De-Carbonizing the Campus: Planning, Tools & Technologies

CampusEnergy2023

February 27 – March 2, 2023

Gaylord Texan Resort & Convention Center | Grapevine, Texas

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

National Institutes of Health
Turning Discovery Into Health

Novel Water Treatment Optimization Technologies Implemented in NIH Central Utility Plant

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Division of Technical Resources
National Institutes of Health

The formulae $\frac{\partial \rho U_i}{\partial t}+\frac{\partial}{\partial x_j}(\rho U_j U_i)=-\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial U_i}{\partial x_j}\right)+g_i(\rho-\rho_0)$ $\frac{\partial \rho U_i E}{\partial t}=\frac{\partial}{\partial x_i}\left(\left(\mu+\frac{\mu_T}{\sigma_\varepsilon}\right)\frac{\partial E}{\partial x_i}\right)+P+G-\rho\varepsilon$ *for building* $\frac{\partial \rho U_i E}{\partial t}=\frac{\partial}{\partial x_i}\left(\left(\mu+\frac{\mu_T}{\sigma_\varepsilon}\right)\frac{\partial E}{\partial x_i}\right)+(C_1-C_{1RNG})\frac{\varepsilon}{k}(P+C_3G)-C_2\rho\frac{\varepsilon^2}{k}$ $\frac{\partial}{\partial t}(\rho U_i U_j)=\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial U_i}{\partial x_j}-\rho\overline{u_i u_j}\right)+g_i(\rho-\rho_0)$ $\frac{\partial \rho U_i E}{\partial t}=\frac{\partial}{\partial x_i}\left(\left(\mu+\frac{\mu_T}{\sigma_\varepsilon}\right)\frac{\partial E}{\partial x_i}\right)+C_1\frac{\varepsilon}{k}(P+C_3G)-C_2\rho\frac{\varepsilon^2}{k}$ $-\rho\overline{u_i u_j}=\mu_T\left(\frac{\partial U_i}{\partial x_j}+\frac{\partial U_j}{\partial x_i}\right)-\frac{1}{3}\rho k\delta_{ij}$ *state of the art* $\frac{\partial}{\partial x_j}(\rho U_i U_j)=\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial U_i}{\partial x_j}-\rho\overline{u_i u_j}\right)+g_i(\rho-\rho_0)$ $\frac{\partial \rho U_i E}{\partial t}=\frac{\partial}{\partial x_i}\left(\left(\mu+\frac{\mu_T}{\sigma_\varepsilon}\right)\frac{\partial E}{\partial x_i}\right)+C_1\frac{\varepsilon}{k}(P+C_3G)-C_2\rho\frac{\varepsilon^2}{k}$ *biomedical research facilities.*

NIH and What We Do

A federal government agency

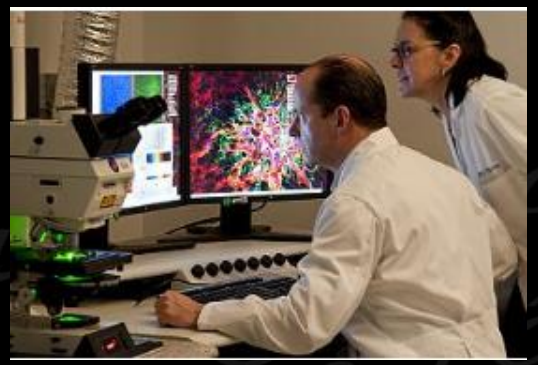
Annual research funding ~ $37 billion

27 biomedical research institutes

75 buildings over 300 acres

Total building area~12 million sqft

Houses a world-class 240-bed research hospital



NIH Central Utility Plant (CUP) Overview

One of the largest CUPs under one roof in the USA

Provides campus with chilled water, steam, electricity, and compressed air

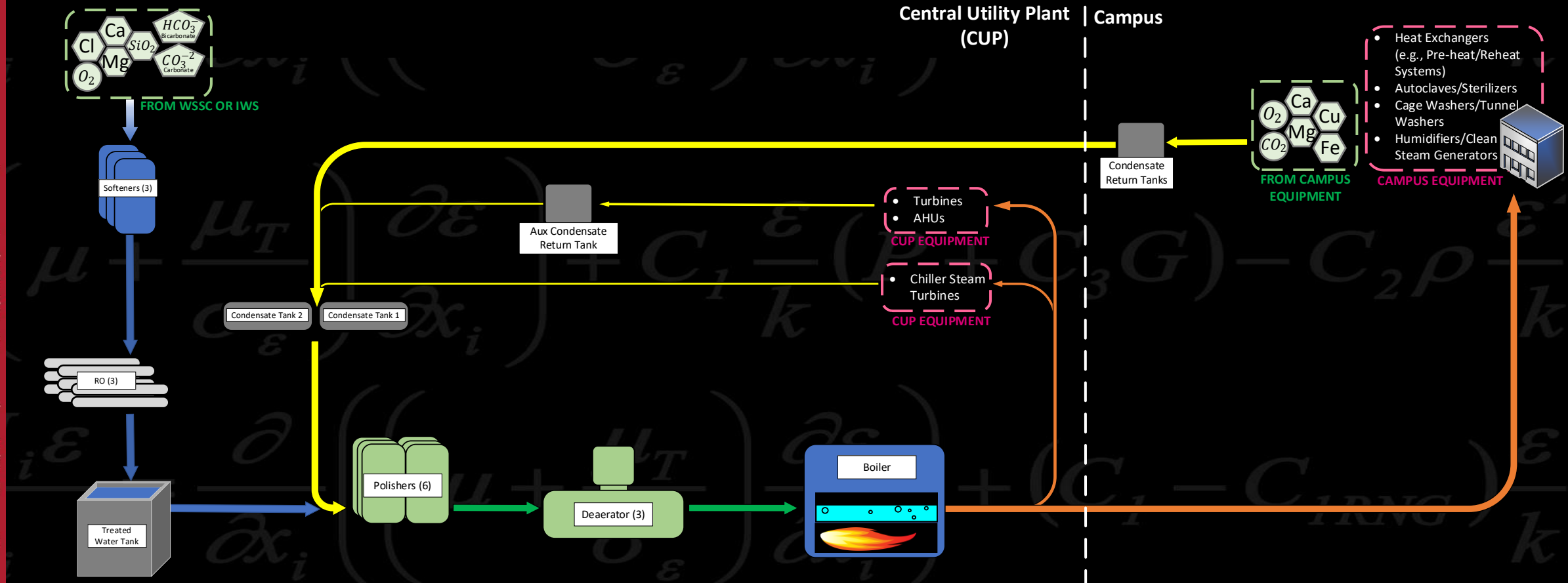
CUP Components

- Twelve 5,000 Ton capacity chillers
- 8-million-gal CHW thermal storage tank
- 5-million-gal Industrial Water System
- Five gas/diesel dual fuel fired boilers
  - 800 KPPH, 980 KPPH with Cogen
- Cogeneration Power Plant
  - One of the largest US government Cogen plants
  - One of the cleanest Cogen plants in the world
  - 23 MW, 180KPPH steam (40% of campus demand)

TES tank

IWS tank

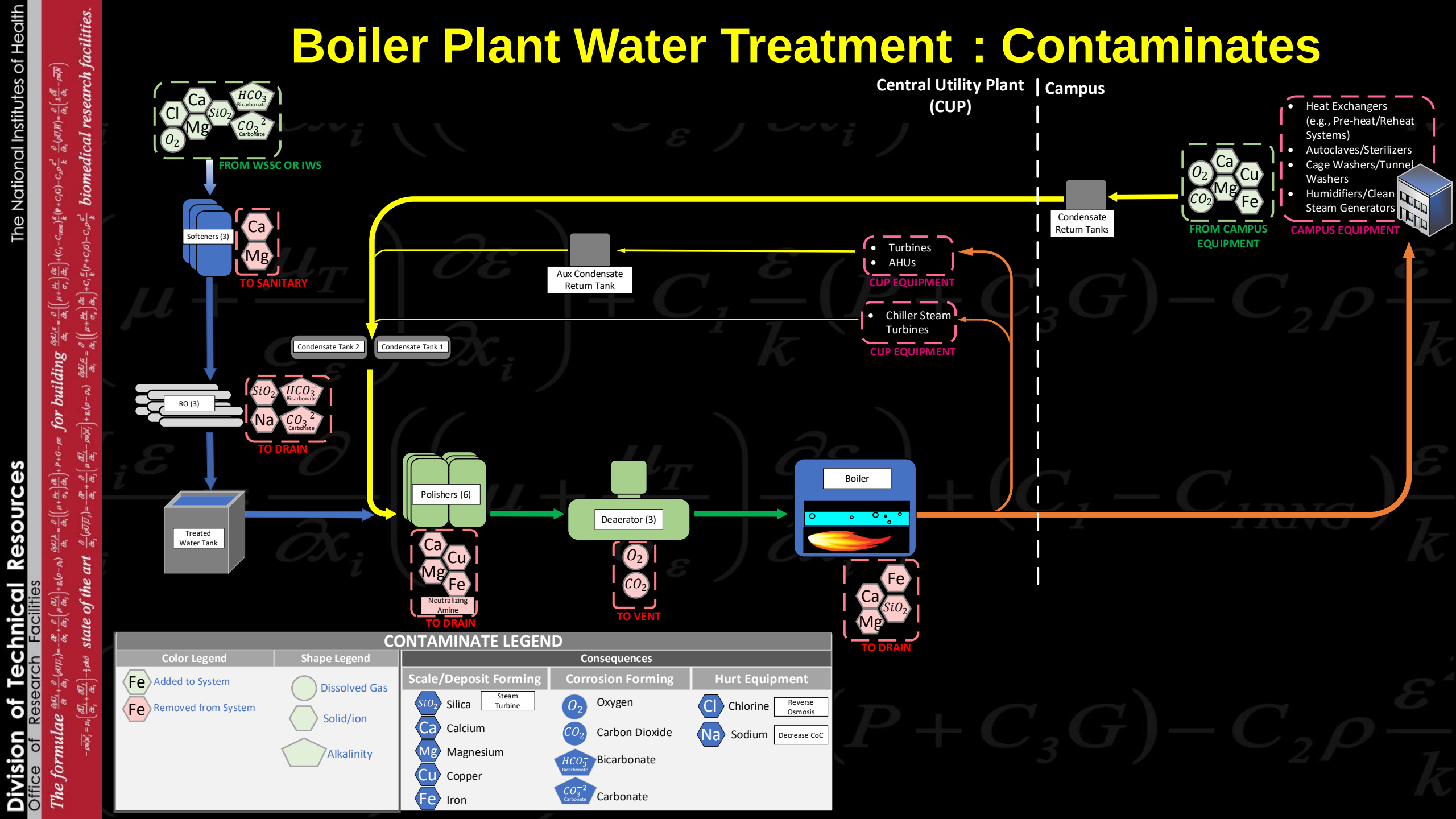
Boiler Plant Water Treatment : Contaminates



CONTAMINATE LEGEND

Color Legend	Shape Legend	Consequences		
		Scale/Deposit Forming	Corrosion Forming	Hurt Equipment
Fe Added to System	Dissolved Gas	SiO_2 Silica — Steam Turbine	O_2 Oxygen	Cl Chlorine — Reverse Osmosis
	Solid/ion	Ca Calcium	CO_2 Carbon Dioxide	Na Sodium — Decrease CoC
	Alkalinity	Mg Magnesium	HCO_3^- Bicarbonate	
		Cu Copper	CO_3^{-2} Carbonate	
		Fe Iron		

Boiler Plant Water Treatment : Contaminates

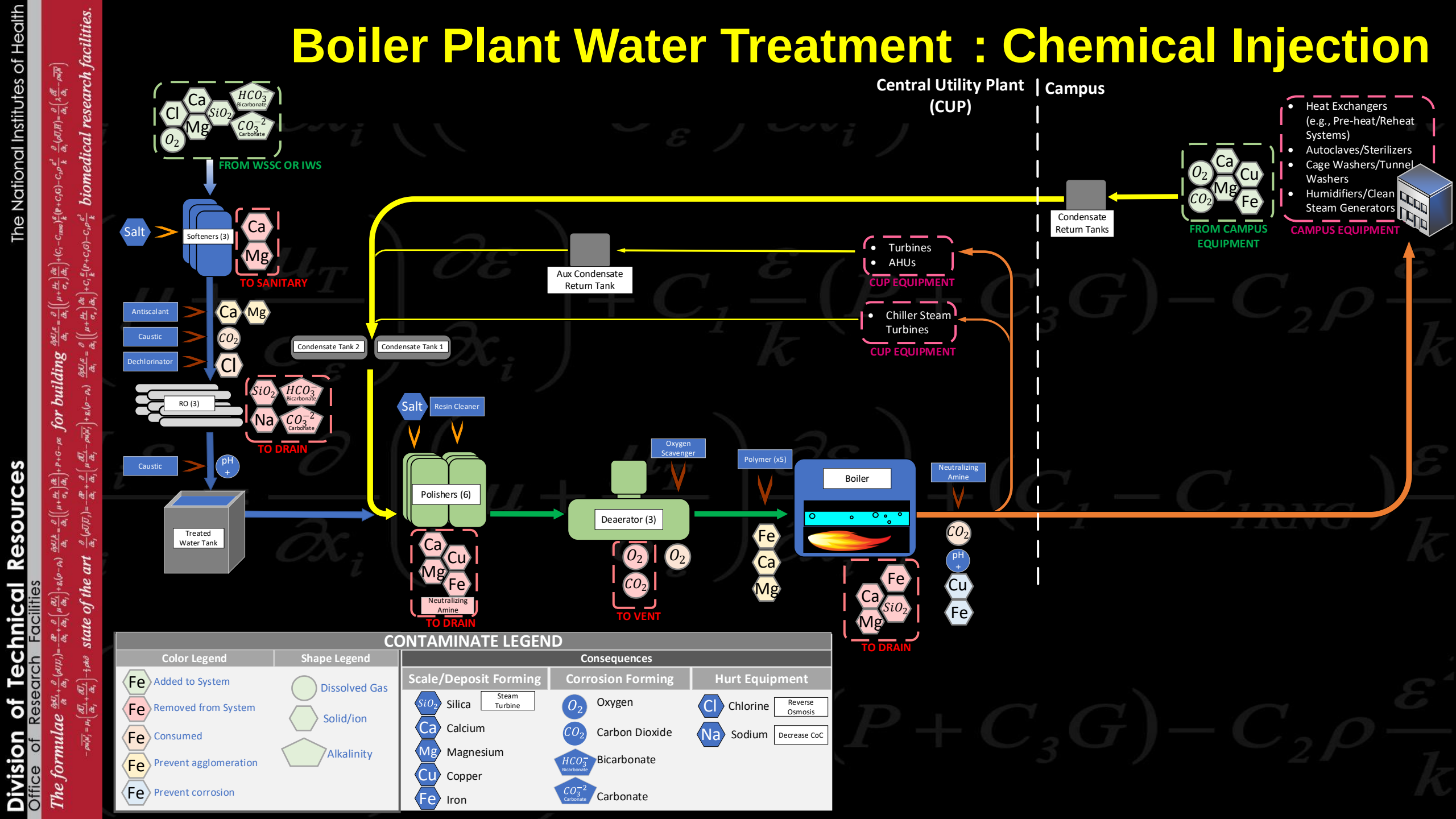


CONTAMINATE LEGEND

Color Legend	Shape Legend
Fe Added to System	Dissolved Gas
Fe Removed from System	Solid/ion
	Alkalinity

Consequences		
Scale/Deposit Forming	Corrosion Forming	Hurt Equipment
SiO_2 Silica (Steam Turbine)	O_2 Oxygen	Cl Chlorine (Reverse Osmosis)
Ca Calcium	CO_2 Carbon Dioxide	Na Sodium (Decrease CoC)
Mg Magnesium	HCO_3^- Bicarbonate	
Cu Copper	CO_3^{-2} Carbonate	
Fe Iron		

Boiler Plant Water Treatment : Chemical Injection

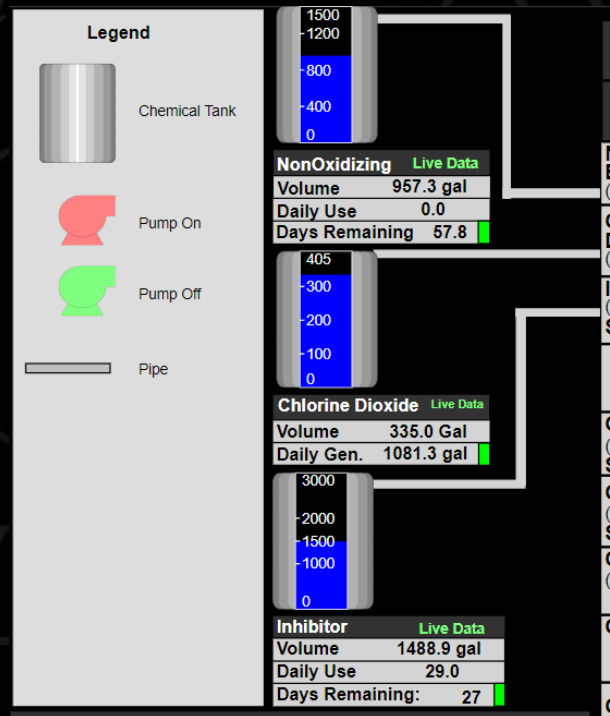


CONTAMINATE LEGEND

Color Legend	Shape Legend
Fe Added to System	Dissolved Gas
Fe Removed from System	Solid/ion
Fe Consumed	Alkalinity
Fe Prevent agglomeration	
Fe Prevent corrosion	

Consequences		
Scale/Deposit Forming	**Corrosion Forming**	**Hurt Equipment**
SiO_2 Silica (Steam Turbine)	O_2 Oxygen	Cl Chlorine (Reverse Osmosis)
Ca Calcium	CO_2 Carbon Dioxide	Na Sodium (Decrease CoC)
Mg Magnesium	HCO_3^- Bicarbonate	
Cu Copper	CO_3^{-2} Carbonate	
Fe Iron		

CUP Water Treatment Dashboard with built-in Auto Fault Detection



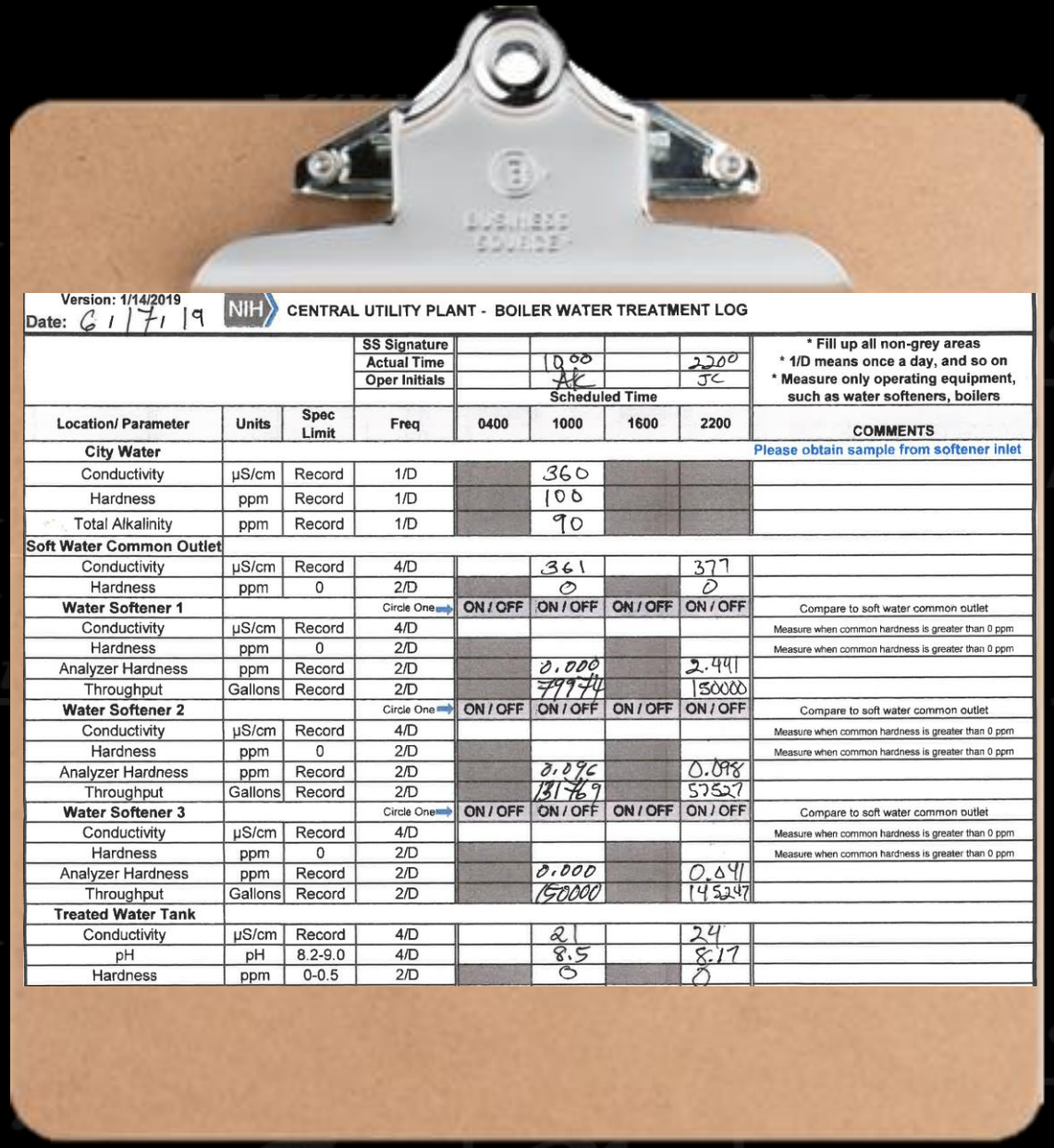
Cooling Towers

	Inhibitor	Chl 21-23	Corrosion	pH	Cond.	ORP	COC	LSI
	Offline	Offline	Offline	Offline	Offline	Offline	Offline	Offline
	<65	<140		< 7.9	< 960	< 160	<2.5	< 1.8
	70-80	140-160		7.9-8.3	960-1200	160-200	2.5-3	1.8-2
	80-120	160-200	0-3	8.3-9	1200-1700	200-500	>3	2-3.8
	120-130	200-220	3-3.3	9-9.45	1700-2000	500-600		3.8-4.2
	> 140	> 220	> 3.3	> 9.45	> 2000	> 600		> 4.2

Tower A Online	CT 16A CT 18A	CT17A	CT19A	CT20A	CT21A	CT22A	CT23A	CT24A	CT25A	CT26A	CT27A	
Tower B Online	CT16B CT18B	CT17B	CT19B	CT20B	CT21B	CT22B	CT23B	CT24B	CT25B	CT26B	CT27B	Free Cooling
Nonox. Biocide (gpm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Chlorine Dioxide (ppm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inhibitor (ppm) Setpoint	1 2	1 2	1 2	1 2	1 2	1 2	1 2	1 2	1 2	1 2	1 2	1 2
pH	12	12	12	12	12	12	12	12	12	12	12	12
Cond. (uS) Setpoint	12	12	12	12	12	12	12	12	12	12	12	12
ORP (mV) Setpoint	12	12	12	12	12	12	12	12	12	12	12	12
Corrosion (mpy)	12	12	12	12	12	12	12	12	12	12	12	12
C.o.C	12	12	12	12	12	12	12	12	12	12	12	12
Cdw Pump Status	16: OffLine 18: OnLine	OffLine	OffLine	OnLine	OffLine	OnLine	OnLine	OffLine	OffLine	OnLine	OffLine	1: OffLine 2: OffLine
Cdw Pump Runtime	12	12	12	12	12	12	12	12	12	12	12	12
LSI	12	12	12	12	12	12	12	12	12	12	12	12

*Not actual data

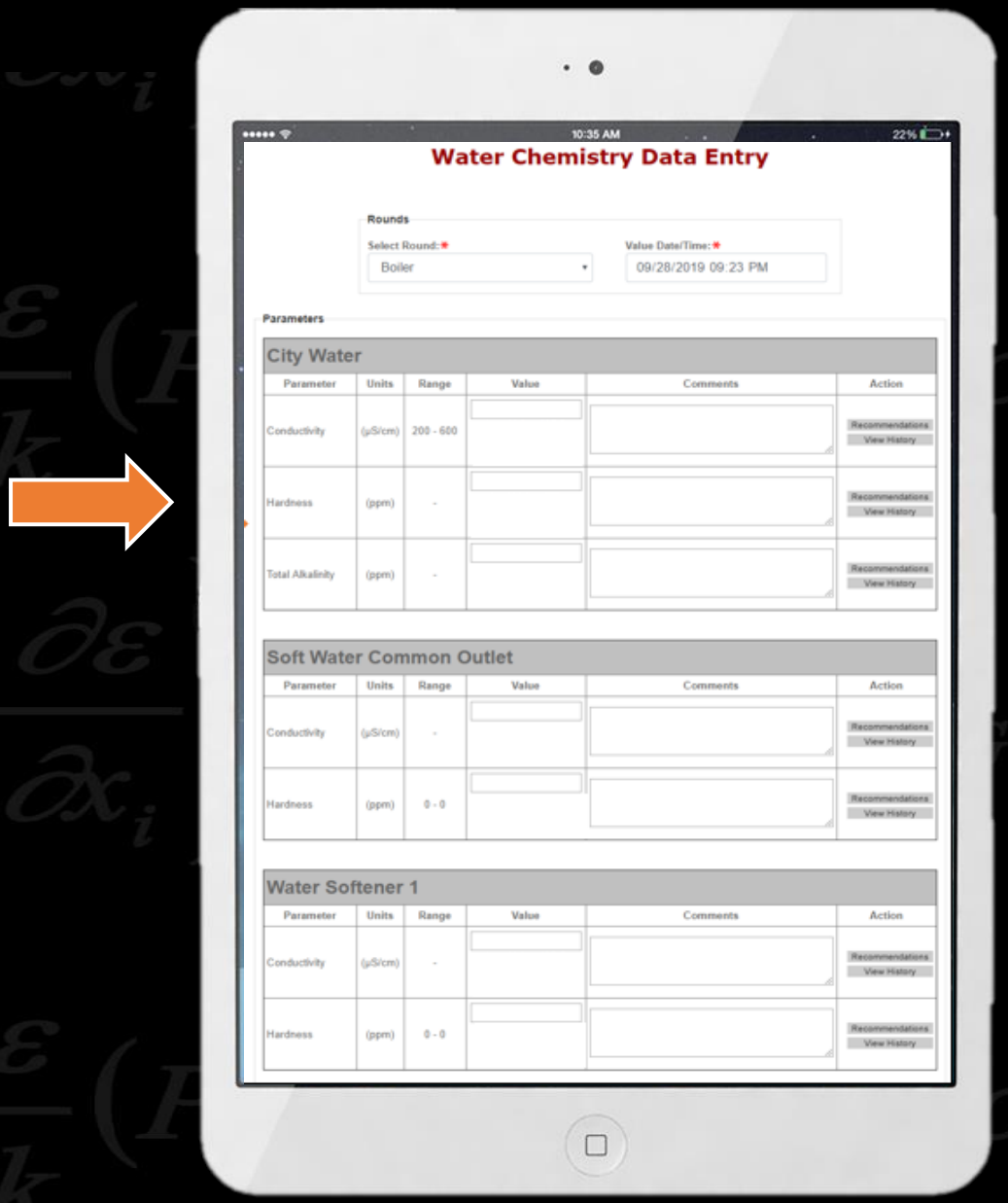
Digitization Plant Operations - Mobile Friendly Round Data Entry



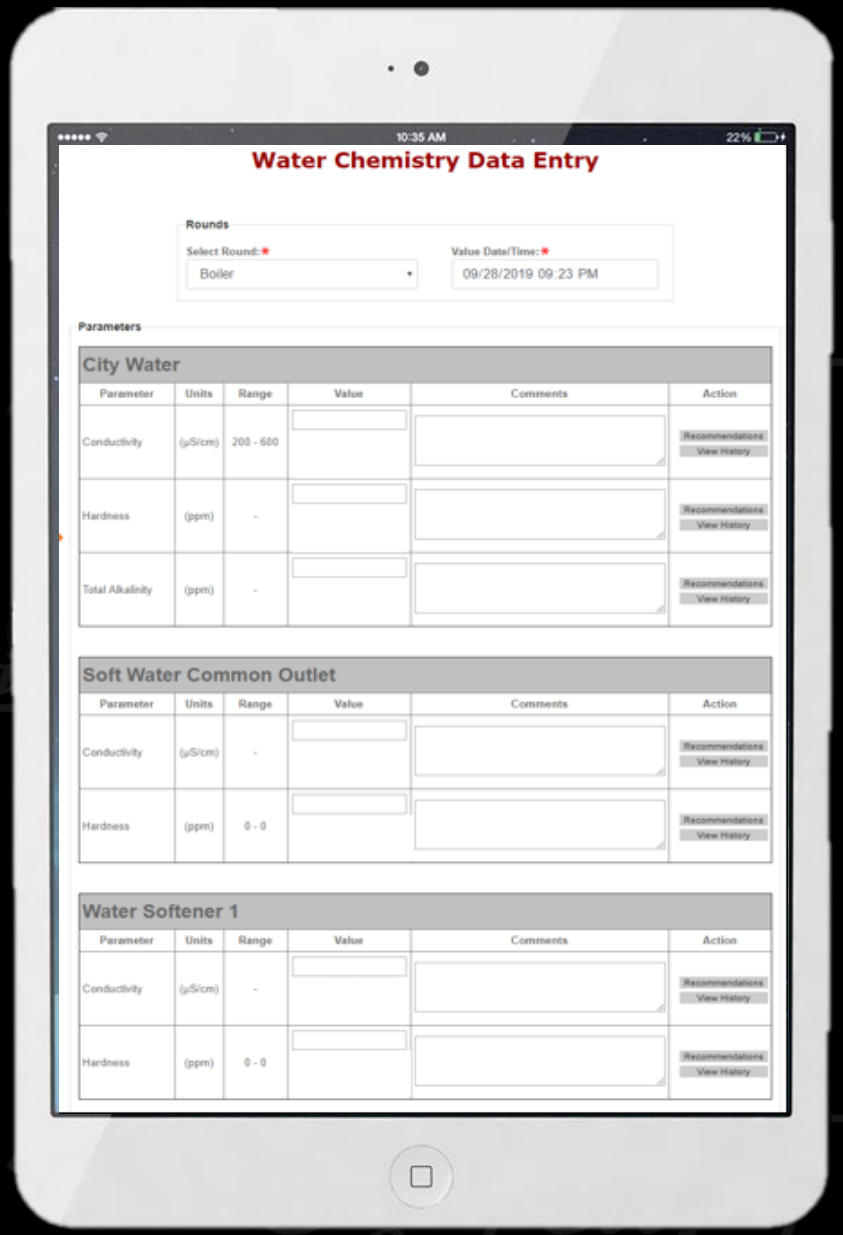
Version: 1/14/2019
Date: 6/7/19

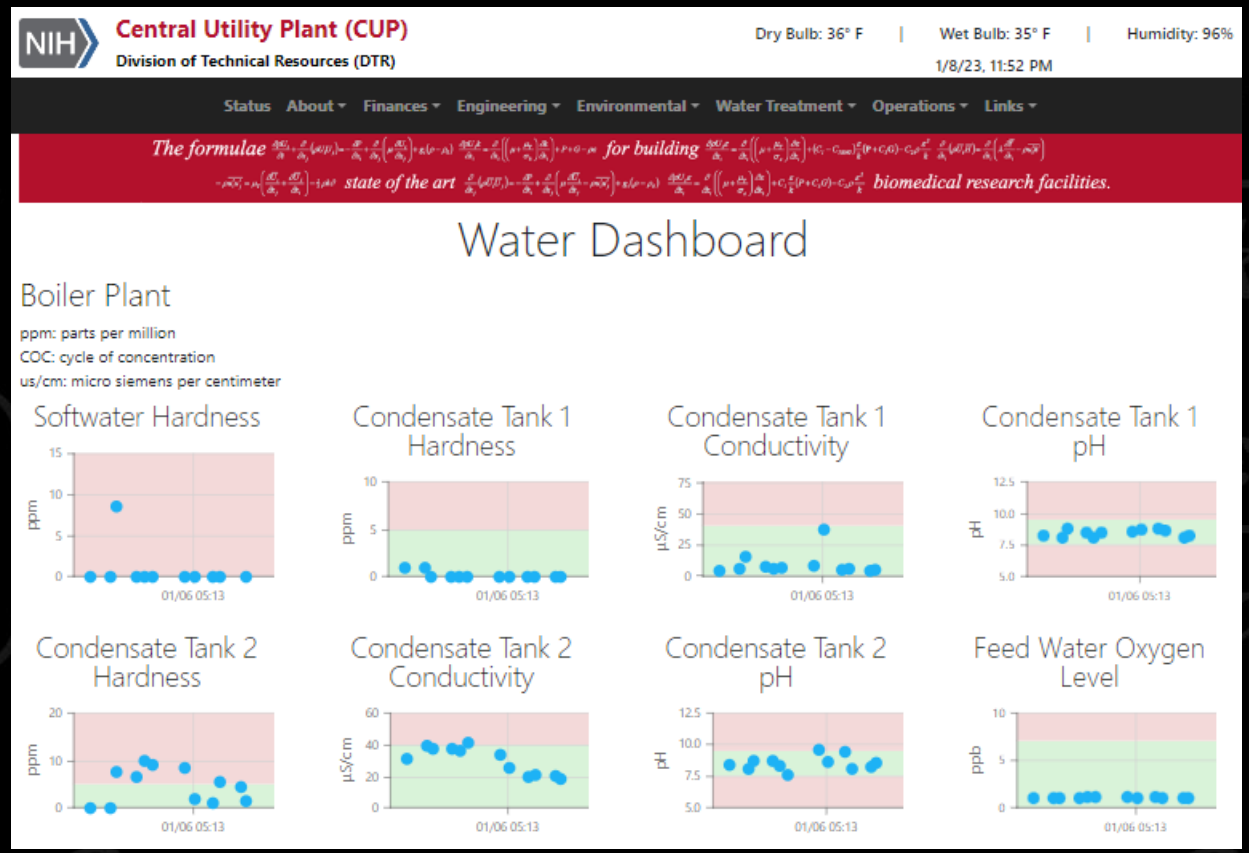
NIH CENTRAL UTILITY PLANT - BOILER WATER TREATMENT LOG

			SS Signature					* Fill up all non-grey areas * 1/D means once a day, and so on * Measure only operating equipment, such as water softeners, boilers
			Actual Time		10:00		2200	
			Oper Initials		AK		JC	
				Scheduled Time				
Location/ Parameter	Units	Spec Limit	Freq	0400	1000	1600	2200	COMMENTS
City Water								Please obtain sample from softener inlet
Conductivity	µS/cm	Record	1/D		360			
Hardness	ppm	Record	1/D		100			
Total Alkalinity	ppm	Record	1/D		90			
Soft Water Common Outlet								
Conductivity	µS/cm	Record	4/D		361		377	
Hardness	ppm	0	2/D		0		0	
Water Softener 1			Circle One→	ON / OFF	ON / OFF	ON / OFF	ON / OFF	Compare to soft water common outlet
Conductivity	µS/cm	Record	4/D					Measure when common hardness is greater than 0 ppm
Hardness	ppm	0	2/D					Measure when common hardness is greater than 0 ppm
Analyzer Hardness	ppm	Record	2/D		0.000		2.441	
Throughput	Gallons	Record	2/D		799774		150000	
Water Softener 2			Circle One→	ON / OFF	ON / OFF	ON / OFF	ON / OFF	Compare to soft water common outlet
Conductivity	µS/cm	Record	4/D					Measure when common hardness is greater than 0 ppm
Hardness	ppm	0	2/D					Measure when common hardness is greater than 0 ppm
Analyzer Hardness	ppm	Record	2/D		0.096		0.098	
Throughput	Gallons	Record	2/D		131769		57527	
Water Softener 3			Circle One→	ON / OFF	ON / OFF	ON / OFF	ON / OFF	Compare to soft water common outlet
Conductivity	µS/cm	Record	4/D					Measure when common hardness is greater than 0 ppm
Hardness	ppm	0	2/D					Measure when common hardness is greater than 0 ppm
Analyzer Hardness	ppm	Record	2/D		0.000		0.041	
Throughput	Gallons	Record	2/D		150000		145247	
Treated Water Tank								
Conductivity	µS/cm	Record	4/D		21		24	
pH	pH	8.2-9.0	4/D		8.5		8.17	
Hardness	ppm	0-0.5	2/D		0		0	



Digitization Plant Operations - Mobile Friendly Round Data Entry

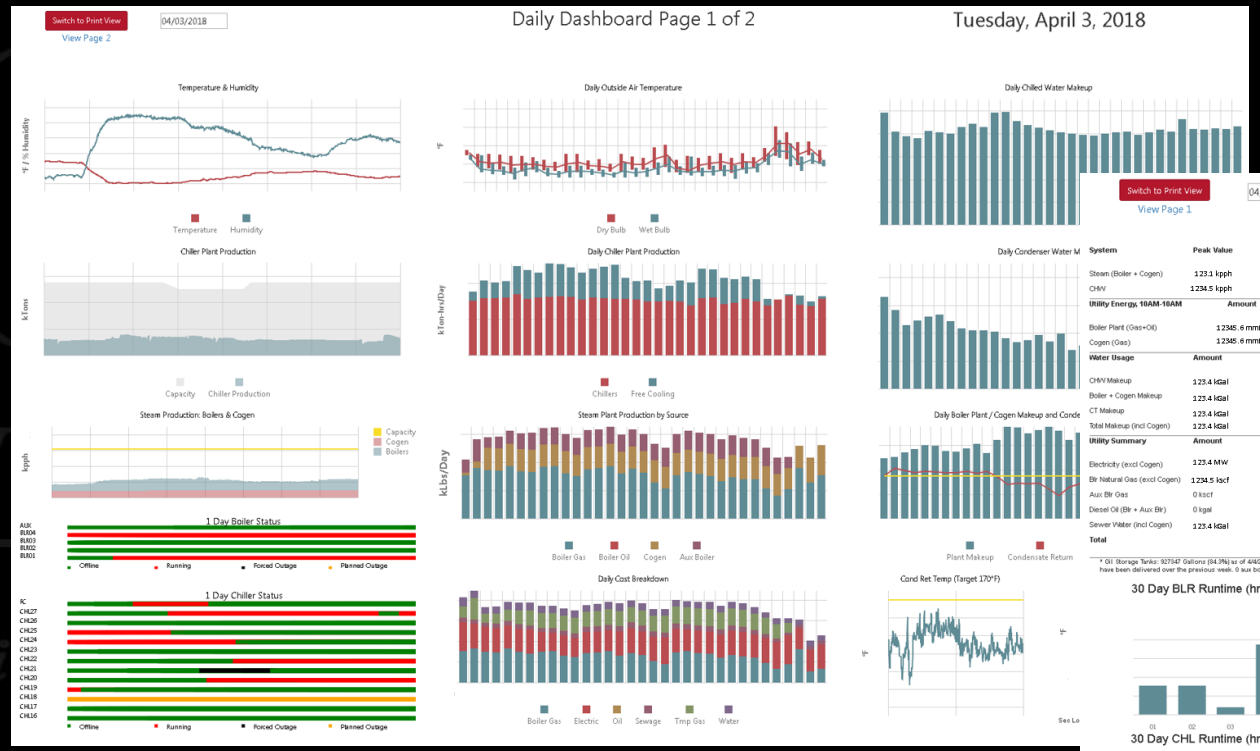


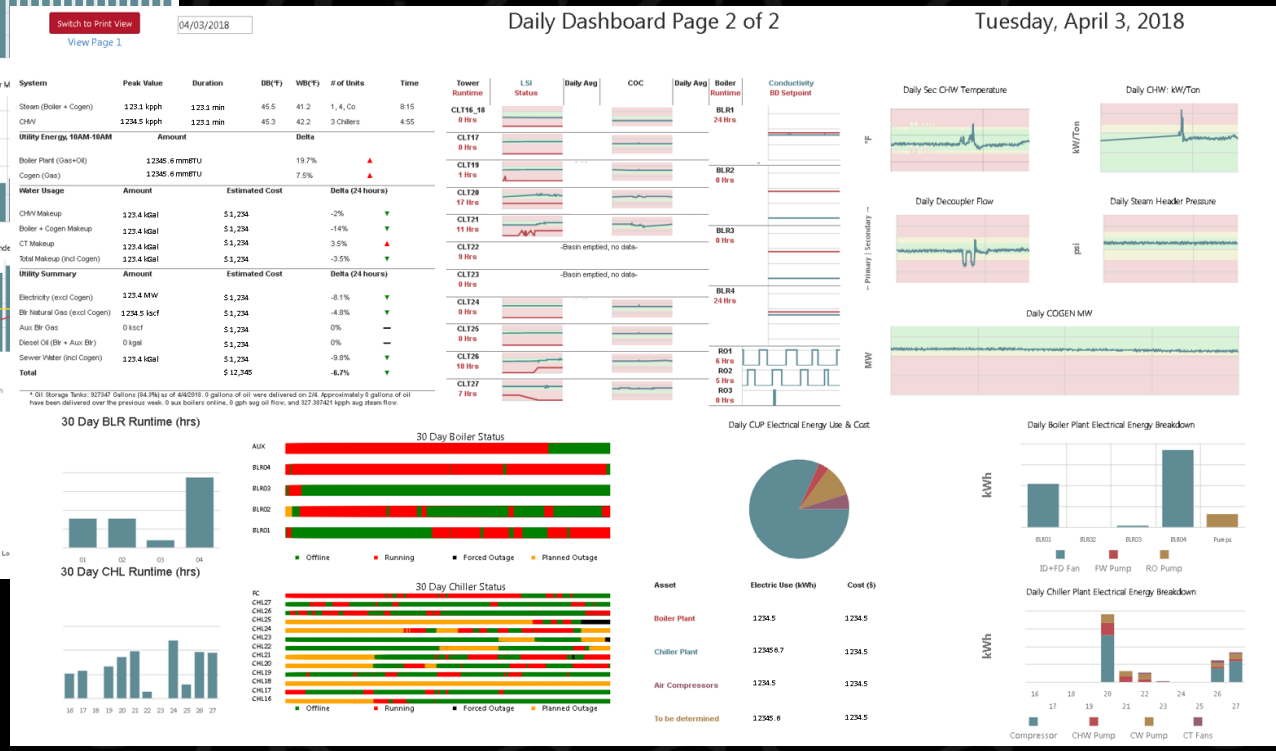


*Not actual data

Web-based Executive Level Summaries and Reporting

High level, executive daily performance data accessible with 1 click



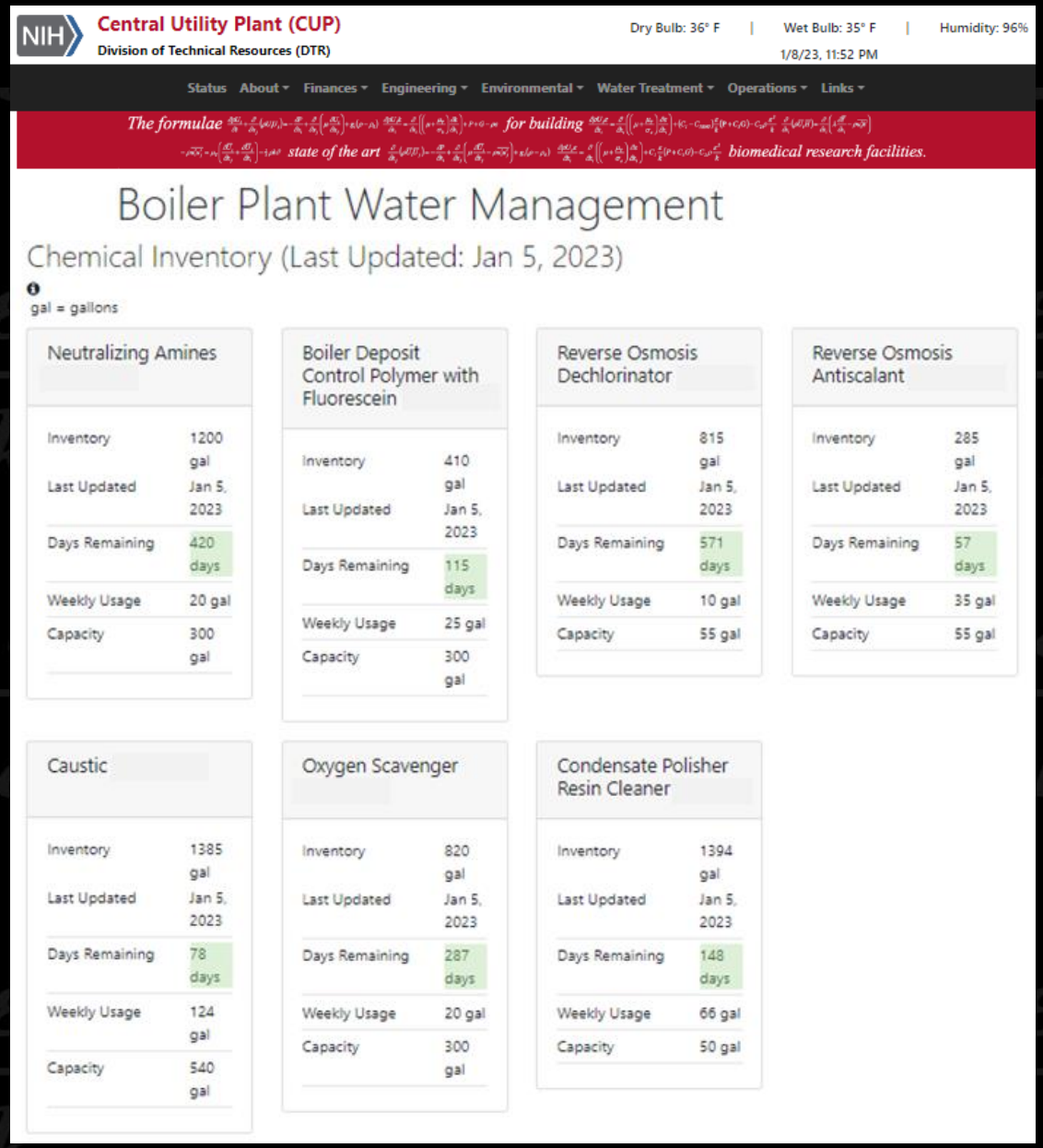


*Not actual data

Chemical Usage

Water Treatment Group tracks and calculated usage for each chemical

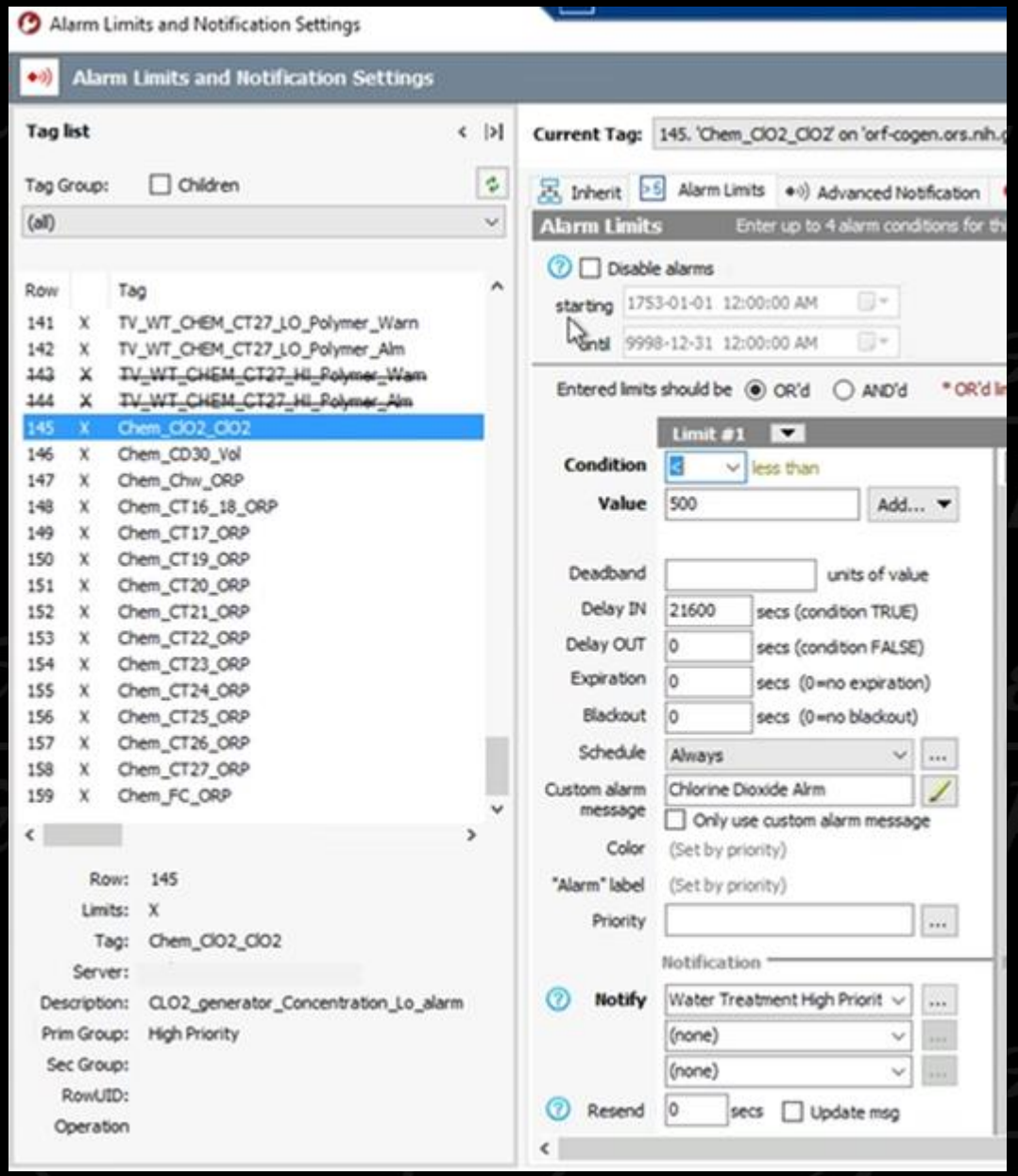
Sensor and Rounds readings used to calculate amount of chemical left in days



*Not actual data

Alarm Management

- Rationalization of existing alarms
- Identification and Implementation of new alarms
- Alarm Notification and Escalation



Alarm Management

Monthly Alarm Report

Identifies protentional Bad Actor alarms for Advanced alarm design to reduce nuisance alarms

Top 10 Alarms

Tag	Frequency
TV_WT_CHEM_CT22_HI_ClO2_Warn	39
TV_WT_CHEM_CT27_HI_ClO2_Warn	38
TV_WT_CHEM_CHW_HI_ClO2_Alm	31
TV_WT_CHEM_CT27_HI_ClO2_Alm	29
TV_WT_CHEM_CT22_HI_ClO2_Alm	26
TV_WT_CHEM_CT26_HI_ClO2_Alm	22
TV_WT_CHEM_CT26_HI_ClO2_Warn	9
TV_WT_CHEM_CT27_LO_Polymer_Warn	3
TV_WT_CHEM_CT19_LO_Polymer_Warn	2
TV_WT_CHEM_CT22_LO_Polymer_Alm	2

Chattering alarm Suspects

Total Number of Chattering Alarms:6

Occurrences	Tag
27	TV_WT_CHEM_CT22_HI_ClO2_Warn
21	TV_WT_CHEM_CT22_HI_ClO2_Alm
19	TV_WT_CHEM_CT27_HI_ClO2_Warn
18	TV_WT_CHEM_CT26_HI_ClO2_Alm
15	TV_WT_CHEM_CT27_HI_ClO2_Alm
14	TV_WT_CHEM_CHW_HI_ClO2_Alm

Fleeting alarm Suspects

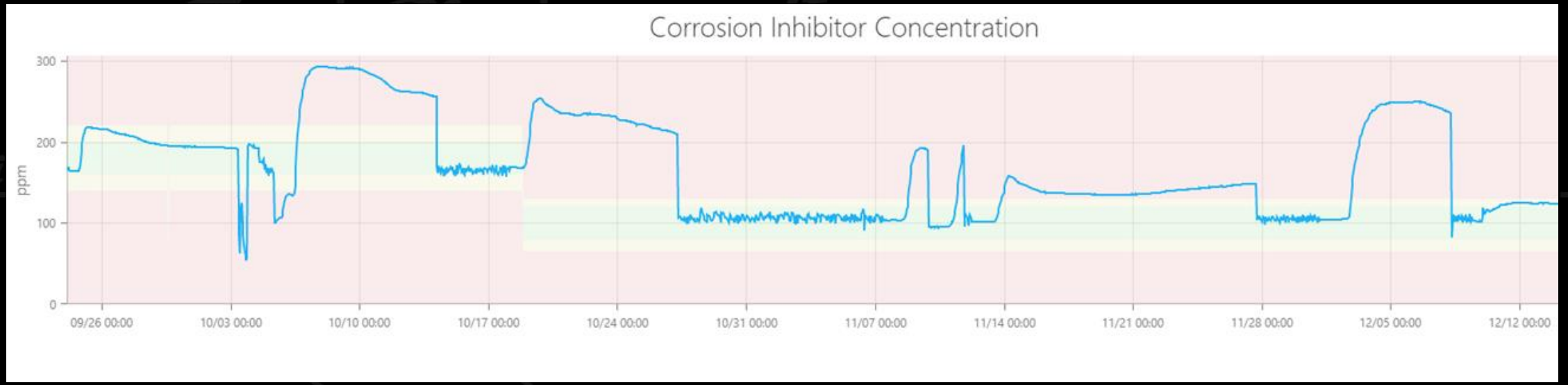
Total Number of Fleeting Alarms:54

Tag	Duration Min
TV_WT_CHEM_CT26_HI_ClO2_Alm	0.1
TV_WT_CHEM_CHW_HI_ClO2_Alm	0.12
TV_WT_CHEM_CHW_HI_ClO2_Alm	0.13
TV_WT_CHEM_CT26_HI_ClO2_Warn	0.13
TV_WT_CHEM_CHW_HI_ClO2_Alm	0.15
TV_WT_CHEM_CT22_HI_ClO2_Alm	0.15

*Not actual data

Dynamic Alarm Setpoints

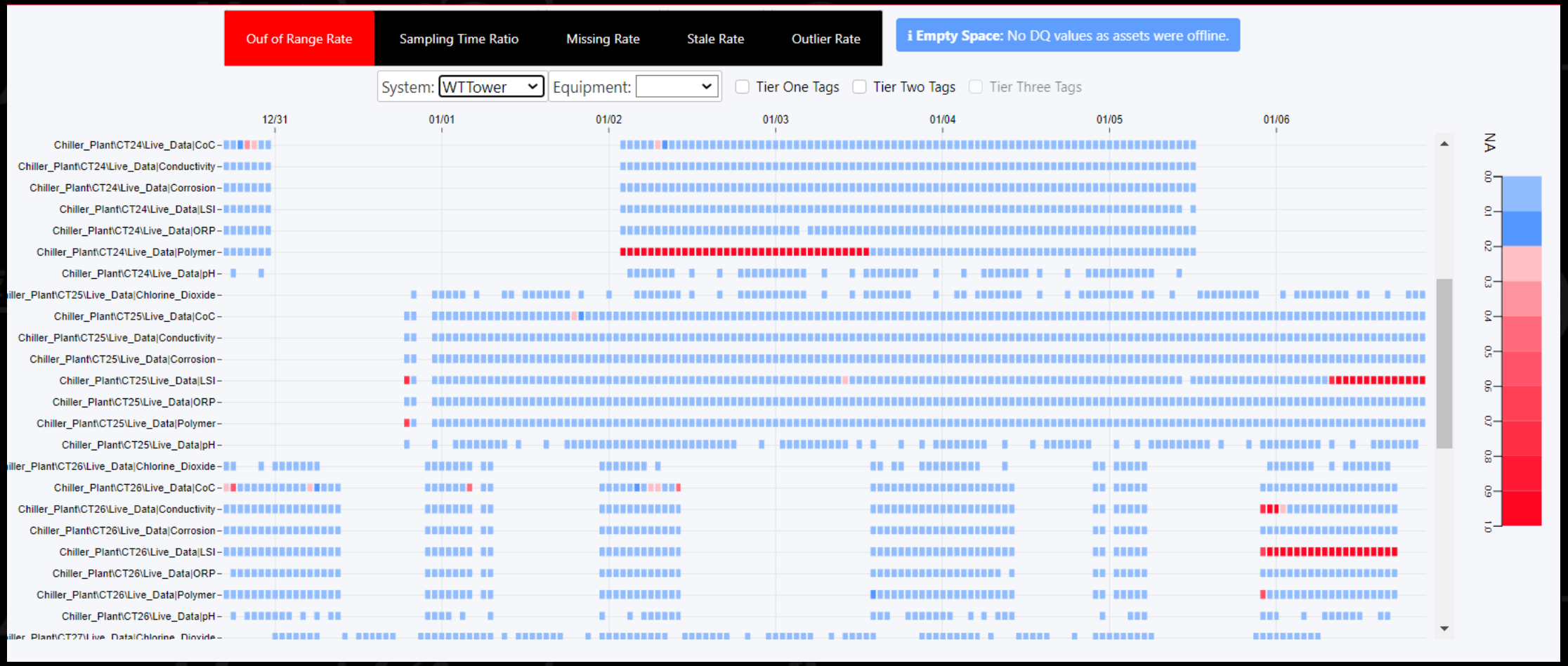
KPI limits set up to automatically adjust based on control factors (e.g., equipment status, makeup water fluctuations)



*Not actual data

Data Quality

Identifies incorrect or irrational data errors that may lead to poor misjudgment



Data Quality Notification

Receive Notification

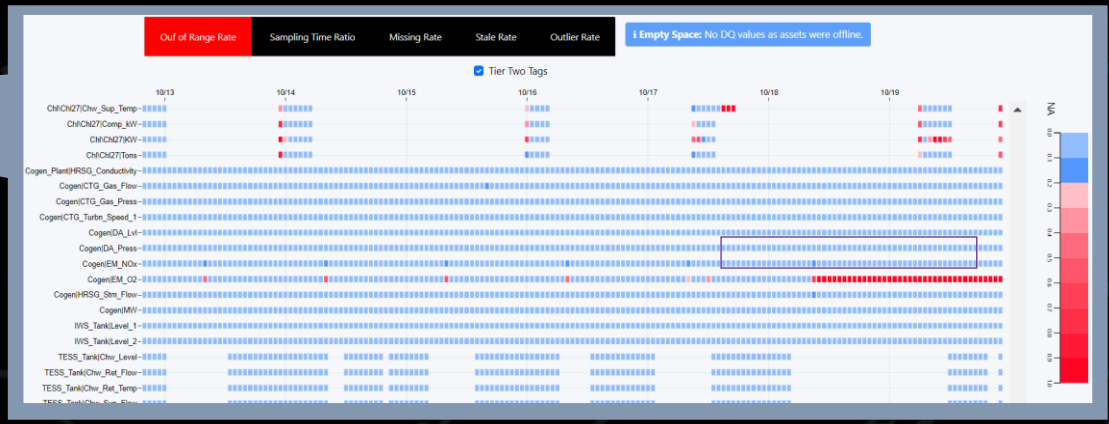
Verify the issue

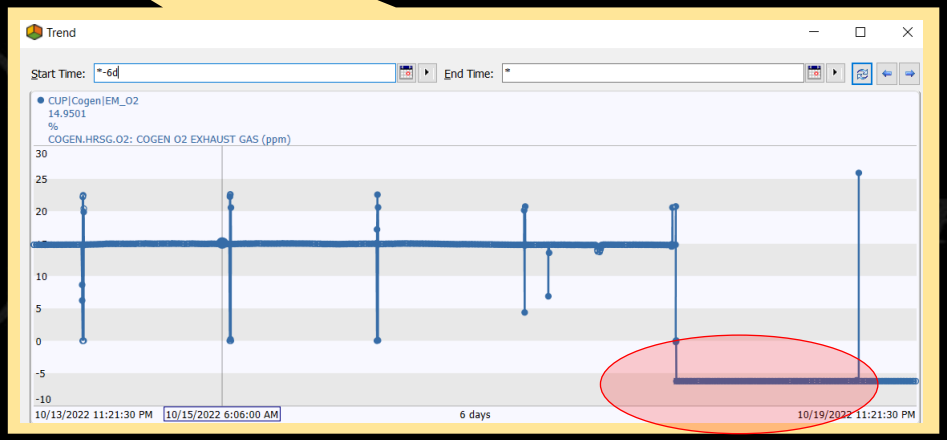
Investigate issue with Water Treatment Group and CUP Engineers

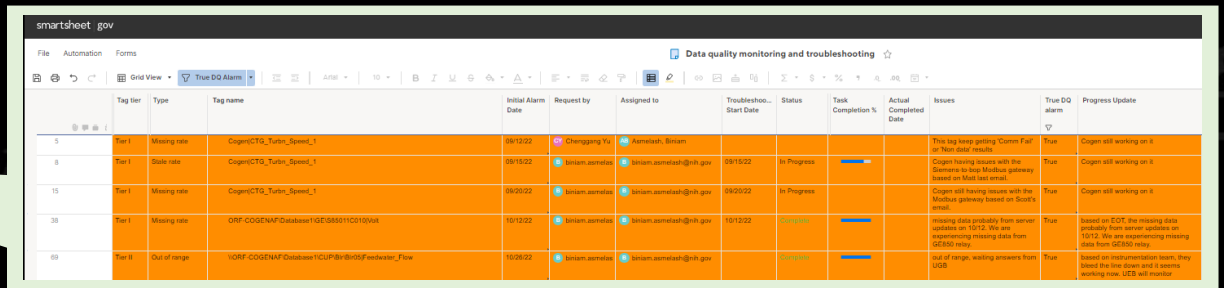
Identify Cause

Rectify Issue

Document incident in searchable Database







Questions?

Thank You

Many thanks to NIH Office of Research Facilities Director Mr. Dan Wheeland, Division of Technical Resources (DTR) Director Dr. Farhad Memarzadeh, Chris Lyon, Dr. Abdul Bhuiyan, Dr. Andrew Gomes and all our colleagues in DTR to make all of this happen!

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