REINHOLD ENVIRONMENTAL Ltd.

2016 NOx-Combustion-CCR Round Table Presentation

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Zero Liquid Discharge System at Stanton Energy Center

Challenges and Solutions

Presented By

Eric Costello, PE, LEED Green Associate – Orlando Utilities Commission

Dean Ritts, PE, CEM, LEED AP O+M – Ritts Sustainable Engineering, LLC

OUC SEC ZLD Background

- History of OUC and SEC
  - Formed at the turn of the 20th Century
  - Purchased by citizens of Orlando in 1922
  - Authority as electric & water utility in 1923 by State
  - OUC operates as Commission
- Stanton Energy Center 1 and 2 Coal Units
  - Each has a gross rating 460 MW
  - Cycled at night

OUC SEC ZLD Background

- What does it mean to have a ZLD system?
  - No process water leaves the site
  - Managing water is essential to operations
  - Recent trends in unit loads and rainfall
  - ZLD site – integrated water management
  - Complimentary alternatives for CCR

Challenge - What changed?

Over Time from 2003:

- Addition of Combined Cycle Units;
- Change in Fossil fuel mix;
- Significant storm events;

Resulting in:

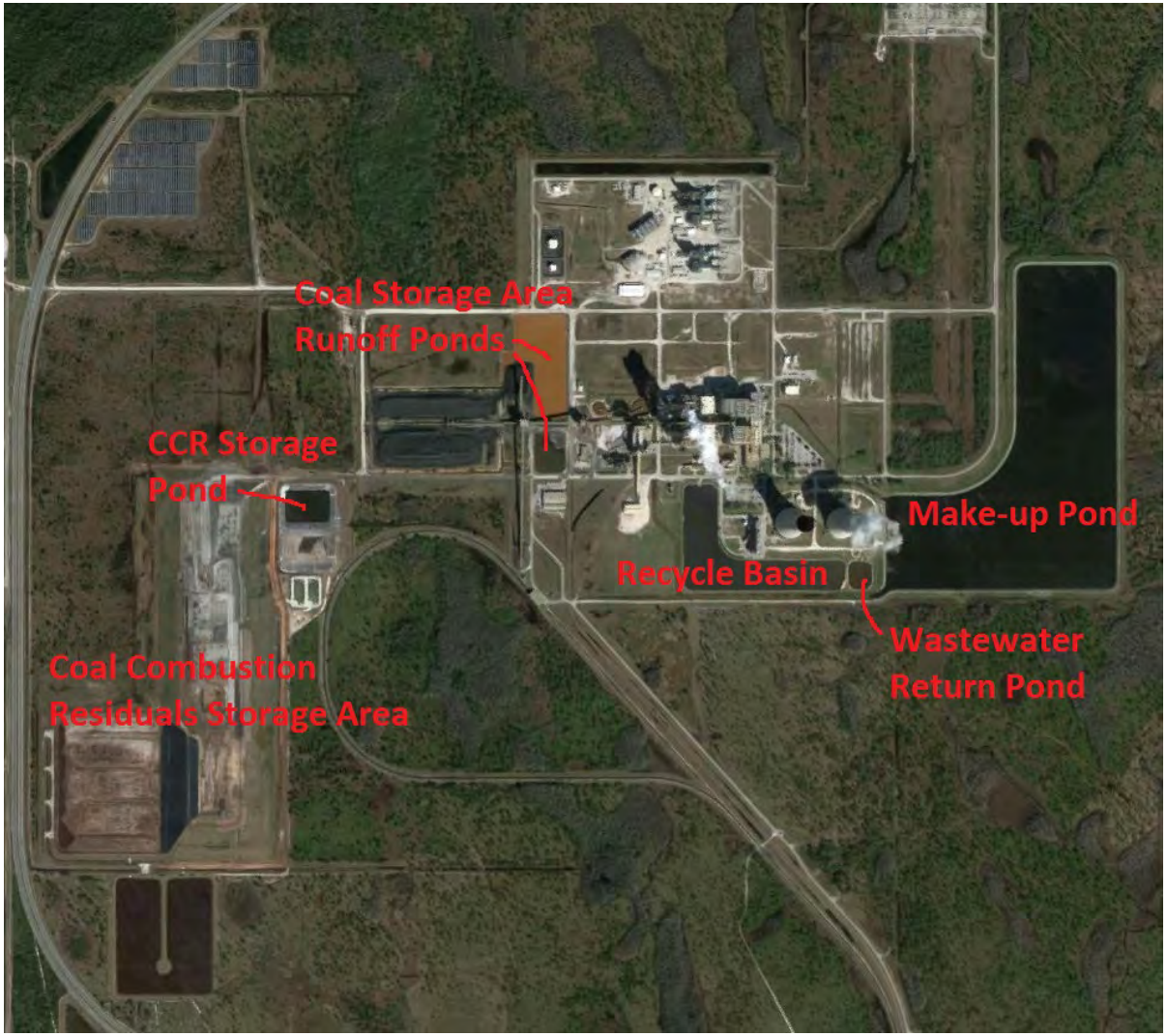
Decreased capacity to cost effectively maintain a zero liquid discharge system when operating cycling coal-fired units

Combined Cycle Units – SEC A and SEC B

OUC SEC ZLD Background

- Main components of the ZLD at SEC?
  - Waste Water Ponds
  - FGD Make-up
  - Brine Plant – mechanical vapor compressor & crystallizer
- Successful ZLD Operation Requires
  - Storage Management
  - Re-use & Recycling

Site Plan – OUC SEC ZLD System



FGD System Evaporation – Full Load

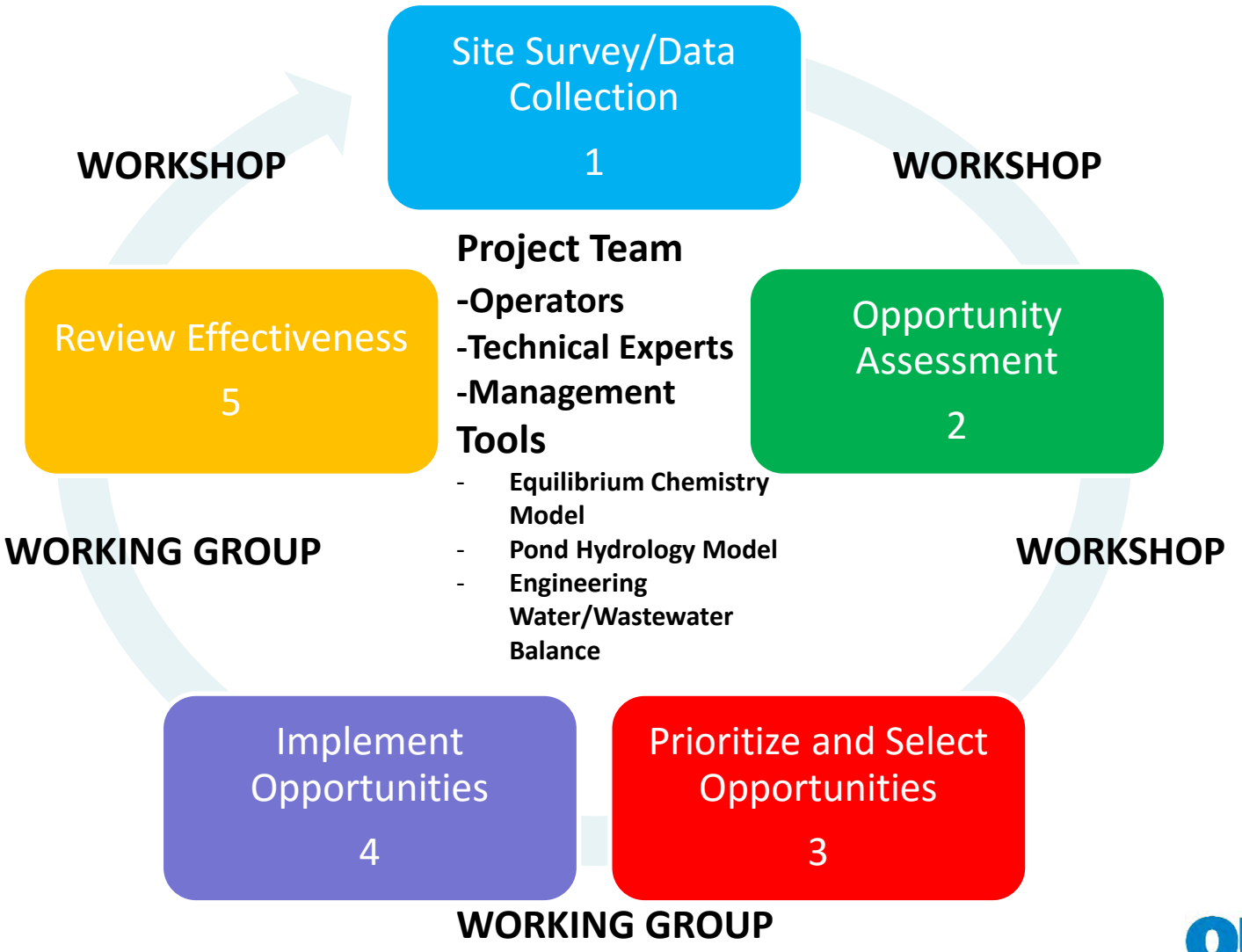
Brine Plant Blowdown SEC 1&2 & SEC A & SEC B

Brine Plant

Solutions needed

- Reduce short term impact of managing water – low cost solutions, maintain zero liquid discharge
- Long term strategy to manage water to maintain ZLD system cost effectively
- Integrate CCR management requirements if possible
- Solution must reflect Engineering, Environment, and Economics
- Process optimization for solids overflow management, Cl control in scrubbers, and stormwater management

Approach – Five Steps to Success



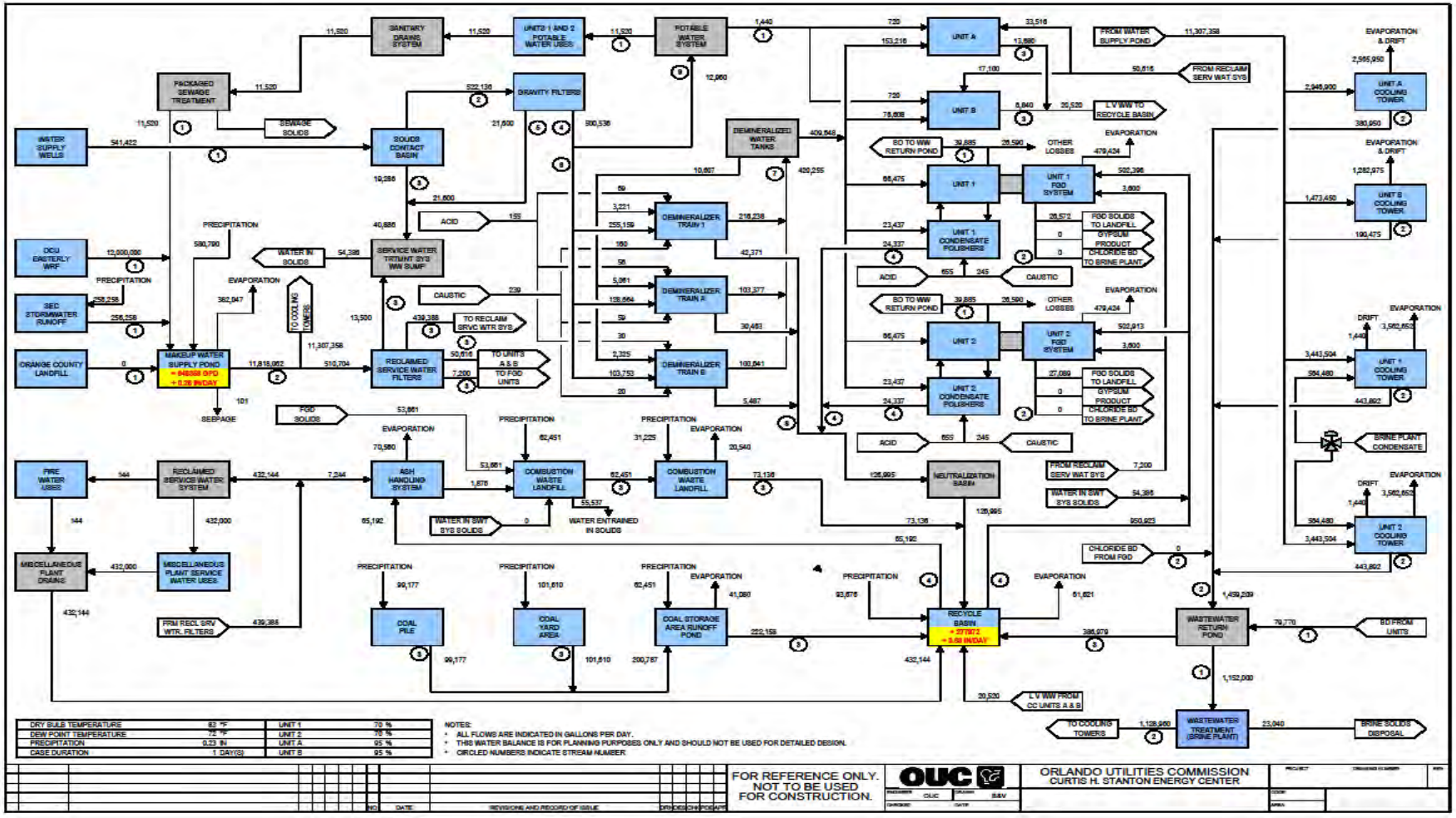
Site Survey - Step 1

- Three day focused site-survey
  - Opening meeting and preliminary review of process and goals
  - “Walk-about” for data collection and interviews with operators
  - Close-out meeting to present survey findings to project team
- Review Data, create tools, develop findings

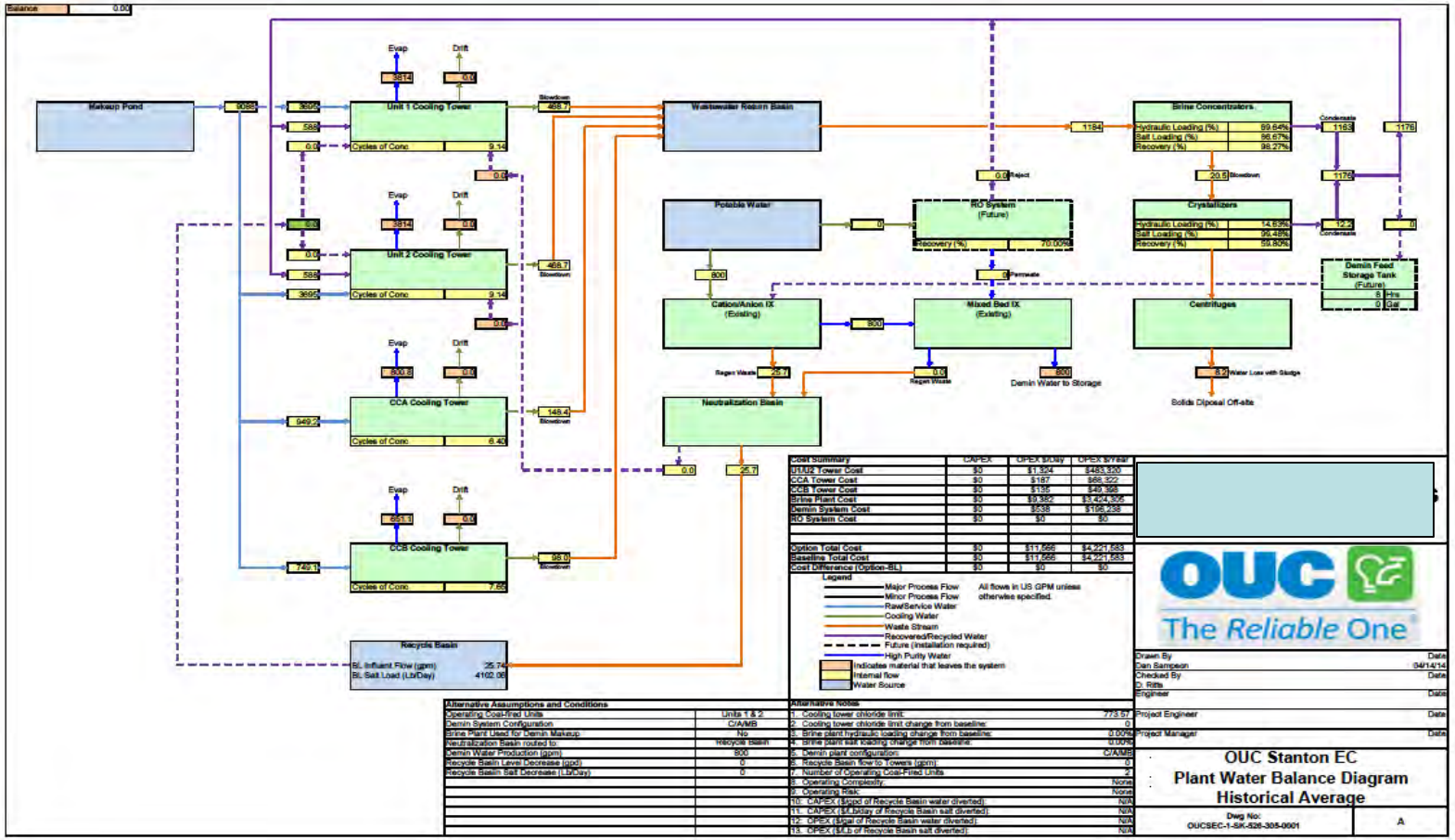
Site Survey Results - Step 1

- Tools Developed from Step 1
  - Engineering Water/Wastewater Balance
  - Equilibrium Chemistry Model for Identified Key Processes (Cooling towers, demineralizers, MVC, etc.)
  - Pond volume flow model – probability of overflow

Engineering Water/wastewater Balance



Equilibrium Chemistry Model for Key Processes



Site Survey Results (continued)

- Major Findings
  - Developed “magic number” of wastewater volume that ideally should be diverted or removed from the Recycle Basin pond every day to allow ZLD to operate efficiently when one FGD is operating: ~ 475,000 gpd
  - Understanding of impact of storm events on recycle basin and ability of one FGD system to keep up: 1 yr. storm event can add 9.1 MG of water to recycle basin
  - Large dischargers and large users of water – including “one-offs” like outages (i.e., boiler flush)

Site Survey Results (continued)

- Major Findings
  - Better understanding of water/wastewater chemistry
  - Collection of operators concerns and observations and their solutions
  - Impact of CCR management and need to reduce solids overflow from scrubbers, coal pile runoff, and solids management pad

Solids Management Pad

Opportunities Assessment & Prioritization – Steps 2 and 3

Develop & Prioritize Alternatives to Reduce Water and Chemistry Load on Recycle Basin

Based on:

- Technical Feasibility
- Impact on problem
- Operational Feasibility
- Cost – CapEx/OpEx
- Impact on Pond Volumes and Probability of Overflow

- Workshops to discuss, select and prioritize
- Spreadsheet approach to catalogue opportunities

Opportunities Assessment Table

DRAFT

Table 1 - Improvement Options Evaluation of Zero Liquids Discharge System
Orlando Utilities Commission

DRAFT

Preferred Option
Second Option
Third Option
Least Feasible Option
Not Feasible

Note: Costs provided are preliminary (conceptual estimates and +/- 30 %.

	OPTION	1	2	3	4	5	6	7	8	9	10	11
	Type of Solution	Chemical	Civil/Mechanical	Civil	Mechanical/Chemical	Civil/Mechanical	Water Treatment	Civil	Civil	Civil/Process	Water Treatment	Water Treatment
Option Information	Description	*Use Recycle Basin Water to blend with Cooling Tower Make-Up Water - Maximize brine plant utilization in terms of chemistry and flow (send excess recycle basin water to brine plant via cooling towers)*	*Pump recycle basin water to increase working storage capacity*	*New recycle pond construction*	*Vacuum filter exhauster and seal water for vacuum filter/filtrate pump re-use or reduction*	*Reduce contact water and process water volume to recycle basin*	*Improve operation of scrubber clarifiers*	*Roof over ash handling area*	*Maximize use of leachate pond water for wetting ash*	*Increase moisture content of ash*	*RO on recycle basin to maximize TDS (e.g., VSEP) and send to cooling towers - size to handle 600,000 gpd*	*Treatment plant (RO and biological) to pre-treat FGD chloride bleed and excess recycle basin water to be further treated in ZLD system (Brine plant)*
	Solution Length (short-term, long-term)	Short-Term and Long-Term	Long-Term	Long-Term	Short term	Short-Term	Short term	long-term	Short Term	Short-term	Long-Term	Long-Term
	Additional Information on Option	Based on model, Brine Plant has enough water and chemistry capacity to enable 80 gpm of Recycle Basin Water to be blended with cooling tower make-up water, with minimal process change. Careful monitoring required as high Mg in recycle basin may impact brine plant precipitating chemistry.	Increase working volume of recycle basin by pumping from a deeper depth. Current limit is 75.5 ft because of pond level and overflow relationship to keep solids out of system. At 75.5 feet the pumps are starved of water.	Adding 8 acre pond, with working storage capacity of 1,280MG.	Water from this system is discharged to the thickener and ultimately to recycle basin. At Rowe Plants, this water is often re-used for other purposes. It is generally clean service water. Also, replace seals on pumps to reduce the amount of water generated.	Discussions with OUC indicate that this approach has been maximized with regards to rainwater becoming contact water except for covering the ash handling area.	Clarifier Overflow to the Recycle Basin occurs daily. This increases solids load and TDS load into the Recycle Basin. The increased loading to the recycle basin impacts the storage capacity of the basin and impacts the types and costs of water re-use alternatives for Recycle basin water.	Reduces amount of contact water generated if stormwater is diverted to non-contact water ditch. 57,000 gal/inch of rainfall	Hold water in leachate pond for use to maintain low volume in leachate pond and limit amount that flows to Recycle basin	Separate chloride bleed and use for ash wetting	Re-use as cooling tower water or service water; need to run treatability tests	Re-use as cooling tower water or service water
		Based on model, Brine Plant has enough water and chemistry capacity to enable more than 150 gpm of Recycle Basin Water to be blended with cooling tower make-up water, with proper cooling tower water chemistry monitoring and control. Cooling water chemistry control would remain as is. Cycles of concentration would lower slightly, but cooling tower chemistry would remain essentially unchanged. More blowdown would be sent to the brine plant, but with the same salt content.	One foot would be significant adding 4 MG storage. More, if new recycle basin is constructed. 2.5 feet would provide much better protection from overflows and reduce coal unit operation.	When operated to maximize 1.5 ft. freeboard this will provide sufficient capacity to reduce need to run coal units by as much as 57%. When operated in conjunction with new ash landfill pond this increases to 92%.	Need to identify water users at power plant and then convey the water to that location (i.e., cooling towers).	Pump coal pile runoff water back to coal pile for dust control	Evaluate clarifier operation and identify root cause of process upsets and seek corrections.	Reduces amount of contact water generated if ash handling area wash downs are controlled and minimal contact water is generated.	maximum 20,000 gpd	Identify high TDS flows and use for Ash wetting	Second pass RO reject will be concentrated and this stream (75 gpm, 108,000 gpd) will have to be managed. This should not go back to the recycle basin will start concentrating the salts. needs to be disposed of or used in other applications such as Ash wetting or at the top of the makeup pond.	Will generate a biosolids and inorganic solid that needs dewatering and landfilling
		Requires piping, pumps, and instruments to deliver recycle basin water to cooling tower and then mix in. Either a mixing tank or add directly to cooling tower basin. Could divert 80 gpm with no significant impact on tower chemistry. Could divert 150 gpm if cooling tower TDS is increased by about 30%. Specialty chemical supplier (Nalco) has reviewed this approach and agrees with our assessment indicates that the current chemical treatment program will work without modification.		Need to maintain working capacity and prevent solids accumulation.		Evaluate the contribution from miscellaneous process waters estimated at 432,000 gpd				Use wet solids for ash wetting	Review difficulty of delivering pern-waste to cooling towers	Will probably need food source for SRR since BOD load is low and when unit runs just on recycle basin water flows not enough to support unit biomass
		Review Process Models for additional detail on chloride impact, etc...				Conduct Power Plant Water/wastewater engineering investigation to seek opportunities				Moisture content of ash is reported as 25% which indicates that there may not be much more room for this option.	RO system (e.g. VSEP) needs softening and acid. Yes2.	Option fully developed in previous study provided to OUC
										Focus is on "free-hanging fruit".	Change in coal will impact treatment system performance	Change in coal will greatly impact treatment system performance
Flow	Volume Diverted Away from Recycle Basin (gpm)	80-150	0	Not Applicable	80 gpm maybe more	Assume 20% reductions is possible - 61 gpm	TBD	57,000 gal/in rain		Variable	417	350
	Volume Diverted Away from Recycle Basin (gpd)	115200-216000	0	6,240,000	115,200	90720	TBD	Depends on size of storm events	20000	Variable	600,000	432,000
	% of Recycle basin Volume of concern[1]	1.15%-2.16%	40 to 100% depending on capacity added.	62%	1%	1%	TBD	1 to 20% or more based on storm size	<1%	Variable	6.00%	4.32%
	Associated Riverate	80-150	0	Not Applicable	80 gpm maybe more	61 gpm	TBD	variable based on storms	Not Applicable	Variable	600,000 gpd	300 gpm total: 100 gpm chloride bleed from fgd scrubber and 200 gpm from recycle basin
	Expected reduction of water draw from OUC Wastewater Plant	115200-216000	0	Not Applicable	80 gpm maybe more	61 gpm	No	could be 1 to 5 MG per year	Not Applicable	Variable	600,000 gpd	600,000 gpd
Stream Information	Description of Diverted Water Stream (TSS, Hardness, Cl, Fe, etc..)	Recycle Basin Water has high TDS, Cl, Mg, etc... as described in Report. This approach would remove high TDS from Recycle Basin; possibly making room in Basin for other chemistry or flows.	Not Applicable	TSS, TDS, Fe, Cl and other constituents of ash handling	low TDS, TSS, mainly service water	variable	Similar to FGD blowdown and clarifier solids	Contact water with ash compounds (TSS, TDS, cl, Mg, metals)	Yes, high TDS, metals	Variable	High TSS, TDS, Cl, Fe, and some metals; little organic load	See Report; chloride bleed from FGD scrubber is very high TDS; recycle basin slightly less
	Solids Diversion	Not Applicable	Not Applicable	Possibly, depending on design and operation. Design intent is to allow solids settling and routine clean-out.	no	variable	Yes	Yes, some ash diverted from pond	Not Applicable	Variable	Not applicable	No

Dean Ritz

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Opportunities Selected for Detailed Study

- Opportunities prioritized by project team in to three categories, high, medium, low
- Fall into four main technical categories:
  - Operational change
  - Mechanical change
    - $10,000 capital/gpm forwarding system
  - Chemical change
  - Civil change
  - combinations

Opportunities Selected for Detailed Study

- Re-route demineralizer wastewater to cooling towers – 26 gpm
- Boiler blowdown to cooling towers – 150 gpm
- Seal pump water – 40 gpm
- RO Regen or replace demineralizer with RO – 150,000 gpd
- Reduce Contact water & misc. drains – 300 gpm
- Brine plant capacity available to treat cooling tower and recycle basin – 200 gpm

Opportunities Around FGD Operation

- Importance of FGD Operation Efficiency
- FGD water balance becomes positive (more makeup than needed) at low load
  - Results in low density and high liquid level in absorbers
  - Increased flow to thickeners. Result in overflow of thickener return water tanks

Opportunities Around FGD Operation

- Revise mist eliminator wash logic to adjust wash frequency based on unit load
- Reduce amount of runoff in CCR stack-out areas
- Reduce seal water to recycle pumps
- Chloride bleed system

ZLD & CCR Management Interface

- Solids Management is critical – keep solids out of recycle basin to:
  - Maintain storage volume
  - Reduce metals and salts in recycle basin increasing opportunities to re-use water around plant
- Considered
  - Conveyor CCR to landfill
  - Rain Cover Over Sludge Area – reduce contact water
  - Pump CCR to landfill

Implementing Opportunities –Step 4

- Implementing Opportunities is a Reiterative and Collaborative Process
- Key Lessons Learned:
  1) Importance of Working Groups to Process
  2) Continue to review data and question assumptions: it yields new opportunities
  3) Don’t throw away opportunities

Economics of Implementing Opportunities

- Risk/reward
- Economics
  - $/gal for treating with brine plant
  - $ to investigate sending small amount to cooling towers – pilot study went from expected 100k to $1M to avoid risk to brine plant and condensate tubes cooling towers
  - $/gallon for treating with RO system on site

Temporary Measures – RO at Recycle Basin

Results Review and Status – Step 5

- Adjust the plan as needed – blend recycle basin water option for example – considered later
- Flow meters will be installed
- Training and follow-up

Next Steps

- New Recycle Pond Construction
- Boiler Blowdown Forwarding System
- Vacuum filter exhauster and vacuum filter filtrate pump re-use
- Neutralization Basin water re-use – pump back to Unit 1 or Unit 2 cooling tower basin

Neutralization Basin

Conclusions

- Five Step Approach to develop a long term strategy to manage water to maintain ZLD system cost effectively
  - Survey, Opportunities Assessment, Prioritize, Implement, Review Effectiveness
- Integrate CCR management requirements if possible
- Solution must reflect Engineering, Environment, and Economics
- Some of best solutions come from process optimization

Discussion