Online Monochloramine Analyzers' Side-by-side Comparison

Lessons learned in a trial study

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PORTLAND WATER BUREAU
FROM FOREST TO FAUCET

CITY OF PORTLAND, OREGON 1851

PNWS-AWWA
Water 2024
Spokane, WA • May 1-3

Agenda

- Overview of the Portland Water Bureau
- Disinfection methods
- Chloramine chemistry
- Importance of real time data
- Experiment design and criteria
- Data collected
- Comparison and takeaways

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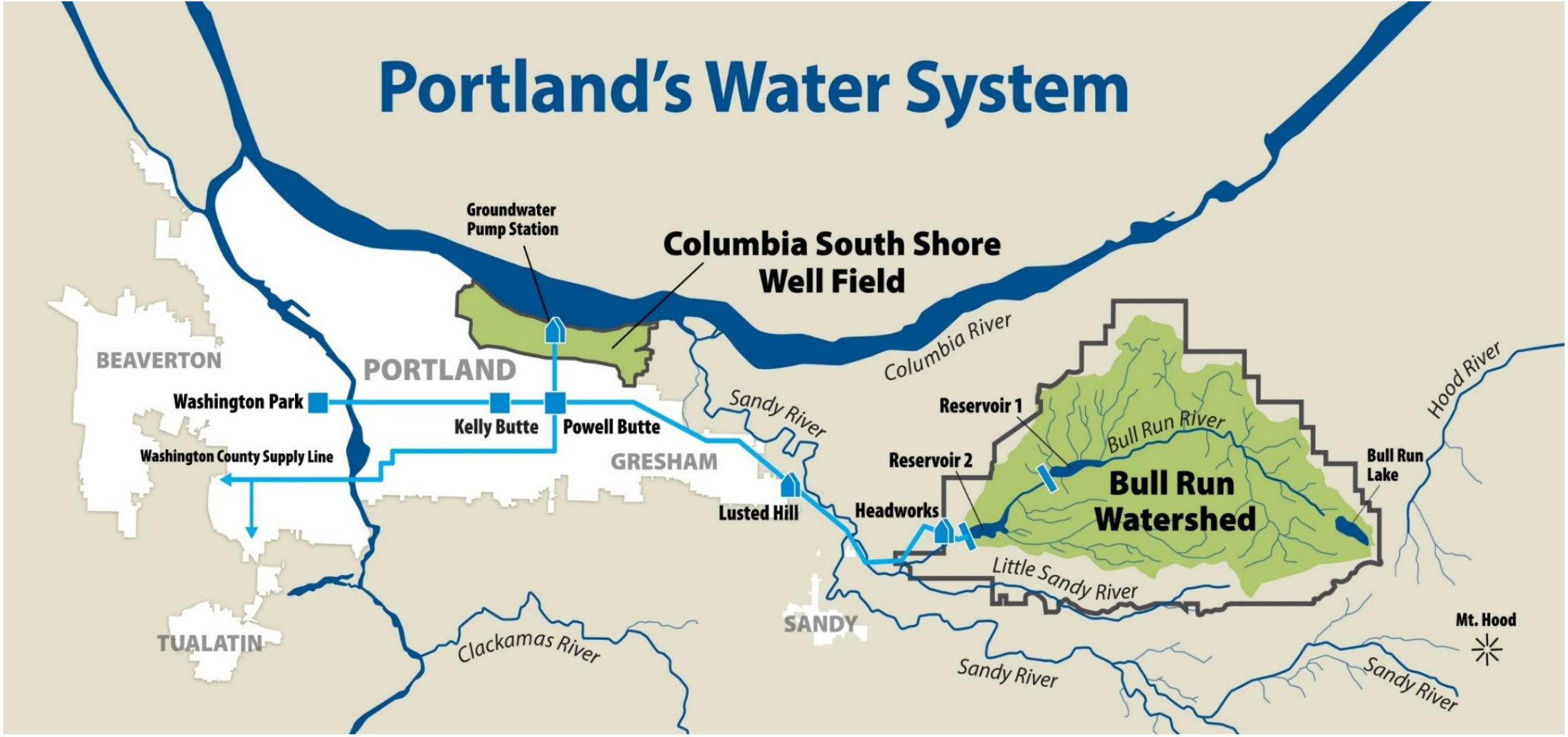


- Serves almost a million people, including 19 wholesale water districts
- 100 MGD average demand

Surface water, Bull Run Watershed

Groundwater, Columbia South Shore Well Field

Disinfection

- **Disinfection**: Partial destruction and inactivation of disease-causing organisms from exposure to chemical agents (e.g., chlorine) or physical processes (e.g., UV irradiation).

  The term “disinfection” is used to refer to:

  (1) **Primary Disinfection**: the inactivation of microorganisms in the water

  (2) **Secondary Disinfection**: maintaining a disinfectant residual in the treated-water distribution system.

  We use Chlorine as our **Primary Disinfection** and Chloramines as our **Secondary Disinfection**.

Why Portland Water Chloraminates

- **control microorganisms**, such as bacteria and viruses
- Longer lasting residual
- We have a large water system, more than 2,250 miles of pipe. Much of it is cast iron.
- Reduced levels of disinfection byproducts

IMPORTANT:
Tight process control parameters are the key to success.

Chloramine Chemistry:

- Chloramines (combined chlorine) are produced by combining chlorine and ammonia:

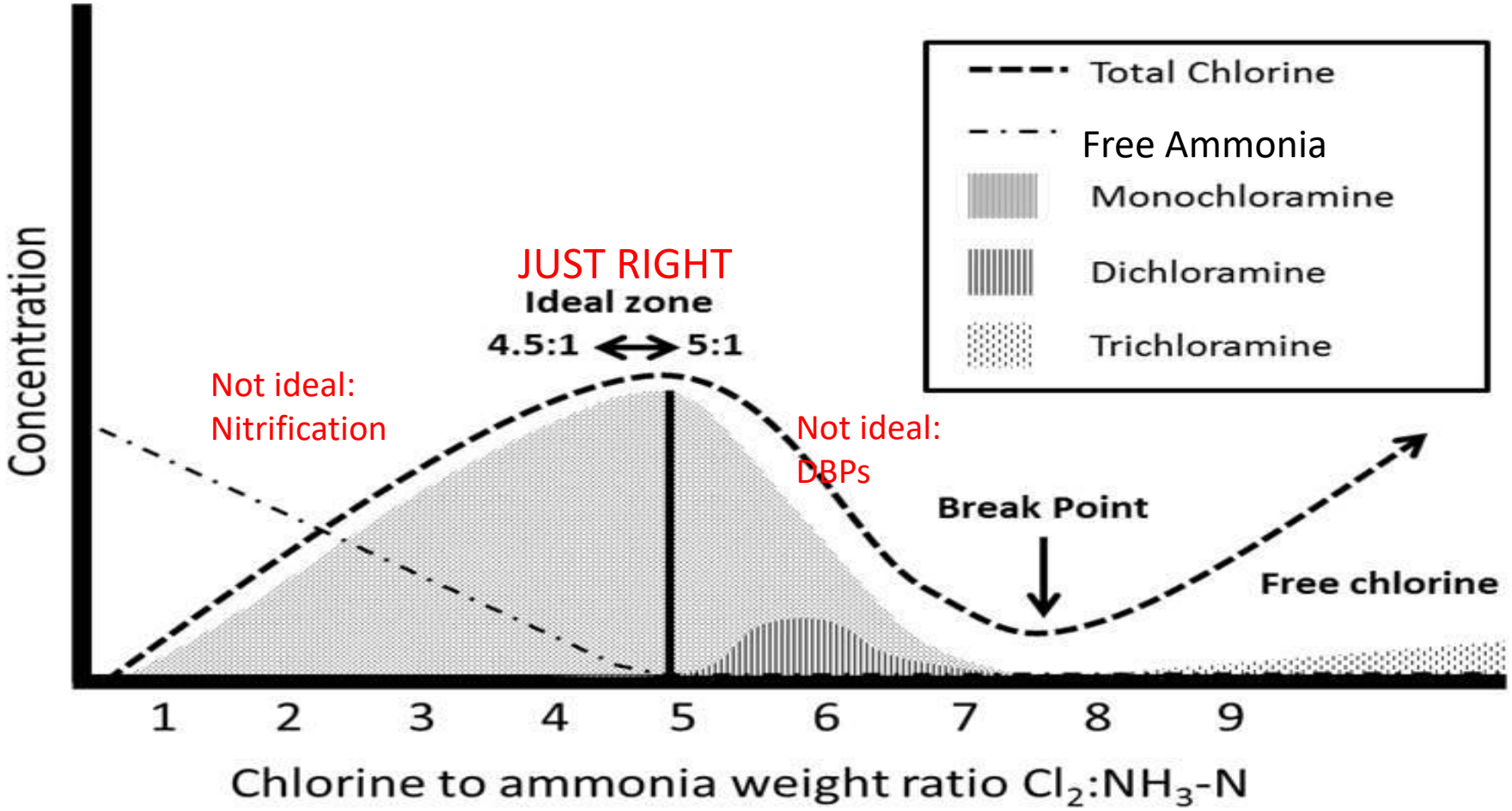
$$NH_3 + HOCl \rightarrow NH_2Cl + H_2O \text{ (monochloramine)}$$ Our key target

$$NH_2Cl + HOCl \rightarrow NHCl_2 + H_2O \text{ (dichloramine)}$$

$$NHCl_2 + HOCl \rightarrow NCl_3 + H_2O \text{ (trichloramine)}$$

- A summary of definitions
  - Free chlorine = HOCl + OCl^-
  - Combined chlorine = NH_2Cl + $NHCl_2$ + NCl_3
  - Total chlorine = free chlorine + combined chlorine

Importance of real-time analyses



Measurement methods for chloramines and Ammonia

Chloramines

- Amperometric Titrator—Free, Total, Mono, Di

Free and Total Ammonia

- Timberline with Auto Sampler—Total and Free

Measurement methods for chloramines and Ammonia

Chloramines, Free and Total Ammonia

HACH SL1000

- Free Chlorine
- Total Chlorine
- Monochloramines
- Total Ammonia
- Free Ammonia (Out of range)
- Uses Chemkeys for analysis

Online Instruments:

MCX Online Monochloramine Analyzer

Online Instruments:

HACH®

Be Right™

5500sc Ammonia Monochloramine Analyzer

Installation

- Space requirements
- Anchor types
- Electrical requirements
- Source of water
- Pressure and flow requirements
- Accessibility
- Hazardous waste volume and disposal

Test plan for the trial

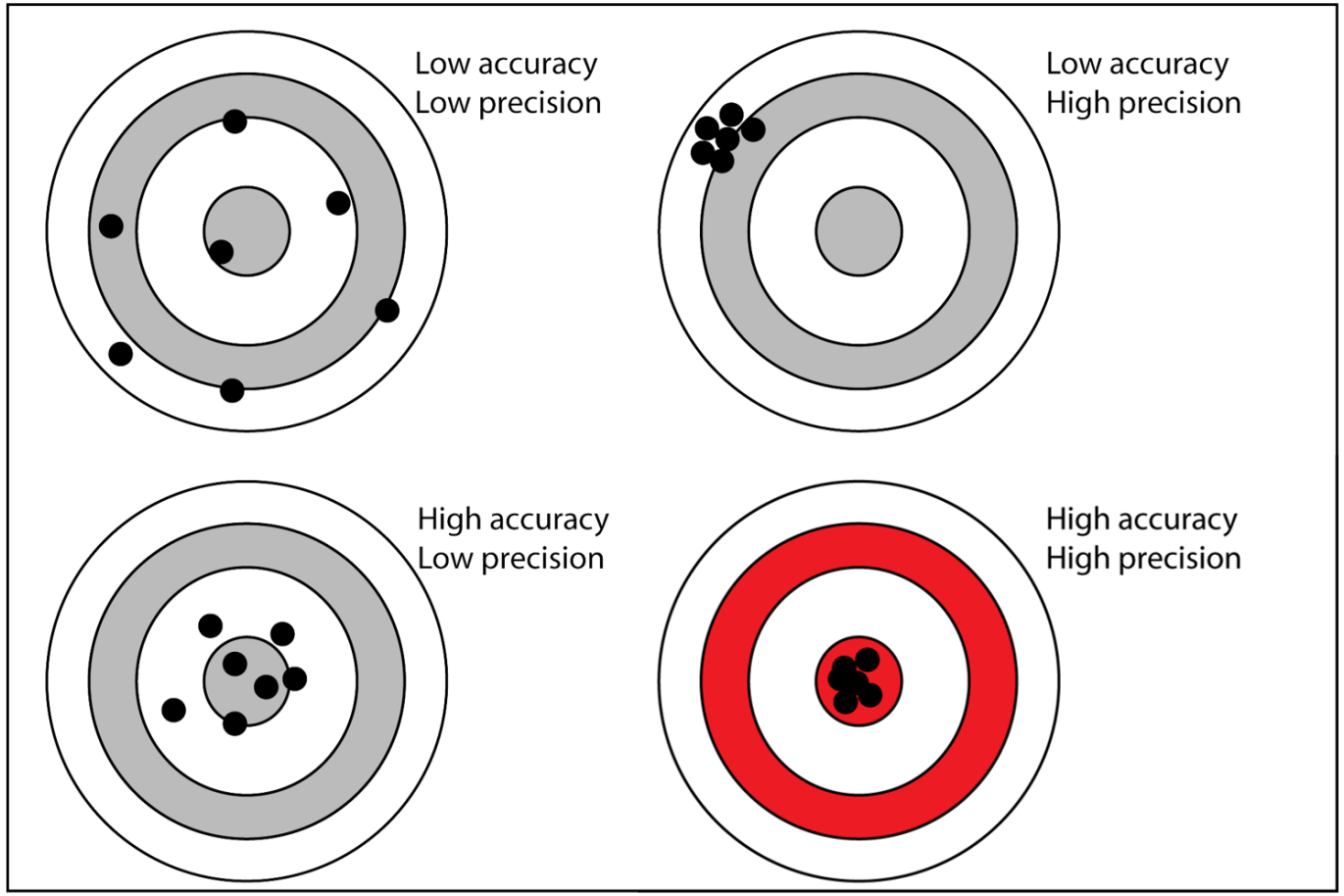
Current daily sample Practice

- Use Amperometric Titrator 6 times a day and recorded the results
- Use Timberline instrument 6 times a day and recorded the results
- Sample upon any flow or chemical changes
- Use HACH SL1000 as a back-up

Added daily sample Practice

- Record the data from the HF and Hach analyzers 6 times a day
- Download the logged data from HF and Hach analyzers weekly
- Used SL1000 device 2 times a day

Data quality



Accuracy - the degree of closeness of measurements of a quantity to its actual (true) value.

Precision - also called reproducibility or repeatability, is the degree to which repeated measurements under unchanged conditions show the same results

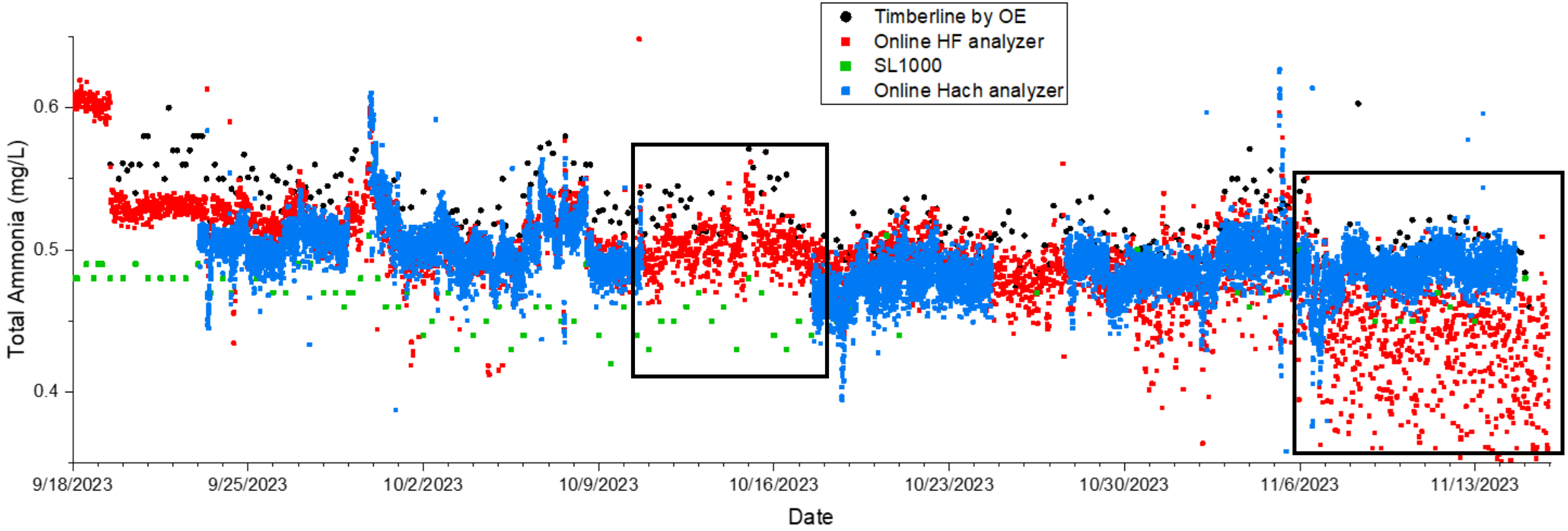
A measurement system is called valid if it is both accurate and precise

Evaluation criteria:

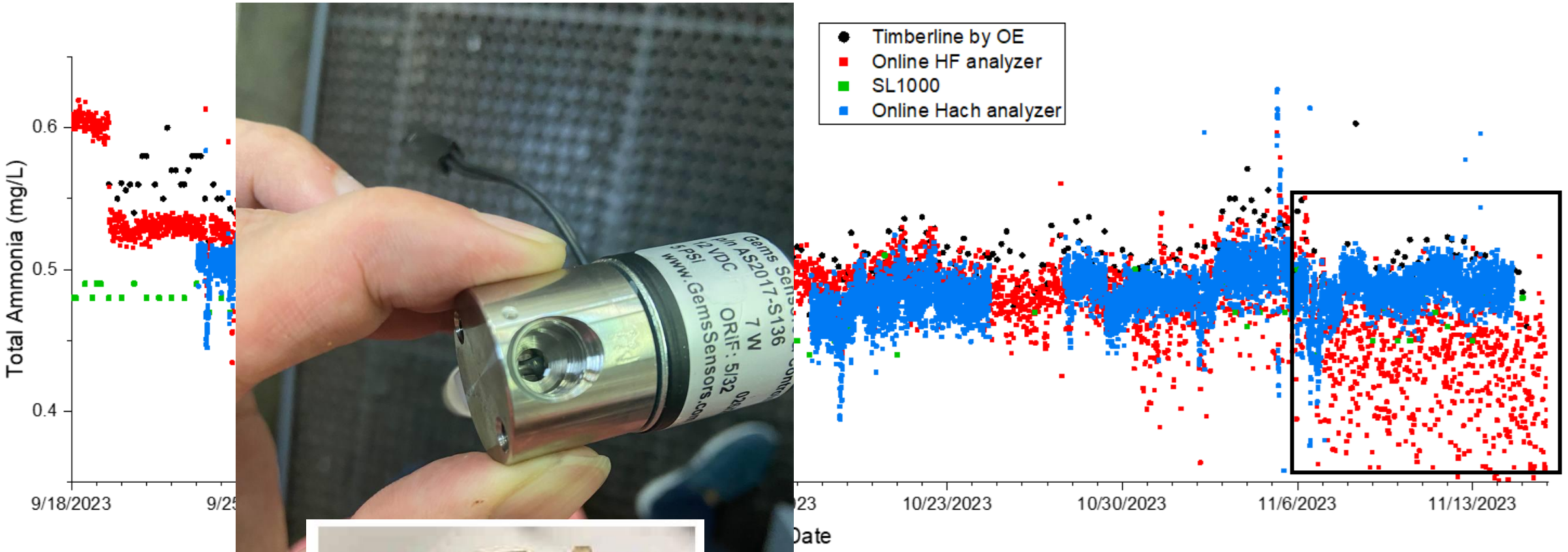
- Cost
  - unit
  - operation
- Ease of operation
- Maintenance frequency
- Technical support and customer service

Results

Groundwater: Total Ammonia



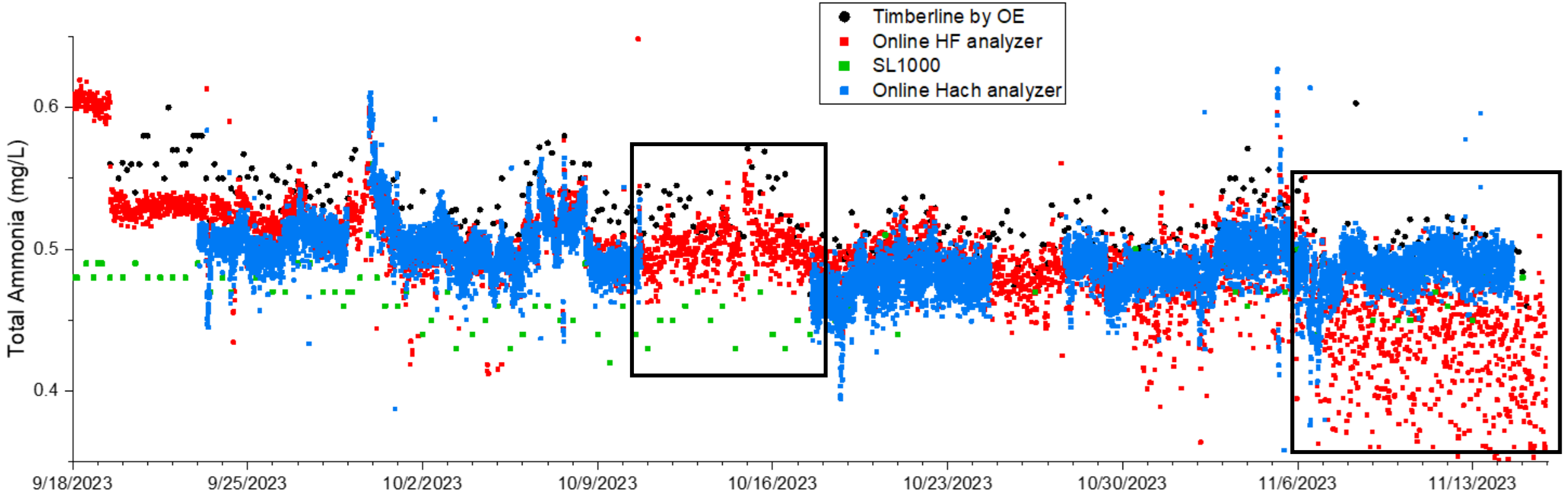
Groundwater: Total Ammonia



Groundwater: Total Ammonia

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
HF	1166	0.5088	0.02593	0.00076
SL1000	36	0.4650	0.02602	0.00434
Hach	4018	0.5045	0.02201	0.00035
Timberline	94	0.5171	0.06598	0.00681



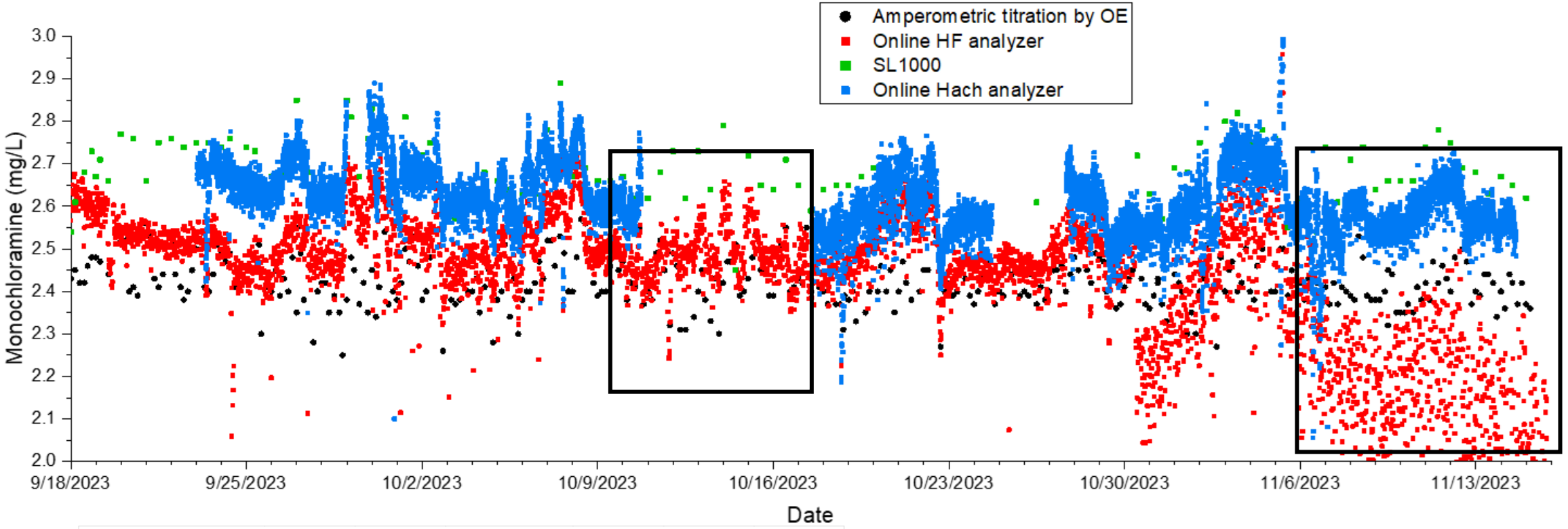
One-Sample Test

	Test Value = 0.52					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval Lower	95% Confidence Interval Upper
HF	-14.770	1165	0.000	-0.01122	-0.0127	-0.0097
SL1000	-12.682	35	0.000	-0.05500	-0.0638	-0.0462
Hach	-44.540	4017	0.000	-0.01547	-0.0161	-0.0148
Timberline	-0.425	93	0.672	-0.00289	-0.0164	0.0106

Groundwater: Monochloramine

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
HF	1166	2.5048	0.08053	0.00236
SL1000	36	2.7008	0.07897	0.01316
Hach	4018	2.6510	0.06715	0.00106
Amperometric Titration	94	2.4218	0.06627	0.00683



One-Sample Test

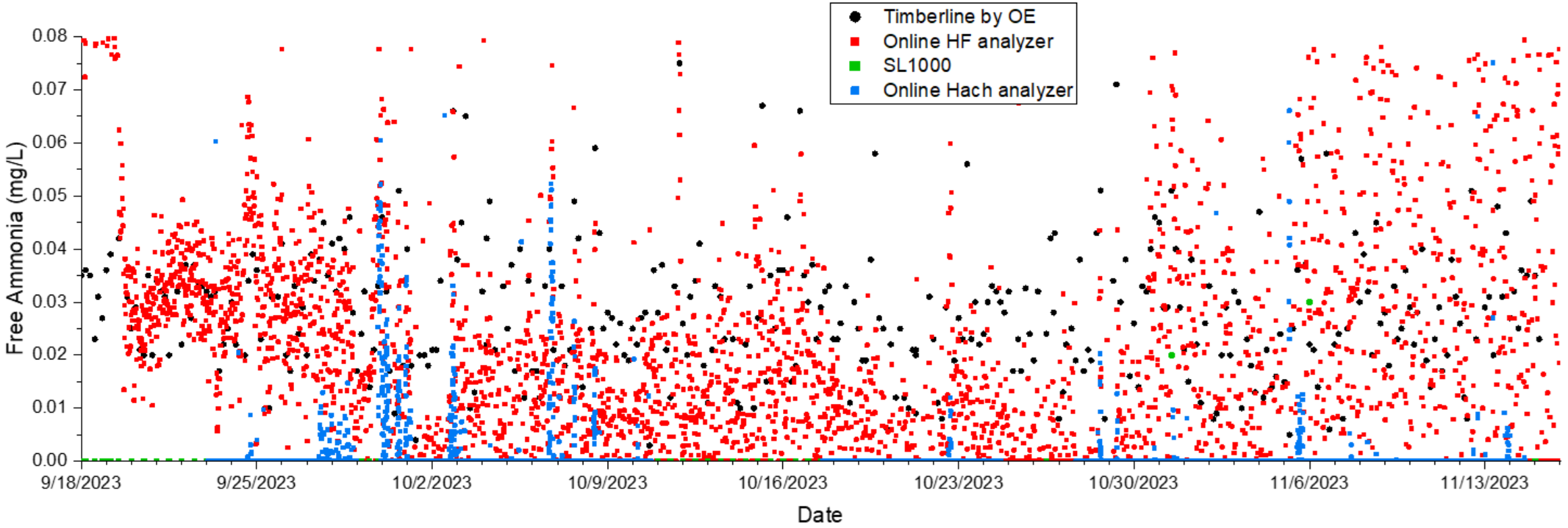
	Test Value = 2.50					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval Lower	Upper
HF	2.034	1165	0.042	0.00480	0.0002	0.0094
SL1000	15.259	35	0.000	0.20083	0.1741	0.2276
Hach	142.575	4017	0.000	0.15103	0.1490	0.1531
Amperometric Titration	-11.440	93	0.000	-0.07819	-0.0918	-0.0646

Groundwater: Free Ammonia

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
HF	1166	0.0170	0.02117	0.00062
SL1000	36	0.0000	.00000[a]	0.00000
Hach	4018	0.0015	0.01082	0.00017
Timberline	94	0.0292	0.01466	0.00151

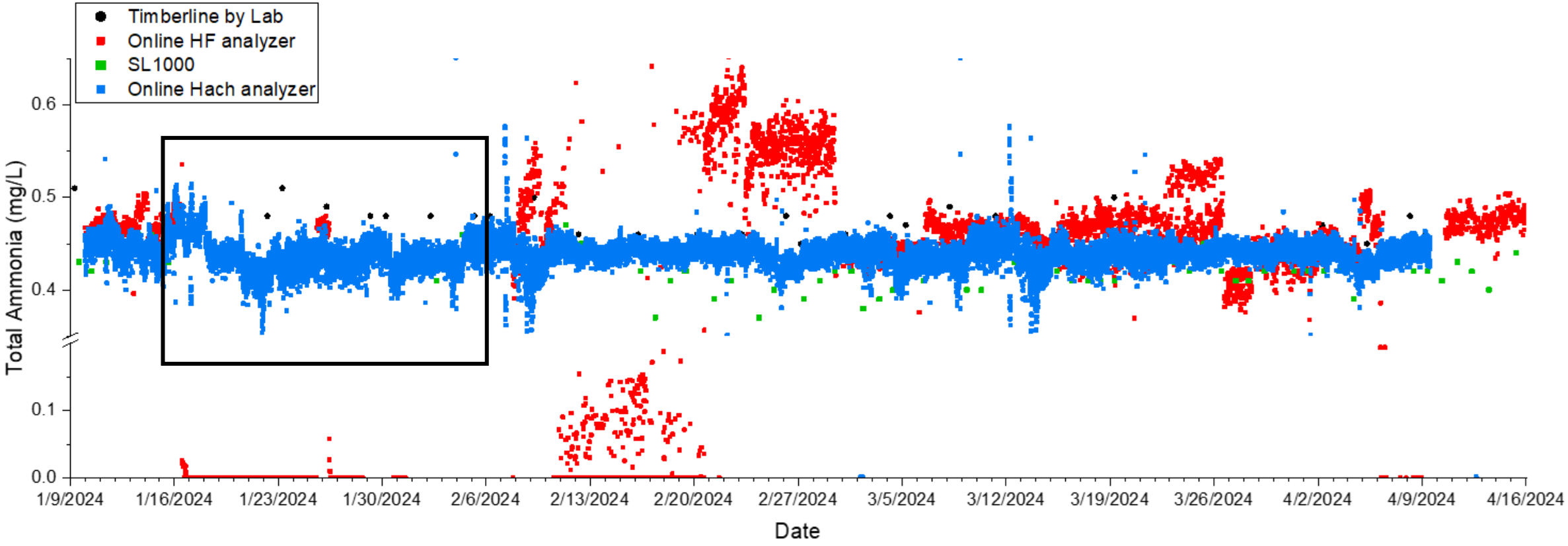
a. t cannot be computed because the standard deviation is 0.



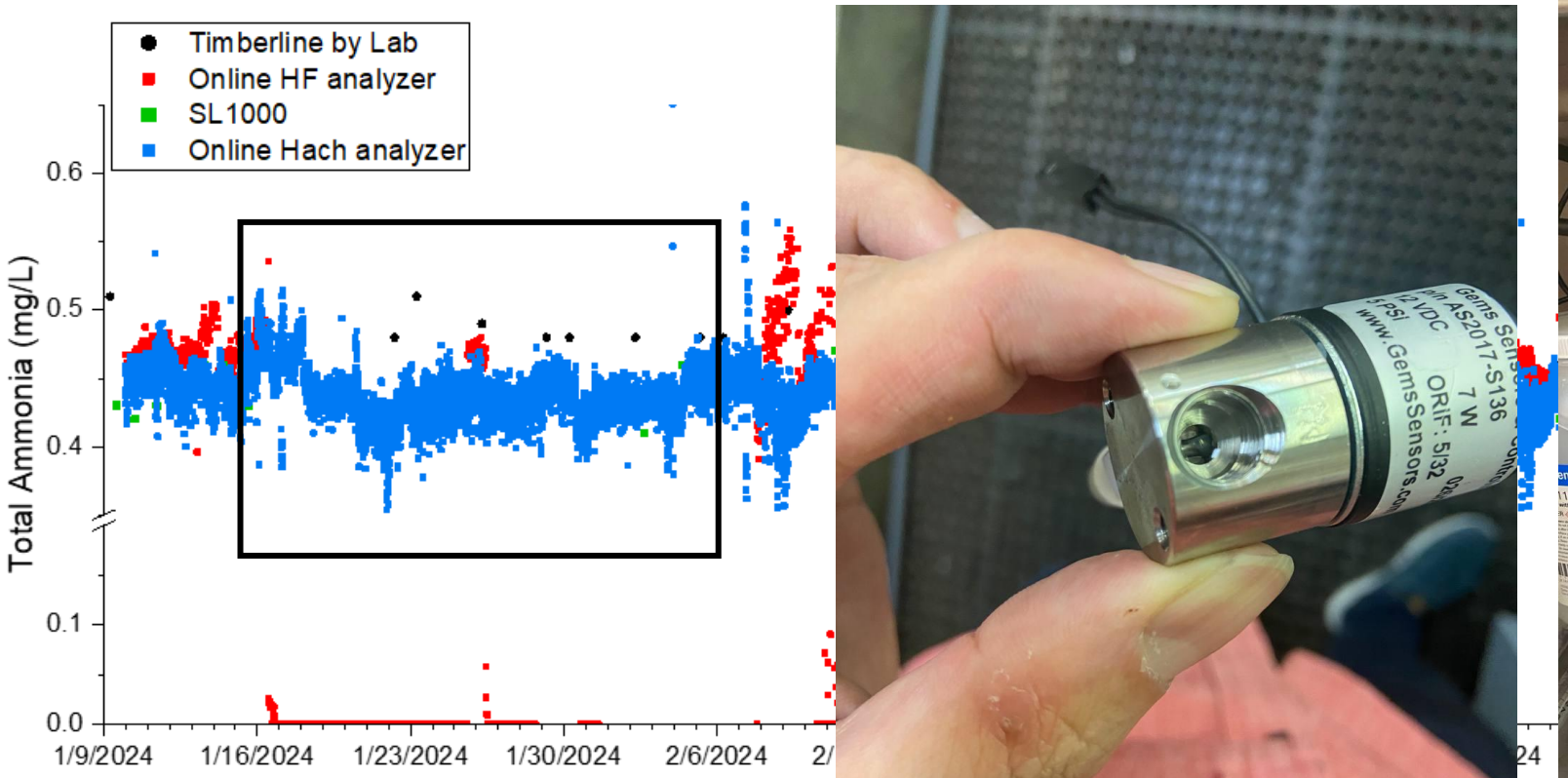
One-Sample Test

	Test Value = 0.03					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval Lower	Upper
HF	-20.894	1165	0.000	-0.01295	-0.0142	-0.0117
Hach	-166.709	4017	0.000	-0.02846	-0.0288	-0.0281
Timberline	-0.535	93	0.594	-0.00081	-0.0038	0.0022

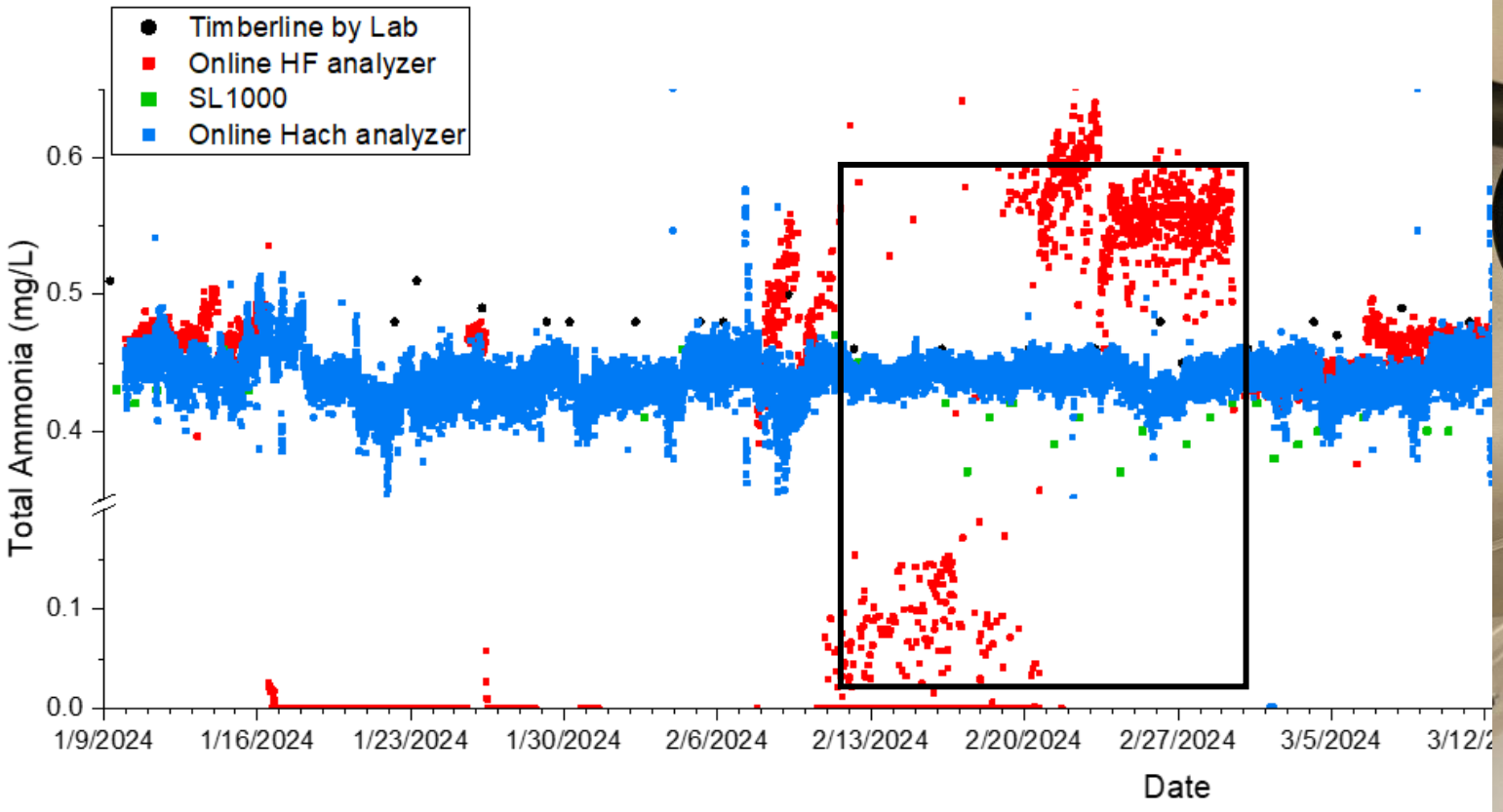
Surface water: Total Ammonia

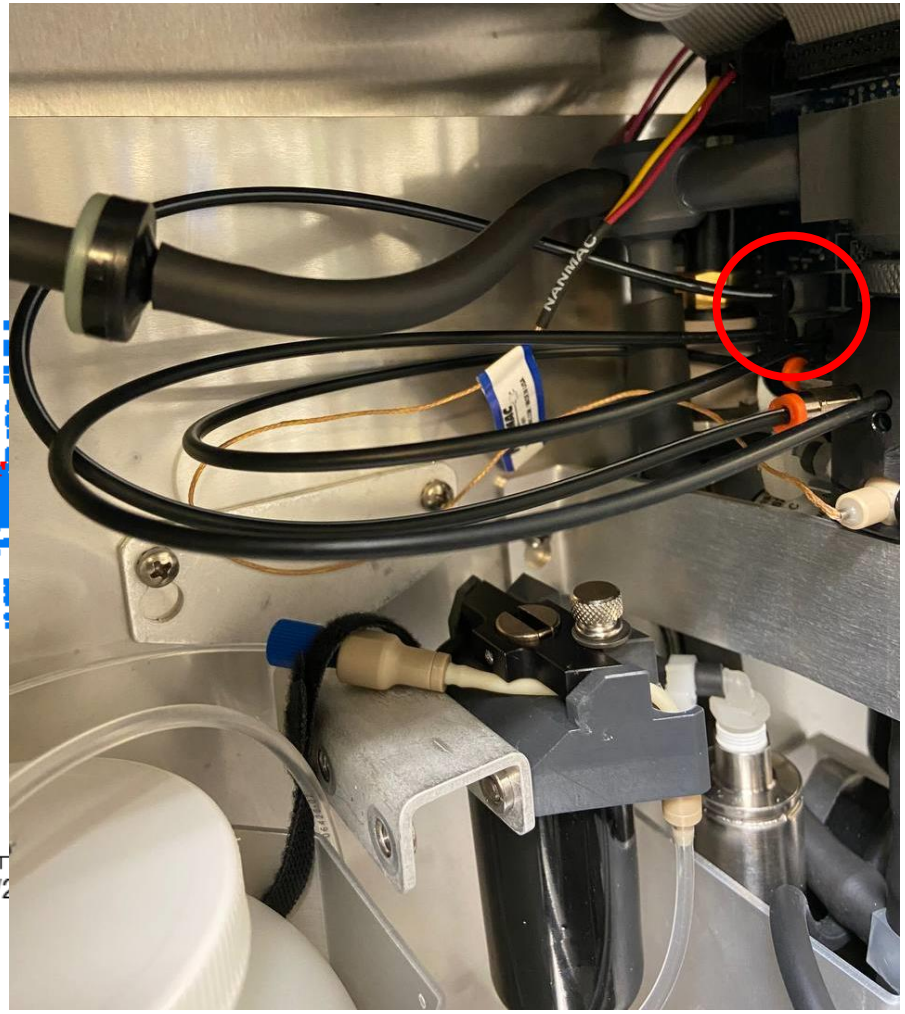


Surface water: Total Ammonia

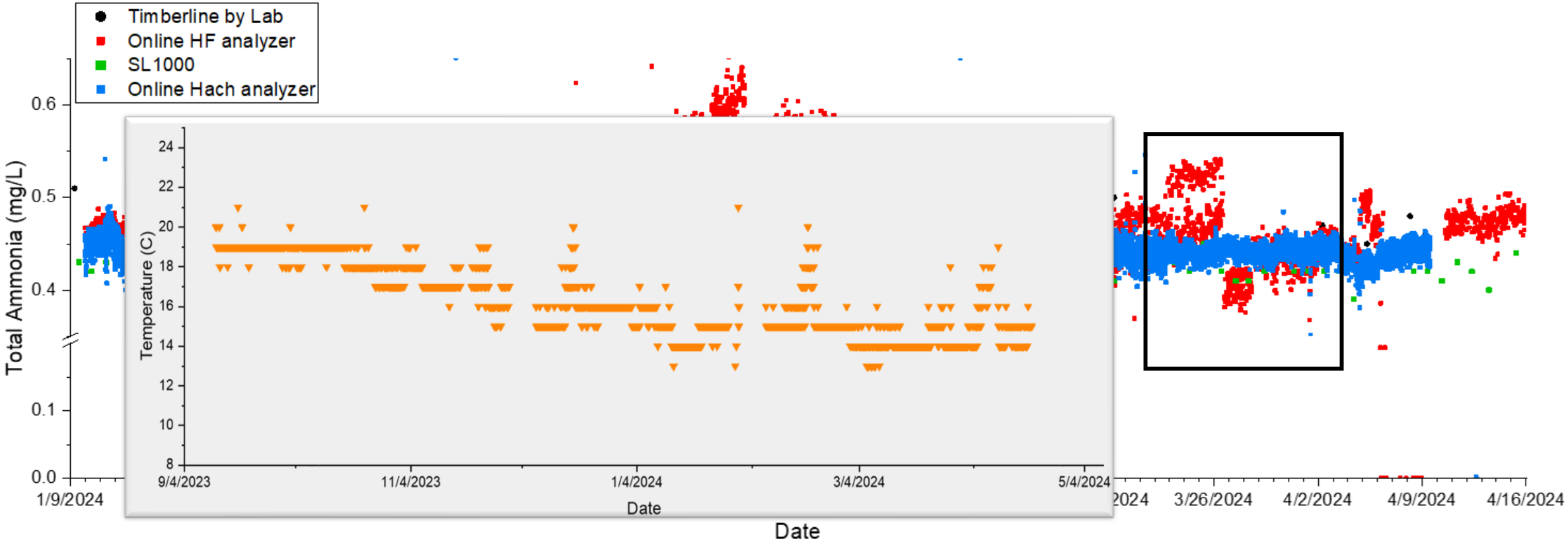


Surface water: Total Ammonia



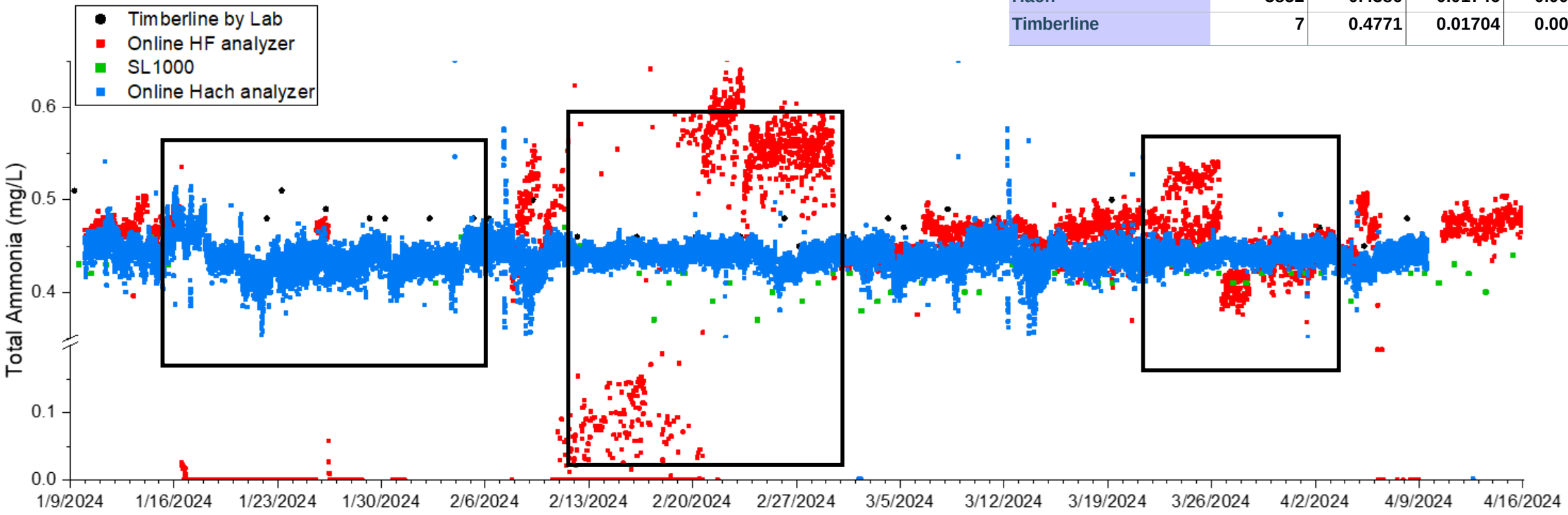


Surface water: Total Ammonia



Surface water: Total Ammonia

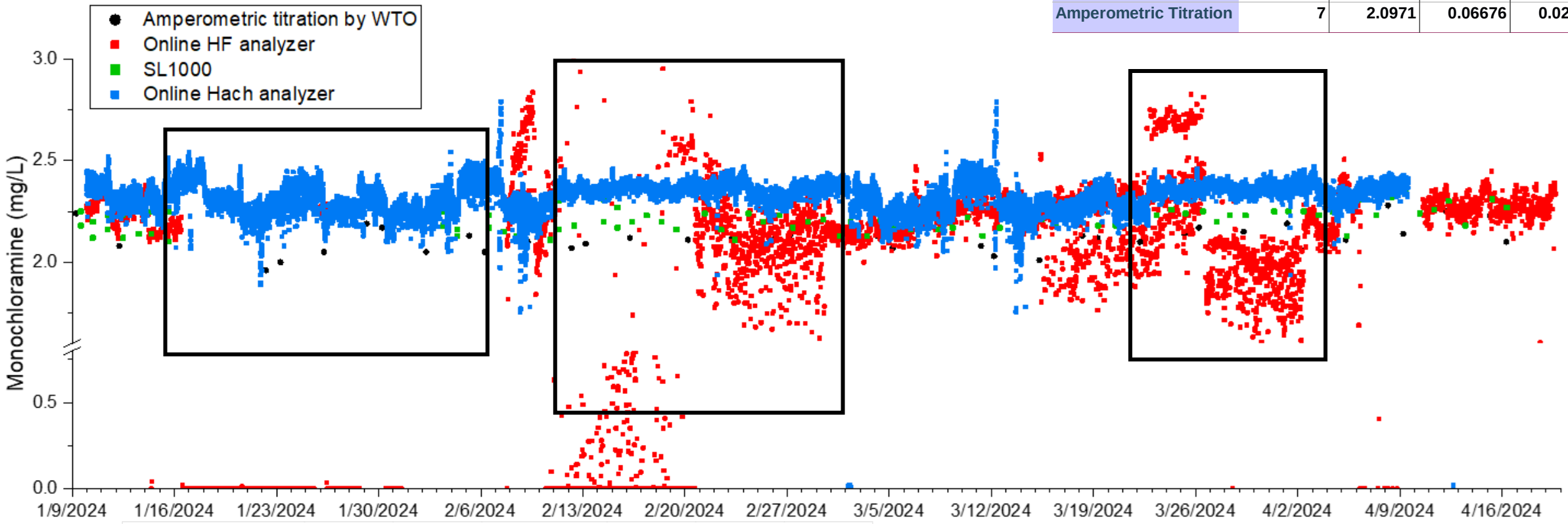
One-Sample Statistics				
	N	Mean	Std. Deviation	Std. Error Mean
HF	914	0.4638	0.02910	0.00096
SL1000	16	0.4219	0.01424	0.00356
Hach	3852	0.4386	0.01746	0.00028
Timberline	7	0.4771	0.01704	0.00644



One-Sample Test						
	Test Value = 0.46					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval Lower	Upper
HF	3.941	913	0.000	0.00379	0.0019	0.0057
SL1000	-10.706	15	0.000	-0.03813	-0.0457	-0.0305
Hach	-76.212	3851	0.000	-0.02145	-0.0220	-0.0209
Timberline	2.661	6	0.037	0.01714	0.0014	0.0329

Surface water: Monochloramine

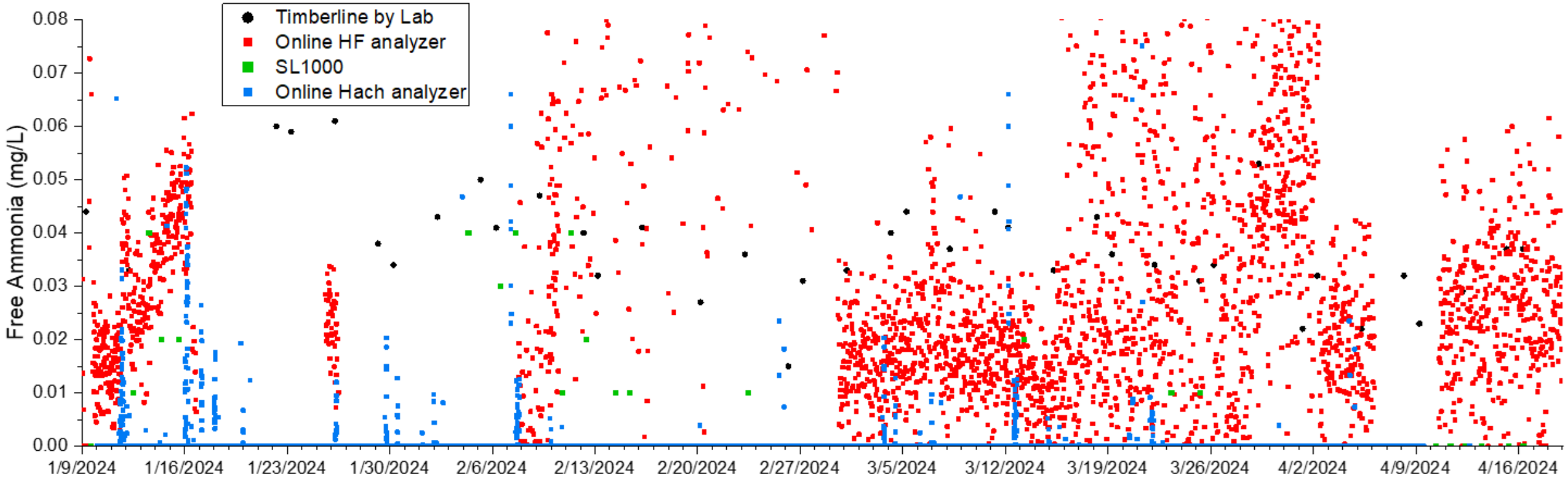
One-Sample Statistics				
	N	Mean	Std. Deviation	Std. Error Mean
HF	913	2.2192	0.13595	0.00450
SL1000	16	2.1919	0.04053	0.01013
Hach	3852	2.2983	0.08122	0.00131
Amperometric Titration	7	2.0971	0.06676	0.02523



One-Sample Test	Date					
	Test Value = 2.2					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval Lower	Upper
HF	4.270	912	0.000	0.01921	0.0104	0.0280
SL1000	-0.802	15	0.435	-0.00812	-0.0297	0.0135
Hach	75.104	3851	0.000	0.09829	0.0957	0.1009
Amperometric Titration	-4.076	6	0.007	-0.10286	-0.1646	-0.0411

Surface water: Free Ammonia

One-Sample Statistics				
	N	Mean	Std. Deviation	Std. Error Mean
HF	914	0.0273	0.03593	0.00119
SL1000	16	0.0013	0.00500	0.00125
Hach	3852	0.0003	0.00402	0.00006
Timberline	7	0.0383	0.00439	0.00166



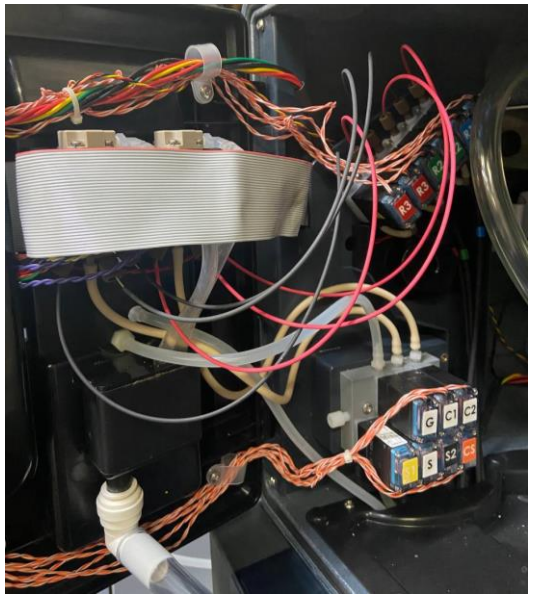
One-Sample Test						
	Test Value = 0.03					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval Lower	Upper
HF	-2.311	913	0.021	-0.00275	-0.0051	-0.0004
SL1000	-23.000	15	0.000	-0.02875	-0.0314	-0.0261
Hach	-459.419	3851	0.000	-0.02973	-0.0299	-0.0296
Timberline	4.998	6	0.002	0.00829	0.0042	0.0123

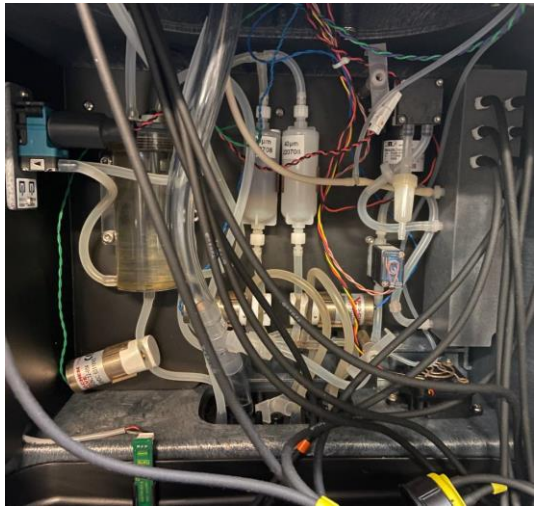
Comparing the Units

HF Scientific

- Hach is a complex unit.
- HF generates much more waste compared to Hach.
- Hach has calibration and cleaning automated.
- Hach had stable readings but the data were not close enough to the benchtop analyses.
- HF ran into multiple issues during the trial.
- HF provides data every 20 minutes vs 7 minutes of Hach since Hach has 2 cells.

Hach





Takeaways

- Reach out to other utilities that are using the analyzers.
- Perform trials if possible, for the analyzers that meet the criteria.
- Length of the trial: planned for 2 months, continued for 6 months.
- Different facilities/water sources may result in having different priorities in the analyzer selection process.

Acknowledgement

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- George Ruano, Carlos Williams; Hach
- Amirali Jiwani, Julie Dawson; HF scientific

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