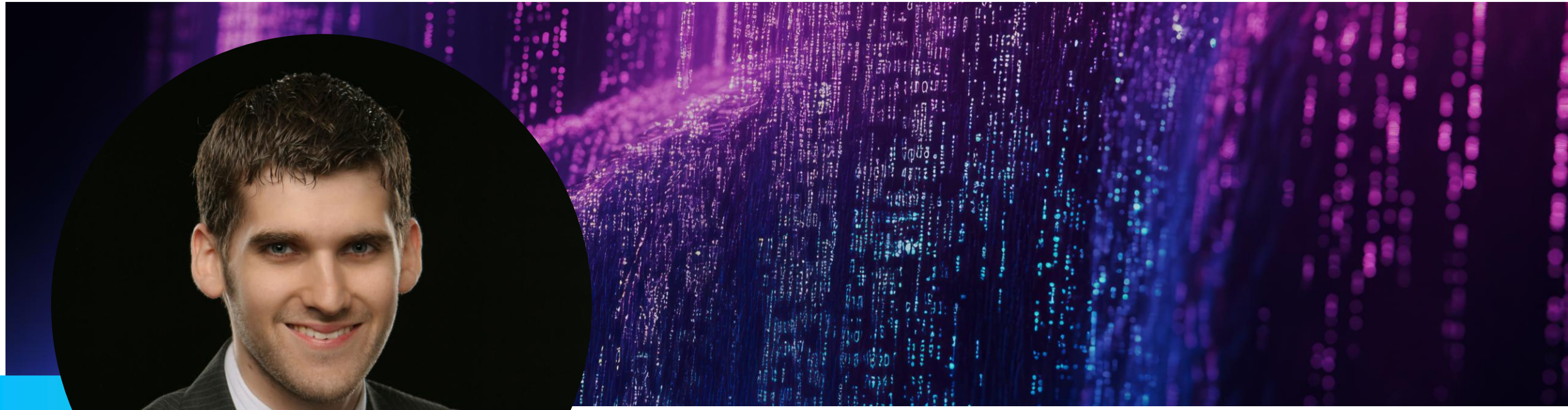

AVEVAWORLD

DATA MODERNIZATION AT THE UNIVERSITY OF IOWA WATER TREATMENT PLANT

Philip Shambaugh

Process Improvement Project Manager

ENGIE



Philip Shambaugh

Process Improvement Project Manager

with ENGIE at the University of Iowa’s

Water Treatment Plant

The University of Iowa and ENGIE

Began a 50 year public private partnership in January 2020

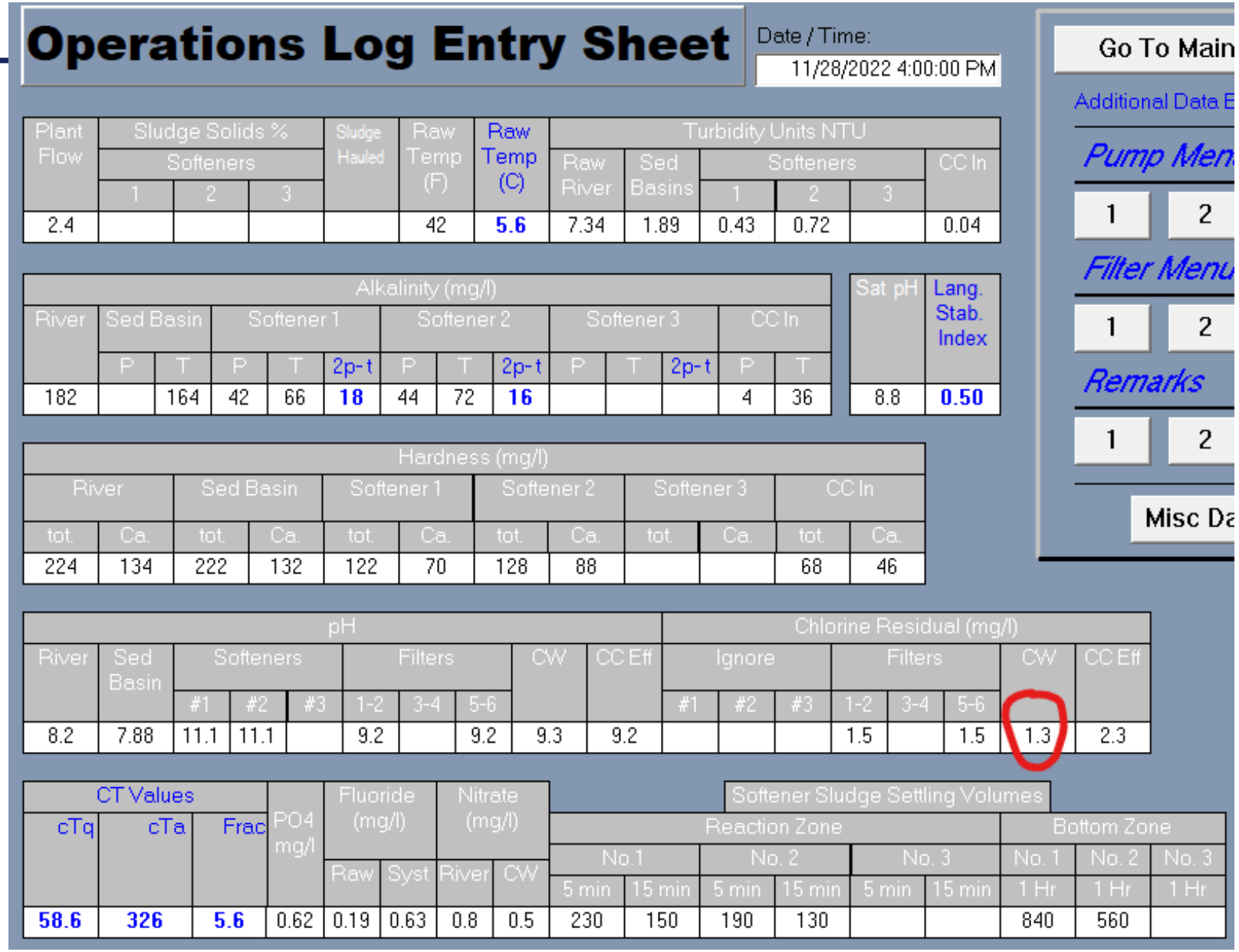
Both have been active PI users since the early 2000s

> **“The core advantage of data is that it tells you something about the world that you didn’t know before.”**

Hilary Mason

Old Methods of Data Capture

- Access database from 1990s
  - Confusing names
  - Broken links
  - Inaccurate constraints
  - What everyone was used to using



Operations Log Entry Sheet

Date / Time: 11/28/2022 4:00:00 PM

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Additional Data E

Pump Men

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Filter Menu

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Remarks

1 2

Misc Da

Plant Flow	Sludge Solids %			Sludge Hauled	Raw Temp (F)	Raw Temp (C)	Turbidity Units NTU					
	Softeners						Raw River	Sed Basins	Softeners			CC In
	1	2	3						1	2	3	
2.4					42	5.6	7.34	1.89	0.43	0.72		0.04

Alkalinity (mg/l)														Sat pH	Lang. Stab. Index
River	Sed Basin		Softener 1			Softener 2			Softener 3			CC In			
	P	T	P	T	2p-t	P	T	2p-t	P	T	2p-t	P	T		
182		164	42	66	18	44	72	16				4	36	8.8	0.50

Hardness (mg/l)												
River		Sed Basin		Softener 1		Softener 2		Softener 3		CC In		
tot.	Ca.	tot.	Ca.	tot.	Ca.	tot.	Ca.	tot.	Ca.	tot.	Ca.	
224	134	222	132	122	70	128	88			68	46	

pH									Chlorine Residual (mg/l)							
River	Sed Basin	Softeners			Filters			CW	CC Eff	Ignore			Filters			CW	CC Eff
		#1	#2	#3	1-2	3-4	5-6			#1	#2	#3	1-2	3-4	5-6		
8.2	7.88	11.1	11.1		9.2		9.2	9.3	9.2				1.5		1.5	1.3	2.3

CT Values			PO4 mg/l	Fluoride (mg/l)		Nitrate (mg/l)		Softener Sludge Settling Volumes								
cTq	cTa	Frac		Raw	Syst	River	CW	Reaction Zone						Bottom Zone		
								No.1		No. 2		No. 3		No. 1	No. 2	No. 3
								5 min	15 min	5 min	15 min	5 min	15 min	1 Hr	1 Hr	1 Hr
58.6	326	5.6	0.62	0.19	0.63	0.8	0.5	230	150	190	130			840	560	

Old Methods of Data Capture

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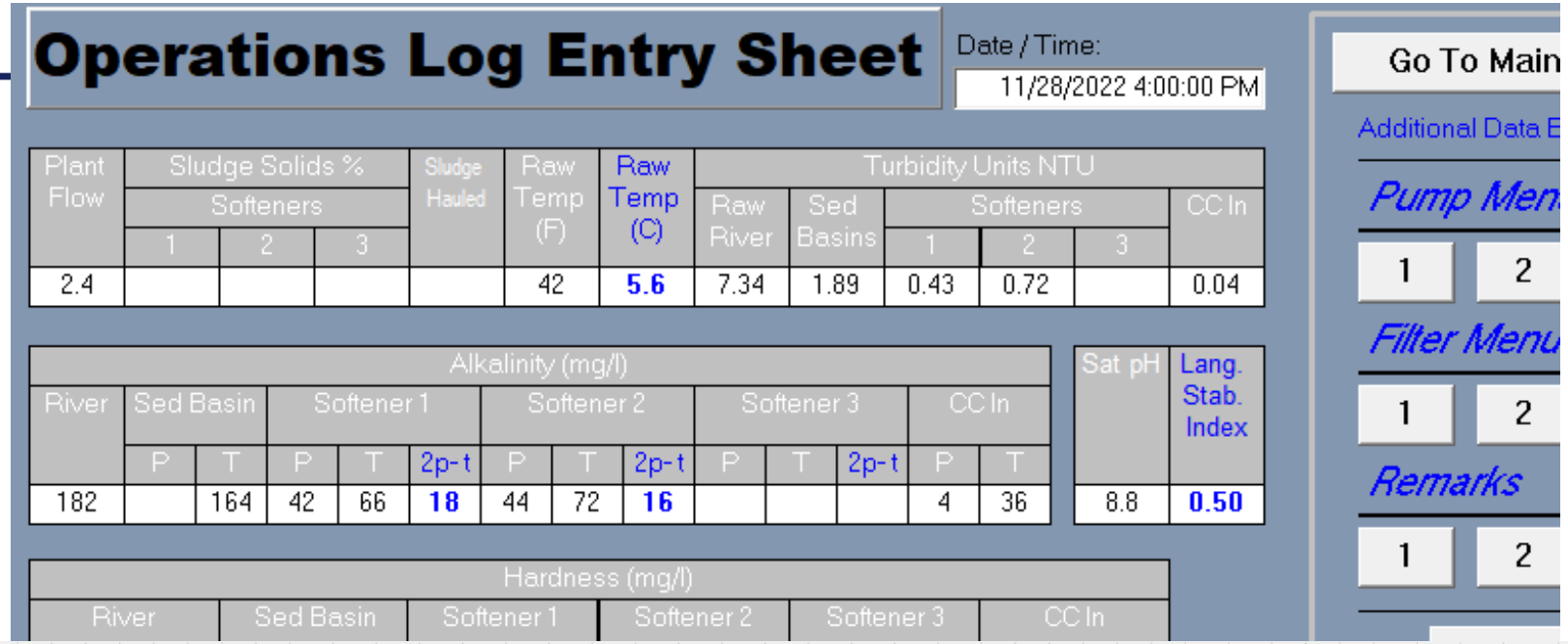
  - Confusing names
  - Broken links
  - Inaccurate constraints
  - What everyone was used to using
  - Inaccessible data



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Plant Flow	Sludge Solids %			Sludge Hauled	Raw Temp (F)	Raw Temp (C)	Turbidity Units NTU					
	Softeners						Raw River	Sed Basins	Softeners			CC In
	1	2	3						1	2	3	
2.4					42	5.6	7.34	1.89	0.43	0.72		0.04

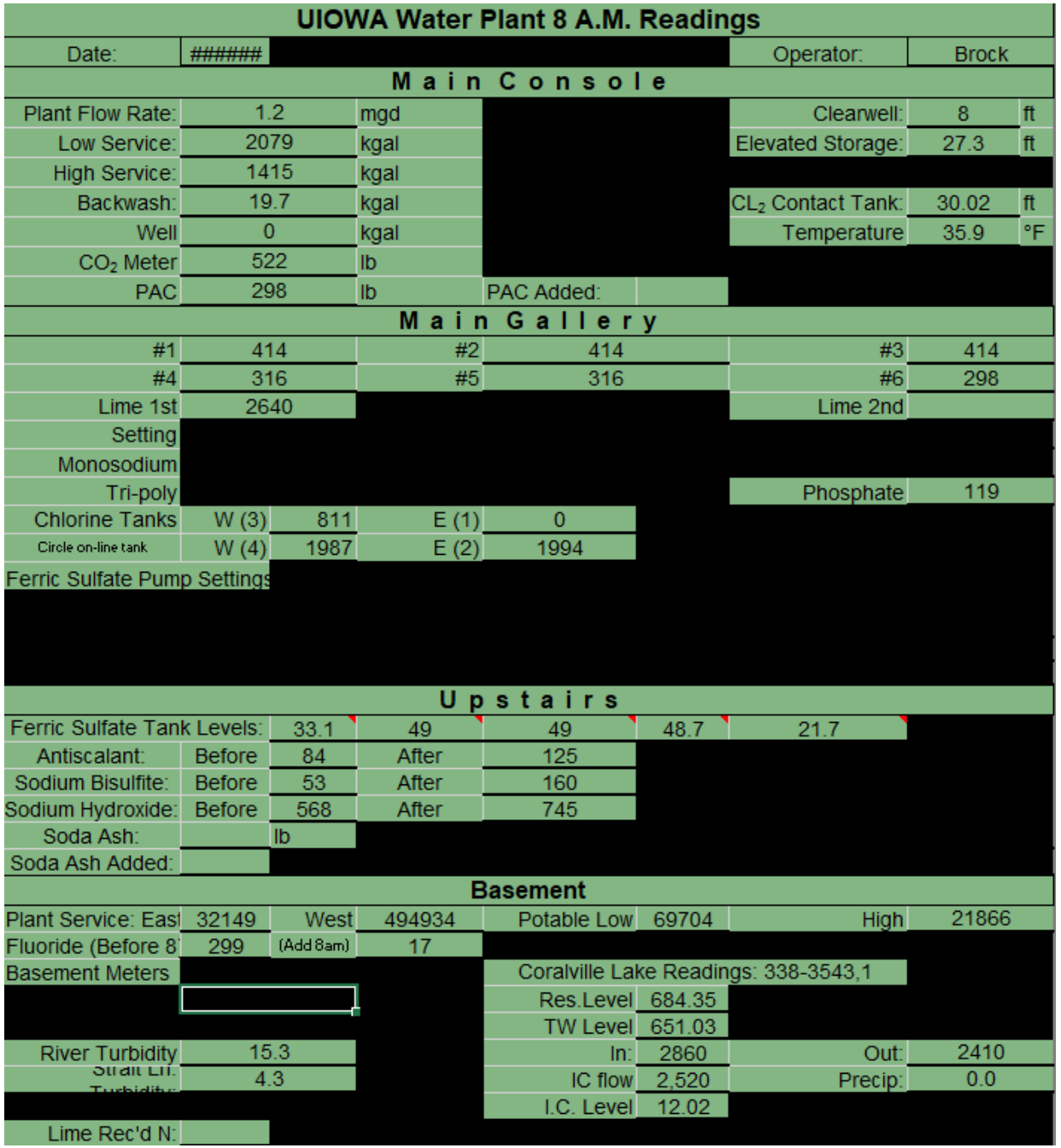
Alkalinity (mg/l)														Sat pH	Lang. Stab. Index
River	Sed Basin		Softener 1			Softener 2			Softener 3			CC In			
	P	T	P	T	2p-t	P	T	2p-t	P	T	2p-t	P	T		
182		164	42	66	18	44	72	16				4	36	8.8	0.50

Hardness (mg/l)						
River	Sed Basin	Softener 1	Softener 2	Softener 3	CC In	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG
1	Date	ant	flo	s-uf-#	s-uf-#	s-uf-#	sh	temp	t-rr	t-esl	t-uf-#1	t-uf-#2	t-uf-#3	t-cw	a-r	a-sl-p	a-sl-1	uf-#1	uf-#2	1 2F	uf-#2	uf-#2	2 2F	uf-#3	uf-#3	3 2F	h-cw-t	a-cw-	si-a	Actual	h-r-t	h-r-c	h-sl-t	h-sl-c	uf-#1-	uf-#1-	uf-#2-	uf-#2-	uf-#3-	uf-#3-	h-cw-th	cw-c	ph-r	ph-esl	h-uf-#	h-uf-#	h-uf-#1	f-#1	f-#2-	f-#3-	ph-cw	ph-cc	f-#1-	f-#3-	f-#5	cl-cw	cl-cc	ct-ctq	ct-cta	ct-fra
2	00-Jan-00	2.4						73.4	16.3	1.4		3.7	0.45	0.04	200		186				44	54	34	28	38	18	10	38	8.35	0.94	246	166	246	170			116	104	100	72	100	74	8.11	7.72		10.7	10.4	9.42		9.44	9.29	9.44	1.7		1.6	1.3	2.2	18.3	315	17.3
3	01-Jul-78	3.5						78.7	11.9	1.9	3.48	0.35		0.08	184		194	28	42	14	30	48	12				2	22	8.85	0.15	224	130	216	132	94	60	102	56			50	30	8	7.9	10.7	10.6		9.4		9.7	9	8.6	1.8		2.1	1.3	1.4	11.5	153	13.3
4	22-Apr-96							54.5	17	1.6	0.9		0.8	0.06	230		212	32	52	12				24	50	-2	4	40	8.6	0.10	260	172	258	168	120	58			120	54	116	60	8.3	7.9	10.4		10.2	8.8		9	8.7	8.8	3.1		3	2.4	2.1			
5	22-Apr-96	3.4						54.32		1.3	0.3		0.3	0.07			208	34	50	18				28	46	10	2	40	8.6	-0.10			254	166	116	56			118	54	114	58		7.8	10.5		10.4	9.1		9.2	8.5	8.7	2.7		2.5	2.2	1.9	29.8	234	7.9
6	22-Apr-96	3.3						53.96	17	1.6	5.1	0.8		0.07	238		206	30	50	10	36	52	20				6	46	8.5	0.10	256	176	250	174	112	60	122	70			112	60	8.1	7.8	10.5	10.8		9.5		9.8	8.6	8.7	3.4		2.5	2.5	2	31.1	263	8.5
7	22-Apr-96	3.3				1		54.32	19	1.9	0.7	0.4		0.08	240		218	38	52	24	38	54	22				10	40	8.5	0.70	256	176	252	170	110	64	116	72			116	66	8.2	7.9	10.5	10.6		9.1		9.1	9.2	9.1	2.8		2.4	2.8	2.3	36.2	299	8.3
8	22-Apr-96	3.3						55.04	18	1.7	0.7	0.5		0.06	236		220	28	50	6	32	50	14				6	46	8.5	0.30	260	166	258	164	122	48	120	54			118	60	8.3	8	10.4	10.7		9.1		8.8	8.8	8.9	3		2.5	2.4	2.2	31.9	273	8.5
9	22-Apr-96	3.3						55.04	17	1.7	0.3	0.4		0.05	220		218	36	50	22	44	60	28				12	48	8.5	0.70	258	166	258	164	116	64	116	62			120	54	8.3	8	11	11		9.4		9.3	9.2	9	3.2		2.9	2.6	2.3	34.5	289	8.4
10	23-Apr-96	3.3						53.6		1.6	0.3	0.3		0.06			216	34	52	16	34	50	18				6	46	8.5	0.30			256	166	116	62	122	68			120	68		8	10.6	10.7		8.8		8.7	8.8	8.7	2.5		2.3	2.3	2.2	32.5	268	8.2
11	23-Apr-96	3.3						53.42	17	1.5		0.7	2	0.06	242		220				38	50	26	34	60	8	6	50	8.5	0.20	258	176	260	164			112	76	126	78	120	66	8.2	7.8		11.1	10.6	8.2		8.3	8.7	8.7	3.1		2.5	2.4	2.2	32.4	273	8.4
12	23-Apr-96	3.3						54.86	17	1.5		0.8	1.8	0.06	238		222				30	46	14	34	64	4	4	46	8.5	0.20	264	172	248	168			118	64	428	58	120	66	8.4	7.9		10.9	10.4	9.3		8.9	8.7	8.7	3		3.5	2.5	2.3	30.8	285	9.2
13	23-Apr-96	3.3						55.58	15	1.8		0.7	2.4	0.07	232		226				32	48	16	24	54	-6	10	50	8.5	0.40	268	174	266	166			116	56	120	44	122	56	8.3	8		10.6	10	8.5		8.3	8.9	8.7	3.3		3.3	2.5	2.4	30.9	292	9.5
14	23-Apr-96	3.3						55.94	16	1.7		0.8	1.3	0.07	230		226				30	52	8	26	60	-8	6	50	8.6	0.20	270	172	264	168			116	52	124	46	118	48	8.4	8		10.5	10	9.3		9.2	8.8	8.7	3.1		4	2.8	2.5	30.4	313	10.3
15	24-Apr-96	3.4	0					56.3	17	1.7		1	2.2	0.08	238		222				39	54	24	49	78	20	8	38	8.7	0.30	270	176	262	170			117	74	137	80	120	50	8.4	8		10.8	10.8	9.2		9.6	9	8.8	3		3.5	2.9	2.7	31.6	322	10.2
16	24-Apr-96	3.3						56.48	17	1.6		0.5	2.5	0.08	236		220				38	48	28	50	80	20	14	50	8.6	0.40	272	178	266	174			116	70	134	78	122	50	8.4	8		10.8	10.8	9.2		9.6	9	9.2	3.2		3.5	3	2.9	33.9	352	10.4
17	24-Apr-96	3.3				5		55.58	17	1.6		0.6	1	0.06	248		240				40	58	22	40	68	12	22	68	8.2	1.30	268	172	262	170			122	84	128	76	134	96	8.4	8.1		11	10.4	8.9		8.4	9.5	9.5	3.2		3.3	2.7	2.5	38.5	309	8.0
18	24-Apr-96	3.3						55.76	16	1.7	7.1		1.3	0.08	242		224	50	80	20				40	68	12	10	68	8.2	0.70	272	176	260	168	134	68			136	72	132	80	8.4	8	10.8		10.5	9.69		8.8	8.9	9.3	2.8		3	2.5	2.6	34.4	307	8.9
19	24-Apr-96	3.3						56.12	16	1.8	1		0.5	0.06	244		226	42	64	20				36	60	12	8	62	8.3	0.80	264	172	268	168	120	60			124	48	130	66	8.5	8.2	10.8		10.6	8.8		9.1	9.1	9.1	3.3		3.1	2.6	2.5	33.5	304	9.1
20	24-Apr-96	3.3						56.66	16	1.8	0.8		0.5	0.06	240		226	32	44	20				40	56	24	4	50	8.5	0.50	260	170	264	168	112	58			118	66	120	60	8.6	8.3	10.8		10.9	8.7		9.3	9	9.1	3.4		3.1	2.4	2.4	32.2	287	8.9
21	25-Apr-96	3.3						56.48	17	1.7	0.7		0.9	0.06	244		230	34	52	16				44	58	30	6	48	8.5	0.50	272	178	268	172	120	74			128	86	122	66	8.5	8	10.8		10.9	9.2		9.5	9	9	3.6		3.2	2.8	2.5	32.2	313	9.7
22	25-Apr-96	3.3						55.94	17	1.5	0.9		0.7	0.07	242		228	34	54	14				34	56	12	6	50	8.4	0.70	266	172	264	170	118	68			122	60	126	72	8.4	8	10.8		10.6	8.9		8.8	9.1	9.2	3.4		2.7	2.6	2.4	34.2	297	8.7
23	25-Apr-96	3.3						55.4	17	1.5	1.4	1		0.07	240		226	30	48	12	48	72	24				12	54	8.4	0.40	266	170	260	170	122	58	134	96			118	66	8.6	8.1	10.5	11		9.1		9.7	8.8	9	2.8		2.6	2.4	2.4	32.3	287	8.9
24	25-Apr-96	3.3						55.5	15	1.8	1.5	1.6		0.06	250		230	36	56	16	48	70	26				241	24	8.4	0.60	280	184	268	180	122	78	134	88			120	78	8.5	8.3	10.5	10.8		9.1		9	9	9	3		2.4	2.3	2.3	32.8	275	8.4
25	25-Apr-96	3.3						56.66	15	1.6	1.3	0.4		0.06	242		232	30	48	12	34	62	6				6	50	8.5	0.20	272	176	268	174	112	50	116	50			124	64	8.5	8.2	10.5	10.3		9		8.3	8.7	8.9	2.6		2.6	2.4	2.3	29.7	280	9.4
26	25-Apr-96	3.3						56.66	15	1.6	2.6	0.4		0.06	244		234	28	54	2	28	50	6				4	50	8.5	0.40	266	174	270	172	122	46	118	48			118	50	8.5	8.1	10.2	10.3		9.1		9.1	8.9	8.8	2.4		2.9	2.4	2.2	29.9	273	9.1

Old Methods of Data Capture

- Access database
- Excel spreadsheets
- Paper log sheets



UIOWA Water Plant 8 A.M. Readings								
Date:	######					Operator:	Brock	
Main Console								
Plant Flow Rate:	1.2	mgd				Clearwell:	8	ft
Low Service:	2079	kgal				Elevated Storage:	27.3	ft
High Service:	1415	kgal						
Backwash:	19.7	kgal				CL_2 Contact Tank:	30.02	ft
Well	0	kgal				Temperature	35.9	°F
CO_2 Meter	522	lb						
PAC	298	lb	PAC Added:					
Main Gallery								
#1	414		#2	414		#3	414	
#4	316		#5	316		#6	298	
Lime 1st	2640					Lime 2nd		
Setting								
Monosodium								
Tri-poly						Phosphate	119	
Chlorine Tanks	W (3)	811	E (1)	0				
Circle on-line tank	W (4)	1987	E (2)	1994				
Ferric Sulfate Pump Settings								
Upstairs								
Ferric Sulfate Tank Levels:	33.1	49	49	48.7	21.7			
Antiscalant:	Before	84	After	125				
Sodium Bisulfite:	Before	53	After	160				
Sodium Hydroxide:	Before	568	After	745				
Soda Ash:		lb						
Soda Ash Added:								
Basement								
Plant Service: East	32149	West	494934	Potable Low	69704	High	21866	
Fluoride (Before 8	299	(Add 8am)	17					
Basement Meters				Coralville Lake Readings: 338-3543,1				
				Res.Level	684.35			
				TW Level	651.03			
River Turbidity	15.3			In:	2860	Out:	2410	
Strait Ln. Turbidity:	4.3			IC flow	2,520	Precip:	0.0	
				I.C. Level	12.02			
Lime Rec'd N:								

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UIOWA Water Plant 8 A.M. Readings

Date:	#######		Operator:	Brock	
Main Console					
Plant Flow Rate:	1.2	mgd	Clearwell:	8	ft
Low Service:	2079	kgal	Elevated Storage:	27.3	ft
High Service:	1415	kgal			
Backwash:	19.7	kgal	CL_2 Contact Tank:	30.02	ft
Well	0	kgal	Temperature	35.9	°F

University of Iowa Water Plant
Daily Water Production Log

Today is: 2/21/2023

Flow Data

		Total Low	Iowa River X1000	Jordan Well X100	Filter Meters No.1	No.2	No.3	No.4	No.5	No.6	Backwash X100	Potable Low X10	Potable High X100	Plant Service E X1000	Plant Service W X1000	High Serv X1000
Today's Readings		2079	#####	0	414	414	414	316	316	298	19.7	69704	21263	32149	416983	1415
Yesterday's Readings	8:00 AM	0	#####	0	0	0	0	0	0	0	0	69570	21263	32135	416983	0
Total for the Day		**2079**	**2079**	**0**	414	414	414	316	316	298	19.7	134	0	14	0	1415

Chemicals Used

	Yesterday's Reading	Today's Reading	Amount Added	Daily Use (LBS)
CO_2	0	522	0	522
Cl_2-East	1994	1994		0
Cl_2-West	2891	2798		93
Cl_2-Total				93
Antiscalant	84	125		41
Sodium Bisulfite	53	160		107
Sodium Hydroxide	568	745		177
Fluoride	333.4	299	17	51.4
Lime 1st	0	2640	0	2640
Lime 2nd	0	0	0	0.0
Total Lime				2640
Mono Phos.	0	0		0
Poly Phos.	0	119	0	119
Total Phos.	0			119
PAC	387	298		135
Soda Ash	0	0		0
B LOW SER	0	0		0
B HIGH SER	0	0		0
FeSO4 SFT	82.9	82.1	0	264
$FeSO_4$ IPM	121	119.4		528

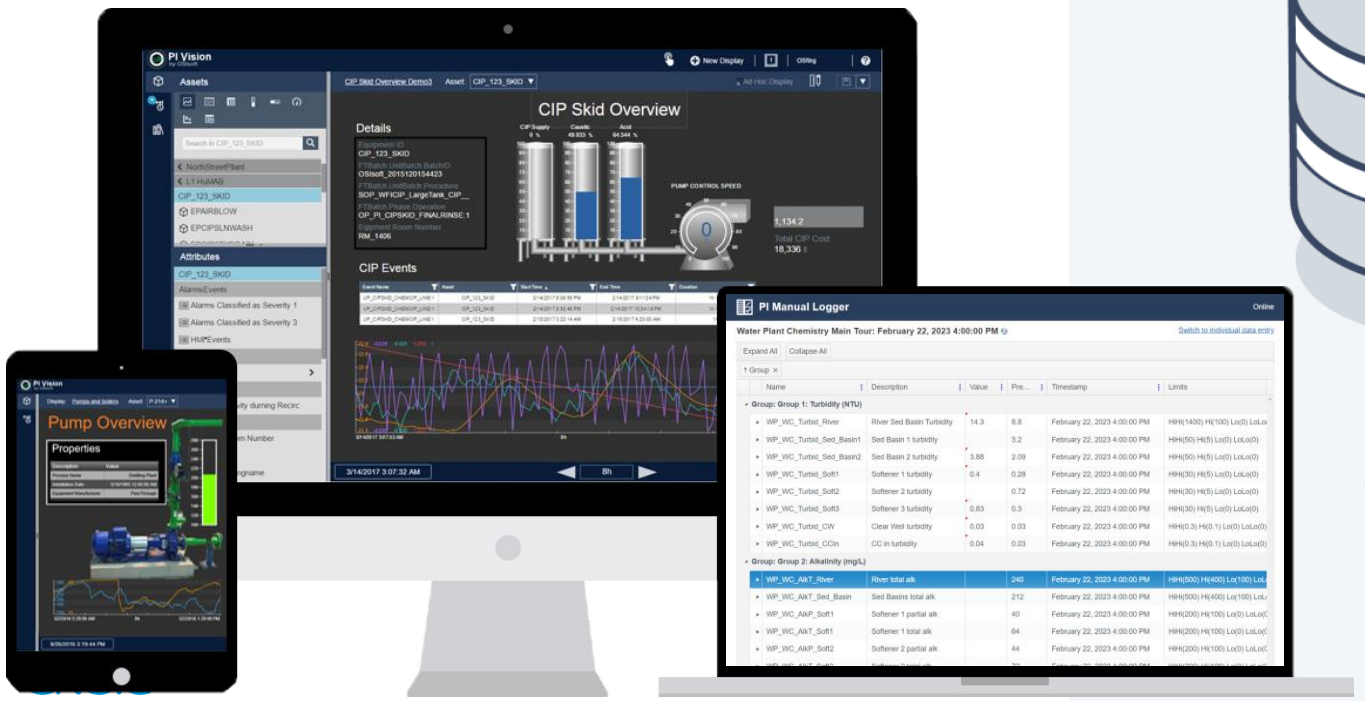
Water Level in Storage @ 8:00 AM		Weather and River Stage	
Clearwell	8.0	Max Air Temp	
Elevated Storage	27.3		0
Ground Storage	0	Min Air Temp	
Chlorine Contact	30.02		0
Water Temp - River	35.9	Precip.	0
Water Temp - CW		Dam Disch.	2410

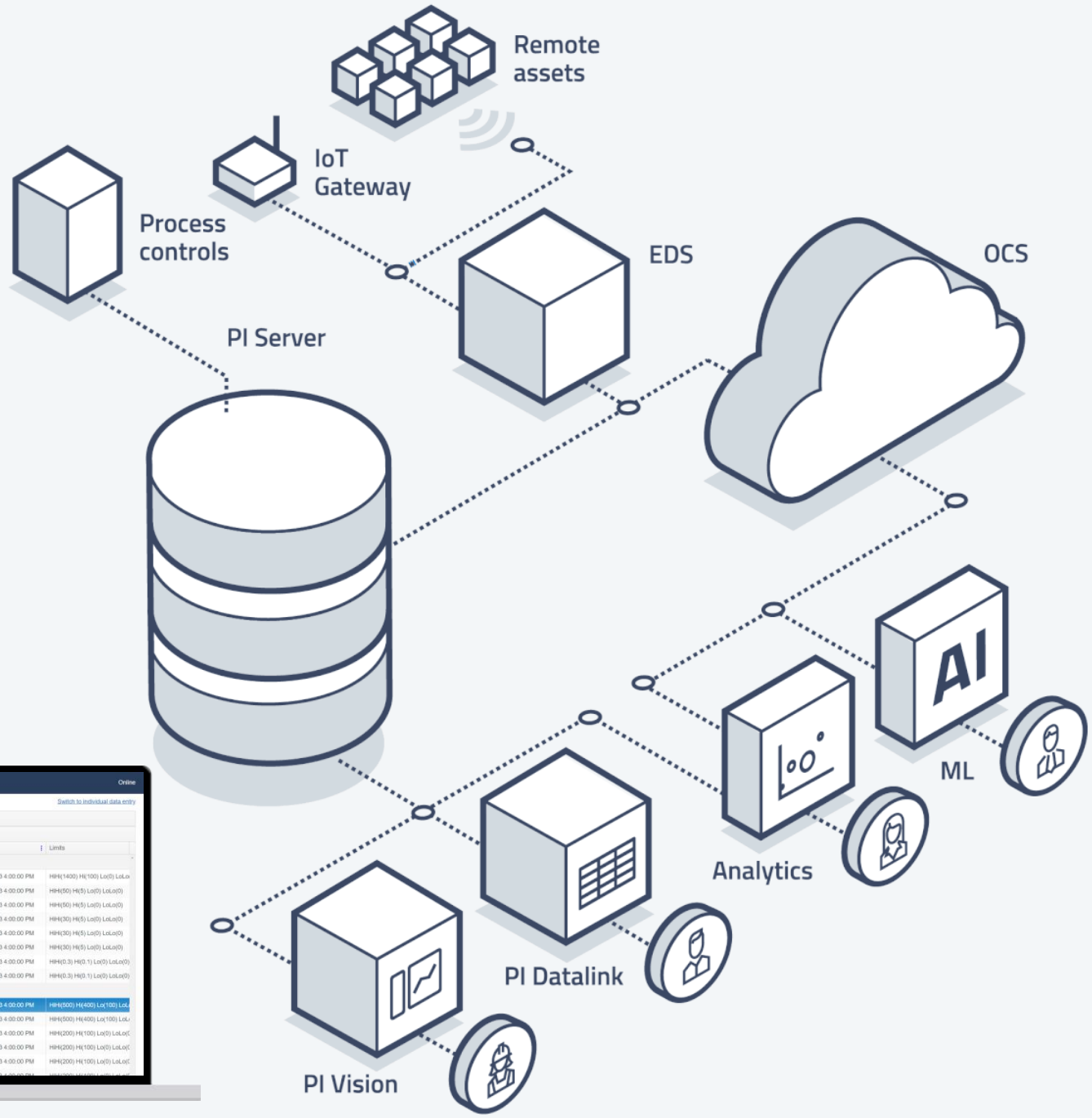
Treatment Summary X 1000 Gals.	
Total Low Service	**2079**
Iowa River	**2079**
Jordan Well	**0**
Filter Effluent	**217.2**
Backwash	**1.97**
Potable Low	**1.34**
Potable High	**0**
Plant Service	**14**
High Service	**1415**
From 8 AM	*******
To 8 AM	*******

414
298
119
21866
2410
0.0

AVEVA™ PI System

- PI Manual Logger
- PI Vision
- Asset Framework





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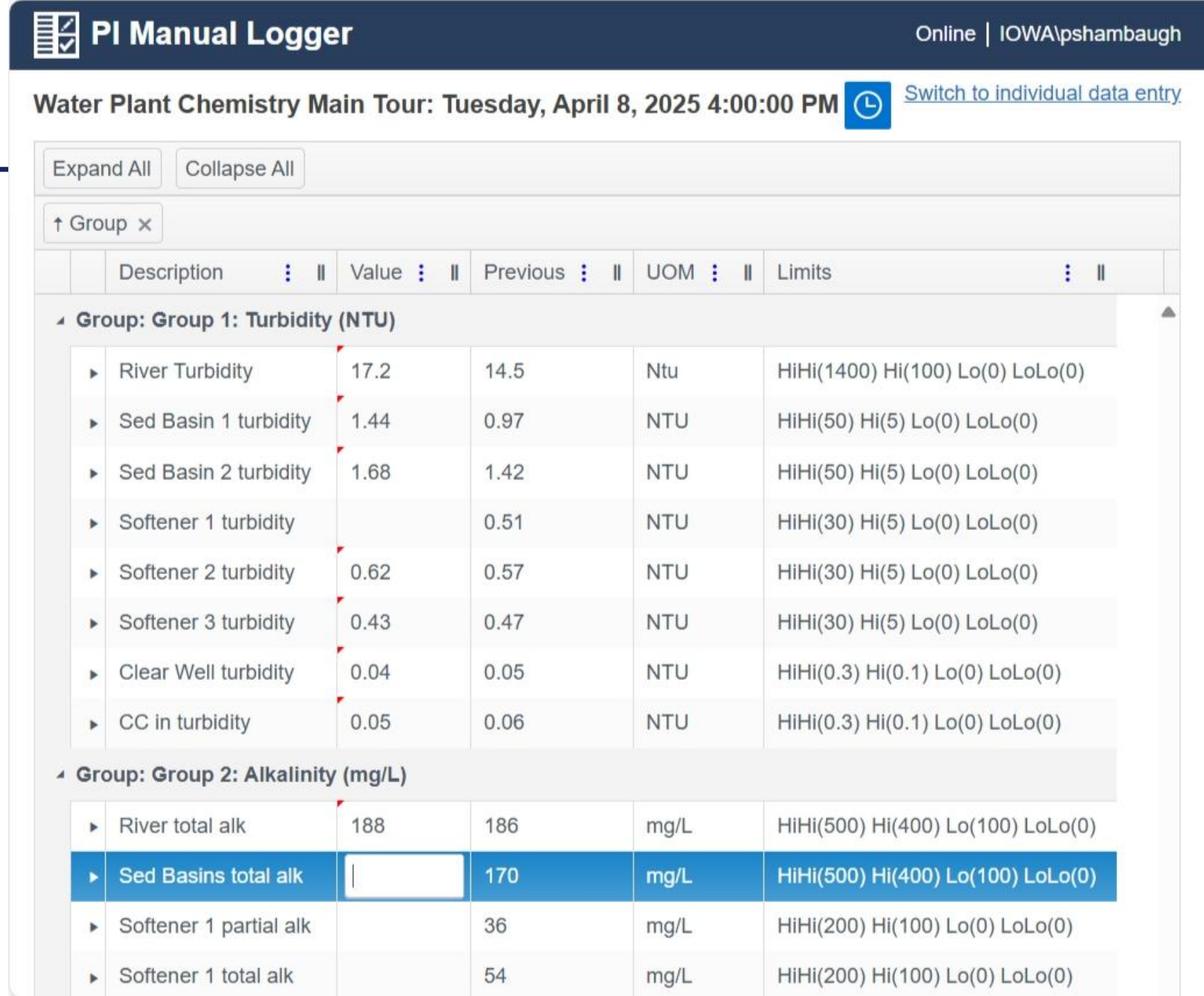

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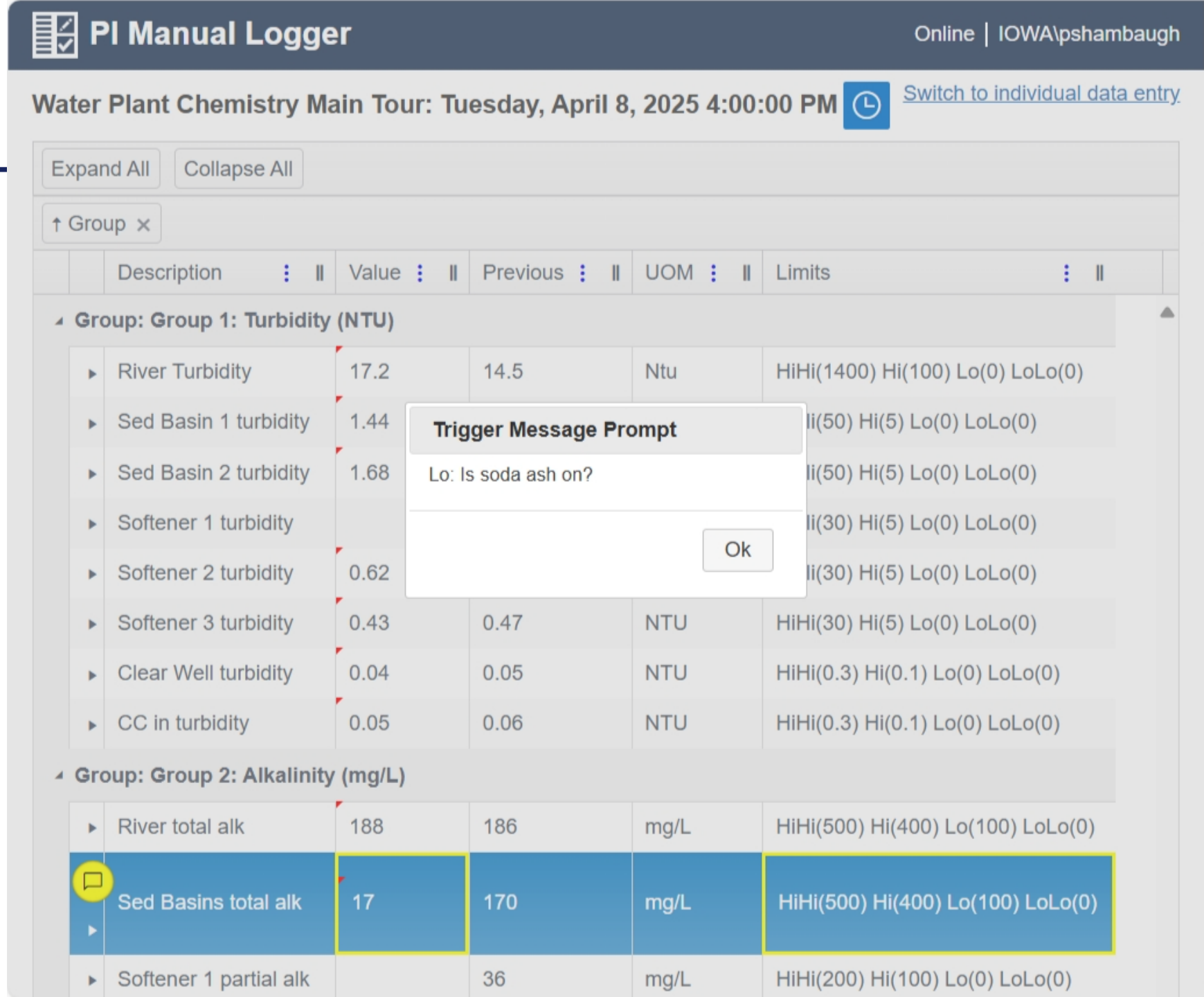

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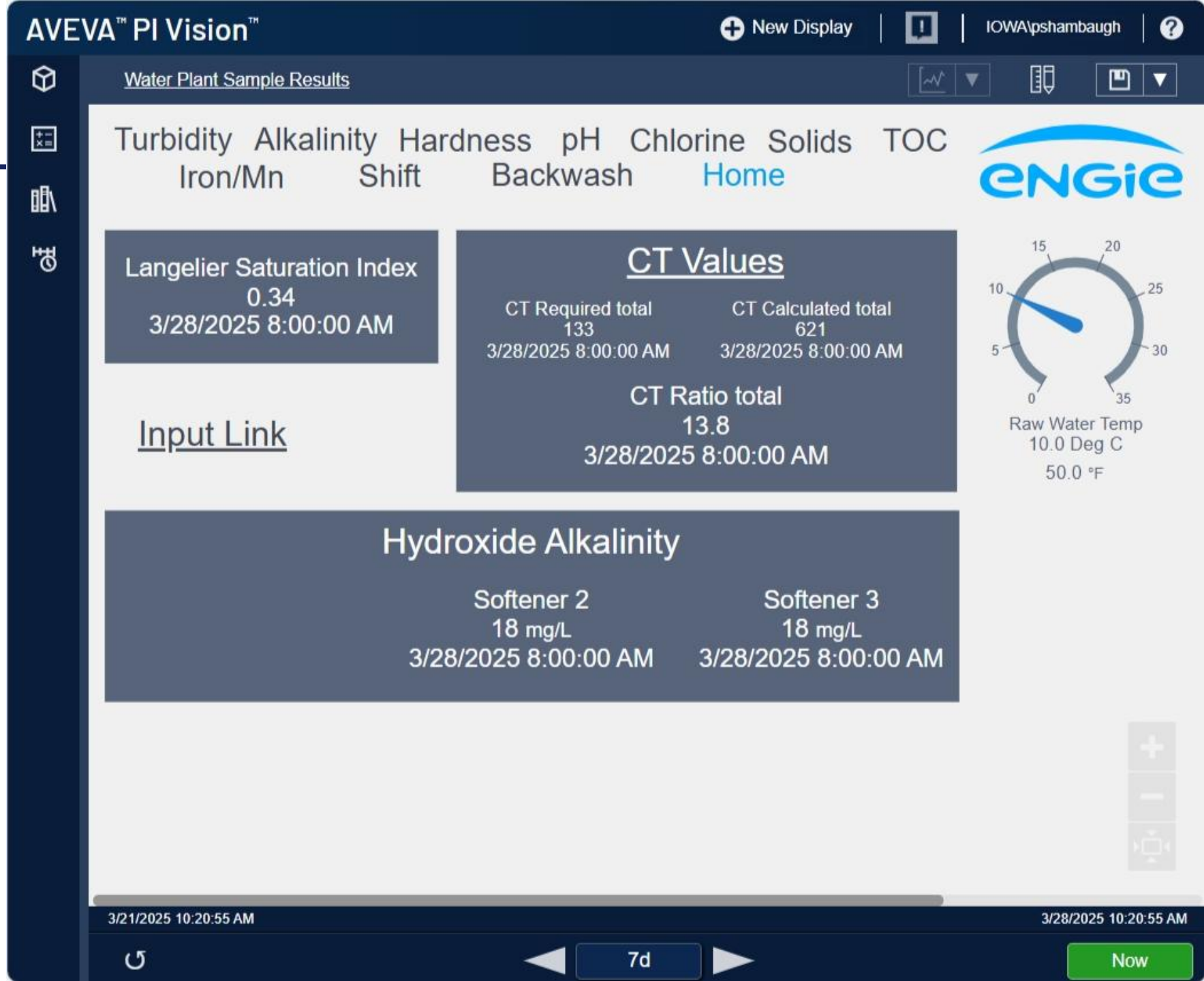

AVEVA™ PI System

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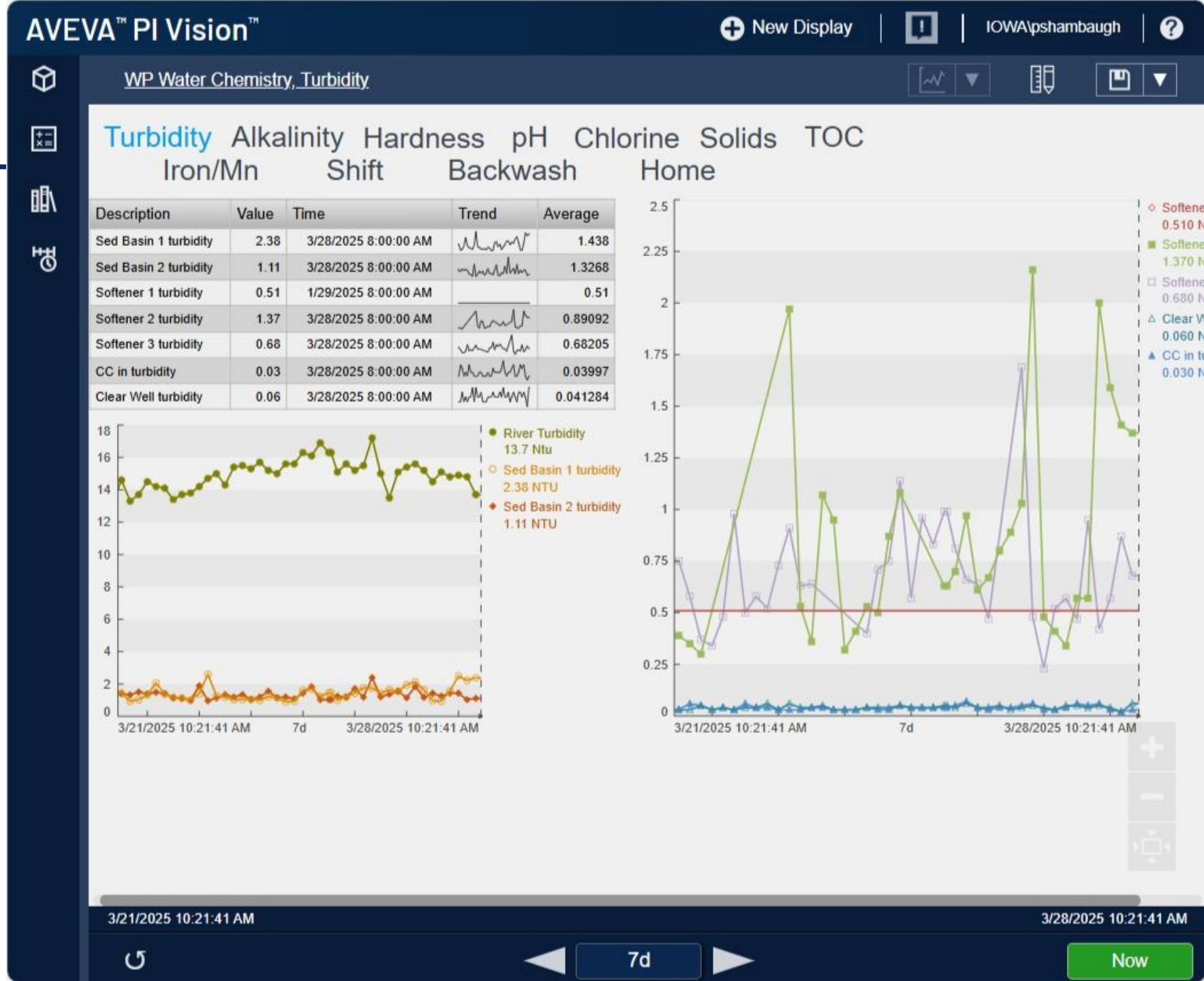
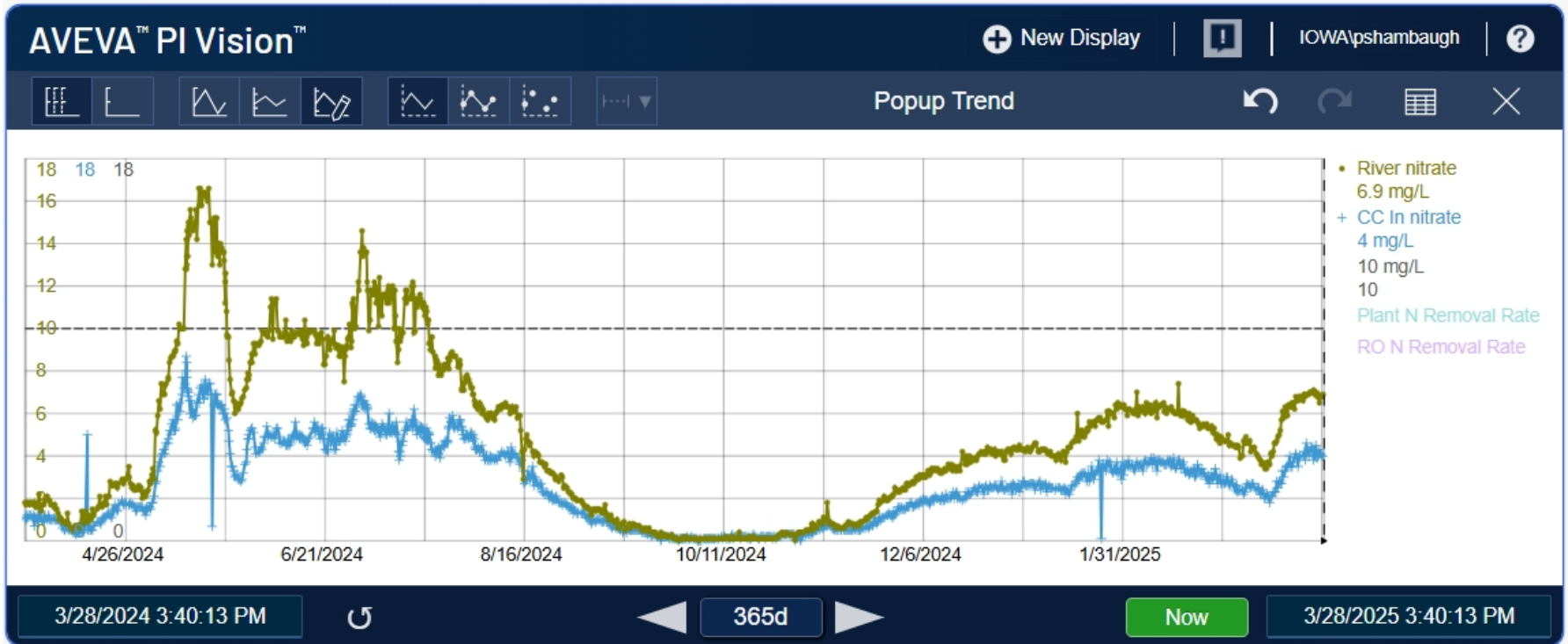
- **PI Vision**
- Asset Framework



AVEVA™ PI System

- PI Manual Logger
- **PI Vision**
- Asset Framework



AVEVA™ PI System

- PI Manual Logger
- PI Vision
- **Asset Framework**

Langelier Saturation Index Calculation

$$LSI = pH - pH_S$$

Where:

pH_S = Saturation pH, estimated using the following

$pH_S = [(9.3 + A + B) - (C + D)]$

$pH_S = (9.3 + ((\text{Log}_{10}[TDS] - 1) / 10) + (-13.2 \times \text{Log}_{10}[\text{Temperature}(°C) + 273] + 34.55)) - ((\text{Log}_{10}[Ca^{+2} \text{ as } CaCO_3] - 0.4) + (\text{Log}_{10}[\text{Alkalinity as } CaCO_3]))$

$WP\_WC\_pH\_LSI = WP\_WC\_pH\_CCIn - [9.3 + ((\text{Log}_{10}[WP\_WC\_TDS\_CCIn] - 1) / 10) + (-13.2 \times \text{Log}_{10}[WP\text{-}CAM.PAC.WaterTempInput\_C + 273] + 34.55)) - ((\text{Log}_{10}[WP\_WC\_HardCa\_CCIn] - 0.4) + (\text{Log}_{10}[WP\_WC\_AlkT\_CCIn]))]$

AVEVA™ PI System

CT Calculations

- Pulled CT equations from an engineering report
- Plugged in both sample data and online process data
- Utilized PI Web API to pull process and sample data, run calculations, and then write the results to new tags

$CT_{calculated}$:

CT_{calc} Filters = Cl_{2CW} x 1440 x 0.75 x (.10 x (# filters in service / 6)) / ($Flow_{CW}$)
CT_{calc} CW = Cl_{2CW} x 1440 x 0.32 x 7.4805 x (3352 x CW level - 9884) / (1,000,000 x $Flow_{CW}$)
CT_{calc} CC Tk = Cl_{2CC} x 1440 x 0.29 x (0.374 x CC Tk level / 13) / ($Flow_{Finished}$)
CT_{calc} = CT_{calc} Filters + CT_{calc} CW + CT_{calc} CC Tk
Where:
Cl_{2CW} is the concentration of free chlorine leaving the clear well. WP_WC_Cl2_CW
Minimum of the previous 4 hrs.
Cl_{2CC} is the concentration of free chlorine leaving the chlorine contact tank. WP_WC_Cl2_CCEf
Triggering event, entered every 4 hrs.
$Flow_{CW}$ is transfer pump flow + Backwash Pump 1 and Pump 2 flows. WP-CAM.PAC.XFP_FIC5000_PV +
Peak flow of the previous 4 hrs.
$Flow_{Finished}$ is the finished water flow leaving the chlorine contact tank. WP-CAM.PAC.MainFlowAvg
Peak flow of the previous 4 hrs.
CW level: Level of Clear Well (1) WP-CAM.PAC.ClearWell1Level
Minimum of the previous 4 hrs.
Chlorine Contact Tank level: WP-CAM.PAC.CL2ContactLevel
Minimum of the previous 4 hrs.
filters in service: Read off of WP-FLT-12(34, 56).PAC.FLTx_FE_FM_815x_FLOW (x=filter #).
Minimum number of the previous 4 hrs. Not less than 3.

$CT_{required}$:

If the temperature is < 5 °C:
CT_{req} Filters = 0.36 x ($pH_{CW}^{2.69}$) x ($Temp_{CW}^{-0.15}$) x ($Cl_{2CW}^{0.15}$) x 0.5
CT_{req} CW = CT_{req} Filters
CT_{req} CC Tk = 0.36 x ($pH_{CC}^{2.69}$) x ($Temp_{CCTk}^{-0.15}$) x ($Cl_{2CC}^{0.15}$) x 0.5
If the temperature is ≥ 5 °C:
CT_{req} Filters = 0.2828 x ($pH_{CW}^{2.69}$) x ($0.933^{(Temp_{CW}-5)}$) x ($Cl_{2CW}^{0.15}$) x 0.5
CT_{req} CW = CT_{req} Filters
CT_{req} CC Tk = 0.2828 x ($pH_{CC}^{2.69}$) x ($0.933^{(Temp_{CCTk}-5)}$) x ($Cl_{2CC}^{0.15}$) x 0.5
So:
CT_{req} = CT_{req} Filters + CT_{req} CW + CT_{req} CC Tk
Where:
Cl_{2CW} is the concentration of free chlorine leaving the Clear Well. WP_WC_Cl2_CW
Minimum of the previous 4 hrs.
Cl_{2CC} is the concentration of free chlorine leaving the Chlorine Contact Tank. WP_WC_Cl2_CCEf
Triggering event.
pH_{CW}: WP_WC_pH_CW
Maximum of the previous 4 hrs.
pH_{CC}: WP_WC_pH_CCEf
Maximum of the previous 4 hrs.
$Temp_{CW}$: WP_WC_Temp_CW
Last temp entered manually.
$Temp_{CCTk}$: WP_WC_Temp_CCIn
Last temp entered manually.

Inactivation Ratio:

CT_{ratio} Filters = CT_{calc} Filters / CT_{req} Filters
CT_{ratio} CW = CT_{calc} CW / CT_{req} CW
CT_{ratio} CC Tk = CT_{calc} CC Tk/ CT_{req} CC Tk

CT_{ratio} = CT_{ratio} Filters + CT_{ratio} CW + CT_{ratio} CC Tk

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pH_{CW}: WP_WC_pH_CW
Maximum of the previous 4 hrs.
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Maximum of the previous 4 hrs.
$Temp_{CW}$: WP_WC_Temp_CW
Last temp entered manually.
$Temp_{CCTk}$: WP_WC_Temp_CCIn
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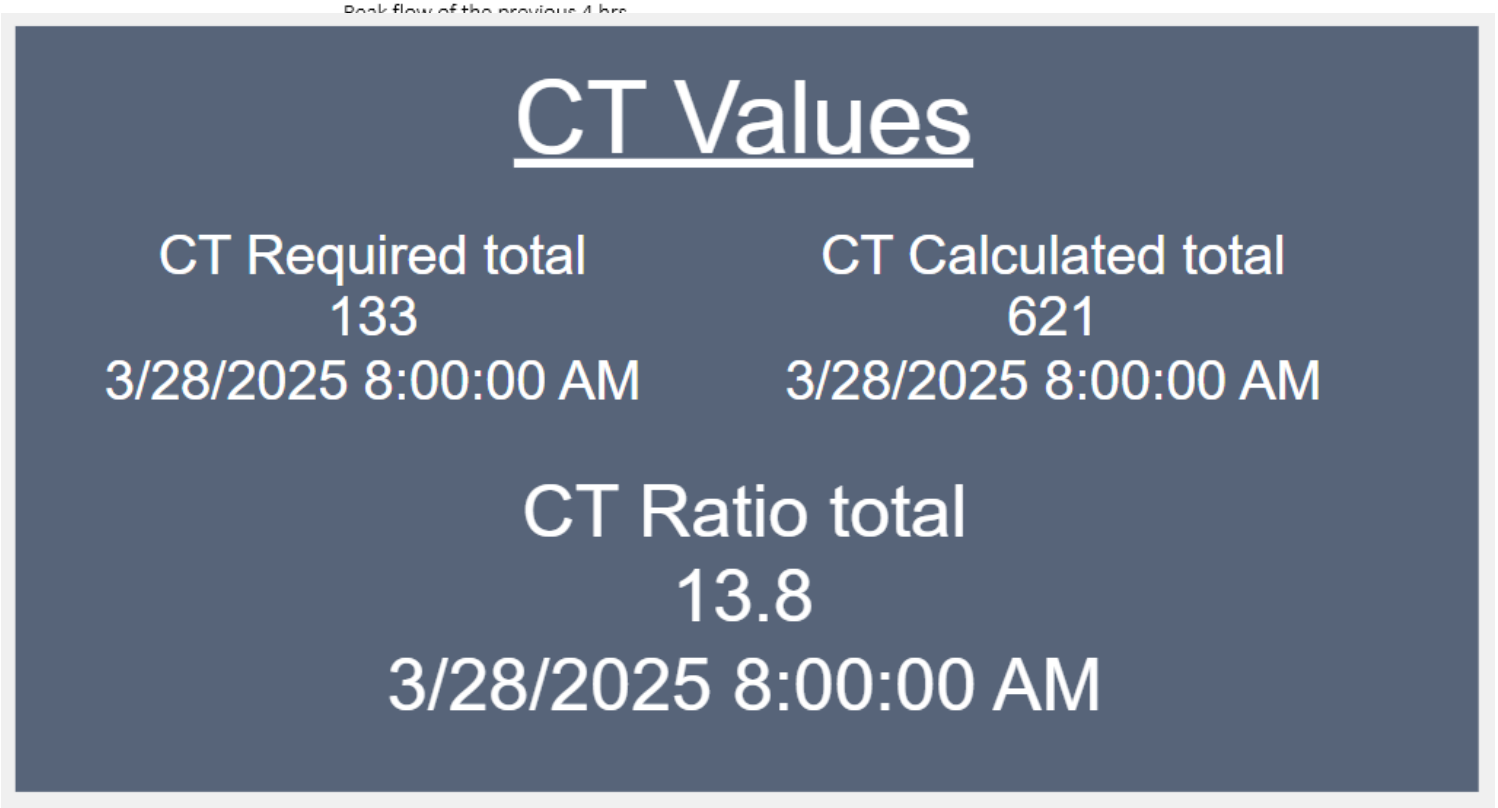

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CT_{ratio} = CT_{ratio} Filters + CT_{ratio} CW + CT_{ratio} CC Tk

WATER TREATMENT | UNIVERSITY OF IOWA

ENGIE uses the PI System to capture and utilize its lab data

Challenge

- An ancient data capture and storage system limited our ability to store and access all our sample and operational data accurately
- Needed an application which would fit a limited budget
- Operators and management were used to the old system and naturally hesitant to changing aspects of it

Solution

- Implemented AVEVA™ PI Manual Logger to capture lab sample data
- Utilized AVEVA™ PI Vision to display sample findings, calculation results, and operational stats side by side
- Organized the resulting new tags and programed calculations in AVEVA PI Server's Asset Framework

Results

- **Created a data entry, storage, calculation, and visualization process contained in one already existent ecosystem**
- **Compiled easily accessible data for operations, management, and project engineers**