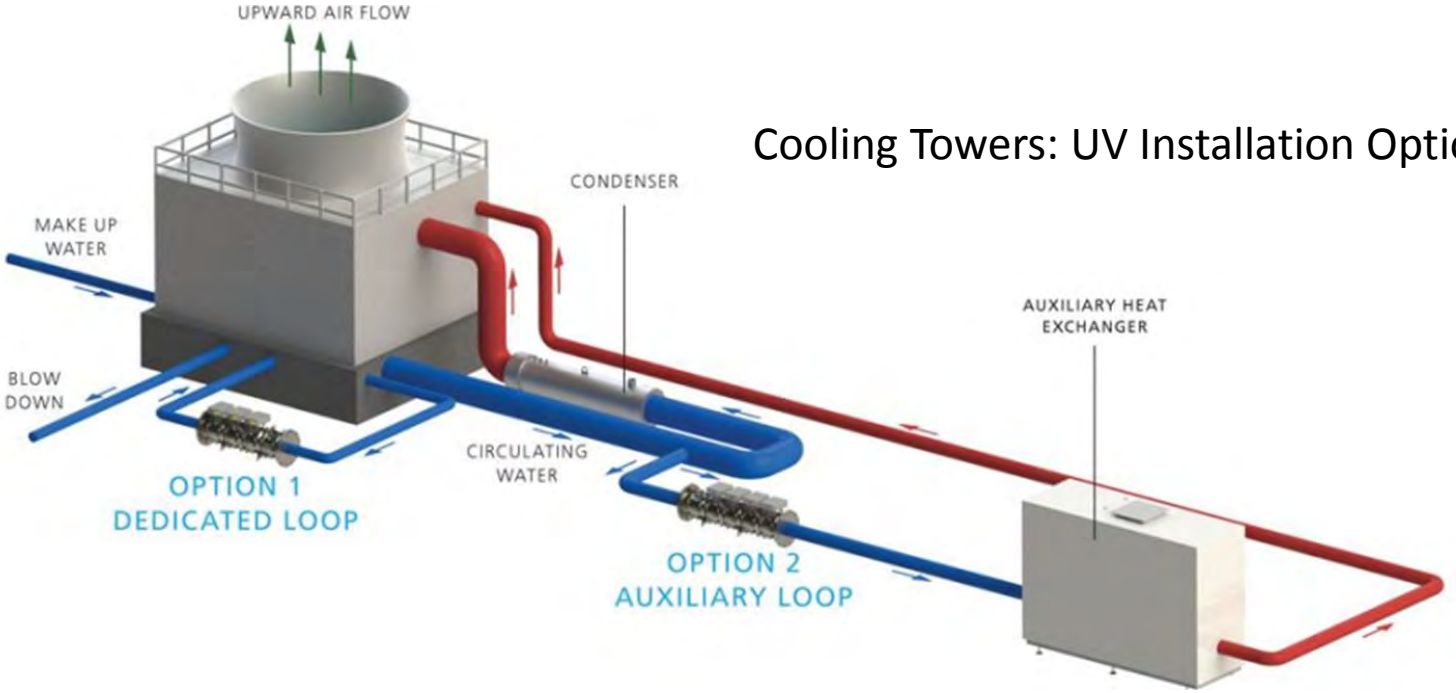
Optimum UV Design with Internal Reflection



- Patented internal reflection technology similar to fiber optic science
- Chamber of high quality quarts surrounded by air block instead of stainless steel
- Trap UV light photons and recycle their energy
- UV wavelength is effectively lengthened (i.e., magnified)
- Provides a greater opportunity to inactivate microorganisms

UV Design

- Dose - In the order up to ten(s) mJ/cm^2 for disinfection & dechlorination
- UVT% - UVT meter used to control power output
- UV Lamp Intensity Meter
- UV Apparatus - Dose pacing by adjusting the electrical power to deliver the needed dose
- Mobile test units available



Cooling Towers: UV Installation Options

UV Technology Benefits

- Reduce chlorination cycles
- Increase life of filters
- Increase life of RO membranes
- Treat incoming water for preventing macro and micro fouling
- Increase efficiency of cooling water system

Sampling plate from untreated bio-box (left) and treated with HOD UV (right)

Strainer basket from untreated bearling cooling water supply (left) and treated with HOD UV (right)

Atlantium
Illuminating Water Technologies

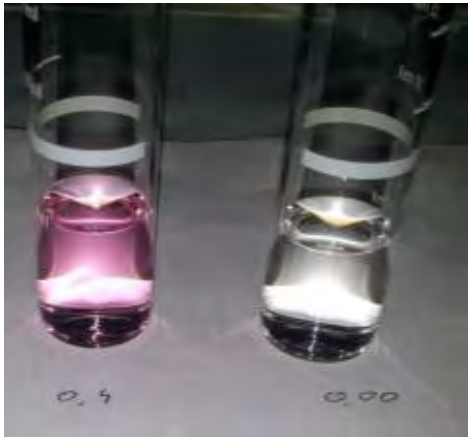
HOD UV Disinfection/Dechlorination Case Study

HOD UV installed at 3,160 MW coal-fired power station:

- 3 systems in series, flowrate 680 gpm (154m^3/hr), 95% UVT
- Inlet free Cl 0.5 ppm, outlet free Cl ≤0.02 ppm (non-detect)

Facility faced:

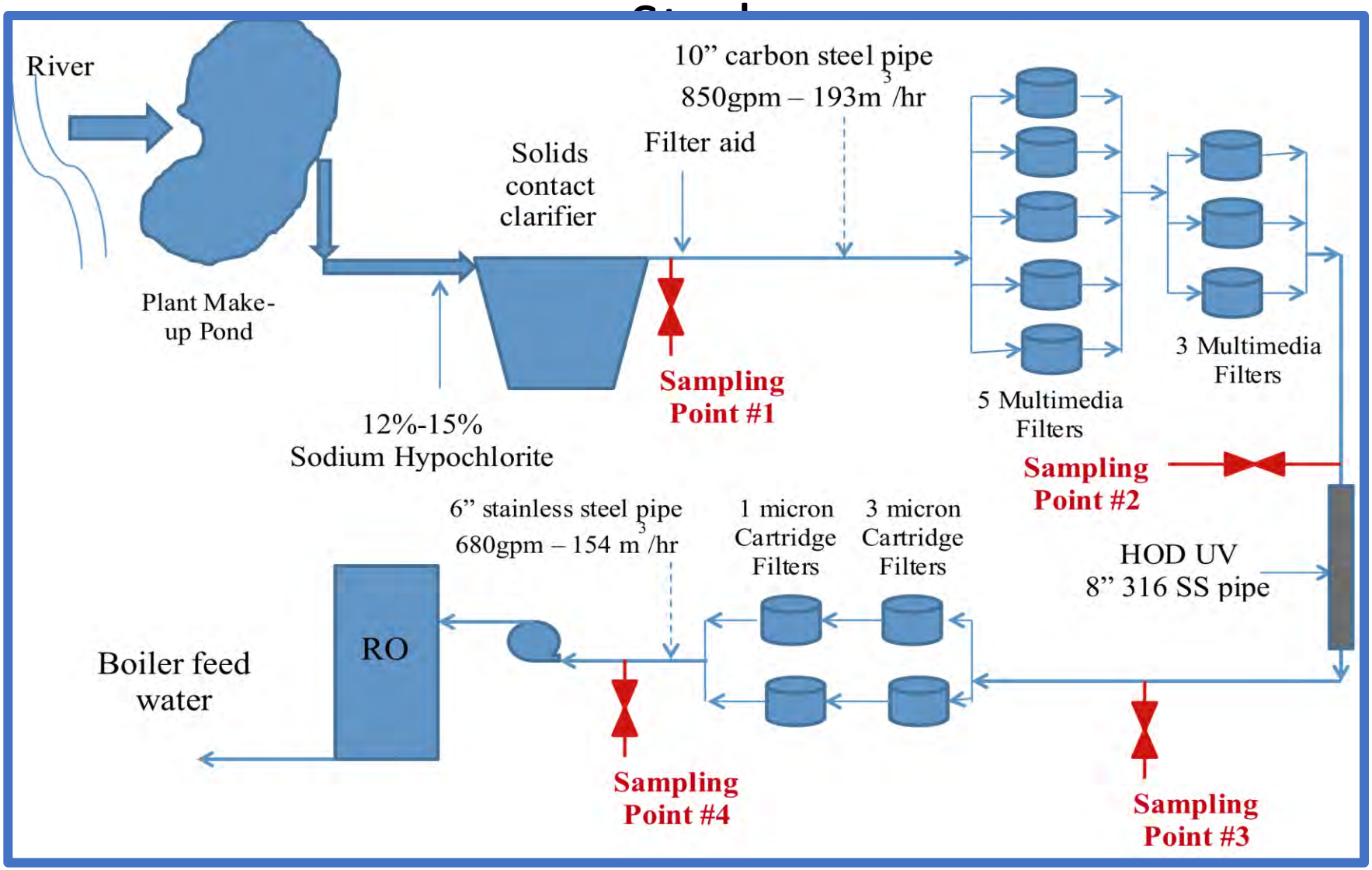
- Frequent membrane & micron filter maintenance & replacement
- Bio and solids-fouling



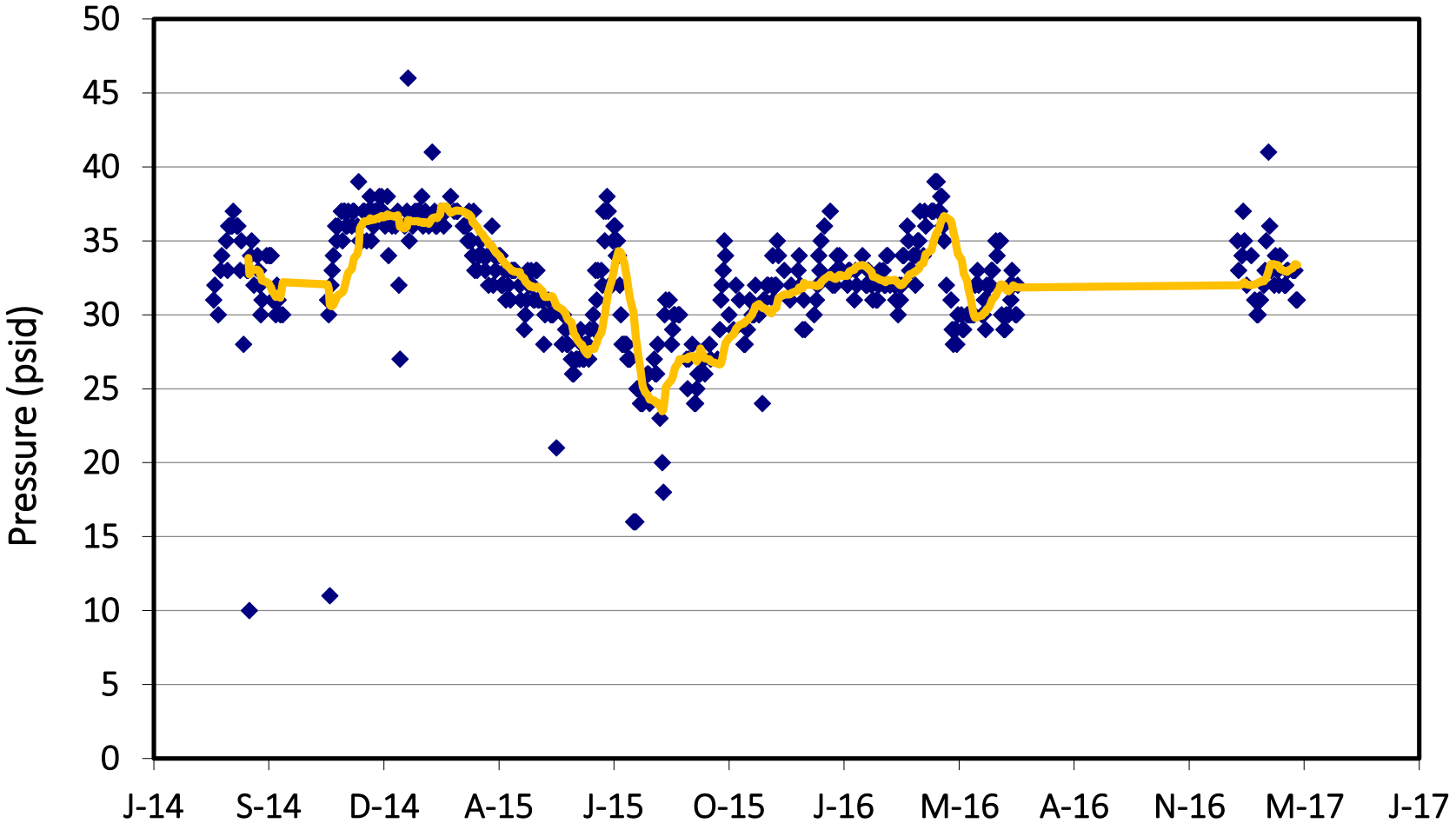
With HOD UV the Facility was able to:

- Replace use of SMBS
- Reduce/eliminate use of chlorination
- Achieve non-chemical dechlorination

HOD UV Disinfection/Dechlorination Case Study



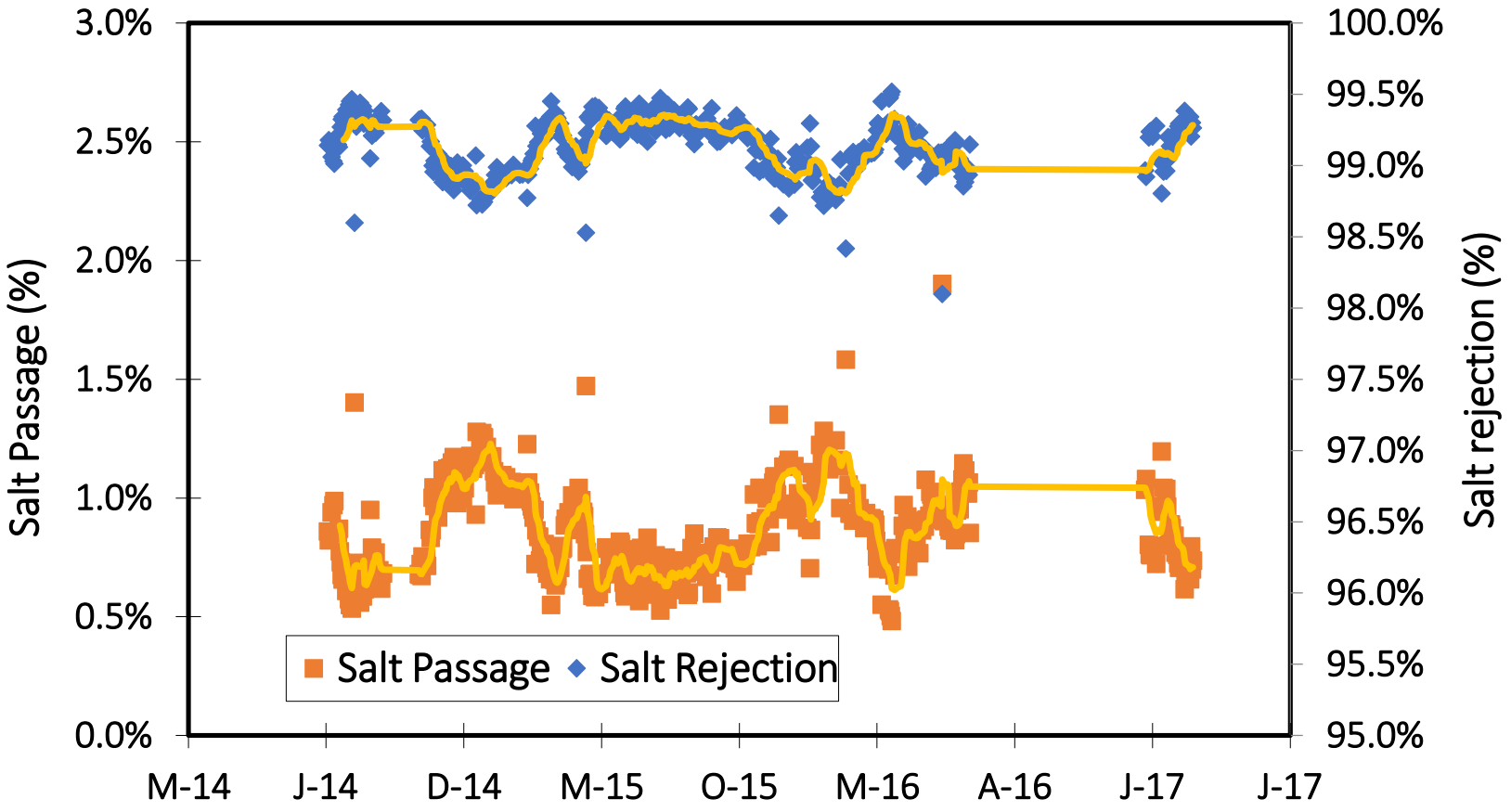
Membrane Performance- Differential Performance



During 940 days of operation with HOD UV the DP is at the same level as with a new membrane

NO CIP since installation of HOD UV system

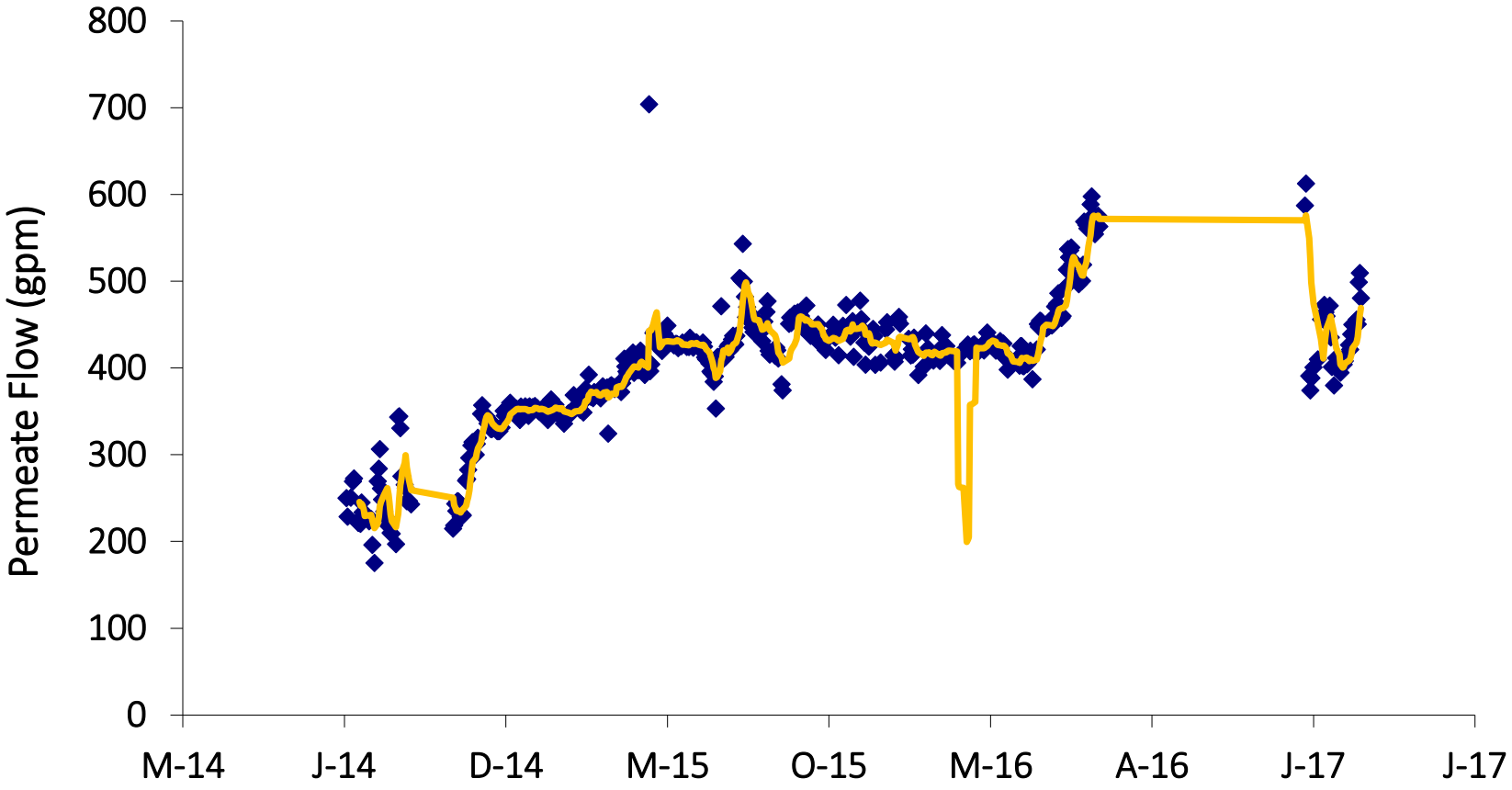
Membrane Performance- Salt Passage & Rejection



During 940 days of operation with HOD UV the salt passage and rejection is at the same level as with a new membrane

NO CIP since installation of HOD UV system

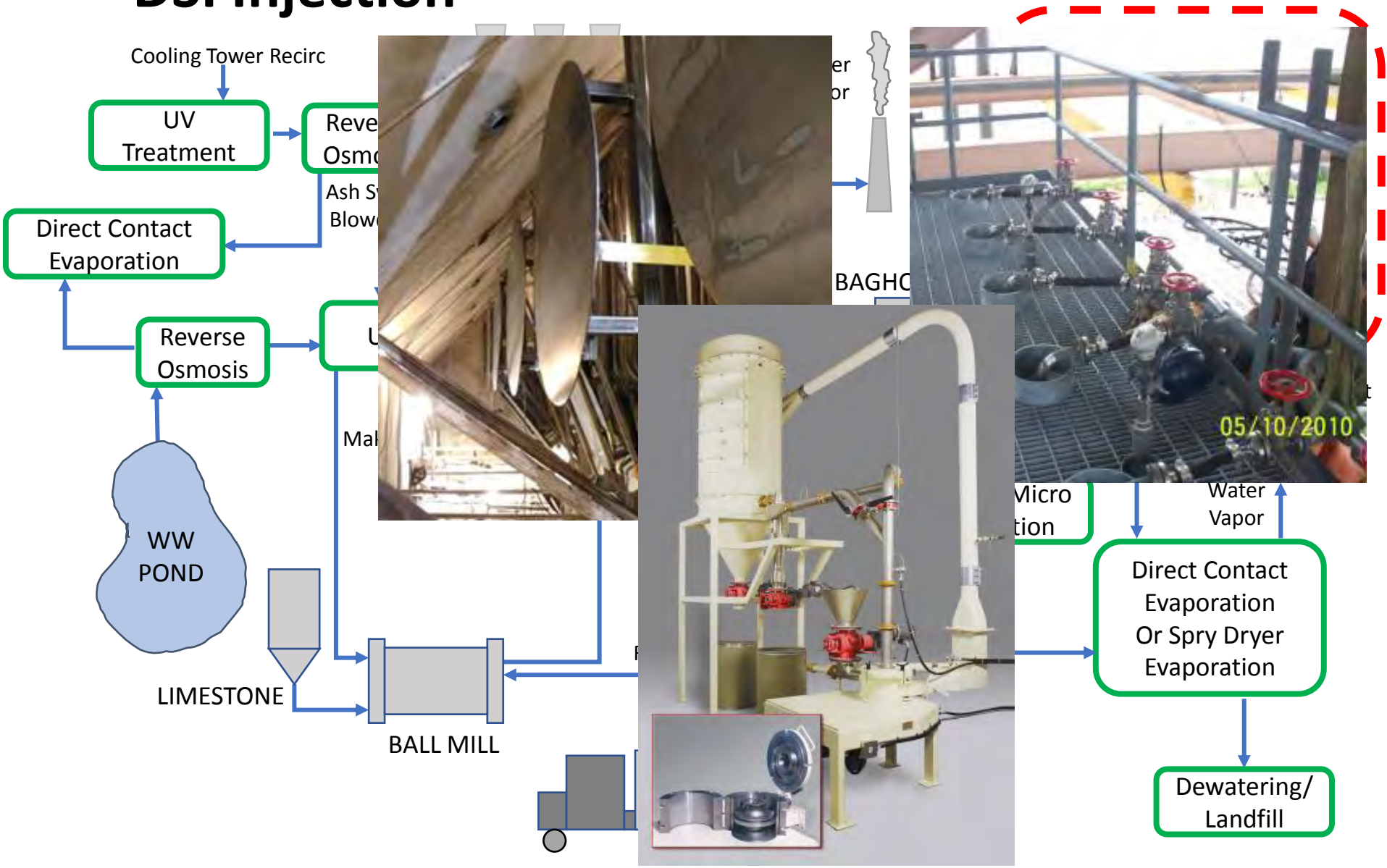
Membrane Performance- Permeate Flow



During 940 days of operation with HOD UV normalized permeate flow is higher compared to a new membrane while permeate quality (salt rejection) is similar to a new membrane.

NO CIP since installation of HOD UV system

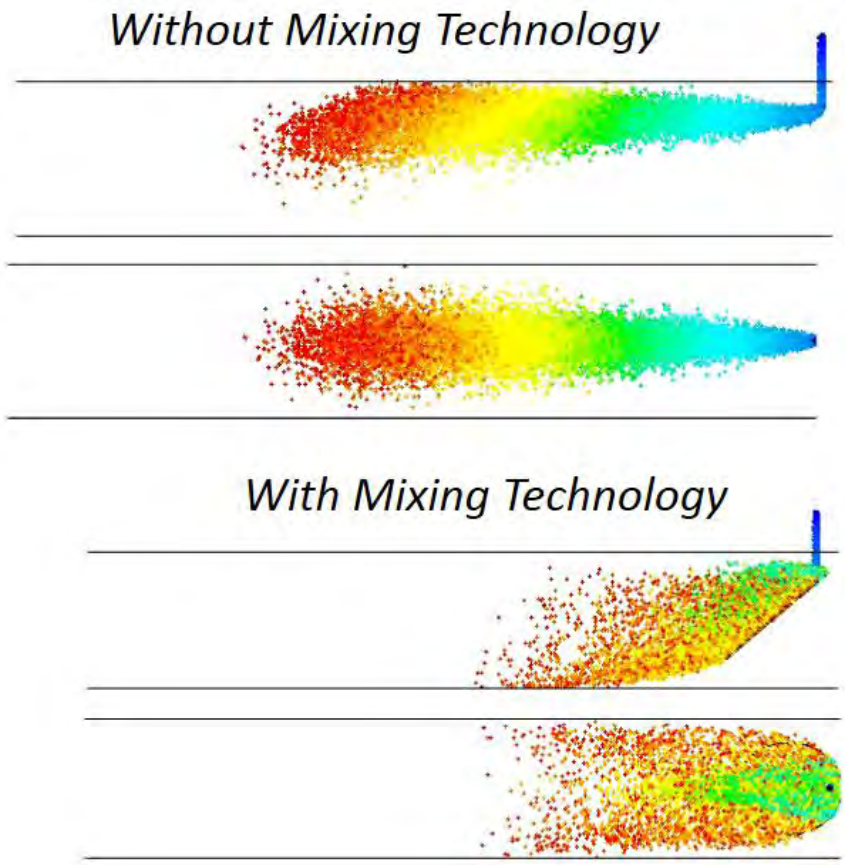
DSI Injection

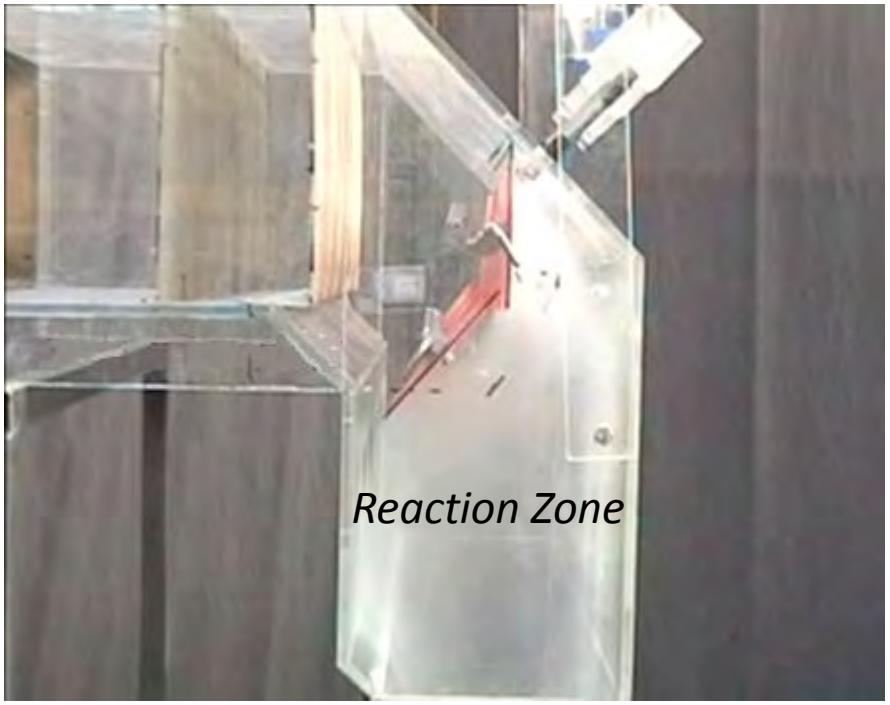


Mixing Technology - DSI

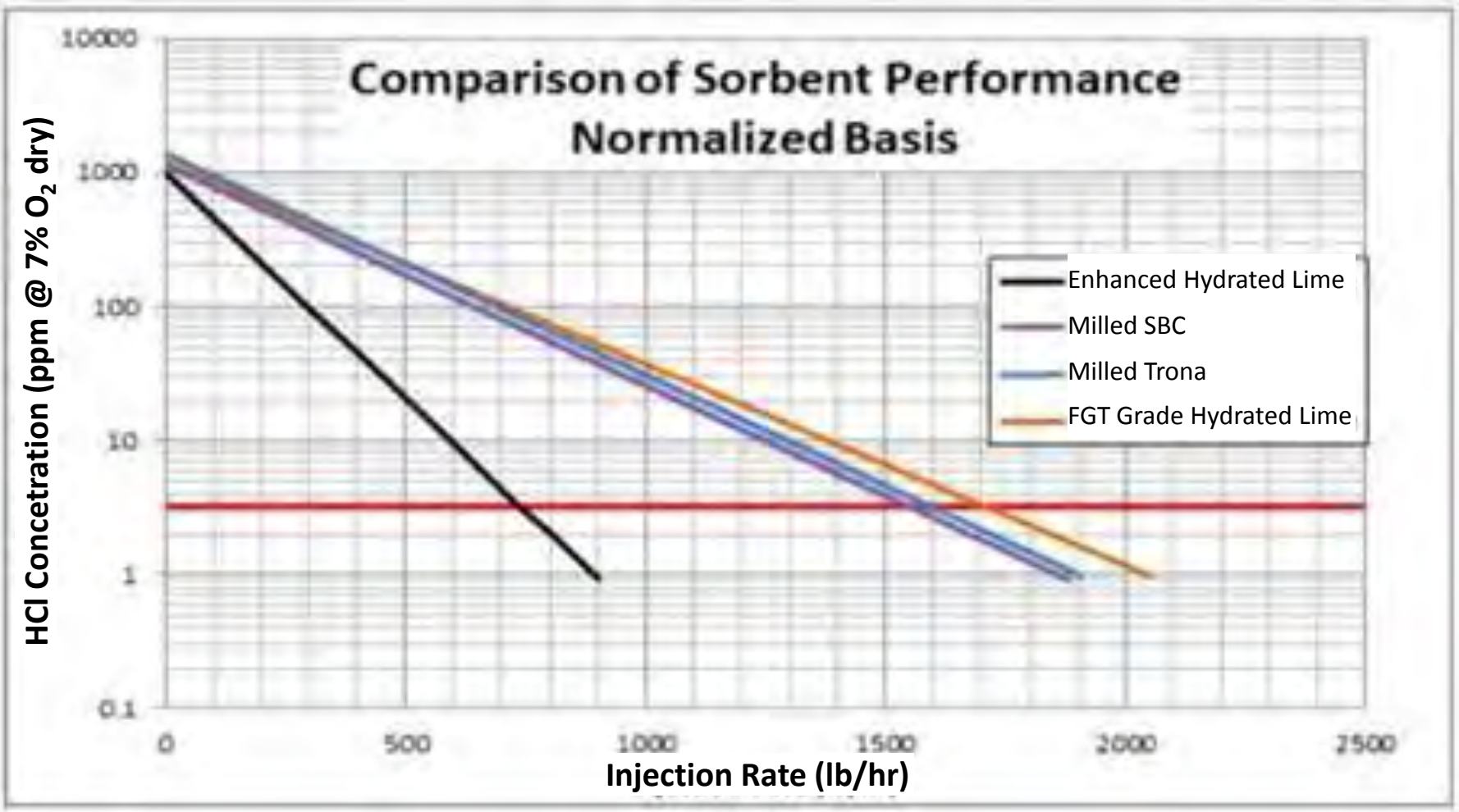
Mixing and distribution at the injection point

- Full mixing in short section of ductwork
- Improve removal and/or reduce sorbent consumption





Sorbent Quality Makes a Difference



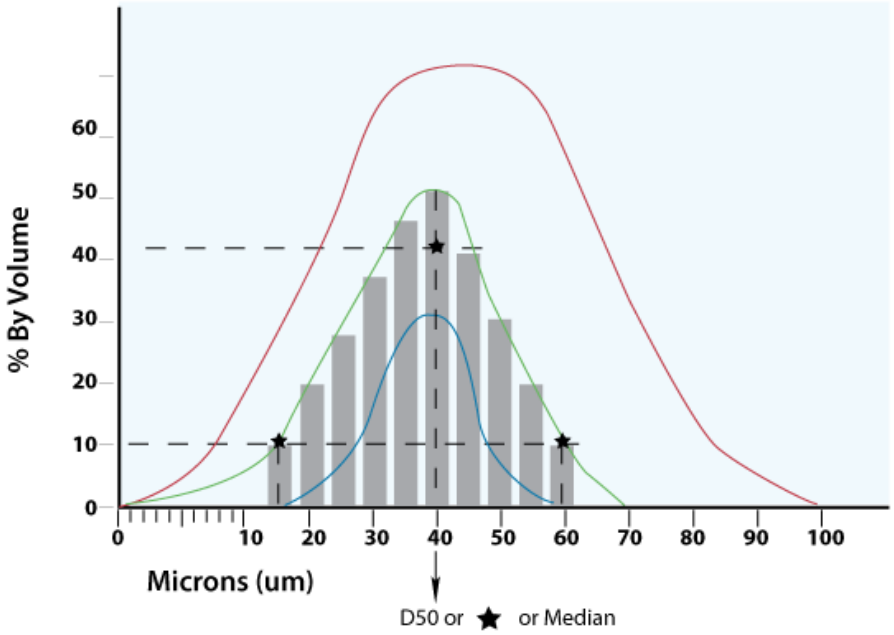
Slide courtesy of BCSI

Advancing Hydrate

- Hydrated Lime can be used in a variety of flue gas treatment, water treatment, construction and industrial applications.
- Standard Grade - Refined hydrated lime with good flow properties
- Hydrated Lime FGT - High porosity hydrated lime with small median particle size, good flow properties and high total and available Ca(OH)2 - Used in dry sorbent injection and a variety of flue gas applications.
- Hydrated Lime HR - High reactivty hydrated lime used in acid gas removal situations where higher performance is needed.
- Hydrated Lime SP - Specially produced hydrated lime with low iron and magnesium and high available and total $Ca(OH)_2$

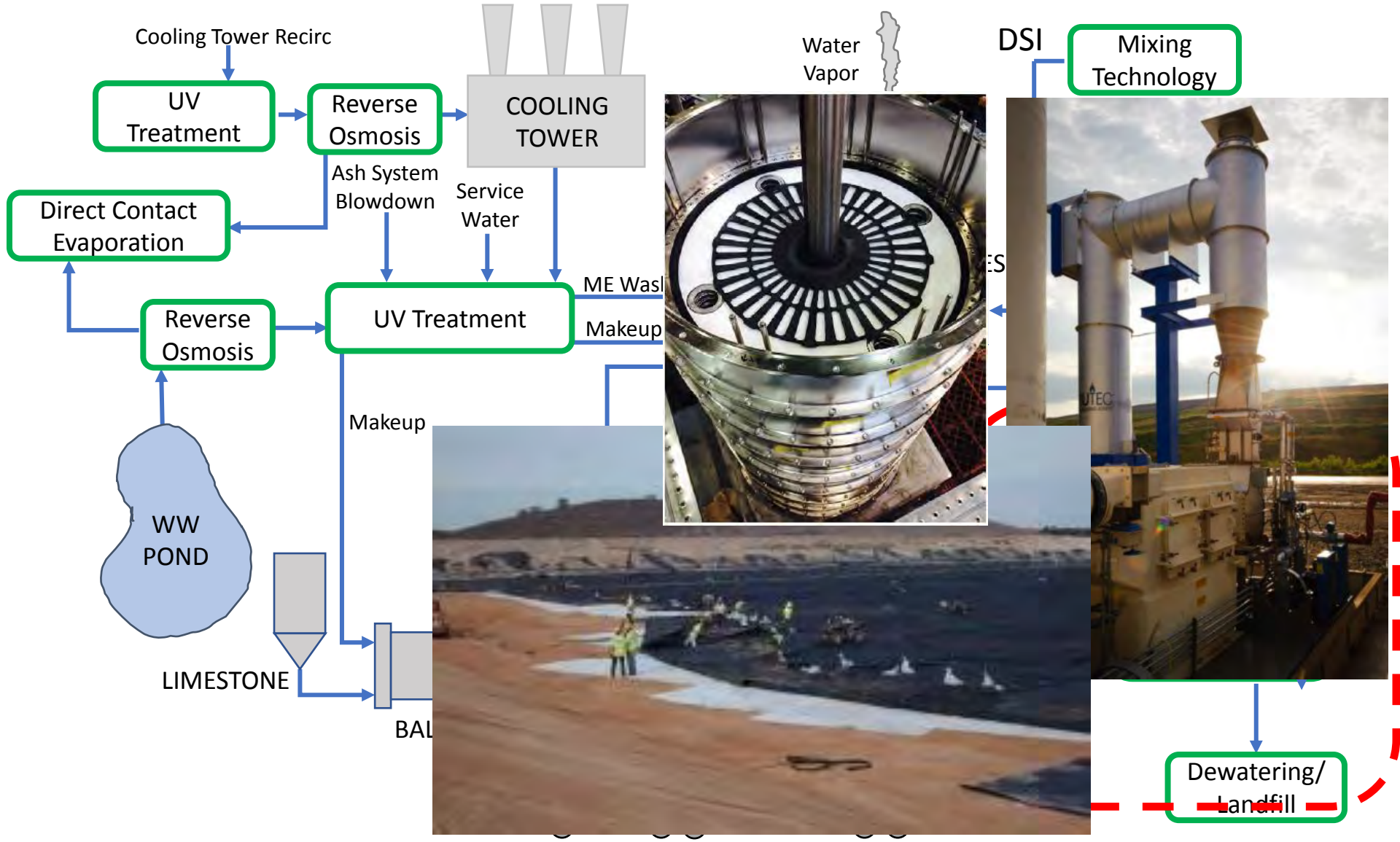
Classifier Milling Systems (CMS)

- DSI performance is largely driven by the milled surface size of the sorbent material (sodium bicarbonate, trona, hydrated lime, powdered activated carbon)



System consistently meets design particle size distribution to optimize the sorbent injection system

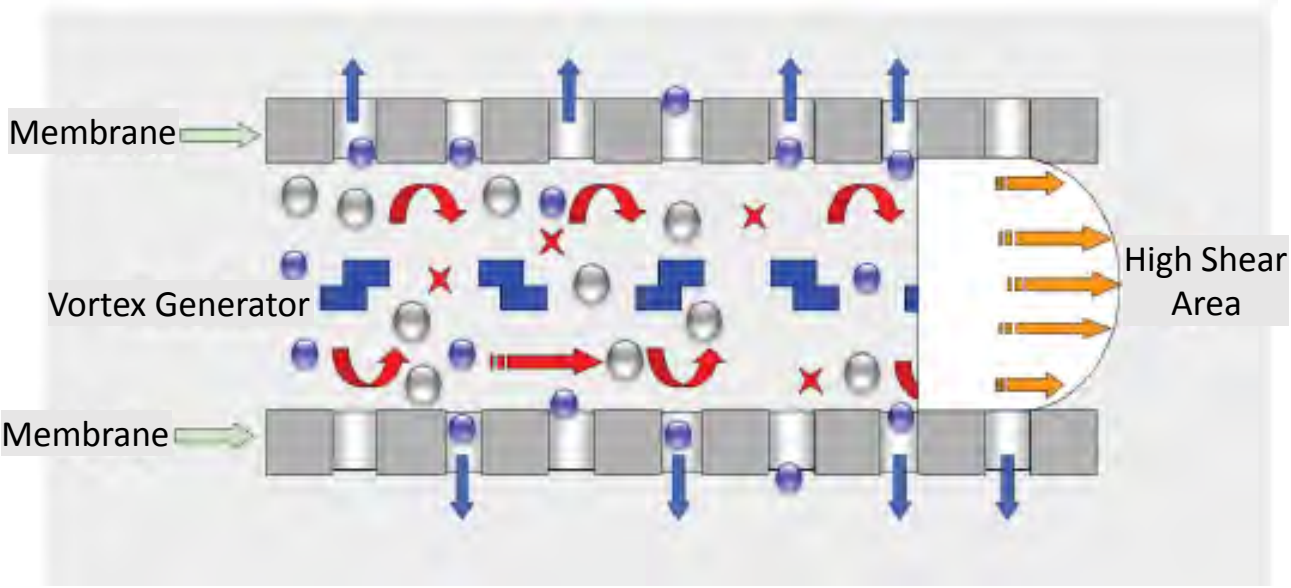
Evaporation and Waste Solids



Nanofiltration

Intermediate Step to Reduce Further Effluent Discharge after Optimization

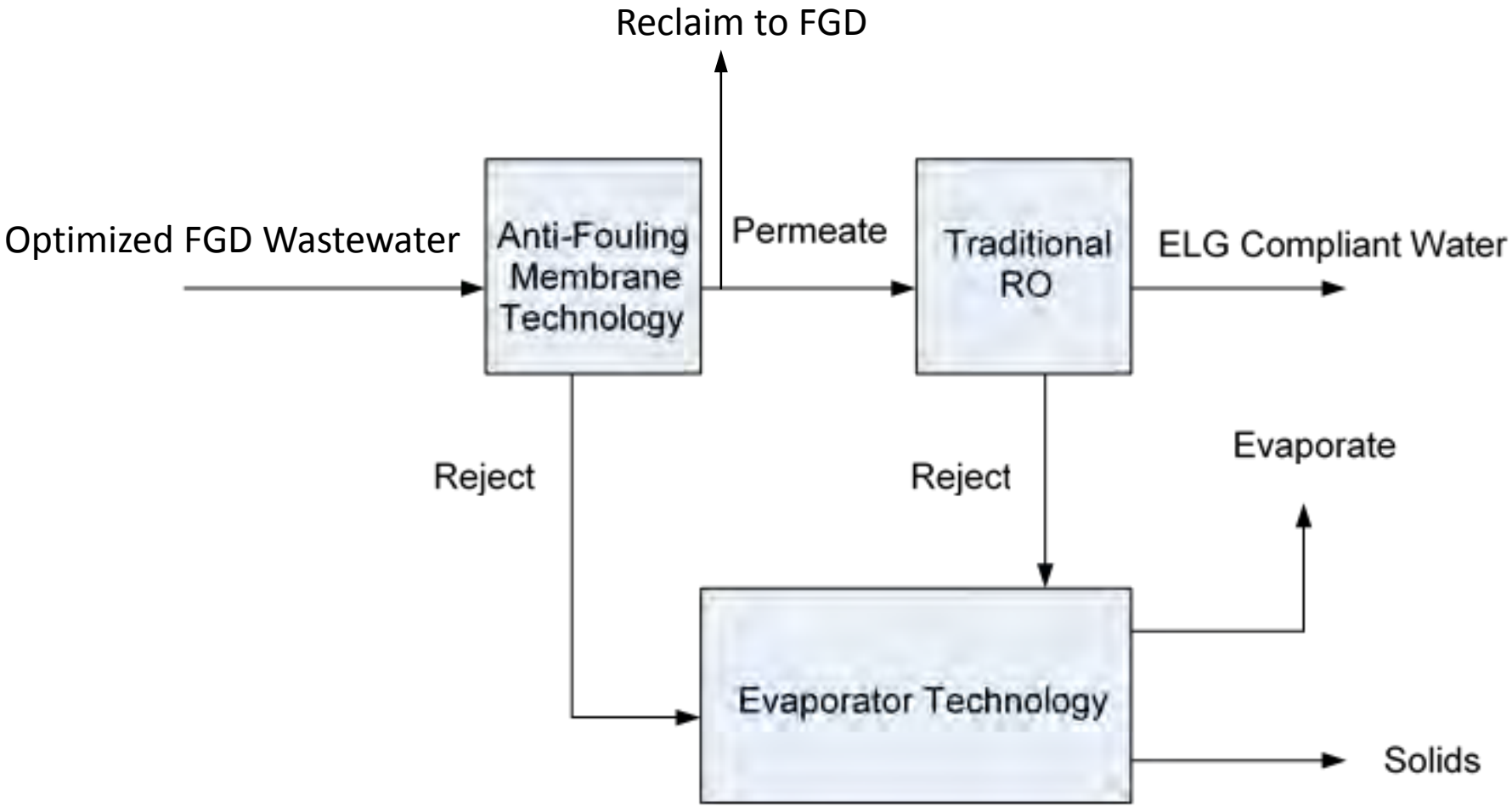
- FGD effluent high in TDS and TSS leads to fouling in traditional RO systems
- Nanofiltration membrane system utilizes vortices to eliminate fouling
- The membrane is dependent on the type of water recovery and chloride levels



Nanofiltration – Cont.

- The effluent from nanofiltration can be directed to a traditional RO system and discharged meeting ELG regulations or reclaimed back to the process
- The concentrated discharge can be dewatered or directed to an evaporative process
- System is modular and mobile
- Mobile test units are available

Nanofiltration Process Flow Diagram



FMX

Case Study 1

PRETREATED

FGD Purge

Steam Electric Power Plant
Eastern US

PLANT CAPACITY: **2,200 MW**

GOAL: **ELG compliance**

OPERATING MODE: **Batch**

PRETREATMENT: **Phys/Chem**

VOLUME TREATED: **200,000 gal**

8 MONTH STUDY TREATMENT RESULTS

	UNITS	FEED	**FMX** EFFLUENT	**FMX+RO** EFFLUENT[1]	% REMOVAL
TDS	ppm	25,500	16,000	1,376	95%
Sulfate[2]	**ppm**	**1,450**	**514**	**5.4**	**99%**
Arsenic	ppb	10	2	2	80%
Mercury	ppt	50	3	2	96%
Selenium	ppb	200	69	1.1	99%
NOx -N (aq)	ppm	25	15	3.3	87%

[1] RO rejection rates based on data from case study 2
[2] Main contributor in scale formation

Case Study 1

PRETREATED

FGD Results

62 GFD AVERAGE FLUX

60-80% RECOVERY

63,000 GPD[1] THROUGHPUT

[1] For our highest capacity single module system

Challenges

Zero Chemicals Added

-No antiscalant

-No pH adjustment

High Influent TDS

Vortex blades reduce interface concentration

Free Chlorine in Influent

De-chlorination maximizes membrane lifespan

Case Study 2

PRELIMINARY RESULTS

Raw FGD

Steam Electric Power Plant
Southeast US

PLANT CAPACITY: **2,600 MW**

GOAL: **Reduce Pond Volume**

FEED: **FGD Holding Pond**

OPERATING MODE: **Single Pass**

PRETREATMENT: **None**

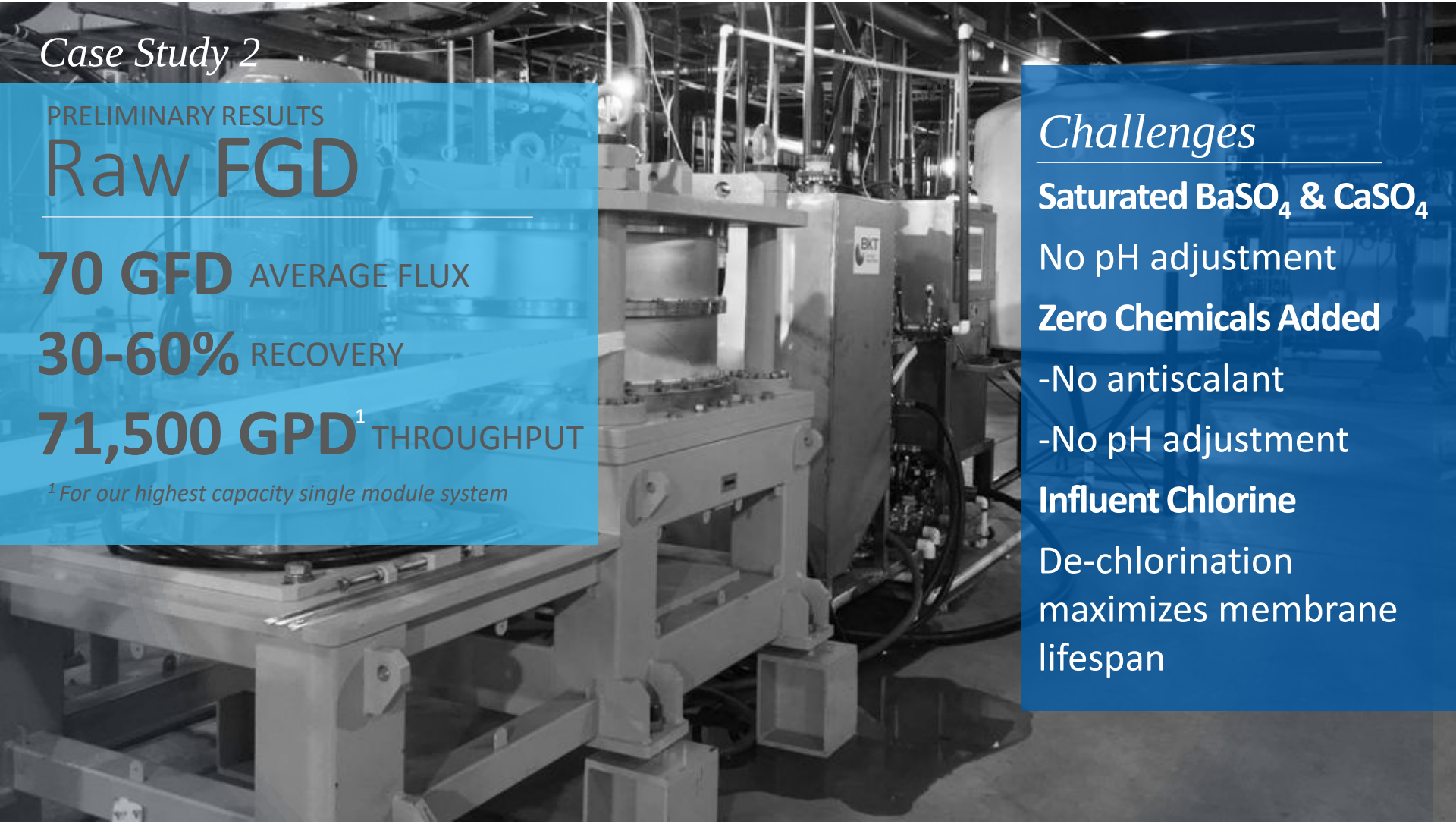
VOLUME TREATED: **110,000 gal**

FMX

PRELIMINARY RESULTS (ONGOING TRIAL)

	UNITS	FEED	**FMX** EFFLUENT	**FMX+RO** EFFLUENT	% REMOVAL
TDS	ppm	3,344	1,661	143	96%
Sulfate[1]	**ppm**	**1,834**	**832**	**6.9**	**99%**
Arsenic	ppb	< 5.5	< 5.5	< 5.5	N/A
Mercury	ppt	225	10	6	97%
Selenium	ppb	1,087	485	7	99%
NO_x -N $_{(aq)}$	ppm	3	2	< 0.5	> 83%

[1] *Main contributor in scale formation*



Case Study 2

PRELIMINARY RESULTS

Raw FGD

70 GFD AVERAGE FLUX

30-60% RECOVERY

71,500 GPD[1] THROUGHPUT

[1] For our highest capacity single module system

Challenges

Saturated $BaSO_4$ & $CaSO_4$

No pH adjustment

Zero Chemicals Added

-No antiscalant

-No pH adjustment

Influent Chlorine

De-chlorination maximizes membrane lifespan

Does it meet **ELG?**

FMX+RO Effluent from both case studies were able to meet and **exceed** EPA BAT targets.

FGD Wastewater Discharge Limits		
BAT Chemical Precipitation + Biological Treatment		
	DAILY MAX	30 DAY AVERAGE
Arsenic	✓	✓
Mercury	✓	✓
Selenium	✓	✓
NO_x -N $_{(aq)}$	✓	✓

BOTTOM LINE

Reliable, Cost-effective *FGD wastewater solution*

→ Volume Reduction
→ Permit Compliance
→ Discharge-Quality
→ Smaller Evaporator
→ Protects RO systems

Reverse Osmosis

- Utilize membrane technology to recover clean water to plant or ELG compliant discharge
- Use raw or concentrated pond water as makeup to dry or wet FGD system

Pond water with larger concentration of chlorides (>100 ppm)

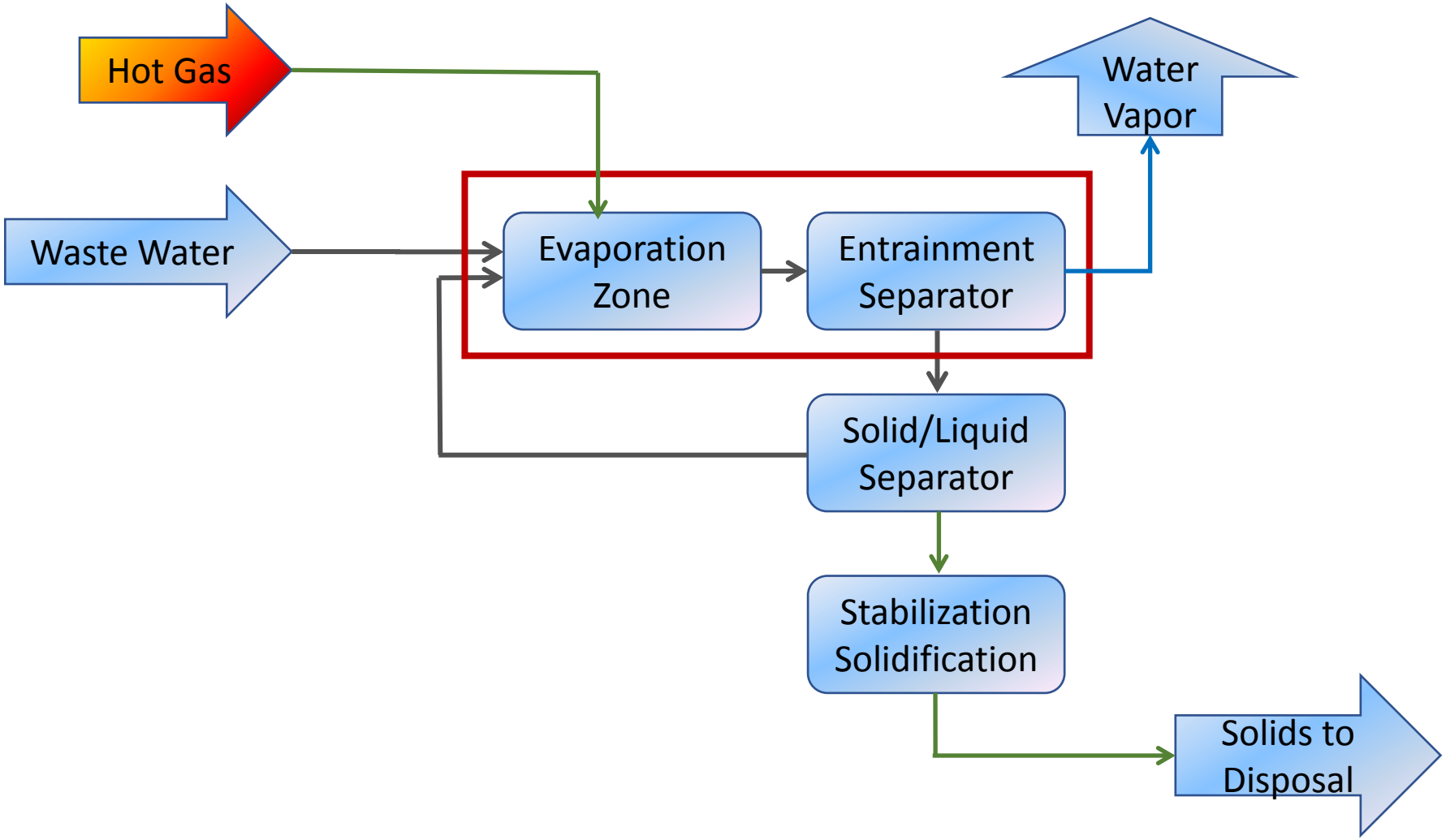
- Utilize membrane technology to recover clean water to plant or FGD system
- Direct concentrated pond water to evaporator system

Direct Contact Evaporation

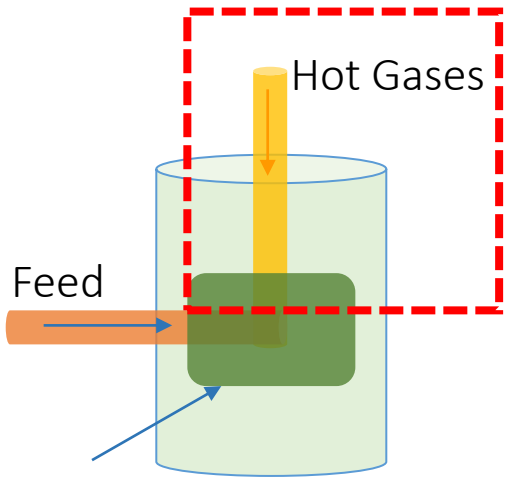
1. Heat Source
2. Concentrator Section
3. Feed and Recirculation
4. Droplet Separator
5. Sump
6. Exhaust

Mobile Test Units Available

Direct Contact Evaporator Process Flow Diagram



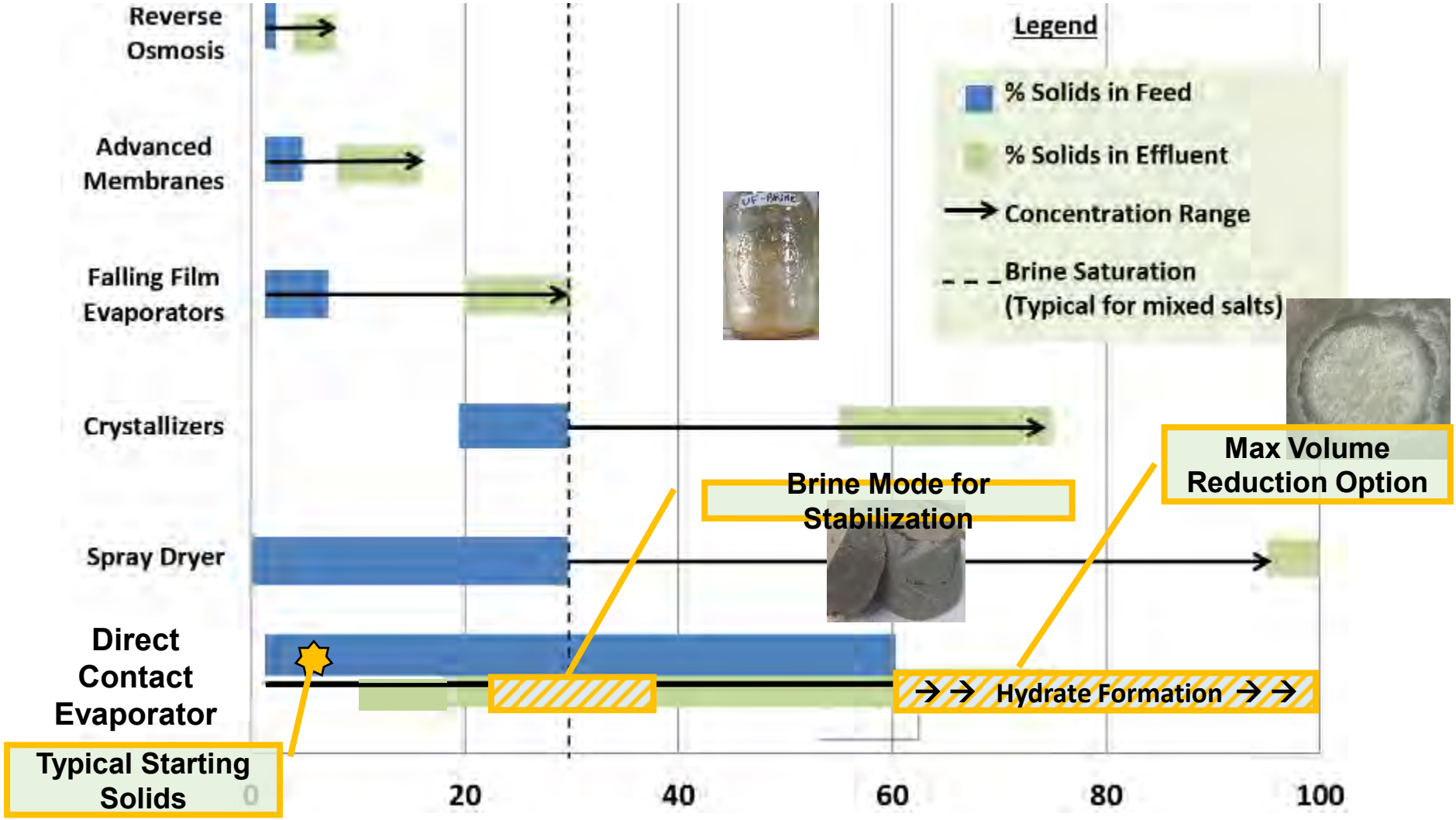
Direct Contact Evaporation vs. Falling Film



Direct Contact
"Concentrator"

- Compact
- No heat exchange surfaces or membranes to foul; low-cost materials
- Direct use of waste heat (exhaust gases) and/or natural gas
- Patented Gas-Liquid Section creates large surface area for rapid evaporation
- Require no pre-treatment
- Simple to operate and maintain

Direct Contact Evaporator Process Flexibility



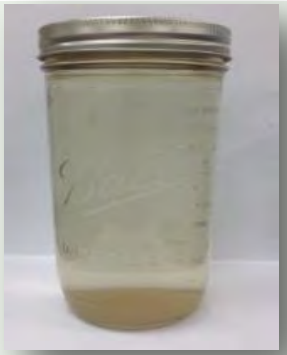
Heartland Water Technology

Power Industry Experience

EPRI Project at Plant Bowen

- FGD wastewater treatment/concentration using flue gas as a waste heat source
- 24/7 study realized 93% availability.
- Integration on operating 900 MW unit successful.
- Fly-ash improved mixing and better solids production
- 97% volume reduction producing solids for disposal passing TCLP

Chemistry Overview – Southern Plant Bowen

	Infeed FGD Purge Water	Process Circulation	Settling Tank Discharge	Secondary Settling
Total Solids	~3.5%	30-40%	**50-60%**	**70-80%**
Total Diss. Solids	~3.5%	30-35%	~10%	<10%
Specific Gravity	1.0	1.2	~1.5	> 1.5
Calcium (mg/L)	~6,500	~55,000	~55,000	N/A
Sodium (mg/L)	~120	>30,000	>20,000	N/A
Chlorides (mg/L)	~15,000	>210,000	>230,000	N/A
Sulfates (mg/L)	~1,000	~350	~300	N/A
				

Heartland Water Technology

Power Industry Experience

EPRI Pilot at Plant Harrison

- Concentrating landfill leachate after pre-concentration in a membrane system
- Project reduced >100,000 gal to <3 totes
- Targeted concentration to 300,000 mg/l achieved then exceeded.
- Unattended operation.

Heartland Water Technology

Power Industry Experience

FGD Project at Midwest Power Plant

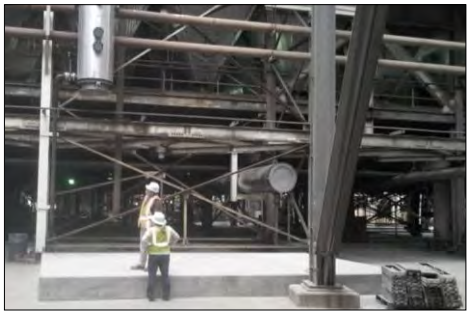
- 2014 Converted pilot plant into fully commissioned commercial unit
- Very high uptime for three years handling all of the FGD wastewater
- Inexpensive capital project
- One of only three Power plant ZLD projects in operation in the U.S.

Thermal Heat Source Flexibility

While economical running on natural gas, Heartland's Concentrator delivers the industry's lowest cost to treat when utilizing unconventional waste heat.

IC Engine Exhaust

Flue Gas



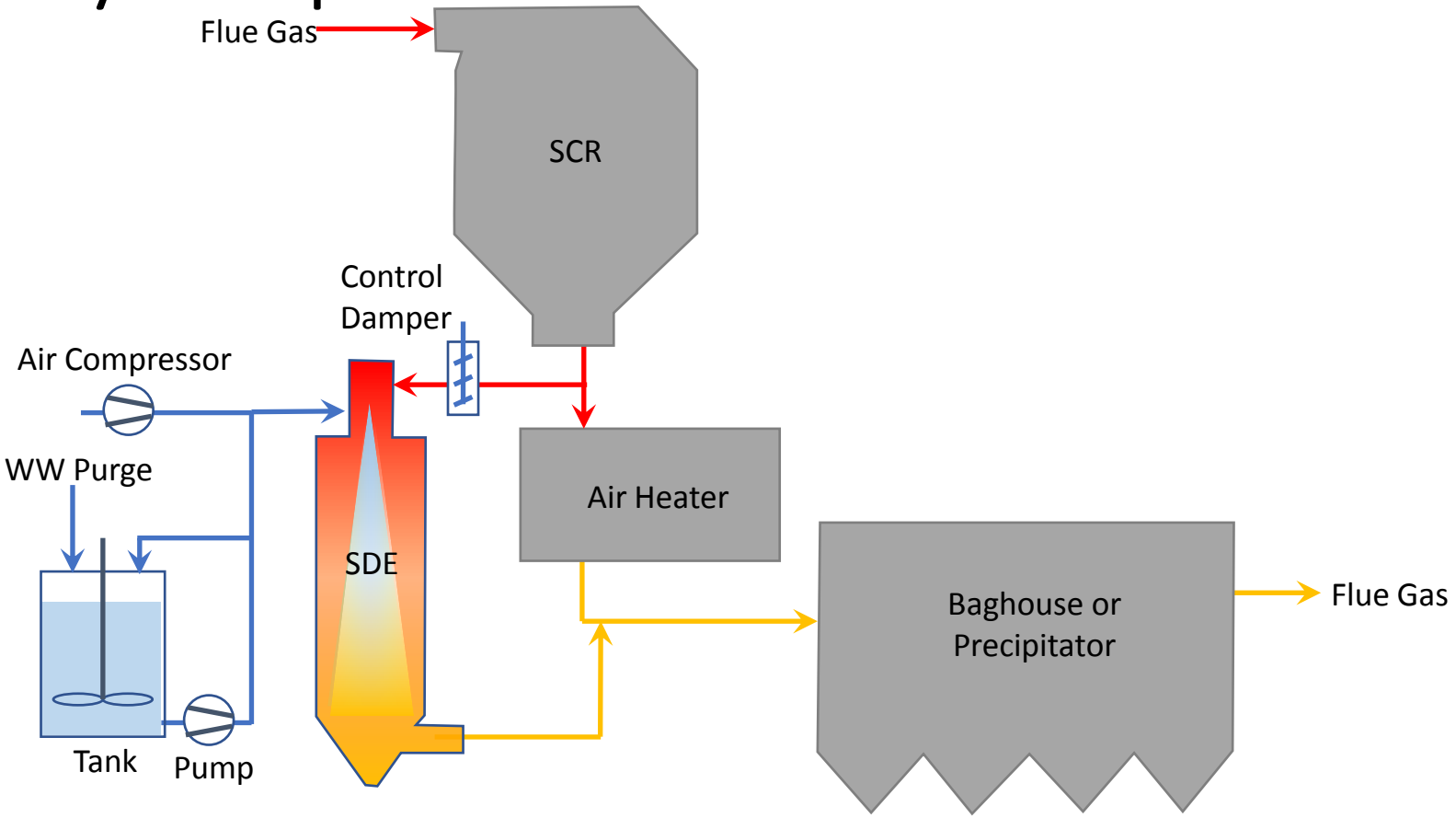
Flare Gas

GT Exhaust

Electric Heater (pilot)

Biogas

Spray Dryer Evaporator



- No water pre-treatment
- Utilizes existing technology
- Flue gas flow independent
- Uses minimal heat

- Does not require additional reagents
- Resulting dry product is easy to handle
- Process approximately 1 gpm/MW to maintain efficiency loss to <2%

Brine Dewatering

- Multiple options for dewatering including:
  - Dewatering tubes
  - Centrifuges
  - Filter presses
- Enhanced stabilization of metals such as selenium
- Producing a solid with improved properties over crystallized salt
- Elimination of a crystallization step

Liner Installation

- Meets CCR Rules
- Wastes are placed inside a geosynthetic lined cell and leachate collection system

GSI Overview

- Distributor, fabricator, and installer of geosynthetic materials for a broad range of applications including landfill sites and coal ash storage
- GSI provides geosynthetic materials, project field support, and installation expertise for containment, dewatering, and erosion control

Geotextile Tubes

GSI Fabricated *GEOSTRUX*™ Geotextile Tubes

- Cost effective and ecologically-friendly process used in a wide variety of projects where dewatering of sediments and industrial wastes is required.
- Applicable for dewatering of contaminated sediments, coal ash,
- Currently engaged in the largest coal ash project to date with 700,000+ cubic yards of coal ash being dredged and dewatered.

Construction Services Liner Installation

GSI is one of the country's largest independent installers of all types of liners.

Jim Dougherty
jdougherty@babcockpower.com
508-854-4013