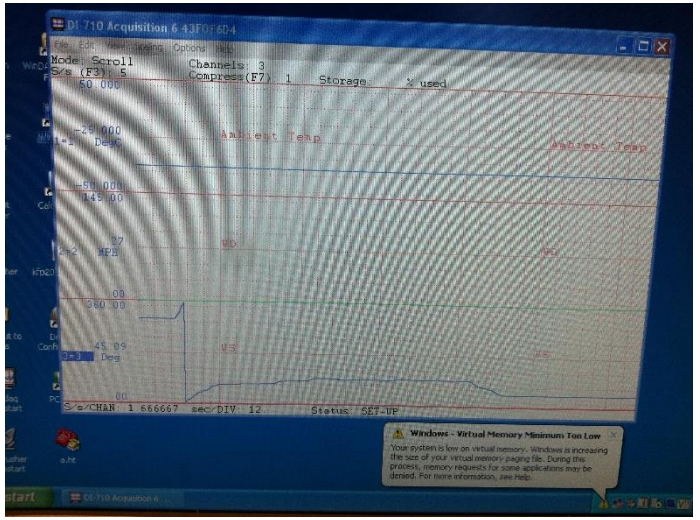
Hand-averaging to email notifications: Oregon DEQ's Journey from manual operations to automation and remote control

08/15/2024
2024 National Ambient Air Monitoring Conference

Matt Shrensel | Oregon Department of Environmental Quality

Oregon DEQ in 2015

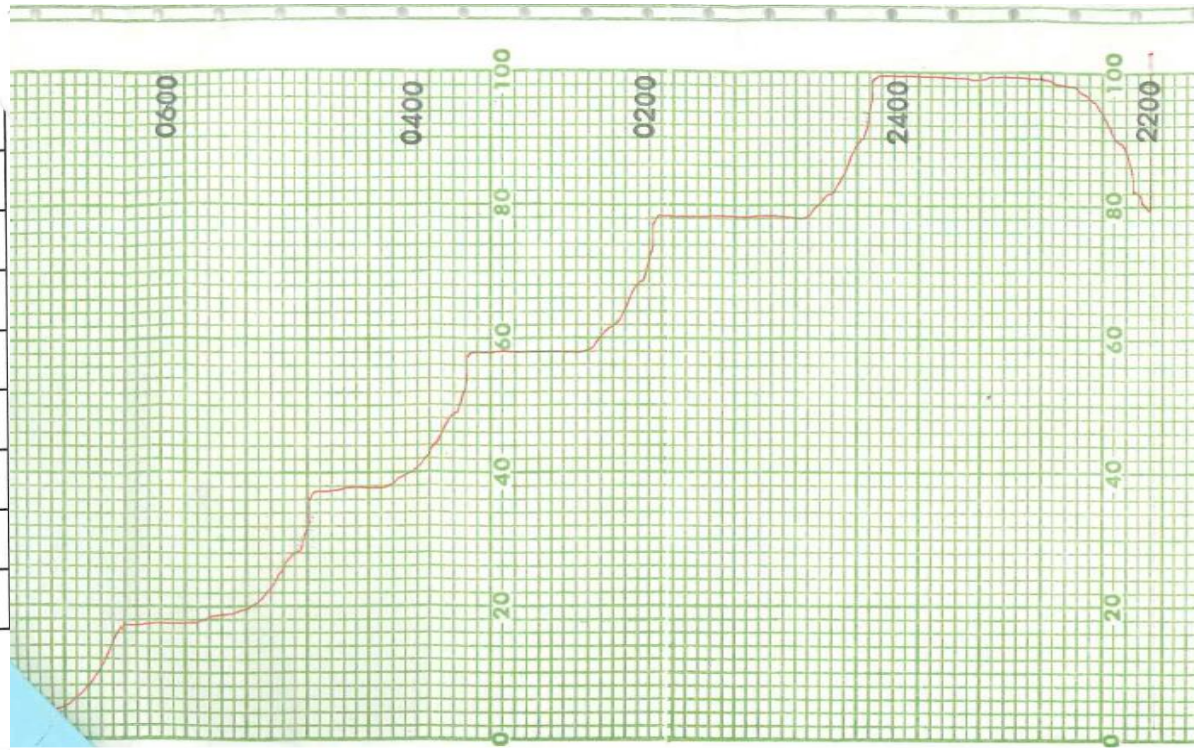
- “Only” 45 monitoring sites (some seasonal) for staff of 12
- Limited DAS software at a few sites
- Antiquated Odessa dataloggers using analog data output!
- Staff performing gas span calculations *by hand* – counting 10 values and averaging them
- Only automation: daily automatic nephelometer auto-zeroes



Ozone verifications in 2015

	0.000		0.475		0.375		0.275		0.175		0.075		0..	
1			482	478	380	373	280	274	180	173	81	76	5	0
2			483	478	379	373	280	274	180	173	81	76	5	0
3			483	477	380	373	280	275	180	173	81	76	5	0
4			483	477	380	374	280	274	180	173	81	76	5	0
5			483	477	380	375	280	274	180	173	81	76	5	0
6			483	478	380	375	280	274	180	173	81	76	5	0
7			483	478	380	375	280	274	180	173	81	76	5	0
8			483	478	380	375	280	274	180	173	81	76	5	0
9			483	478	380	375	280	274	180	173	81	75	5	0
10			483	478	380	375	280	274	180	173	81	76	5	0
ave Primary			483		380		280		180		81		5	
Test Instrument			478		375		274		173		76		0	

Instrument 372 Date 22 April '15



Ozone span & verification records in 2024

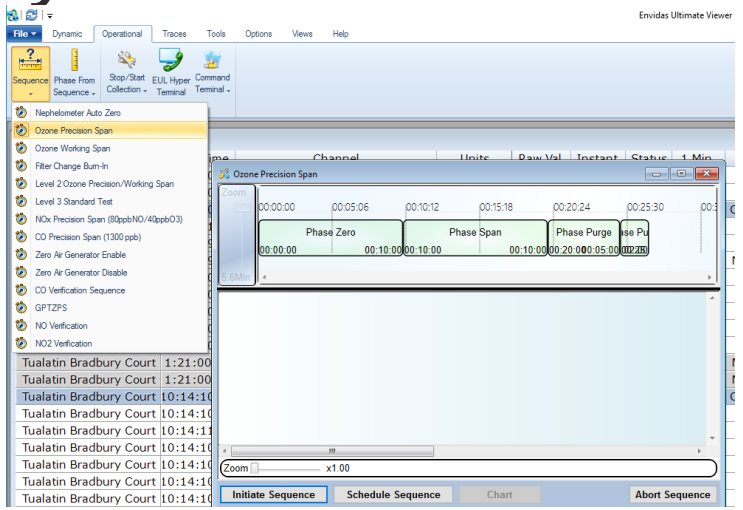
Report Type: Calibration Avg Type: Calib_2Points

Date Time: 07/2024 Time Base: None

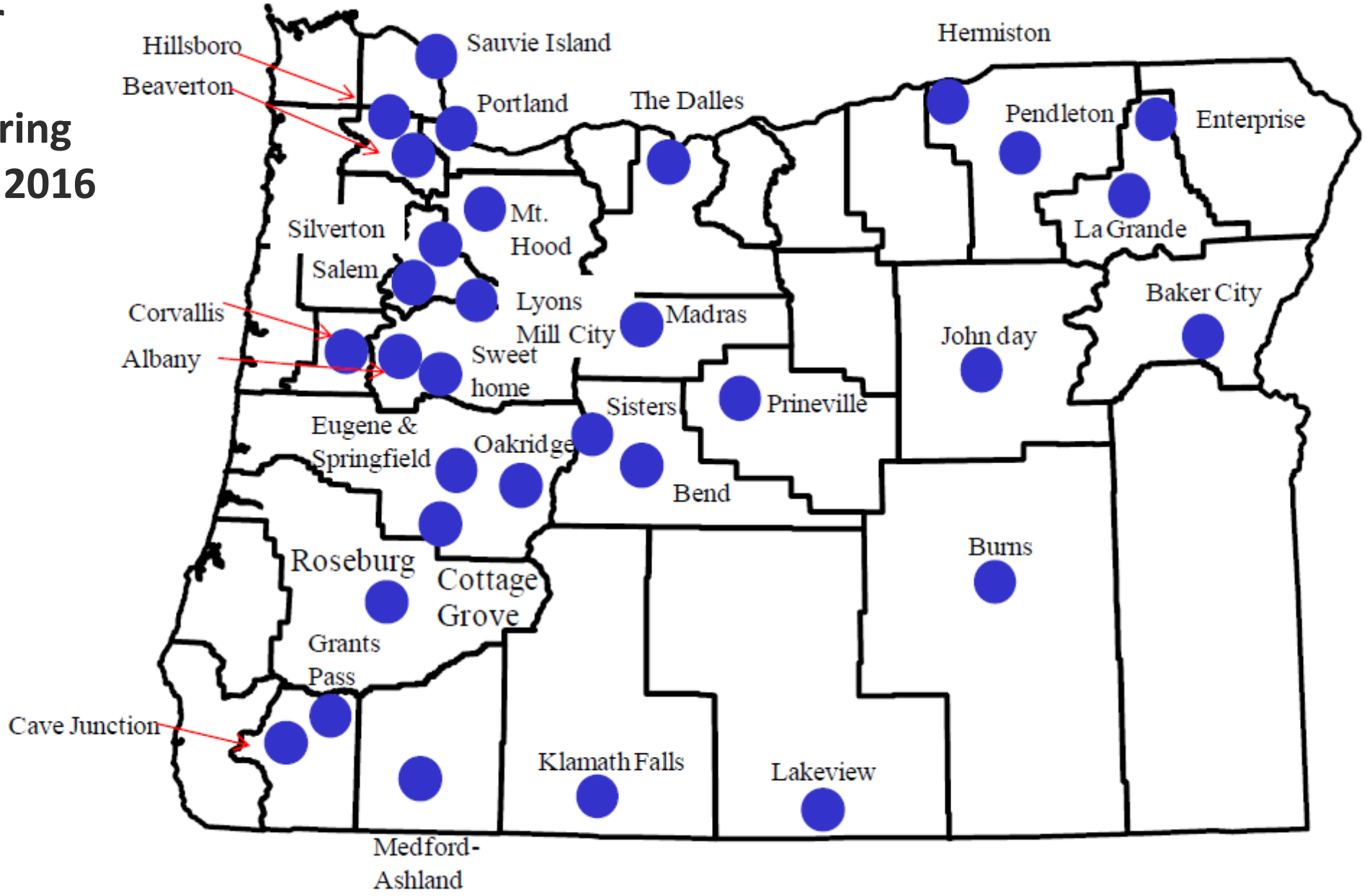
			Zero					Span						Result		
Date	Monitor	Units	ZRef	ZMeas	ZDiff(%FS)	ZDiffLast	ZStd	SRef	SMeas	SDiff(%FS)	SDiff(%REF)	SDiffLast(%)	SStd	Zero	Factor	Status
7/2/2024 11:13 PM	Ozone	ppb	0.0	0.5	0.1	0.3	0.2	70.1	70.5	0.1	0.6	0.1	0.3	0.5	1.003	Valid
7/3/2024 11:13 PM	Ozone	ppb	0.0	0.3	0.1	0.2	0.2	139.8	141.0	0.2	0.9	-0.3	0.3	0.3	0.994	Valid
7/4/2024 11:13 PM	Ozone	ppb	0.0	0.8	0.2	-0.5	0.2	70.0	70.5	0.1	0.7	0.2	0.3	0.8	1.003	Valid
7/5/2024 11:13 PM	Ozone	ppb	0.0	0.3	0.1	0.5	0.2	70.1	71.0	0.2	1.3	-0.6	0.3	0.3	0.991	Valid
7/6/2024 11:13 PM	Ozone	ppb	0.0	0.1	0.0	0.2	0.3	69.9	70.4	0.1	0.7	0.6	0.3	0.1	0.995	Valid
7/7/2024 11:13 PM	Ozone	ppb	0.0	-0.1	0.0	0.2	0.3	70.0	70.1	0.0	0.1	0.6	0.3	-0.1	0.997	Valid
7/8/2024 11:13 PM	Ozone	ppb	0.0	0.4	0.1	-0.5	0.2	70.0	70.6	0.1	0.9	-0.8	0.3	0.4	0.997	Valid
7/9/2024 11:13 PM	Ozone	ppb	0.0	0.1	0.0	0.3	0.3	69.9	70.1	0.0	0.3	0.6	0.3	0.1	0.998	Valid
7/10/2024 11:13 PM	Ozone	ppb	0.0	0.3	0.1	-0.2	0.1	140.0	141.1	0.2	0.8	-0.5	0.3	0.3	0.994	Valid
7/11/2024 11:13 PM	Ozone	ppb	0.0	0.4	0.1	-0.1	0.2	70.0	70.2	0.0	0.3	0.5	0.5	0.4	1.004	Valid
7/12/2024 11:13 PM	Ozone	ppb	0.0	0.2	0.0	0.2	0.1	70.1	70.5	0.1	0.6	-0.3	0.4	0.2	0.996	Valid
7/13/2024 11:13 PM	Ozone	ppb	0.0	0.2	0.0	0.0	0.1	70.0	70.4	0.1	0.6	0.0	0.4	0.2	0.998	Valid
7/14/2024 11:13 PM	Ozone	ppb	0.0	0.6	0.1	-0.4	0.3	70.1	70.2	0.0	0.1	0.5	0.4	0.6	1.007	Valid
7/15/2024 11:13 PM	Ozone	ppb	0.0	0.3	0.1	0.3	0.2	69.9	70.1	0.0	0.3	-0.2	0.3	0.3	1.002	Valid
7/16/2024 11:13 PM	Ozone	ppb	0.0	0.5	0.1	-0.2	0.3	70.1	70.1	0.0	0.0	0.3	0.3	0.5	1.007	Valid
7/17/2024 11:13 PM	Ozone	ppb	0.0	0.1	0.0	0.4	0.4	139.8	140.6	0.2	0.6	-0.6	0.3	0.1	0.995	Valid
7/18/2024 11:13 PM	Ozone	ppb	0.0	0.8	0.2	-0.7	0.4	70.1	70.6	0.1	0.7	-0.1	0.4	0.8	1.003	Valid
7/19/2024 11:13 PM	Ozone	ppb	0.0	1.0	0.2	-0.2	0.4	70.1	70.3	0.0	0.3	0.4	0.4	1.0	1.011	Valid
7/20/2024 11:13 PM	Ozone	ppb	0.0	0.2	0.0	0.8	0.1	70.0	69.6	-0.1	-0.6	0.9	0.4	0.2	1.010	Valid
7/21/2024 11:13 PM	Ozone	ppb	0.0	0.3	0.1	-0.1	0.4	70.0	70.2	0.0	0.3	-0.9	0.5	0.3	1.002	Valid
7/22/2024 11:13 PM	Ozone	ppb	0.0	0.9	0.2	-0.6	0.3	70.0	70.2	0.0	0.3	0.0	0.3	0.9	1.011	Valid
7/23/2024 11:13 PM	Ozone	ppb	0.0	1.2	0.2	-0.3	0.2	70.1	71.2	0.2	1.6	-1.3	0.3	1.2	1.001	Valid
7/24/2024 11:13 PM	Ozone	ppb	0.0	0.9	0.2	0.3	0.4	139.9	140.9	0.2	0.7	0.9	0.2	0.9	0.999	Valid
7/25/2024 11:13 PM	Ozone	ppb	0.0	0.5	0.1	0.4	0.1	70.0	70.1	0.0	0.1	0.6	0.5	0.5	1.006	Valid
7/26/2024 11:13 PM	Ozone	ppb	0.0	0.3	0.1	0.2	0.2	70.0	70.1	0.0	0.1	0.0	0.3	0.3	1.004	Valid
7/27/2024 11:13 PM	Ozone	ppb	0.0	0.1	0.0	0.2	0.2	70.0	70.5	0.1	0.7	-0.6	0.5	0.1	0.993	Valid
7/28/2024 11:13 PM	Ozone	ppb	0.0	0.6	0.1	-0.5	0.2	70.1	70.7	0.1	0.9	-0.2	0.4	0.6	1.000	Valid
7/29/2024 11:13 PM	Ozone	ppb	0.0	0.4	0.1	0.2	0.2	70.0	69.8	0.0	-0.3	1.2	0.5	0.4	1.008	Valid
7/30/2024 11:13 PM	Ozone	ppb	0.0	0.8	0.2	-0.4	0.3	70.0	70.2	0.0	0.3	-0.6	0.3	0.8	1.009	Valid
7/31/2024 11:13 PM	Ozone	ppb	0.0	0.3	0.1	0.5	0.1	139.9	140.4	0.1	0.4	-0.1	0.2	0.3	0.999	Valid

What did we *want* from automation?

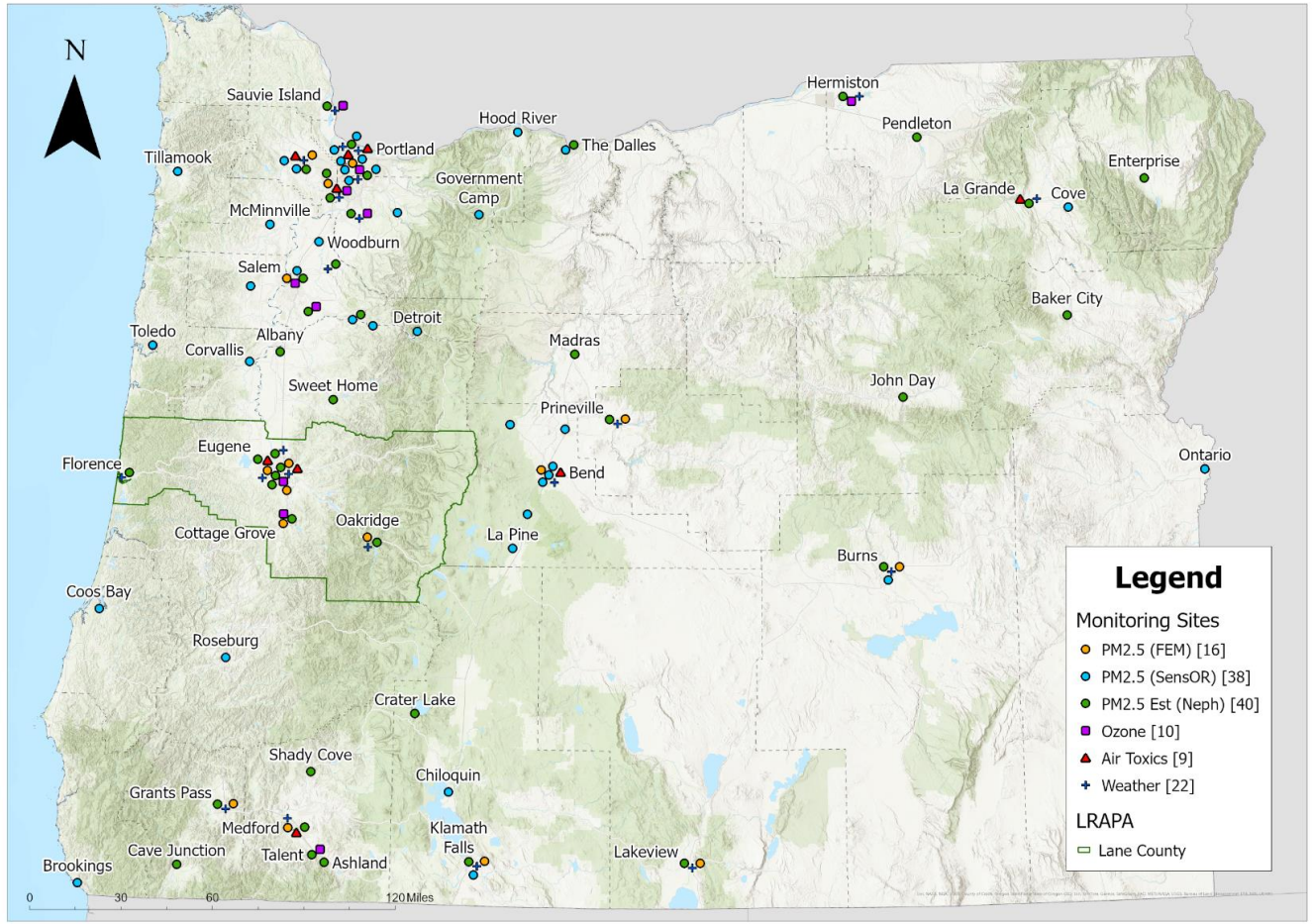
- Make gas spans *consistent* – remove operator judgement
- Make gas spans *automatic*
- Make calculations and checks automatically
- Automatic communication of validity and/or function
- Report on instrument anomalies
- Automatic email notifications
- Improve efficiency



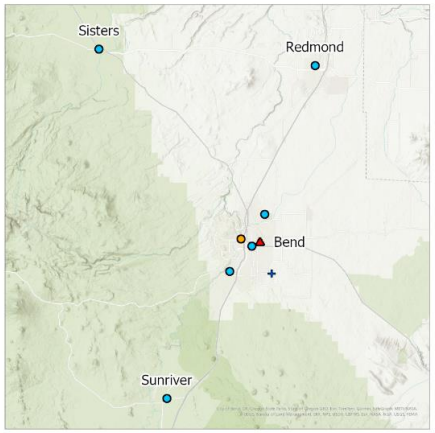
DEQ Air Quality Monitoring Sites in 2016



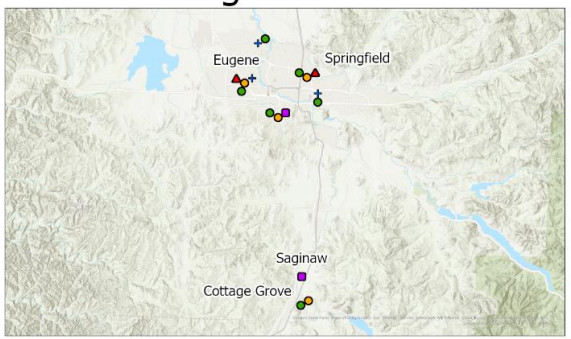
DEQ Air Quality Monitoring Sites in 2024



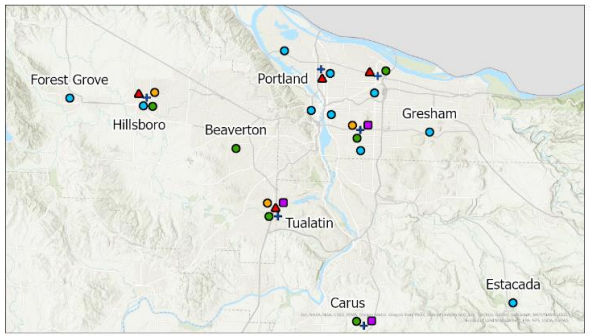
Bend Area



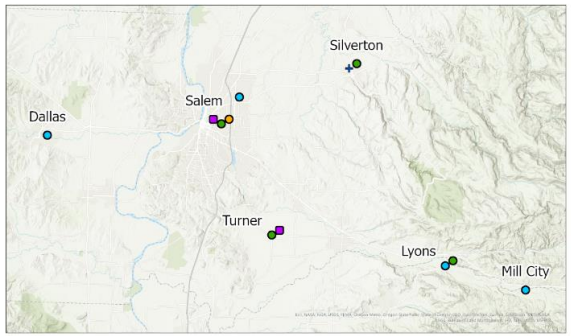
Eugene Area



Portland Area

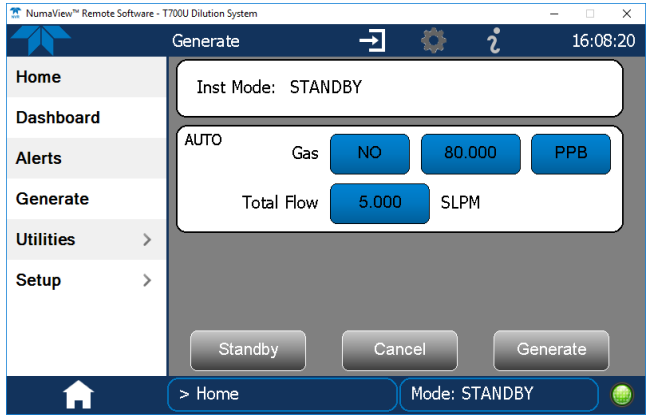


Salem Area



Principles in our automation design

- Implement in the simplest possible way:
  - As little new hardware as possible
  - Accomplish as much as you can in software
  - Modular, predictable configuration

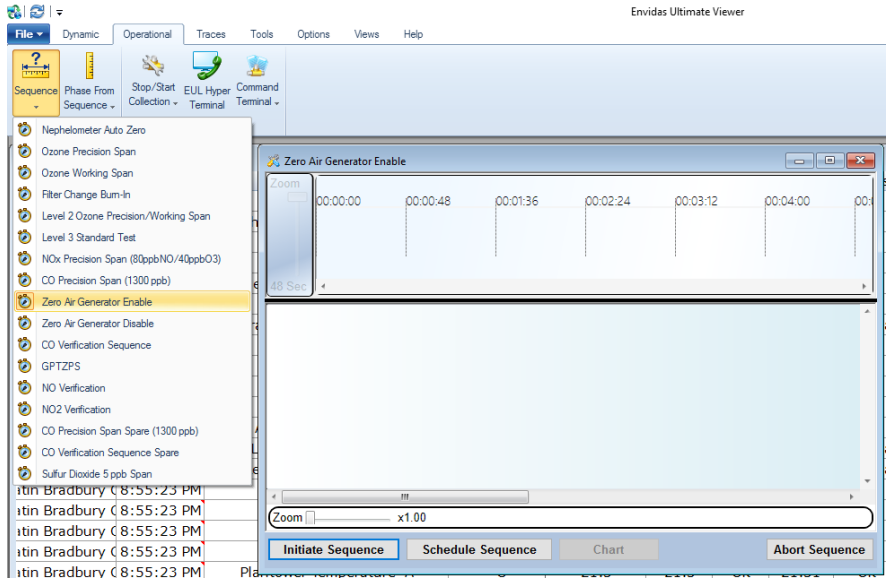


- Log all data and metadata receivable from instruments
- Standardize modular hardware and procedures
- Remote configurability
- Remote controllability
- Simple to use for new users or irregular users (QA)

Complete replacement of gas analyzers

DEQ's specific implementation notes

- Calibration manifolds and single-gas cylinders to chase high accuracy and use software valve controls, on-analyzer
- Separate ozone calibrators, monitors, and zero air generators, all sequence controlled by software - EnviDAS
- Extensive work with software vendor to enable full communication of status and automatic flagging of data from instruments
- PC hardware and software configured and controlled by AQM itself



Ozone span & verification records in 2024

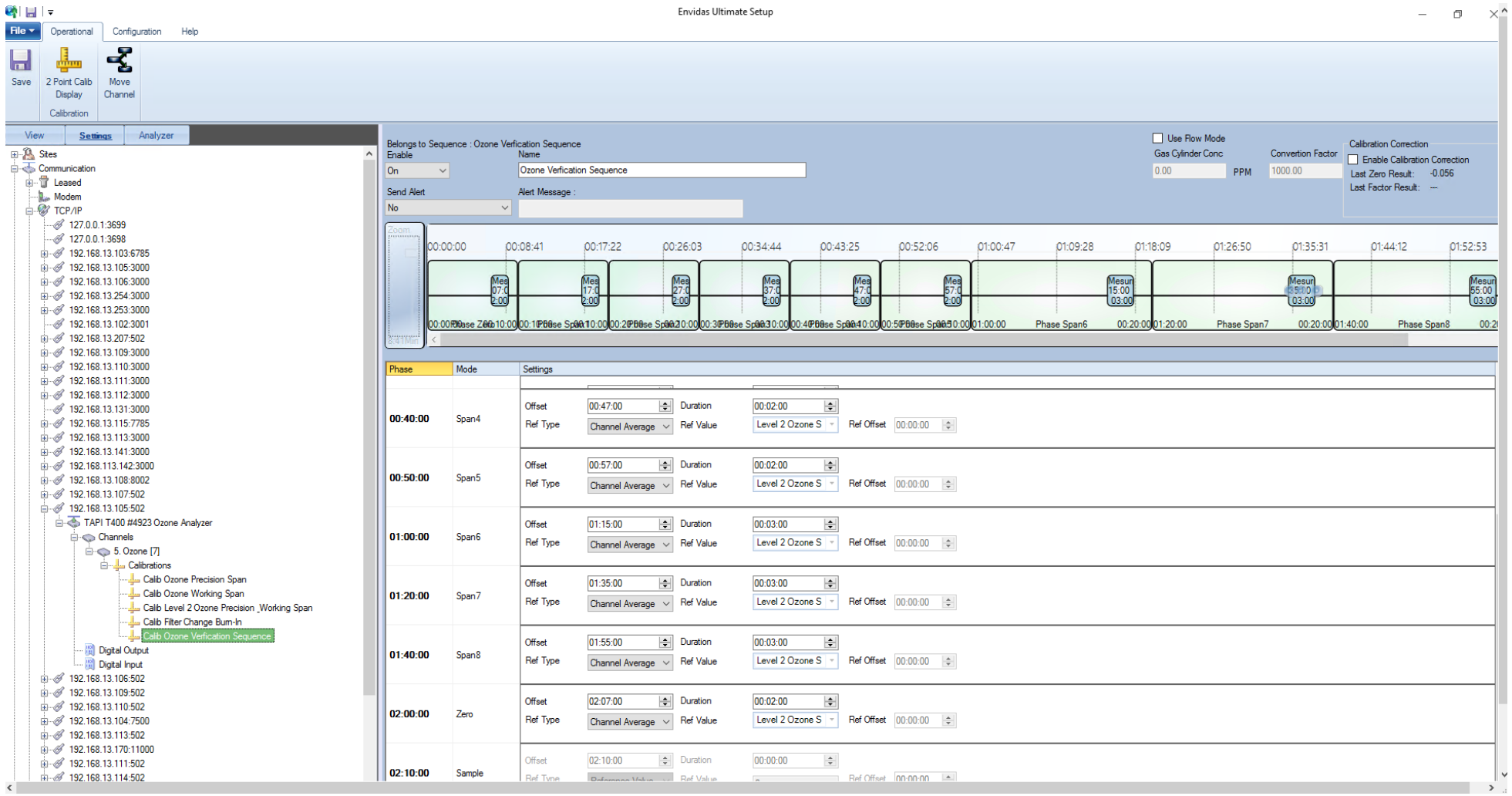
Date & Time	Ozone (Level 2 Standard) #4817	Status	T703 Serial # 705 Ozone	Status	T400 Serial #4926 Ozone Analyzer	Status	T400 Serial #4927 Ozone Analyzer
	ppb		ppb		ppb		ppb
4/23/2023 12:40 PM	0.6	Ok	0.4	Ok	2.4	Ok	0
4/23/2023 12:41 PM	0.3	Ok	0.6	Ok	2.2	Ok	0
4/23/2023 12:42 PM	0.4	Ok	1.2	Zero	2.4	Ok	0.3
4/23/2023 12:43 PM	0.1	Ok	0.9	Zero	2.4	Ok	0.3
4/23/2023 12:44 PM	-0.1	Ok	0.6	Zero	2.1	Ok	0.1
4/23/2023 12:45 PM	0.5	Ok	0.8	Zero	2.3	Ok	-0.1
4/23/2023 12:46 PM	0.4	Ok	0.9	Zero	2.5	Ok	0
4/23/2023 12:47 PM	0.2	Ok	0.7	Zero	2.6	Ok	0.3
4/23/2023 12:48 PM	0.1	Ok	0.6	Zero	2.1	Ok	0.6
4/23/2023 12:49 PM	0.3	Ok	1.1	Zero	2.2	Ok	0.3
4/23/2023 12:50 PM	0.4	Ok	1.5	Zero	2.6	Ok	0
4/23/2023 12:51 PM	0.7	Ok	2.4	Calib	2.5	Ok	0.4
4/23/2023 12:52 PM	289.4	Ok	192.8	Span1	272.9	Ok	232.3
4/23/2023 12:53 PM	212.9	Ok	213.4	Span1	205	Ok	213
4/23/2023 12:54 PM	209.4	Ok	210.7	Span1	195.6	Ok	209.9
4/23/2023 12:55 PM	200.4	Ok	196	Span1	185.3	Ok	201
4/23/2023 12:56 PM	196.1	Ok	195.6	Span1	186.8	Ok	196.7
4/23/2023 12:57 PM	196.9	Ok	197.1	Span1	188.2	Ok	197.6
4/23/2023 12:58 PM	197.5	Ok	198.9	Span1	189.5	Ok	198.7
4/23/2023 12:59 PM	197.8	Ok	199.2	Span1	189.2	Ok	199.6
4/23/2023 1:00 PM	198.4	Ok	199.3	Span1	189.4	Ok	200
4/23/2023 1:01 PM	199.7	Ok	198.7	Calib	191.9	Ok	201.4
4/23/2023 1:02 PM	177.3	Ok	174.3	Span2	168.8	Ok	181.7
4/23/2023 1:03 PM	173.7	Ok	173.6	Span2	162.1	Ok	174.8
4/23/2023 1:04 PM	172.2	Ok	172.8	Span2	163.4	Ok	173.4
4/23/2023 1:05 PM	169.2	Ok	170.8	Span2	160.4	Ok	169.9
4/23/2023 1:06 PM	169.1	Ok	169.6	Span2	159.6	Ok	169.9
4/23/2023 1:07 PM	169.5	Ok	170.2	Span2	156.9	Ok	170.5
4/23/2023 1:08 PM	170.1	Ok	170.1	Span2	161.1	Ok	170.7
4/23/2023 1:09 PM	170.8	Ok	170.8	Span2	159.8	Ok	171.6
4/23/2023 1:10 PM	170.4	Ok	171	Span2	159.8	Ok	171.7
4/23/2023 1:11 PM	170.3	Ok	170.6	Calib	161	Ok	171.3
4/23/2023 1:12 PM	146	Ok	143.2	Span3	142.8	Ok	147.8
4/23/2023 1:13 PM	141.3	Ok	141.4	Span3	131.1	Ok	141.9
4/23/2023 1:14 PM	140.9	Ok	141.8	Span3	131.6	Ok	141.2
4/23/2023 1:15 PM	139.8	Ok	141.3	Span3	132.9	Ok	141
4/23/2023 1:16 PM	140.2	Ok	140.7	Span3	133.2	Ok	141.4
4/23/2023 1:17 PM	141.6	Ok	141.6	Span3	134	Ok	142.3
4/23/2023 1:18 PM	142.7	Ok	141.7	Span3	134.2	Ok	142.8
4/23/2023 1:19 PM	142.3	Ok	141.1	Span3	133.9	Ok	142.4
4/23/2023 1:20 PM	140.8	Ok	141.5	Span3	133.1	Ok	141.5
4/23/2023 1:21 PM	140	Ok	140.6	Calib	132.1	Ok	140.9
4/23/2023 1:22 PM	106.5	Ok	105.1	Span4	104.8	Ok	108.8
4/23/2023 1:23 PM	101.9	Ok	102.9	Span4	96.5	Ok	103.3

Date & Time	Photometer detector measure reading	Photometer detector reference reading	Slope for range #1	Offset for range #1	Ozone concentration (Range #1)	Concentration stability	Photometer lamp temperature	Sample temperature	Sample flow rate	Sample Pressure	Internal box temperature	Ground reference	Precision 4.096 mV reference
	mV	mV	---	ppb	ppb	ppb	°C	°C	cc/minute	" Hg	°C	mV	mV
4/23/2023 12:40 PM	4795.958	4795.832	1	-2.1	2.103	0.264	57.992	36.701	860.987	27.415	25.205	0.025	4097.685
4/23/2023 12:41 PM	4795.262	4795.515	1	-2.1	2.32	0.253	57.996	36.702	860.223	27.432	25.202	0.025	4097.748
4/23/2023 12:42 PM	4795.135	4795.135	1	-2.1	2.501	0.251	57.999	36.706	867.999	27.425	25.195	-0.038	4097.685
4/23/2023 12:43 PM	4795.389	4795.389	1	-2.1	2.061	0.254	57.999	36.71	872.651	27.418	25.197	-0.038	4097.748
4/23/2023 12:44 PM	4795.579	4795.705	1	-2.1	2.281	0.26	57.996	36.71	861.22	27.435	25.194	-0.038	4097.621
4/23/2023 12:45 PM	4795.515	4795.452	1	-2.1	2.261	0.276	58	36.712	865.207	27.414	25.2	0.025	4097.685
4/23/2023 12:46 PM	4795.705	4795.832	1	-2.1	2.642	0.28	57.993	36.702	856.502	27.432	25.213	0.025	4097.685
4/23/2023 12:47 PM	4795.579	4795.452	1	-2.1	2.361	0.296	57.992	36.701	877.569	27.414	25.216	0.025	4097.621
4/23/2023 12:48 PM	4795.262	4795.389	1	-2.1	1.839	0.315	57.991	36.706	874.877	27.438	25.22	0.025	4097.875
4/23/2023 12:49 PM	4795.389	4795.389	1	-2.1	2.64	0.305	57.999	36.707	871.089	27.389	25.21	0.025	4097.621
4/23/2023 12:50 PM	4795.452	4795.515	1	-2.1	2.26	0.327	57.999	36.712	880.692	27.454	25.21	0.025	4097.621
4/23/2023 12:51 PM	4734.234	4795.199	1	-2.1	2.379	0.315	58.003	36.716	869.328	27.416	25.202	0.025	4097.685
4/23/2023 12:52 PM	4784.88	4795.389	1	-2.1	206.305	148.554	57.995	36.716	862.283	27.43	25.205	0.025	4097.685
4/23/2023 12:53 PM	4785.64	4795.389	1	-2.1	202.356	150.013	57.999	36.71	870.723	27.421	25.213	0.025	4097.621
4/23/2023 12:54 PM	4786.019	4795.325	1	-2.1	178.973	133.893	57.998	36.709	875.807	27.418	25.223	0.025	4097.621
4/23/2023 12:55 PM	4785.956	4795.452	1	-2.1	186.459	95.065	57.998	36.702	877.535	27.429	25.236	0.025	4097.621
4/23/2023 12:56 PM	4786.842	4795.389	1	-2.1	187.482	9.067	57.998	36.696	862.516	27.415	25.242	0.025	4097.558
4/23/2023 12:57 PM	4785.576	4795.262	1	-2.1	189.478	5.986	57.996	36.694	882.975	27.435	25.242	0.025	4097.558
4/23/2023 12:58 PM	4786.779	4795.262	1	-2.1	190.691	3.168	57.999	36.696	859.293	27.413	25.249	0.025	4097.621
4/23/2023 12:59 PM	4785.576	4795.389	1	-2.1	188.48	1.536	58.002	36.695	878.233	27.432	25.251	0.025	4098.634
4/23/2023 1:00 PM	4785.703	4795.389	1	-2.1	191.336	1.291	58.006	36.703	868.032	27.383	25.244	-0.038	4097.621
4/23/2023 1:01 PM	4787.222	4795.389	1	-2.1	178.452	4.023	57.996	36.712	861.353	27.449	25.251	0.025	4097.685
4/23/2023 1:02 PM	4786.716	4795.325	1	-2.1	160.817	11.35	58.003	36.714	874.91	27.407	25.246	-0.038	4097.685
4/23/2023 1:03 PM	4788.362	4795.389	1	-2.1	164.052	13.974	58.002	36.714	873.349	27.43	25.246	0.025	4097.621
4/23/2023 1:04 PM	4787.412	4795.515	1	-2.1	161.089	13.175	58.003	36.716	874.079	27.428	25.247	0.025	4097.685
4/23/2023 1:05 PM	4787.729	4795.325	1	-2.1	160.841	5.847	57.999	36.713	875.774	27.416	25.246	0.025	4097.685
4/23/2023 1:06 PM	4787.729	4795.199	1	-2.1	150.5	4.032	57.999	36.71	865.972	27.435	25.244	0.025	4097.621
4/23/2023 1:07 PM	4787.032	4795.262	1	-2.1	159.907	4.159	57.999	36.713	876.539	27.415	25.242	-0.038	4097.685
4/23/2023 1:08 PM	4788.298	4795.199	1	-2.1	159.491	3.759	57.999	36.707	872.385	27.435	25.251	-0.038	4097.685
4/23/2023 1:09 PM	4786.716	4795.072	1	-2.1	158.633	5.111	58.006	36.709	864.809	27.418	25.244	0.025	4097.685
4/23/2023 1:10 PM	4788.235	4795.135	1	-2.1	161.171	4.068	58.002	36.712	874.711	27.431	25.242	-0.038	4097.621
4/23/2023 1:11 PM	4787.918	4795.199	1	-2.1	159.403	3.642	57.995	36.713	878.665	27.396	25.236	0.025	4097.685
4/23/2023 1:12 PM	4788.235	4794.882	1	-2.1	139.799	10.405	58.002	36.712	871.056	27.455	25.233	0.025	4097.621
4/23/2023 1:13 PM	4789.564	4795.452	1	-2.1	129.411	14.317	57.998	36.714	851.418	27.428	25.229	0.025	4097.748
4/23/2023 1:14 PM	4788.805	4795.452	1	-2.1	133.706	14.193	57.999	36.714	851.916	27.436	25.229	0.025	4097.685
4/23/2023 1:15 PM	4789.311	4795.389	1	-2.1	132.879	9.302	58	36.713	879.596	27.43	25.231	0.025	4097.621
4/23/2023 1:16 PM	4788.678	4795.642	1	-2.1	133.379	2.663	57.995	36.716	873.349	27.419	25.236	-0.038	4097.621

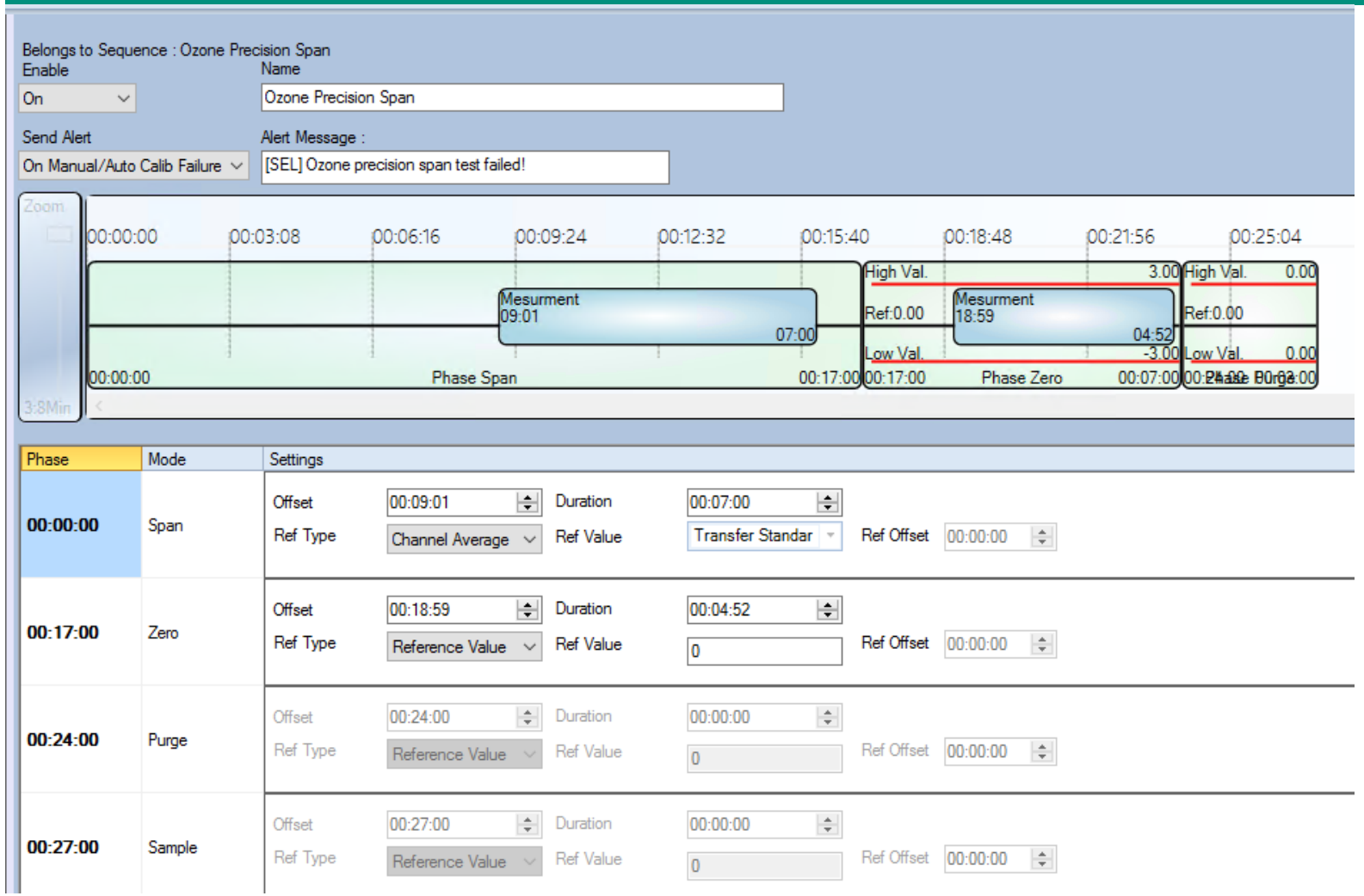
Other span/audit records in 2024

7/26/2024 6:10 AM	Nephelometer	Bscat	Zero	0.21	0.23	0.02	9.5%	0.2%	0.2	0.01	Valid
			Span	No data	No data	No data	---	---	---	---	
7/26/2024 8:00 AM	PM2.5L_BAM1022	µg/m3(L)	Zero	0.00	0.56	0.56	---	0.6%	0.0	---	Valid
			Span	16.92	16.71	1.048	-1.2%	-1.8%	-0.6	---	
7/26/2024 11:13 PM	Ozone	ppb	Zero	0.0	0.6	0.6	---	21.7%	21.1	0.2	Valid
			Span	70.8	71.0	1.007	0.3%	-69.1%	-69.4	1.9	
7/27/2024 6:10 AM	Nephelometer	Bscat	Zero	0.21	0.23	0.02	9.5%	0.2%	0.2	0.01	Valid
			Span	No data	No data	No data	---	---	---	---	
7/27/2024 11:13 PM	Ozone	ppb	Zero	0.0	0.8	0.8	---	0.6%	-0.2	0.3	Valid
			Span	69.9	70.6	1.000	1.0%	0.3%	-0.7	0.5	
7/28/2024 6:10 AM	Nephelometer	Bscat	Zero	0.21	0.23	0.02	9.5%	0.2%	0.2	0.01	Valid
			Span	No data	No data	No data	---	---	---	---	
7/28/2024 11:13 PM	Ozone	ppb	Zero	0.0	0.8	0.8	---	0.8%	0.0	0.2	Valid
			Span	70.0	70.1	1.010	0.1%	1.0%	0.9	0.4	
7/29/2024 2:49 AM	Carbon Monoxide	ppb	Zero	0.0	31.0	31.0	---	39.1%	8.1	7.7	Valid
			Span	1501.1	1492.8	1.027	-0.6%	-0.8%	-0.2	5.4	
7/29/2024 4:06 AM	Nitric Oxide	ppb	Zero	0.0	0.2	0.2	---	0.1%	-0.1	0.0	Valid
			Span	80.5	74.8	1.079	-7.1%	-6.6%	0.5	0.2	
7/29/2024 4:06 AM	Nitrogen Dioxide	ppb	Zero	0.0	0.0	0.0	---	0.1%	0.1	0.1	Valid
			Span	60.0	52.3	1.148	-12.8%	-12.3%	0.5	7.2	
7/29/2024 4:06 AM	Oxides of Nitrogen	ppb	Zero	0.0	0.2	0.2	---	0.2%	0.0	0.0	Valid
			Span	80.5	75.0	1.075	-6.8%	-9.1%	-2.3	9.4	
7/29/2024 5:45 AM	Sulfur Dioxide	ppb	Zero	0.00	0.13	0.13	---	0.1%	0.0	0.00	Valid
			Span	5.00	5.08	1.009	1.6%	-2.0%	-3.6	0.00	
7/29/2024 6:10 AM	Nephelometer	Bscat	Zero	0.21	0.22	0.01	4.8%	0.2%	0.2	0.00	Valid
			Span	No data	No data	No data	---	---	---	---	
7/29/2024 11:13 PM	Ozone	ppb	Zero	0.0	0.7	0.7	---	0.8%	0.1	0.2	Valid
			Span	69.9	69.0	1.024	-1.3%	0.1%	1.4	0.7	
7/30/2024 6:10 AM	Nephelometer	Bscat	Zero	0.21	0.24	0.03	14.3%	0.2%	0.2	0.00	Valid

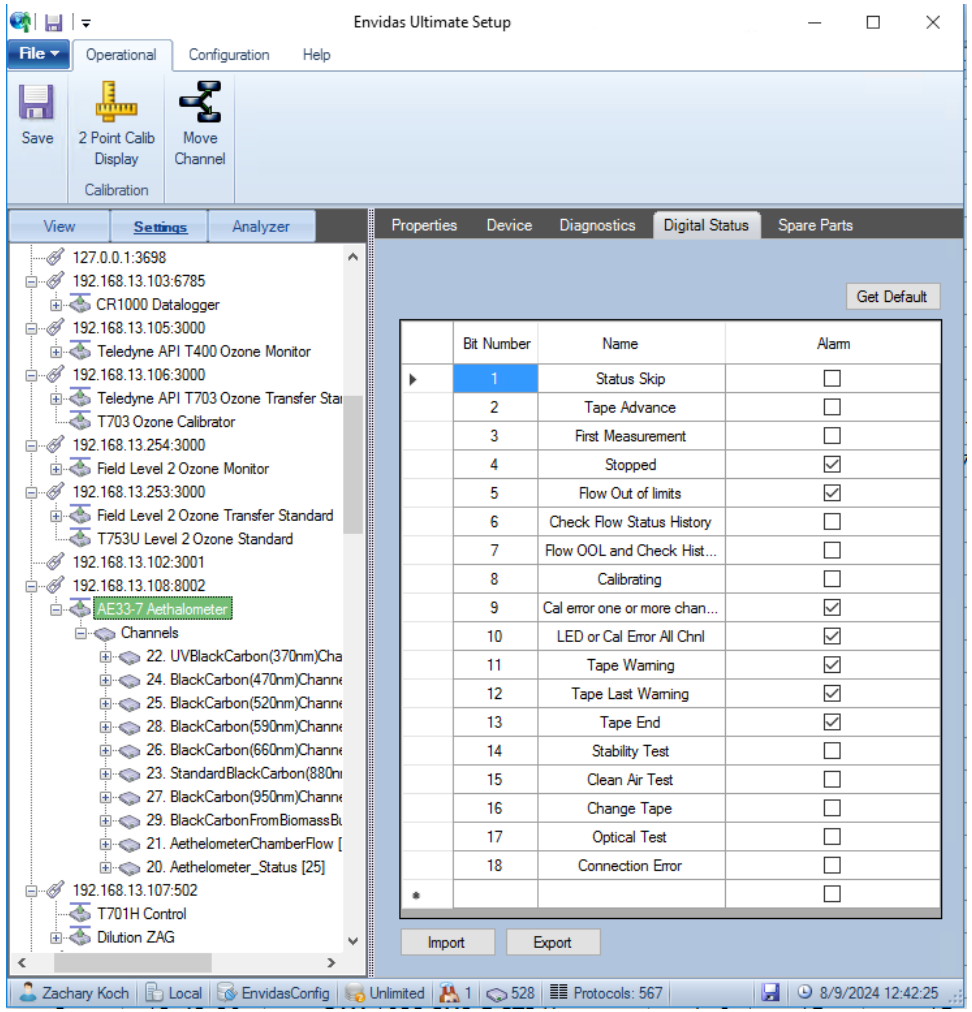
Multipoint verification configuration



Ozone span configuration



Automatic Validation at work



Clear List

Load

	Bit Place	Name	Active	Invalid When
▶	1	Status Skip	☐	On
	2	Tape Advance	☑	On
	3	First Measurement	☐	On
	4	Stopped	☑	On
	5	Flow Out of limits	☑	On
	6	Check Flow Status History	☐	On
	7	Flow OOL and Check History	☐	On
	8	Calibrating	☐	On
	9	Cal error one or more channels	☐	On
	10	LED or Cal Error All Chnl	☐	On
	11	Tape Warning	☐	On
	12	Tape Last Warning	☐	On
	13	Tape End	☑	On
	14	Stability Test	☑	On
	15	Clean Air Test	☑	On
	16	Change Tape	☑	On
	17	Optical Test	☑	On
	18	Connection Error	☐	On
*			☐	

Automatic Validation at work

Tualatin Bradbury Court	12:47:40	BAM_1022_PM25_LTP_Hour	µg/m³	-15	-15	InVld	-15	InVld	-15	InVld
Tualatin Bradbury Court	12:47:41	BAM 1022 PM2.5 Real Time	µg/m³	22.5	22.5	Ok	17.1	Ok	2.9	Ok
Tualatin Bradbury Court	12:47:40	BAM 1022 Flow	L/Min	16.55	16.55	InVld	16.66	InVld	16.68	InVld
Tualatin Bradbury Court	12:47:50	Std Dev BAM 1022 Flow		16.55	16.55	InVld	49.98	InVld	250.19	InVld
Tualatin Bradbury Court	12:47:40	BAM 1022 Ambient Temperature	°C	29.5	29.5	Ok	29.5	Ok	29.4	Ok
Tualatin Bradbury Court	12:47:41	BAM 1022 Ambient Pressure	mmHG	756	756	Ok	756	Ok	756	Ok
Tualatin Bradbury Court	12:47:41	BAM 1022 Relative Humidity	%	45	45	Ok	45	Ok	45	Ok
Tualatin Bradbury Court	12:47:41	BAM 1022 PM2.5 STP Hour	µg/m³	-15	-15	InVld	-15	InVld	-15	InVld
Tualatin Bradbury Court	12:47:41	BAM 1022 Status		256	256	Ok	256	Ok	256	Ok
Tualatin Bradbury Court	12:47:41	BAM 1022 Filter Temperature	°C	38.9	38.9	Ok	38.8	Ok	38.6	Ok
Tualatin Bradbury Court	12:47:41	BAM 1022 Filter Relative Humidity	%	21	21	Ok	21	Ok	21	Ok

Show Date Time & Status ToolTips

Shut Down | OFF SCAN | FORCE STATUS | On | NO CONNECTION

Digital Monitor Status

Digital Monitor Statuses of BAM 1022

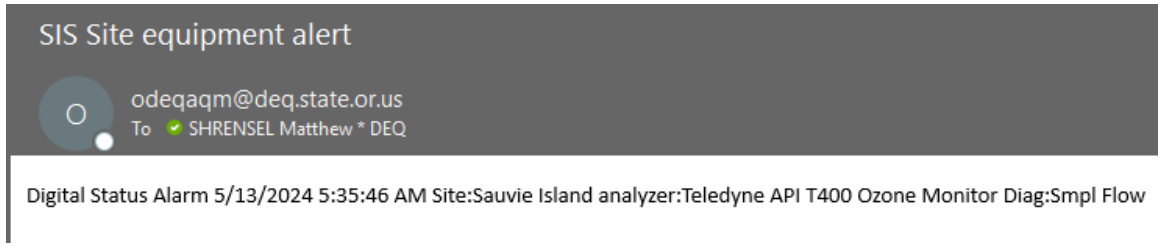
Last Receive 8/9/2024 11:38:40

Bit	State	Channel Validation
1	Tape Break [Off]	BAM_1022_PM25_LTP_Hour,BAM 1022 Flow,BAM 1022 PM2.5 STP Hour
2	Beta Detector [Off]	BAM_1022_PM25_LTP_Hour,BAM 1022 Flow,BAM 1022 PM2.5 STP Hour
3	Sensor Range [Off]	BAM_1022_PM25_LTP_Hour,BAM 1022 Flow,BAM 1022 PM2.5 STP Hour
4	Tape Advance [Off]	BAM 1022 Flow
5	Flow Failure [Off]	BAM_1022_PM25_LTP_Hour,BAM 1022 Flow,BAM 1022 PM2.5 STP Hour
6	Nozzle Failure [Off]	BAM_1022_PM25_LTP_Hour,BAM 1022 Flow,BAM 1022 PM2.5 STP Hour
7	Digital Link Failure [O	BAM_1022_PM25_LTP_Hour,BAM 1022 Flow,BAM 1022 PM2.5 STP Hour
8	Power Failure [Off]	BAM_1022_PM25_LTP_Hour,BAM 1022 Flow,BAM 1022 PM2.5 STP Hour
9	Short Sample [On]	BAM_1022_PM25_LTP_Hour,BAM 1022 Flow,BAM 1022 PM2.5 STP Hour
10	Maintenance [Off]	BAM_1022_PM25_LTP_Hour,BAM 1022 Flow,BAM 1022 PM2.5 STP Hour

Automated calibration station in action

Definite recommendations – what worked well

- Simplified connections – electrical, signals, pneumatics
- Same make/brand of a category of instrument
- Flexible/modular components
- Email notifications worked *very* well
- Bringing in diagnostics and digital status codes enabled effective sleuthing during data validation



What (still works, but) works less well

- Some known hardware issues – every so often, our analyzers' onboard solenoid valves cause clogging which must be manually cleaned
- Software support and full software integration can be a moving target! Be prepared to work with your vendors, even if you feel like a beta tester
- Reactive gases may need extra "purge time" if the lines remain plumbed and open
- Configuration changes may take a lot of work to roll out to many sites
- DAS configuration is finicky…train as many people to perform it as possible!

Other useful benefits

- Automatic notification of exceedances
- Automated multi-point verifications with more steps
- Speed along testing of improvements
- Consistent processes
- Enable fewer staff to maintain a larger monitoring network

Ozone Data Comparison (1 Minute Averages)			
Setpoint	**Level 2**	**T400**	% Difference
0.0 ppb	0.1 ppb	1.0 ppb	0.9
150.0 ppb	149.7 ppb	149.9 ppb	0.13
130.0 ppb	129.4 ppb	129.8 ppb	0.31
100.0 ppb	108.9 ppb	109.3 ppb	0.37
90.0 ppb	89.9 ppb	90.3 ppb	0.44
70.0 ppb	69.2 ppb	69.6 ppb	0.58
50.0 ppb	50.2 ppb	50.3 ppb	0.20
30.0 ppb	29.6 ppb	29.4 ppb	-0.68
15.0 ppb	15.4 ppb	15.7 ppb	0.3

Acknowledgements

- The dedicated team at Oregon DEQ AQM (past & present)
- Our colleagues in Region 10 and elsewhere who helped us solve numerous thorny problems
- Our hardware and software tech support people at:
  - DR-DAS
  - Teledyne API
  - Campbell Scientific

Questions? Comments?

- Feel free to reach out to me if you'd like to know more:
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