Use of Reclaimed Wastewater in District Cooling and Power Generation

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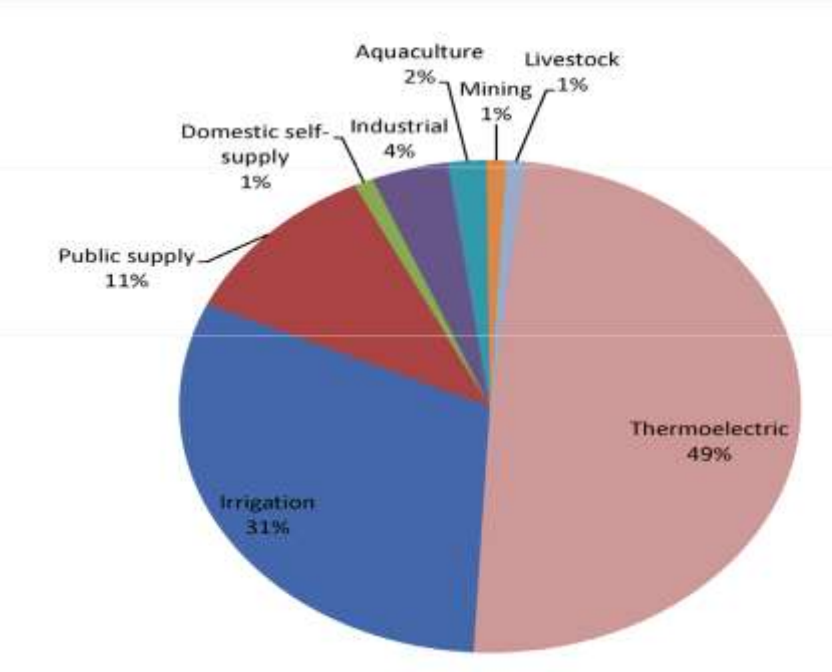
U.S. WATER
The future of water

Presentation Outline

- Introduction
- Reclaim Water Quality
- Reclaim Water Considerations
- Case Study
  - University Central Utility Plant
- Conclusions

Introduction

- Fresh Water Demand Increasing
  - Population
  - Food Production
- Thermoelectric Power = 49% U.S. Demand



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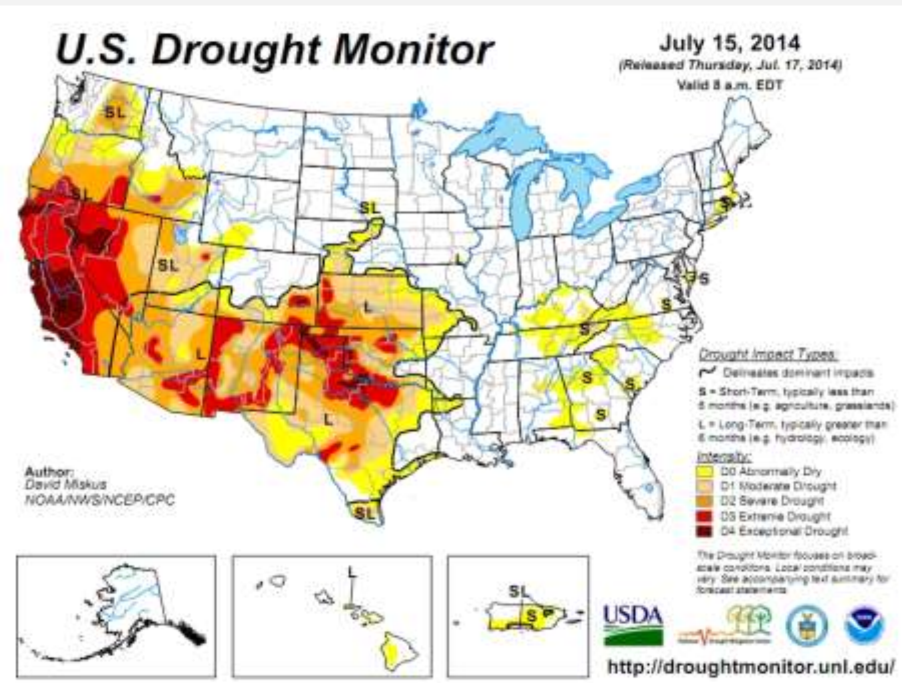
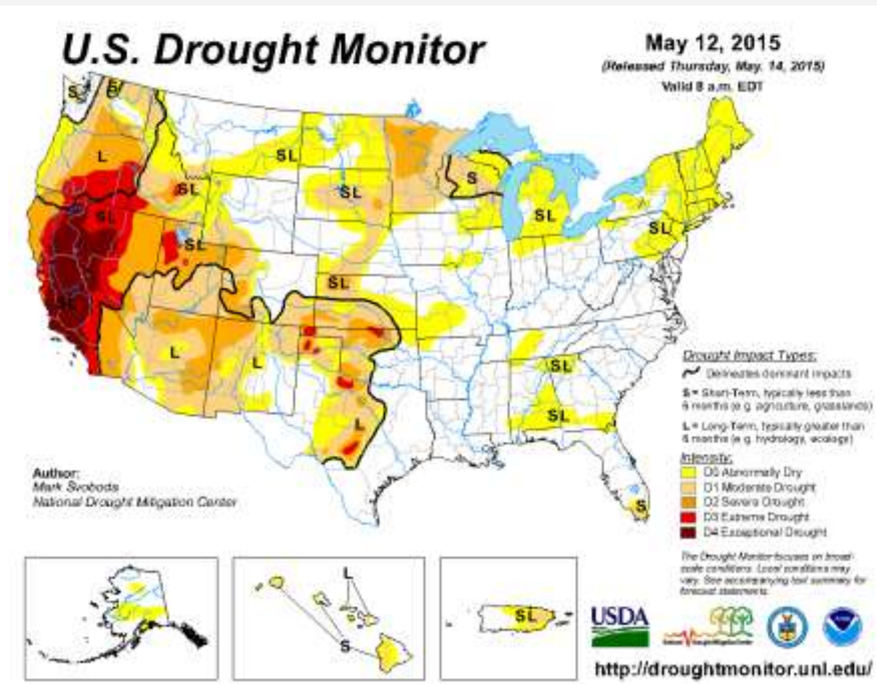
Introduction

- Regional Water Shortages





Introduction

- Water Shortages Highlight Need For Sustainable Alternatives
  - Quantity
  - Quality
  - Regulation
  - Cost
- ASME/WEF Identify Municipal Reclaim Water as Power Generation Alternative

Reclaim Water Quality

	Large Municipal	Small Municipal
Flow (MGD)	189 - 358	0.02 - 21
*Suspended Solid (mg/l)	30 - 69	1 - 40
*BOD (mg/l)	69 - 105	NA - 62
*O & G (mg/l)	10 - 17	0.5 - 28
*Ammonia - N (mg/l)	24 - 30	0.23 - 36
*Phosphate- P (mg/l)	NA - 4	NA - 5
Turbidity (NTU)	22 -51	0.9 - 47

Reclaim Water Considerations

Parameter	Concern	Issue
Ammonia- N	Nutrient, Yellow (Cu) Metal, Halogen	Bio-growth, Fouling, SCC
BOD	Food Source	Bio-growth, Fouling, MIC
*Chloride - Cl	Stainless Steel	SCC
Phosphate - P	Nutrient, Hardness	Bio-growth, Fouling, Scaling
Regulations	Compliance	State Control
Variability	Diurnal, Seasonal Changes	Program Control

Reclaim Water Considerations

Ammonia Level Limits For Cu Alloys*

Alloy	Max NH_3 (mg/l)
Cu	None
Cu/Zn (Admiralty)	None
Cu/Ni (90/10)	10
Cu/Ni (70/30	20

Suggested Chloride Limits For SS*

	Chlorides as Cl^- (mg/l)	
Metal Alloy	80º F	140º F
304	200	150
304-L	300	200
316	600	400
316-L	1,000	800
317	1,200	1,000

*Puckorius, 2014

Regulations

Category	Subcategory	# States Regulate
Urban Reuse	Unrestricted	32
Urban Reuse	Restricted	40
Agricultural Reuse	Food Crops	27
Agricultural Reuse	Processed Food Crops	43
Impoundments	Unrestricted	13
Impoundments	Restricted	17
Environmental Reuse		17
Industrial Reuse	Includes Power	31
Groundwater Recharge	Non-potable	16

Municipal Reclaimed Wastewater Case Study

University of Texas - Austin

University of Texas - Austin

- Over 50,000 students
- >160 buildings
- 17 million square feet of space
- Produce 345 million kWH annually
- 4 chilling stations
  - 45,000 ton capacity currently
  - >145,000 operating ton hours
  - Chilled water volume >5.5 mm gallons (4mm in TES)

UT Water Use

- Texas under moderate to severe drought
- UT cooling water make-up for power generation and chilled water production is ≈ 350mm gpy
- Chilling Station water use ≈ 245mm gpy
- City water costs: $13.45/1,000 gal water and sewer
  - $5.22 water
  - $8.23 sewer
- City of Austin offering wastewater reclaim at a cost of $1.50/1,000 gal

*Fiscal year 2013

UT Chill Station 5

- Decision made to bring reclaim water to the campus for use
  - Required installation of pipe to campus
  - CS 5 was chosen for proximity and load
- Estimates of savings:
  - Replace 60 – 80 mm gallons treated potable water with City reclaim wastewater
  - Savings of $3.72/1,000 gallons
  - $220,000 - $297,000 potential dollar savings

UT Chill Station 5

- 13,000 tons
- 3 York OM centrifugal chillers. 1, 5 ton and 2, 4 ton.
- Cooling tower volume 170,000 gallons.

Reclaim Water Quality

	City Water	Reclaim Water
pH	9.3	7.3
TDS (µmhos)	330	900
TAlk (as CaCO3), ppm	56	60 – 90
TH (as $CaCO_3$)*,ppm	98	100 – 250
CaH (as CaCO3), ppm	29	100 – 135
MgH (as CaCO3), ppm	69	100 – 140
Ortho phosphate (as PO4)*, ppm	1.5	5 – 15
Silica (as SiO2), ppm	6	9.5
Chloride (as Cl)*, ppm	48	110 – 150
Sulfate (as SO4)*, ppm	31	120 – 170
TOC (ppm as C)*, ppm	2.5	5 – 50

Water Treatment Challenges

- High TOC increases potential for biofilm related issues.
- High TH, o-PO_4 levels increase deposit potential.
- High Cl and SO_4 levels increase potential for localized corrosion.
- Off-line condensers subject to solids precipitation and subsequent fouling/corrosion.
- Off-line equipment susceptible to MIC due to TOC.

Water Treatment Program

- Minimize issues in off-line condensers
  - Pumps activated at full flow 2-4 hours, 3 days per week
  - Reduces settling of solids, introduces microbicide and fresh inhibitor
- Custom polymer blend to tolerate stresses of high hardness and $PO_{4.}$
- To reduce corrosion potential
  - Condenser water boxes and tube sheets were coated
- Acid pH control to minimize $CaCO_3$, $MgSiO_3$ and extend PO_4 solubility.
- Robust biofilm control program implemented
  - Chlorine is continuously fed based on ORP.
  - ClO_2 is fed in timed additions several times a week for additional biofilm control.
  - Non-oxidizing microbicide fed weekly.

CS 5 Condenser Water

Parameter	Typical Operating Condition
pH	7.0 – 7.3
TDS (µmhos)	3,990
TAlk (as CaCO3), ppm	40–50
TH (as $CaCO_3$), ppm	800-1000
CaH (as CaCO3), ppm	400-500
MgH (as CaCO3), ppm	400-600
o-Phosphate (as PO4), ppm	40–50
Chloride (as Cl), ppm	450-650
Sulfate (as SO4), ppm	800-1000

Program Monitoring

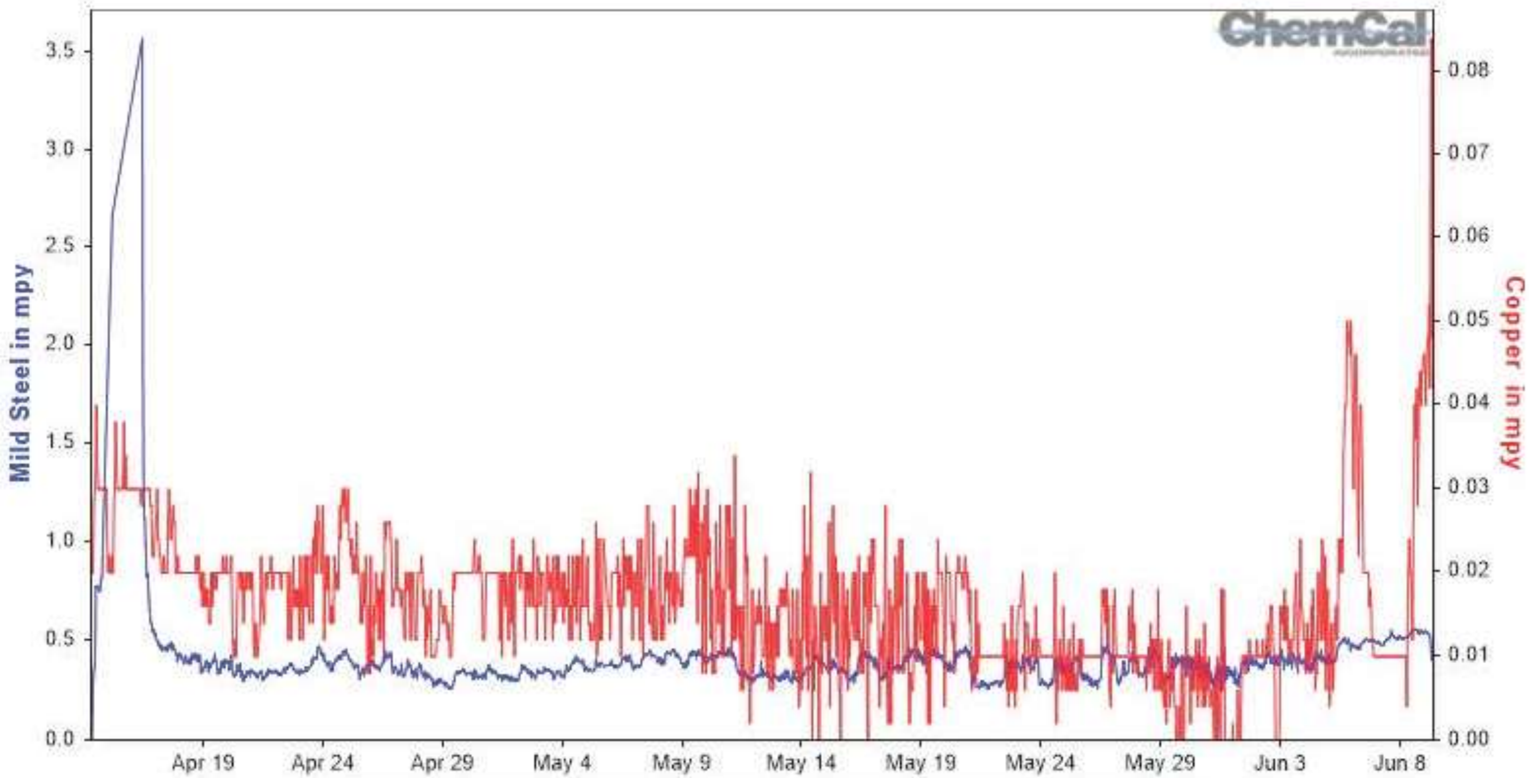
- Up-to-date feed and control equipment
  - Parameters constantly measured and controlled
  - Information outputted directly to web-based data management program
- Corrosion rates continuously monitored using LPR probes
- MB activity monitored using both culture and ATP

Deposition Monitoring

- DATS deposition monitor continuously measures heat transfer efficiency.
- Heat exchanger surface temperatures are set at 10°F over operating condensers to provide early warning of issues.

Performance - Corrosion

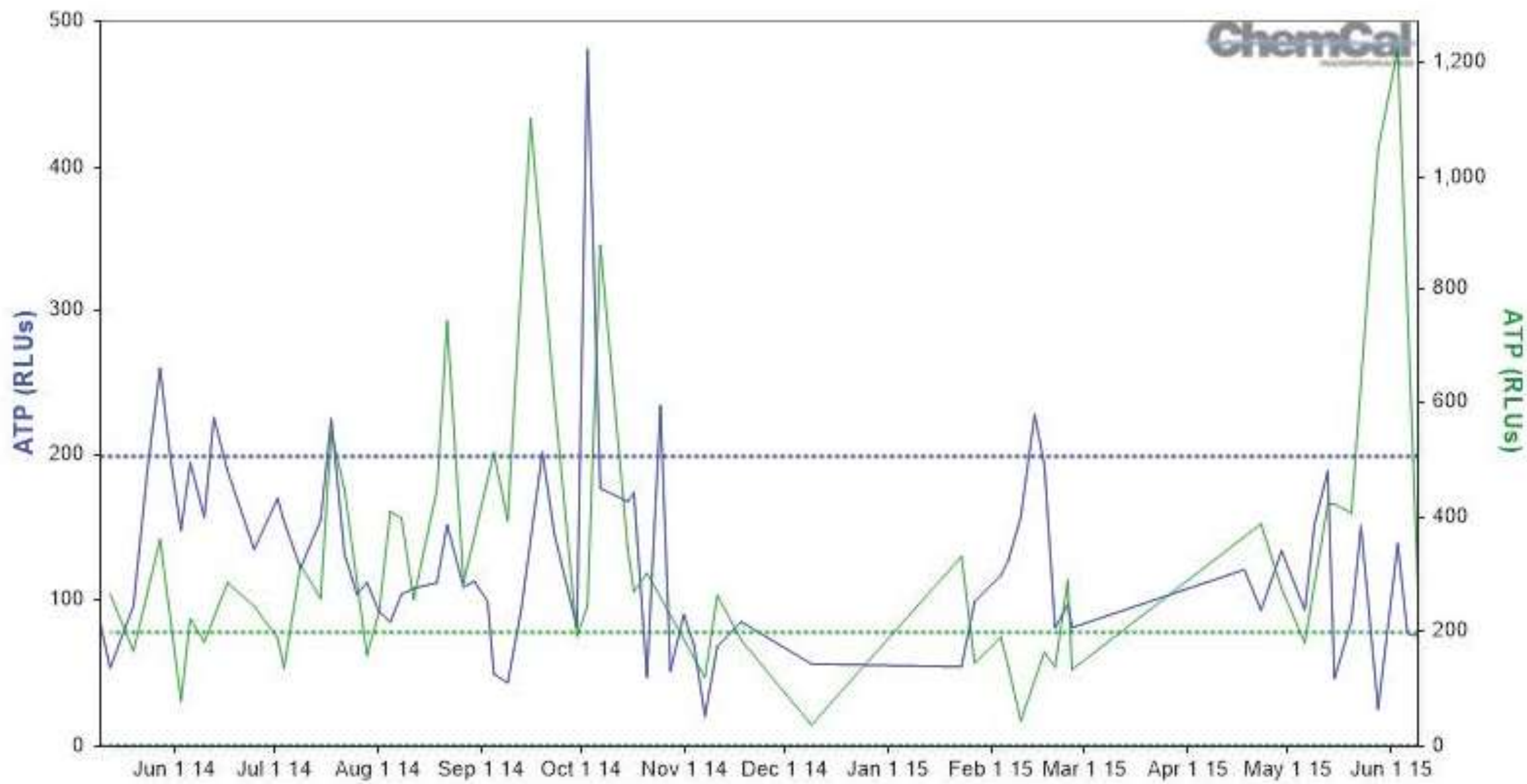
University of Texas at Austin
Utilities and Energy Management - Campus → Chill Stations → Chill Stations



Type	Component	Test Name	Avg	# Days	# Tests	# High	# Low	% in Range
	Chill Station 5	Mild Steel	0.4	62	7,812	-	-	-
	Chill Station 5	Copper	0.02	62	8,035	-	-	-

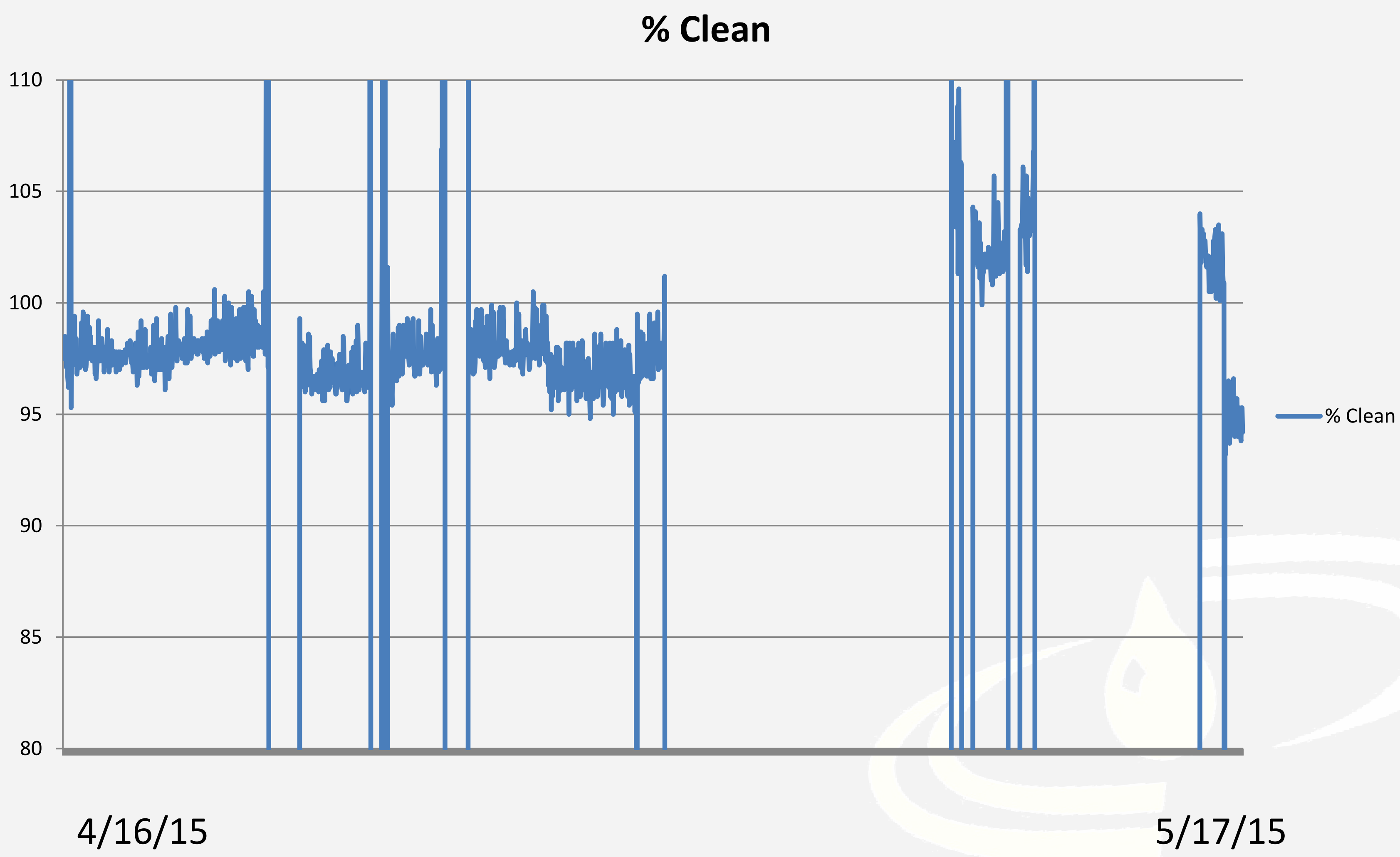
Performance MB Control - ATP

University of Texas at Austin
Utilities and Energy Management - Campus → Chill Stations → Chill Stations



Type	Component	Test Name	Avg	# Days	# Tests	# High	# Low	% in Range
	Chill Station 5	ATP (RLUs)	127	397	72	7	0	90.28%
	CS5 Purple Water	ATP (RLUs)	342	397	55	37	0	32.73%

Performance - Deposition



Performance Summary

- Current results are promising
  - After almost 2 years there have been no deposition or corrosion related issues
  - Inspections of CS 5 chillers have not revealed deposition or corrosion issues
  - Some localized corrosion has occurred where the epoxy coating may have been compromised
- The system has been up and down over the time period so steady state not yet achieved
- UT currently building a new 15,000 ton chilling station
  - Will use reclaim water for cooling tower make-up

Conclusions

- Municipal Reclaim Water Can Successfully Replace Potable Water in District Energy/Power Applications
- Reclaim Water Analyses Over Extended Time Frames
  - Capture Diurnal and Seasonal Variability
- Identify Critical Parameters From Each Source Unique to Reclaim Water
  - Cl
  - PO_4
  - NH_3
  - TOC
  - TSS
- Evaluate Options to Address (Design, Materials, Chemical, Operational)
  - System Metallurgy/Materials of Construction
  - Low Fouling Tower Fill
  - Coatings
  - Operational Control Limits
  - Chemical Treatment
  - Pretreatment/Selective Removal
- Utilize Monitoring and Control Technology

Thank You

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QUESTIONS?

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