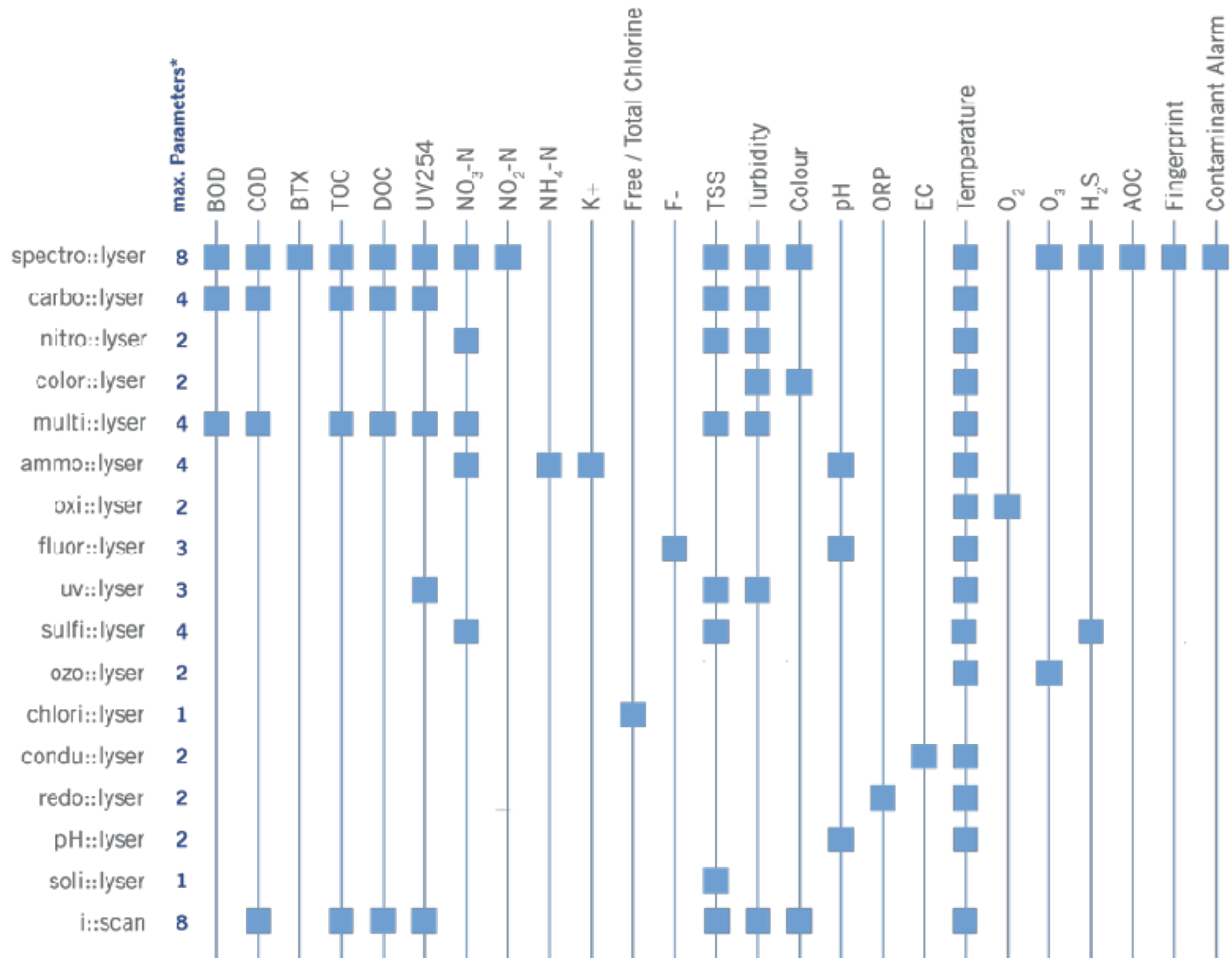


Online Wastewater Process Monitoring

s::scan Measuring Systems

Gary Girolimon, P.E.
Ted D. Miller Associates, Inc.

Parameter Overview



* The number of parameters is depending on the specific configuration of the monitoring system.

Probe Types

Spectrometer
Probes



ISE
Probes



Electrochem.
Probes



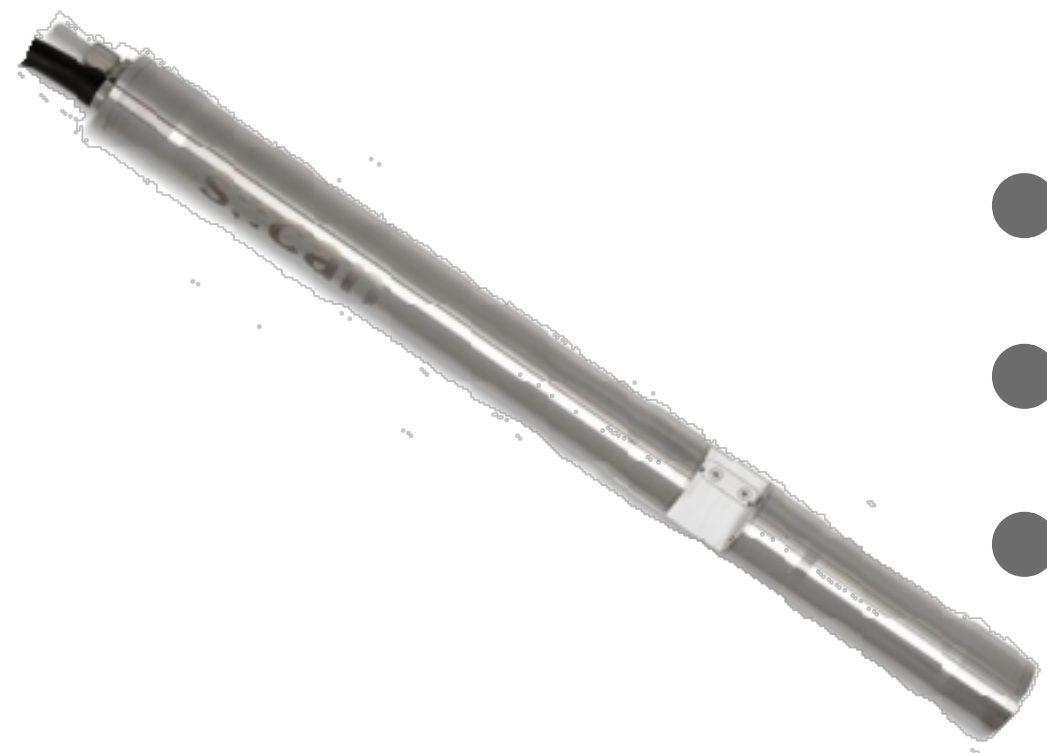
other optical
Probes



Spectrometer Probes



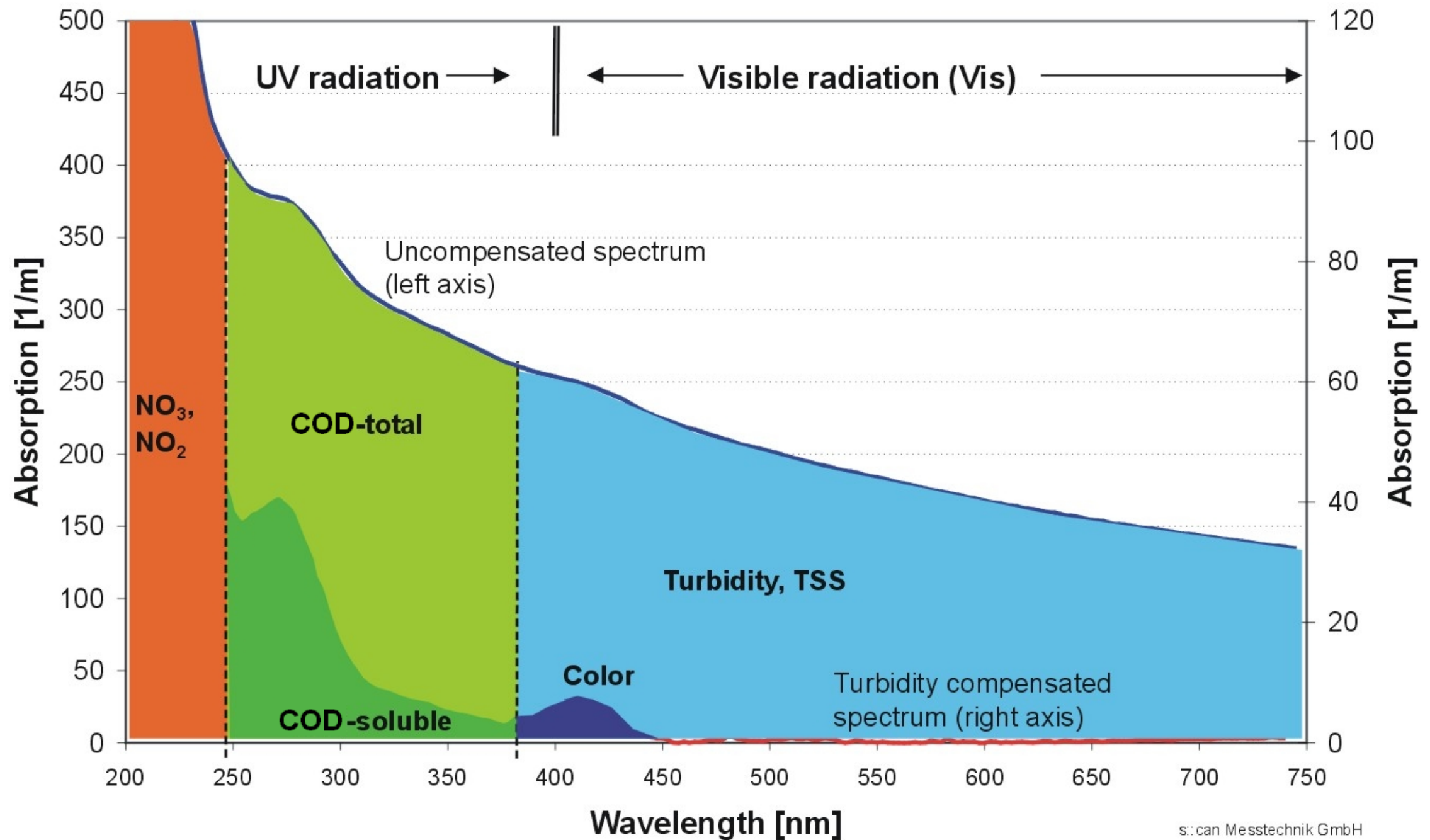
- UV to visible light spectroscopy
 - 200 to 750 nm
 - UV254



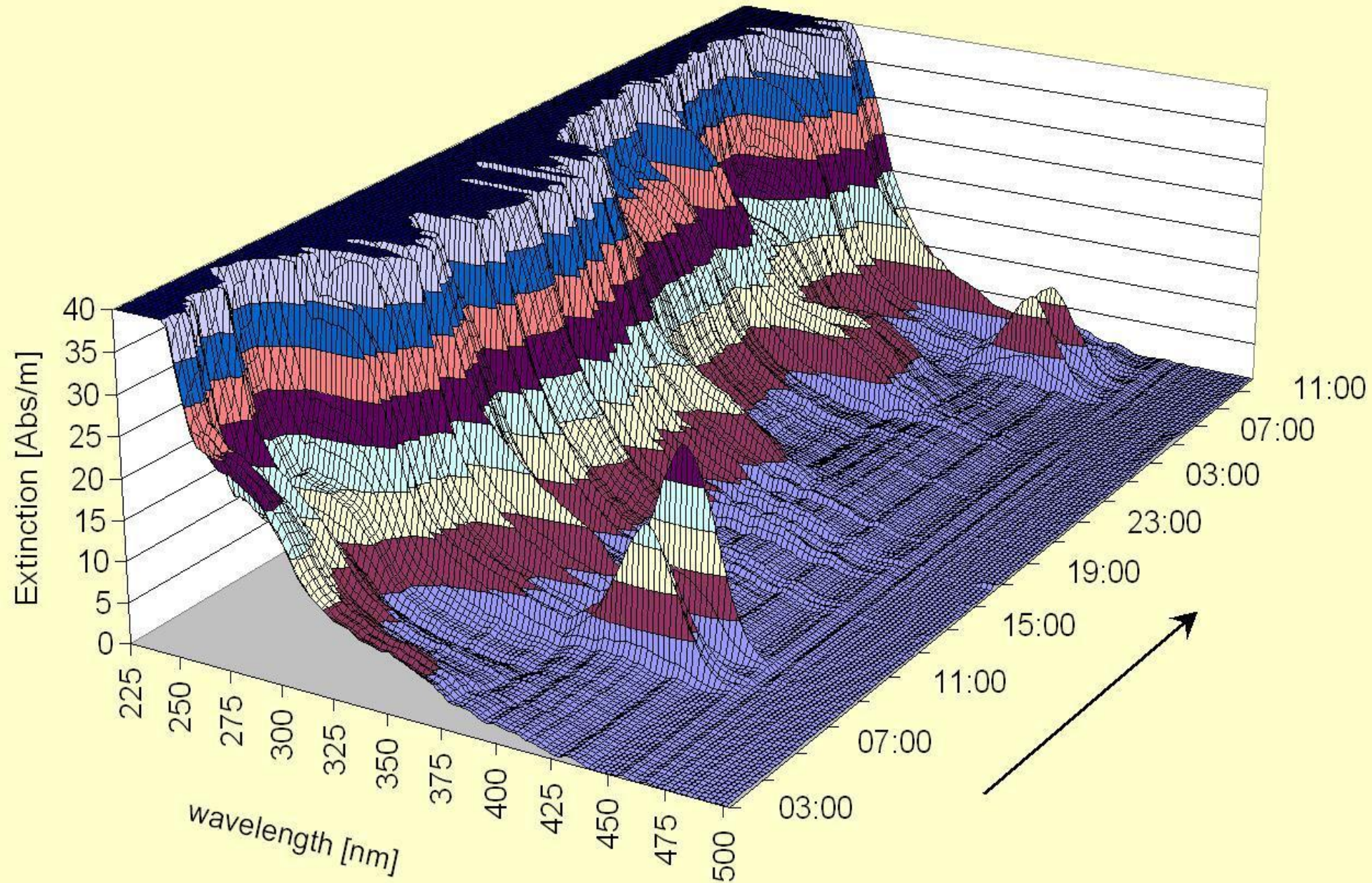
- Organic carbon (TOC, COD, BOD...)
- NO_2 , NO_3 , H_2S , Aromatic hydrocarbons (BTEx)
- Turbidity
- Suspended solids
- Color

Measuring Principle

UV-Vis Spectroscopy



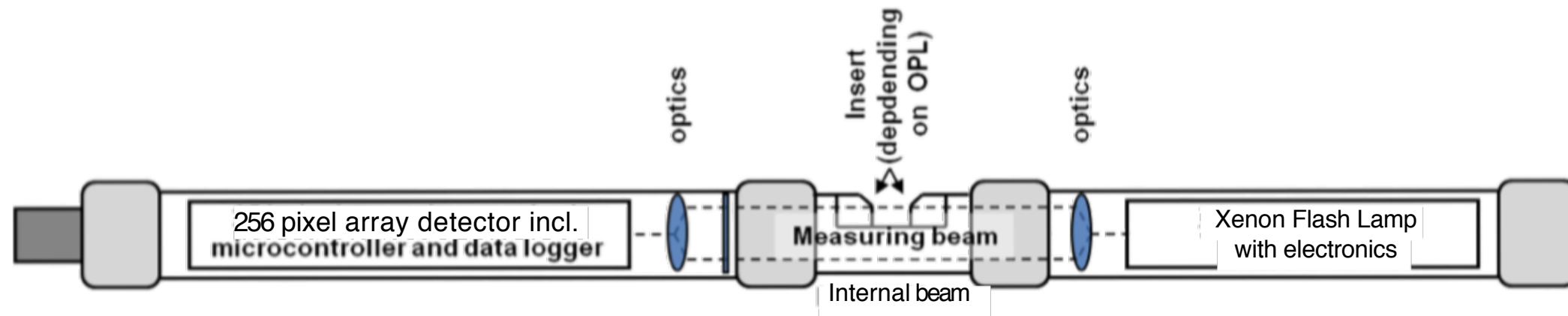
Optical Spectra Over Time



© s::can Messtechnik GmbH

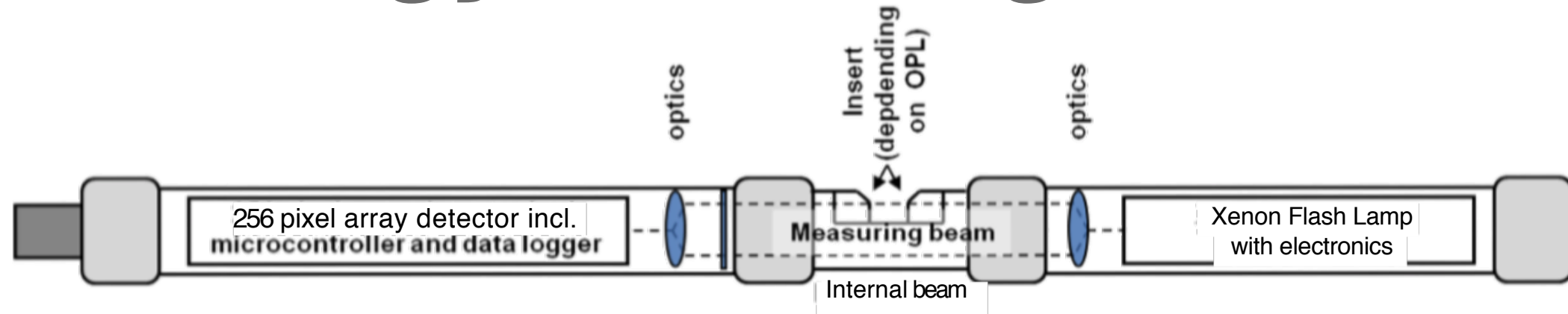
Optical spectra over time are observed and pattern “fingerprint” is trained automatically. Any deviation of the trained pattern is detected and alarmed.

How Spectrometer Probes Works



- The measurement makes use of the specific absorbance caused by substances
- Xeon flash-lamp light source
- 256-pixel photodiode array detector measures absorption between 200 - 750 nm
- Split light beam provides internal reference
- Adjustable measurement path lengths for different waste streams

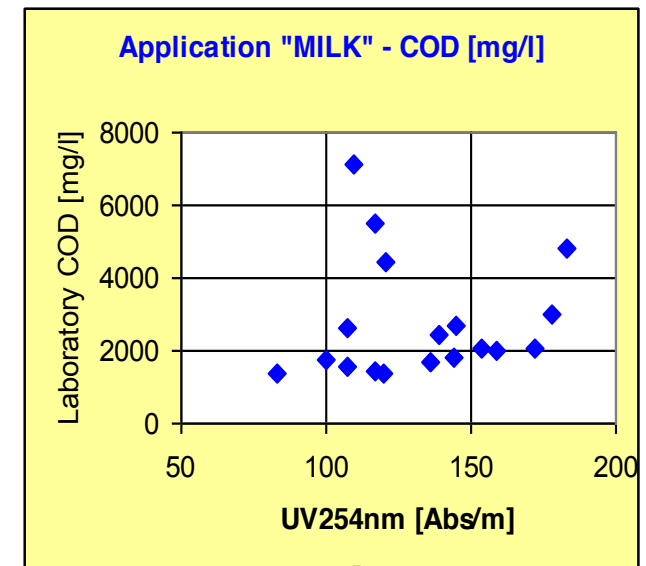
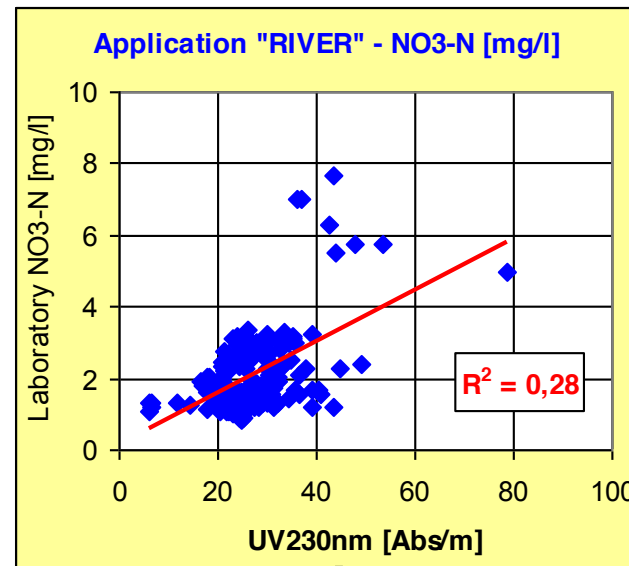
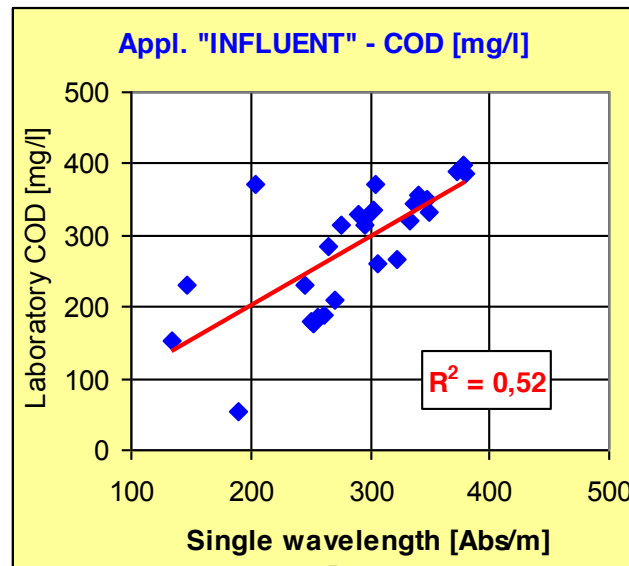
Technology Advantages



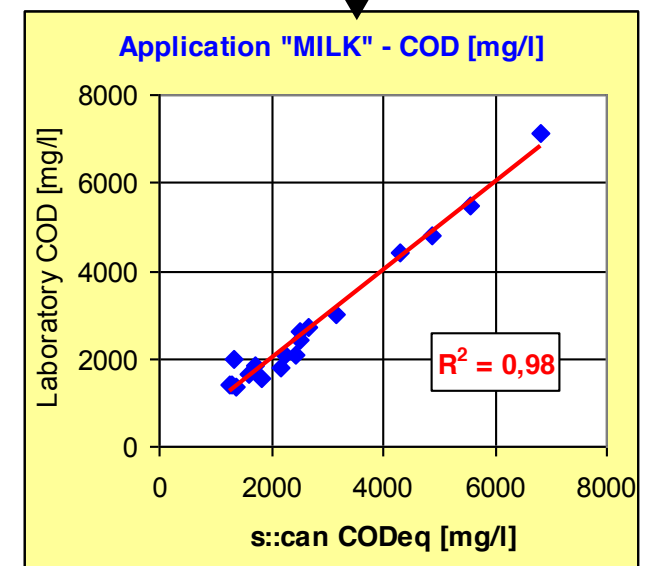
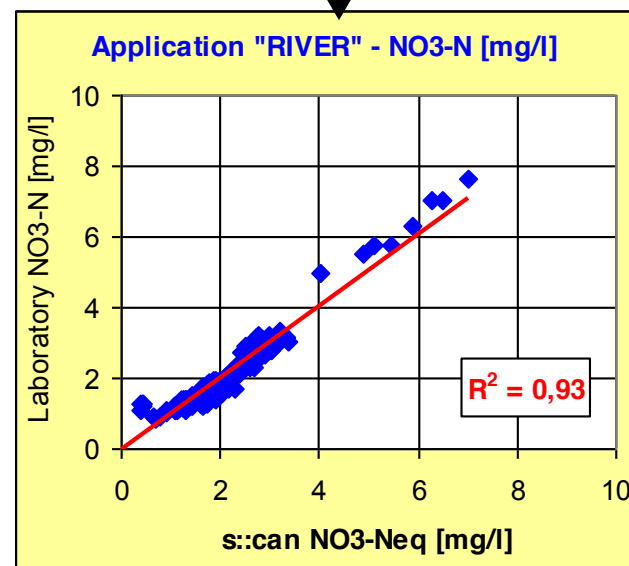
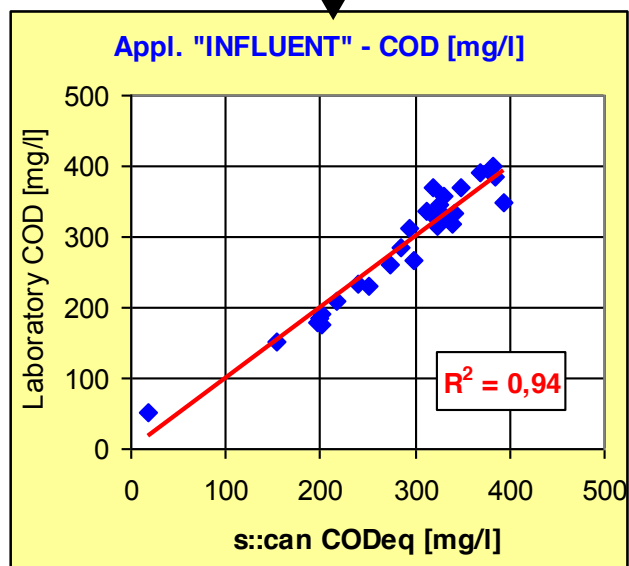
- Full spectrum analysis allows for complete compensation of cross-sensitivities and for compound differentiation
- No consumables or sample preparation required
- Allows for direct deployment into waste stream
- Split beam internal reference means:
 - No need to recalibrate sensor - automatic compensation for lamp and sensor aging
 - Automatically detects and alerts for any problems with optical components
- Typical lamp life of ≈ 10 -years

Spectral Scan vs Single Wavelength Measurements

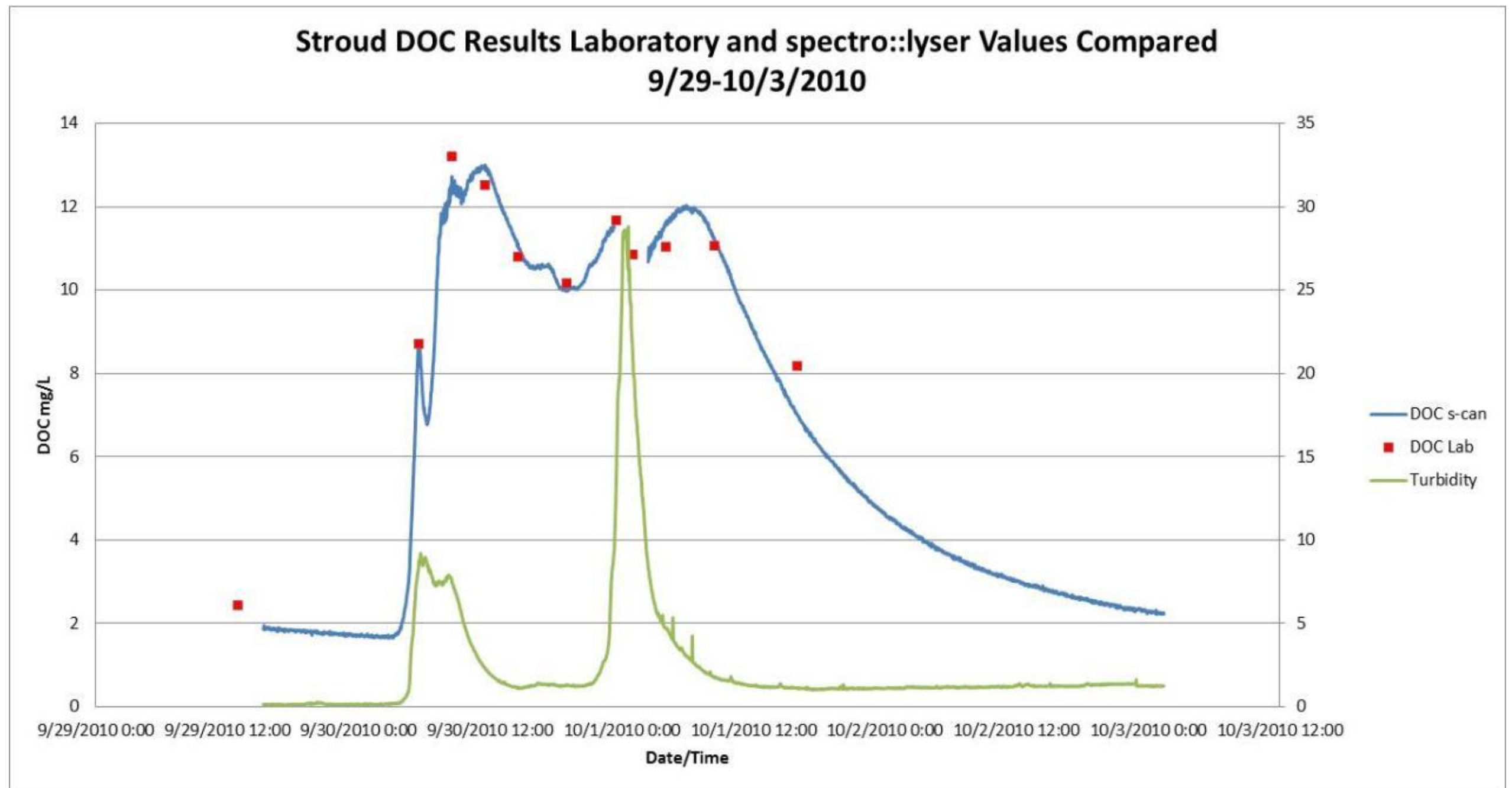
Single wavelength



Spectral (s::can)



DOC and Turbidity Monitoring



Global Calibration

- Factory calibrations for many different applications
 - WWTP Influent
 - WWTP Aeration Basins
 - WWTP Effluent
 - Surface and Ground Water
 - Industrial Wastewater (breweries, dairies,...)
- Developed using thousands of spectra from thousands of samples and applications

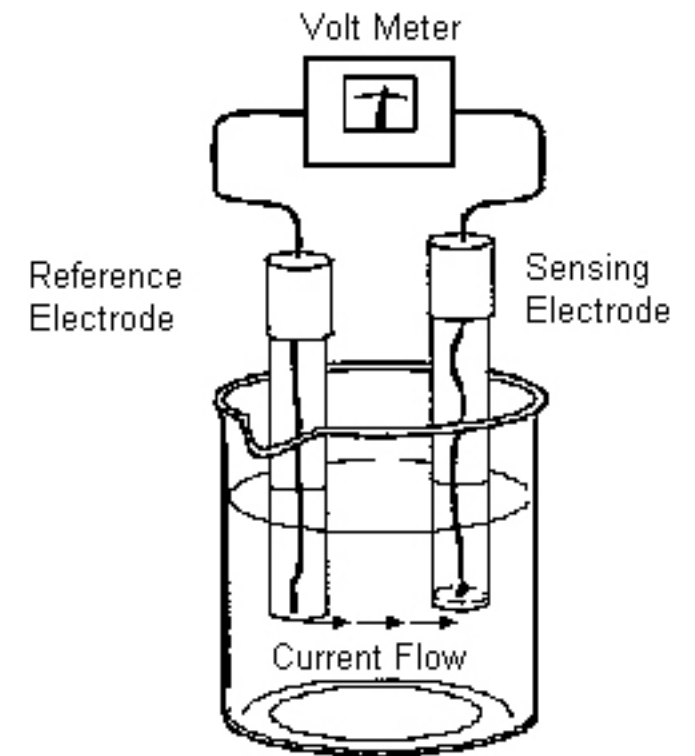
Ion Selective Electrodes (ISE)

- Membrane electrodes that respond selectively to specific ions
- pH is the most common
- Common wastewater ISE probes:
 - Ammonium
 - Nitrate
 - Potassium (NH_4 correction)
 - ORP
- Others include: chloride, fluoride, cadmium, bromide, and gases in solution (NH_3 , CO_2 , NO_x)

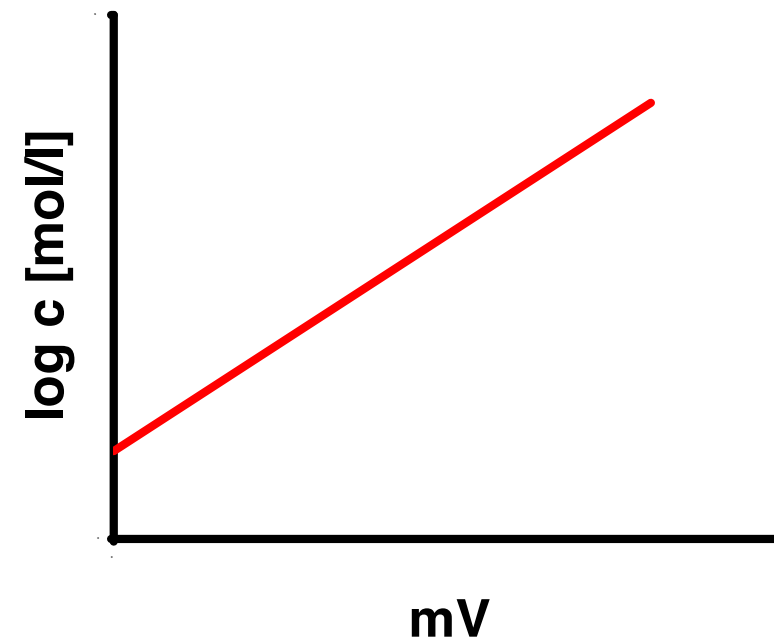
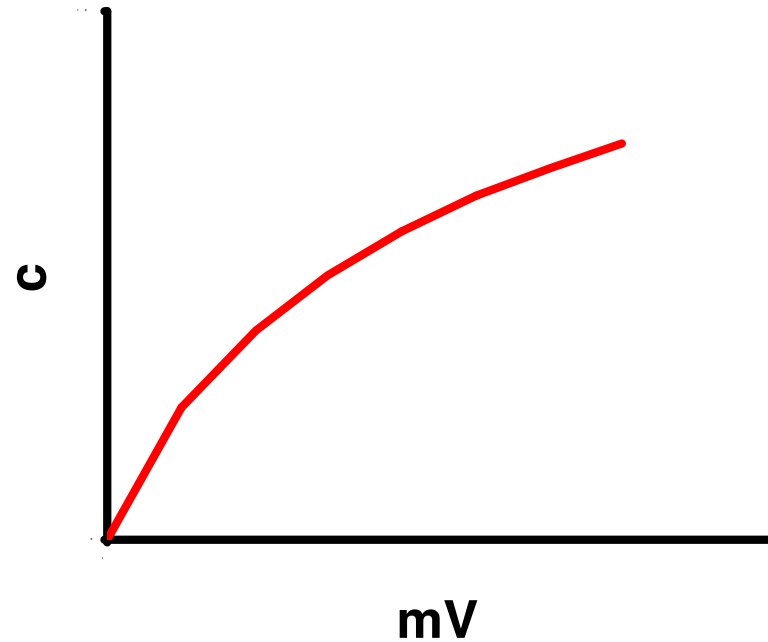


ISE Measuring Principle

- The ISE has a selective membrane attached to the end of a probe that contains an internal reference electrode
- ISE measure the potential of a specific ion in solution
- ISE potential is measured against a stable reference electrode of constant potential in the same solution
- The potential difference between the two electrodes will depend upon the activity of the specific ion in solution



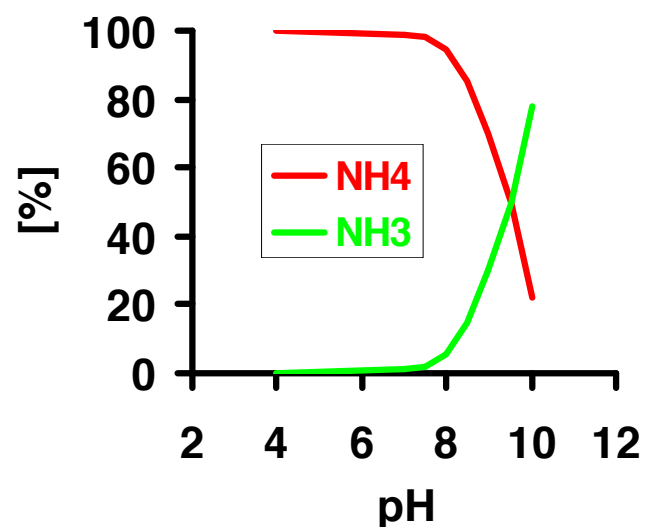
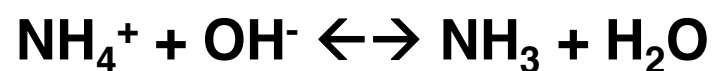
ISE Measuring Principle



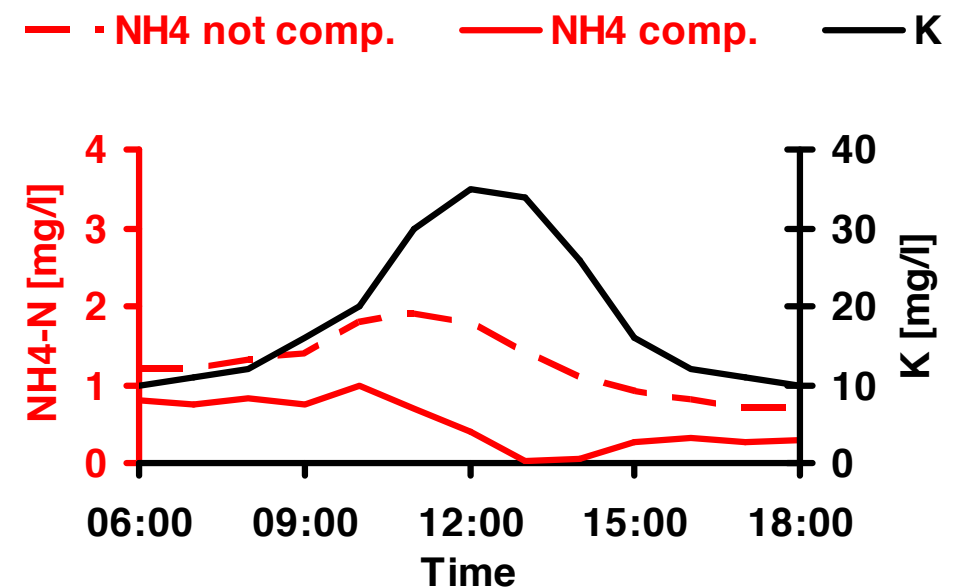
- This activity is related to the concentration of that specific ion
- The dependency between the concentration and ion activity is not linear

ISE Parameter Compensation

- Temperature compensation required for all ISE parameter measurement
- pH compensation for ammonium
- Potassium compensation for high ammonium accuracy



NH₄⁺ membrane is cross sensitive to K⁺ ion (1:25)

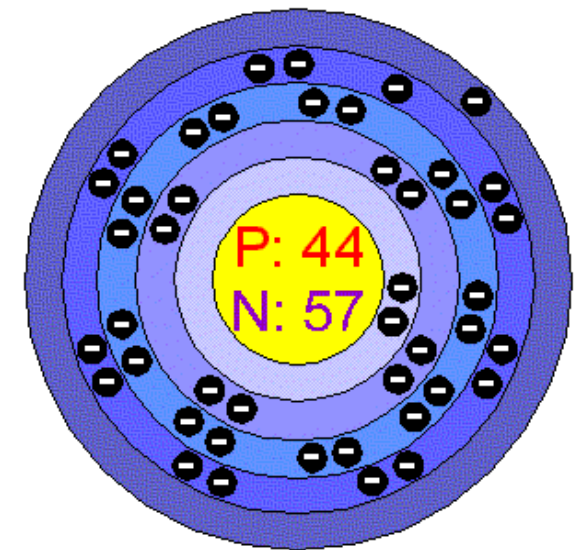
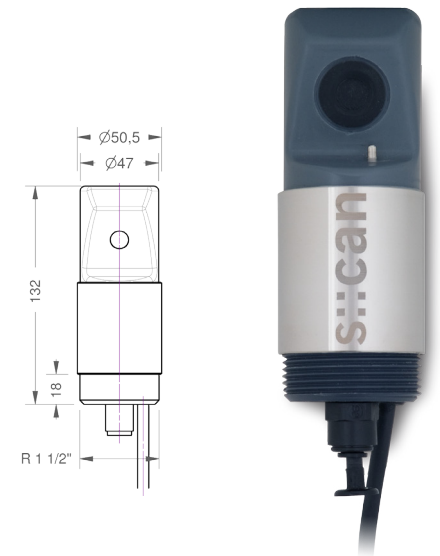


ISE Maintenance

- Exchange NH_4 electrode every 6 to 12 months prior to failure
- Exchange reference and pH electrodes every 12 to 24 months prior to failure
- Overnight conditioning of new electrodes in medium before calibration
- Use 1-point offset calibration
- In general a monthly check should be sufficient
- Perform offset calibration if readings are out of specification - otherwise keep system as is

Optical Probes

- DO
 - Optical fluorescence
 - Ruthenium is “excited” by energy with a wavelength of 475 nanometers
 - Fluorescence occurs when the electrons makes a transition back from a higher to a lower energy state
 - The presence of oxygen will bleed off some of this energy (quenching).
 - As the concentration of oxygen increases, the amount of red light emitted decreases.



Suspended Solids Optical Sensor

- MLSS, WAS/RAS
- Near infrared optical absorbance (880 nm)
 - Single gap light absorption
 - Minimize color effects
- Calibrated in place to the specific application



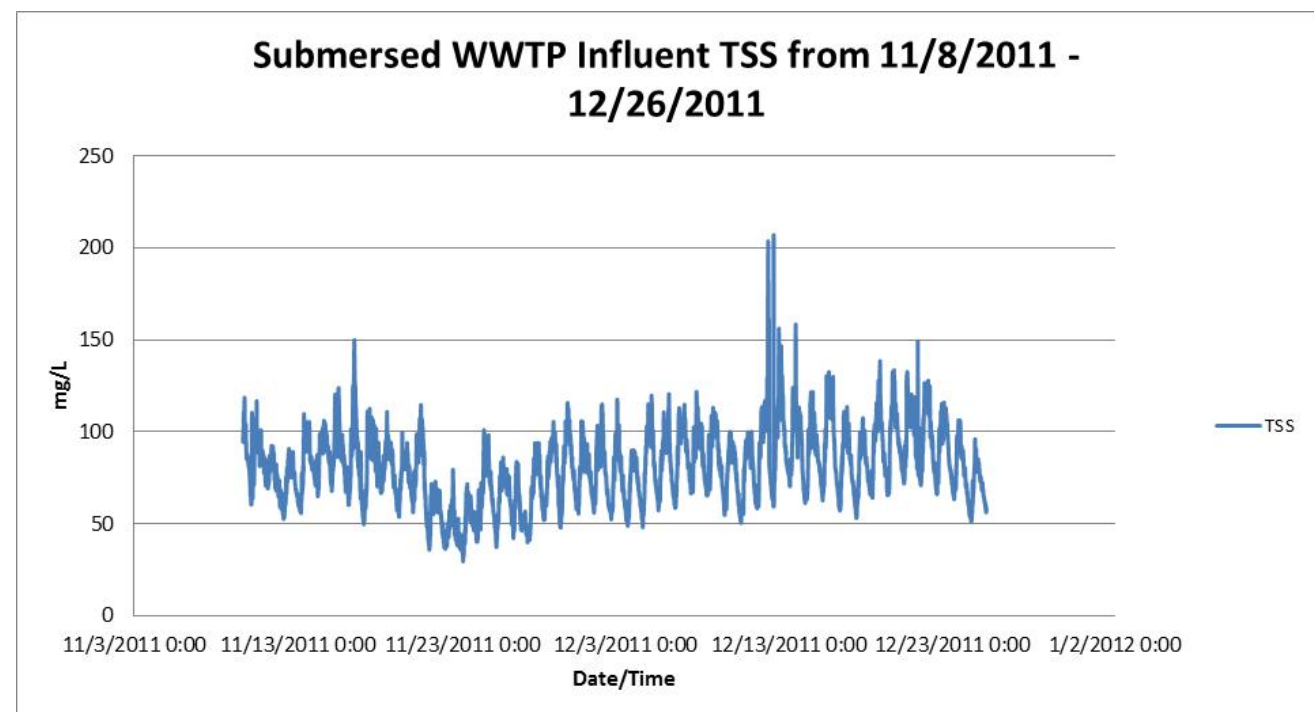
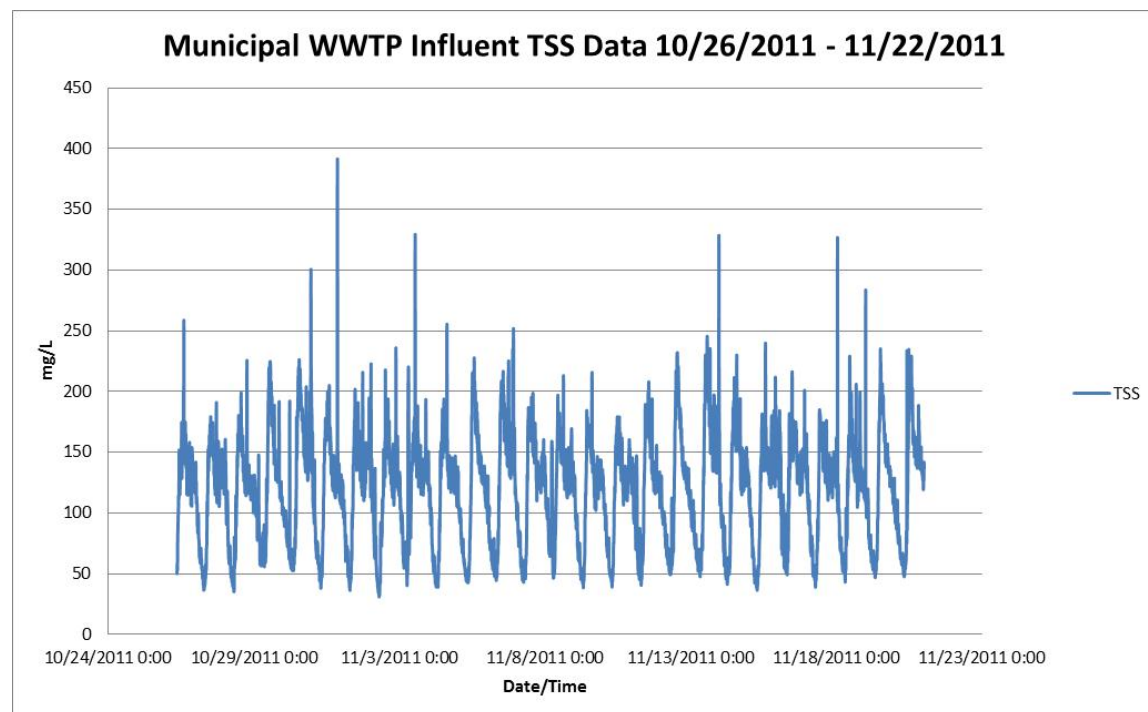
Maintenance and Service

- Manual cleaning unnecessary
- Automatic high-pressure air compressor
- 12 V dc, normally closed, solenoid valve controlled by Spectrometer probe or controller
- High pressure blast acts as a “sand-blaster” to clean the windows with the solids in the process
- Avoids smearing and inefficient cleaning

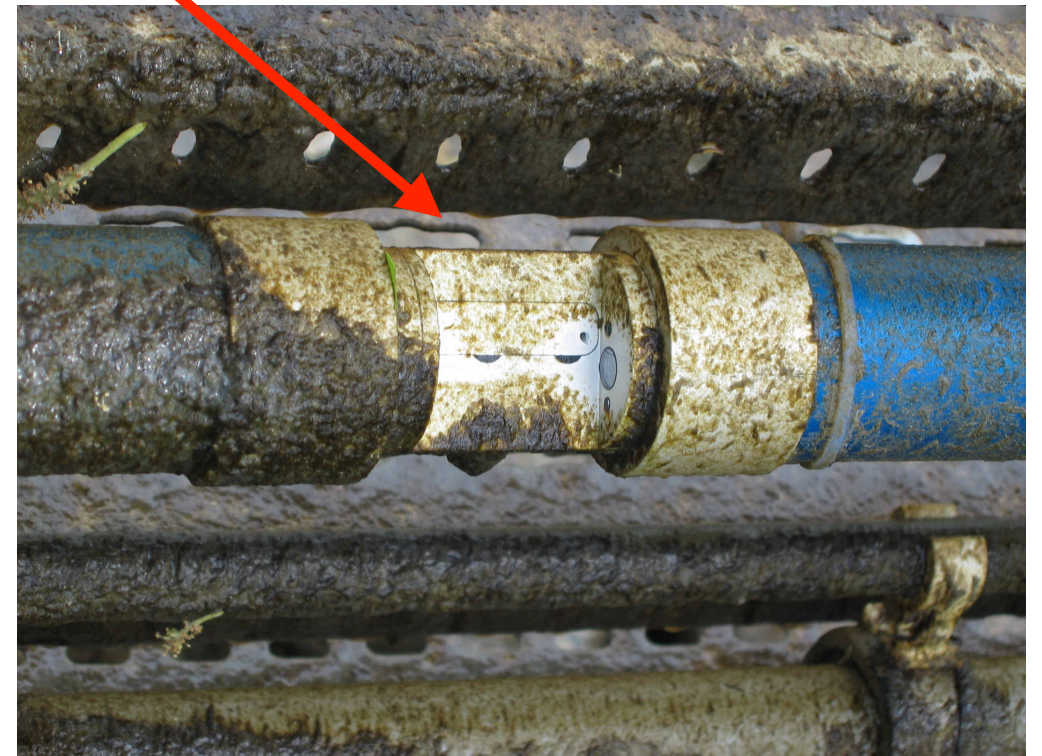


Automatic Cleaning with Compressed Air

- Data from 2012 wastewater installations
- Essentially no drift
- Only compressed air cleaning



Examples of automatic
cleaning with pressurized air





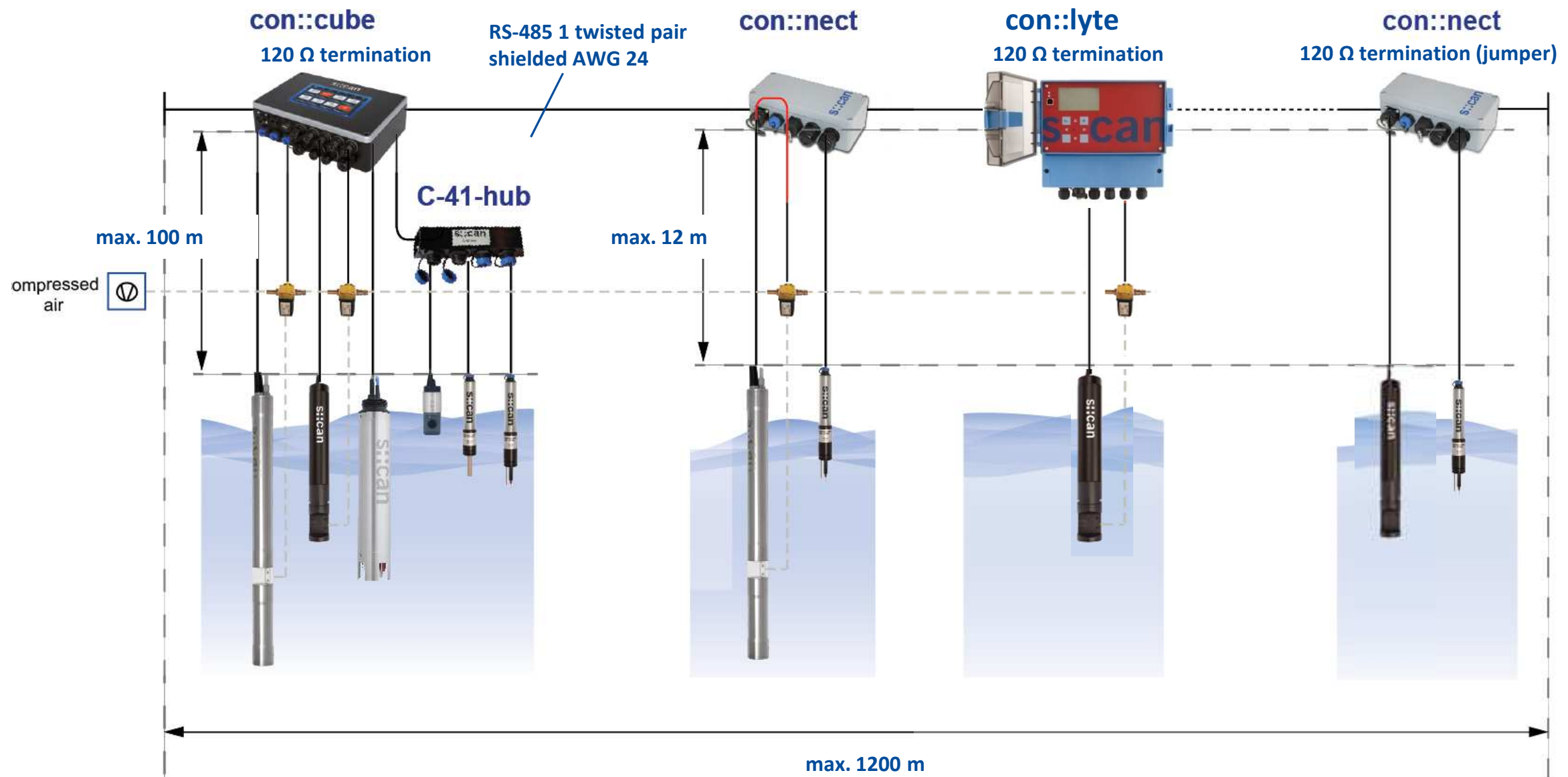
Controls con::cube

- con::cube - industrial PC
 - Manage all sensors - up to 64 parameters
 - Logs data
 - Can interface with 4-20 mA, Modbus RTU/TCP, Profibus, SDI-12, Ethernet IP, ...)
 - Internal modem for remote control, data analyses, data transfer, and other tasks
- moni::tool used to set up process control, automatic data export, free formulas analyses, data analysis and validation, camera input

use con::nect and con::lyte to add more sensors

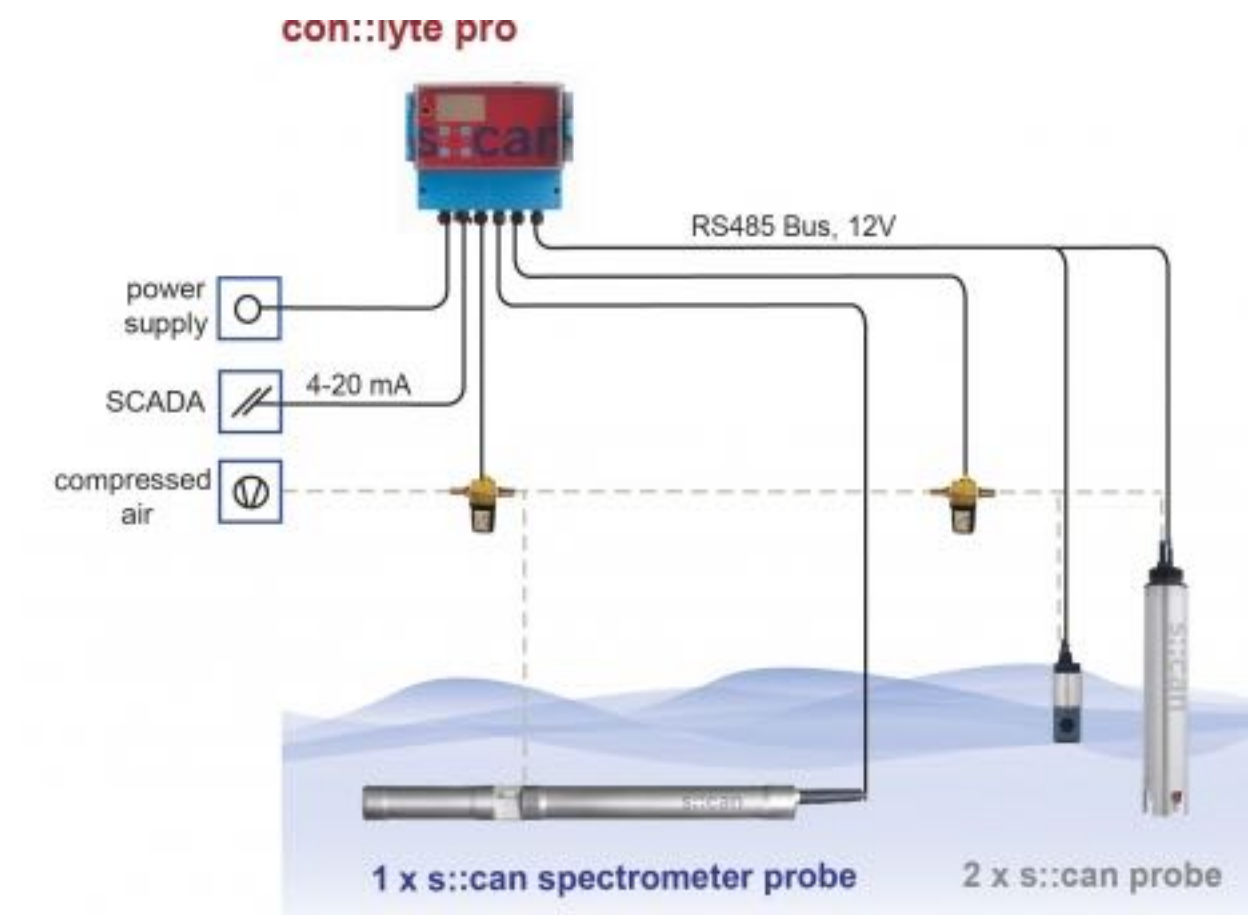
cleaning over con::lyte is supported in combination with all sensors

cleaning over con::nect is supported in combination with spectrometer, only



Controls con::lyte

- con::lyte operation of up to three s::can sensors/probes
- Display up to 4 parameters
- 4 - 20 mA outputs
- low cost transmitter

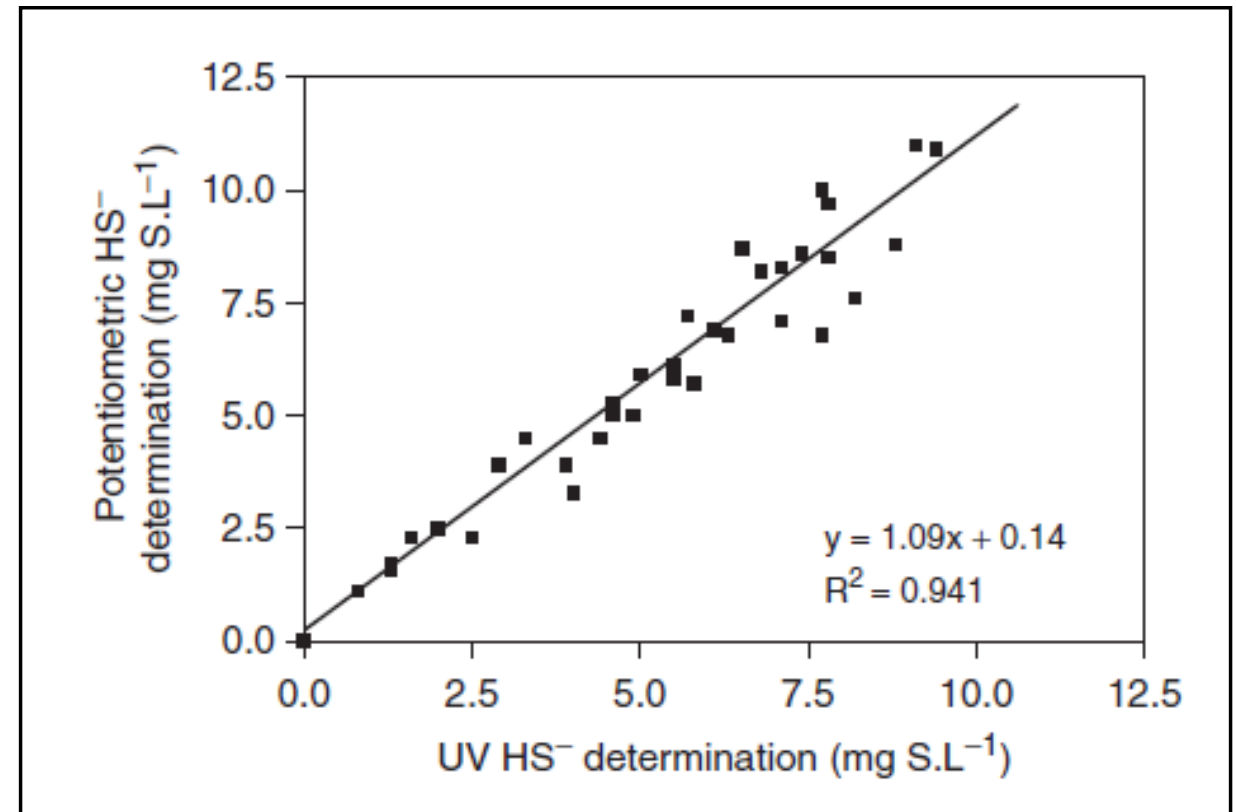
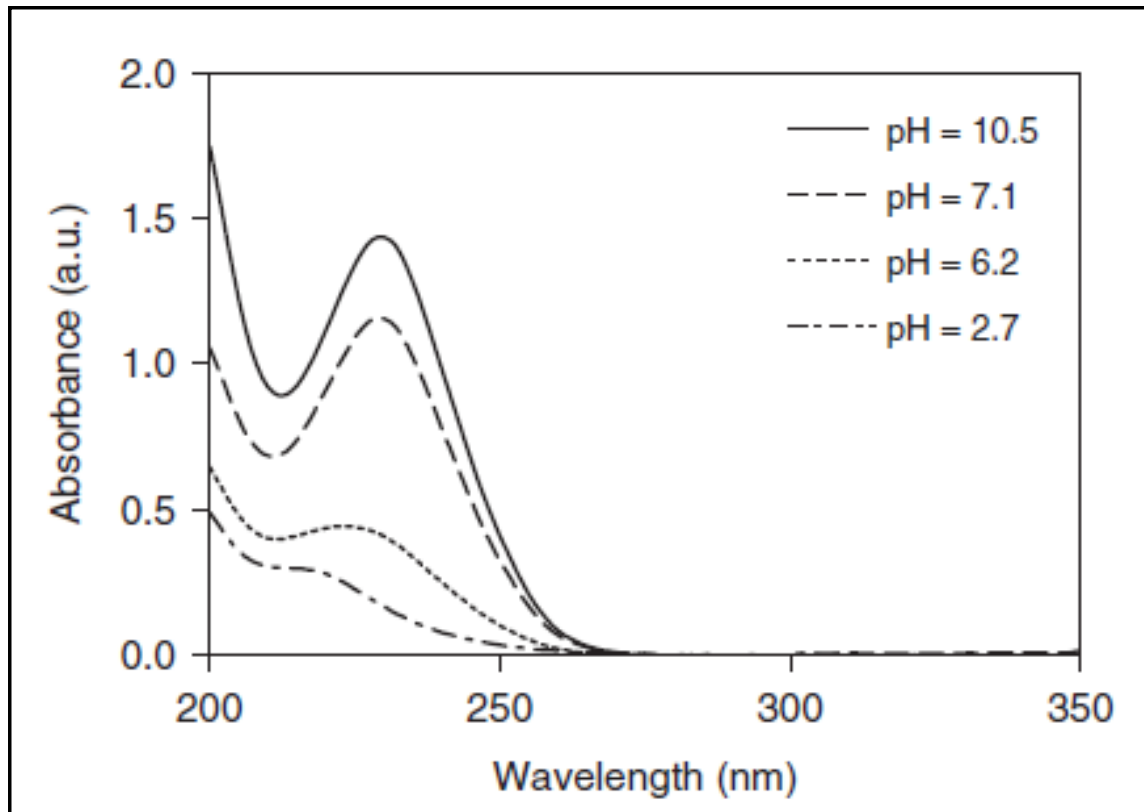


Wastewater Monitoring

Applications - Odor Control

- Hydrogen sulfide exists in a liquid/gas equilibrium
- In the aqueous phase there are three species
 - $H_2S \rightleftharpoons HS^- + H^+$
 - $HS^- \rightleftharpoons S^{2-} + H^+$
- The active species absorbs in the UV spectrum without the use of reagents
- Cross-sensitivities must be compensated for using advanced algorithms
- A pH sensor is utilized to compensate for the equilibrium shift between species

Odor Control



- UV-Vis spectra and dissolved hydrogen sulfide versus lab
- Even with a difficult wastewater matrix (i.e., nitrate and COD fluctuations) the dissolved sulfide signal is strong enough for reliable quantification

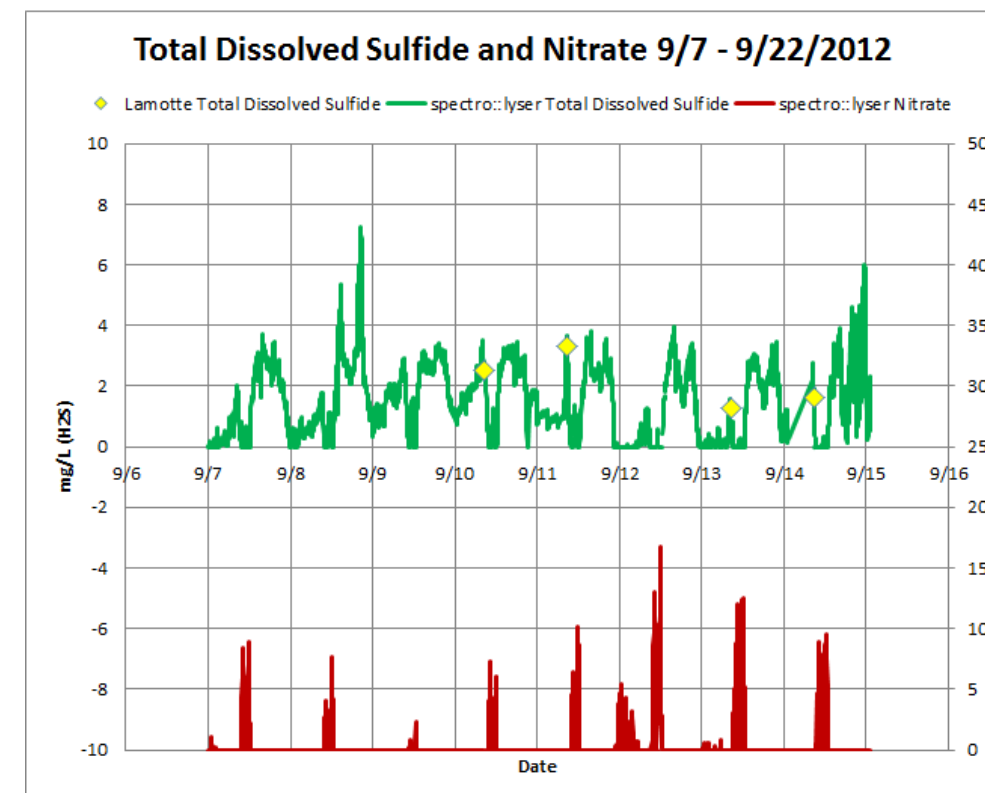
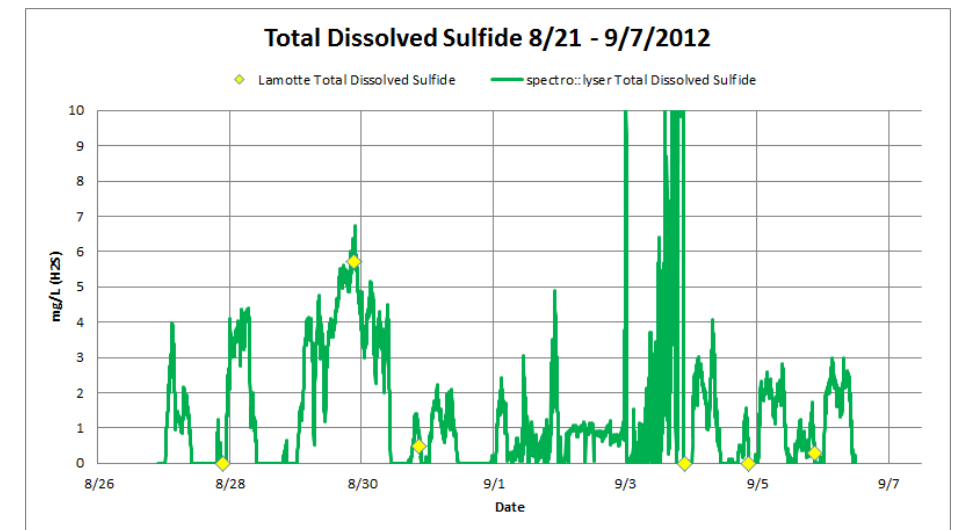
Santa Cruz County Dissolved Sulfide Monitoring

- A force main that discharges into the city of Santa Cruz WWTP suffers from very high dissolved sulfide loads that varies seasonally and diurnally
- BIOXIDE used to mitigate odor/corrosion problem was added based solely on flow rate and periodic test kit results.
- Dissolved sulfide target is set to $< 3 \text{ mg/l}$



Odor Control

- Initial data showed that dissolved sulfide concentrations changed quickly and in an unpredictable manner
- spectro::lyser used for UV measurement also measures nitrate, providing an accurate indicator that BIOXIDE was being overdosed
- Time series data collection showed that nitrate residuals were only apparent when the dissolved sulfide is zero



Odor Control Next Step

- Integrate data into chemical dosing system for real-time feedback and control
- Determine optimal sensor location for fast feedback and effective control
- Explore additional uses for COD and SS information for other process controls

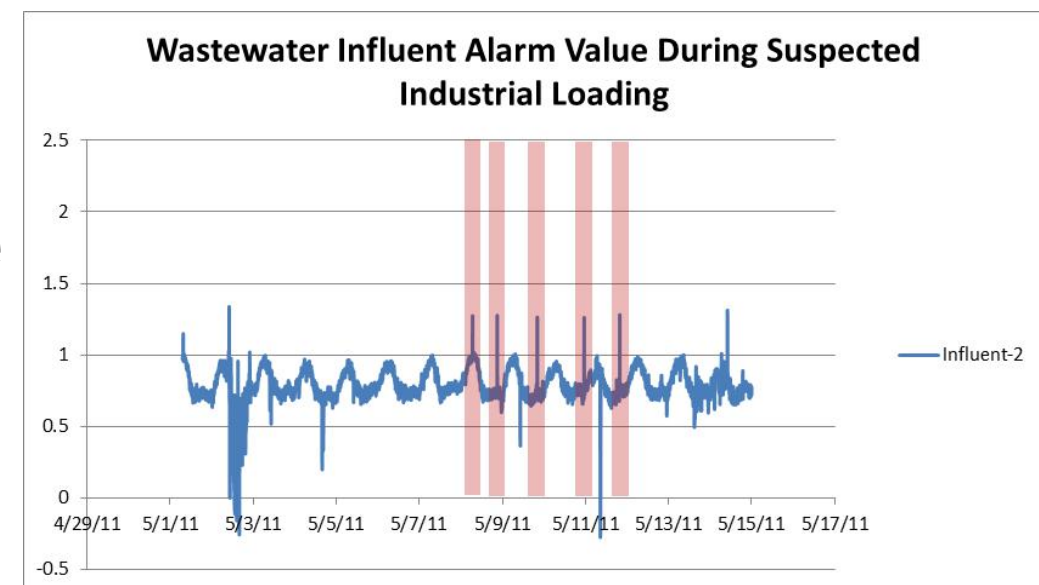
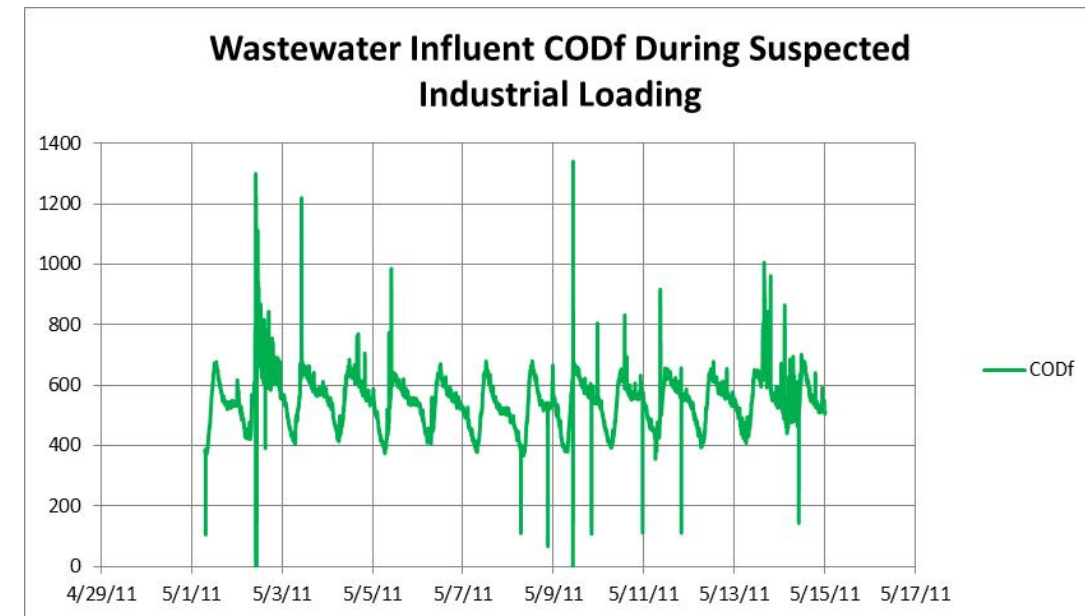
Industrial Wastewater Alarms

- City of Phoenix installed scanalyzer and ammono:lyser in WWTP aeration basins and influent to monitor NO_2 , NO_3 , NH_4 , COD, soluble COD, and suspended solids
- The influent scanalyzer configured to alarm based on abnormal changes in the UV-Vis spectra
- All sensors are cleaned by compressed air cleaning



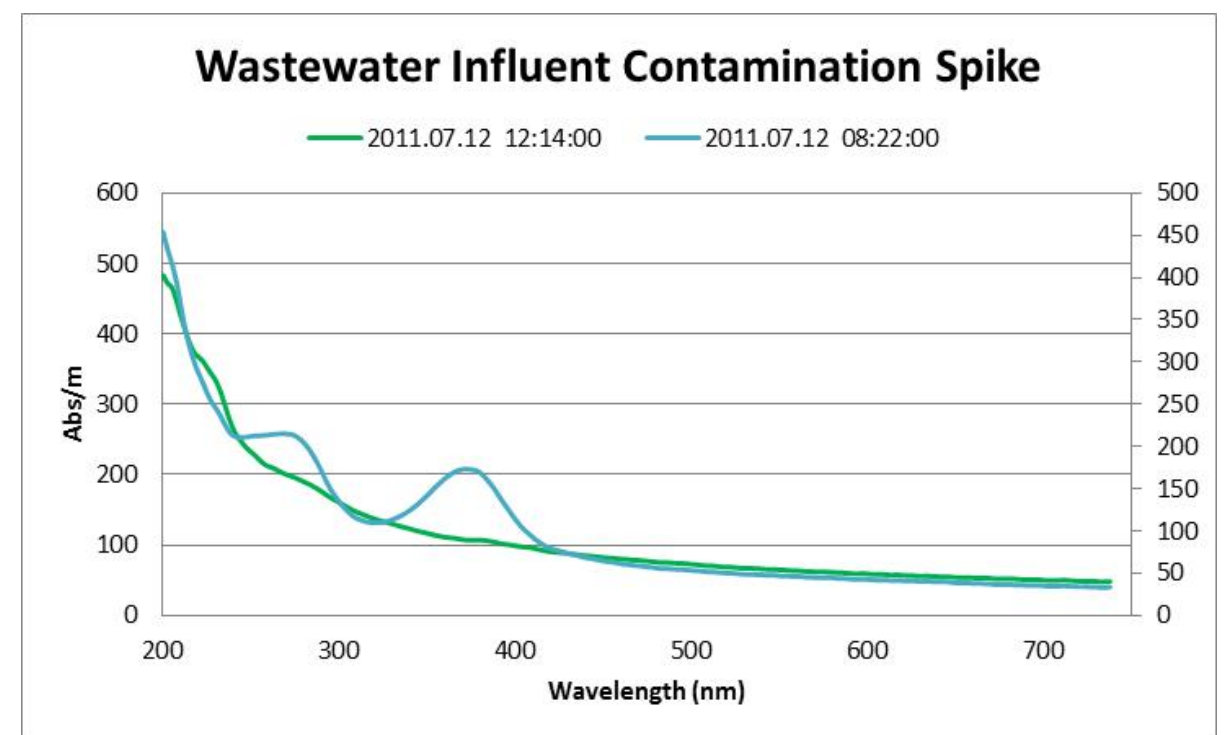
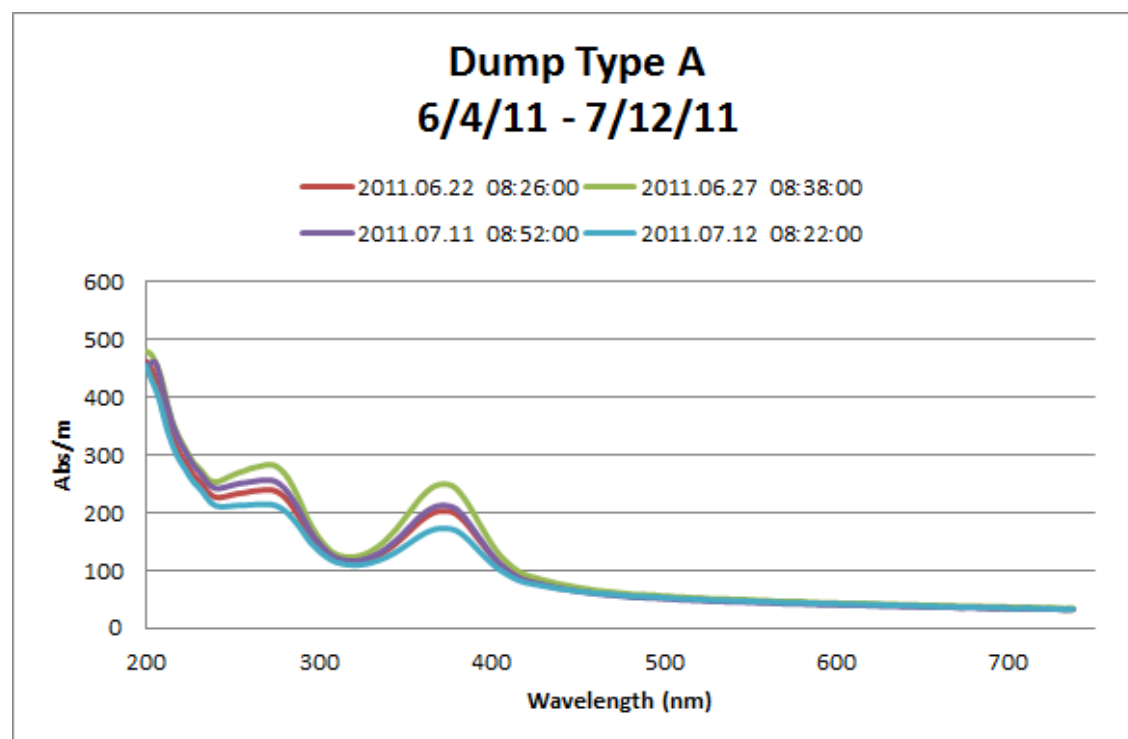
Industrial Wastewater Alarms

- A review of the station influent data indicated a suspected unauthorized industrial discharge
- COD signal showed normal diurnal fluctuations with some short-duration changes on multiple days over a two-month timeframe
- The spectral alarm showed significant deviations during some of the short COD spikes (highlighted in red)



Industrial Wastewater Alarms

- Fingerprint alarms led to an investigation of individual spectra
- A distinct spectral was noted repeatedly indicating a specific waste discharge
- Other abnormal spectra were also identified suggesting multiple dischargers

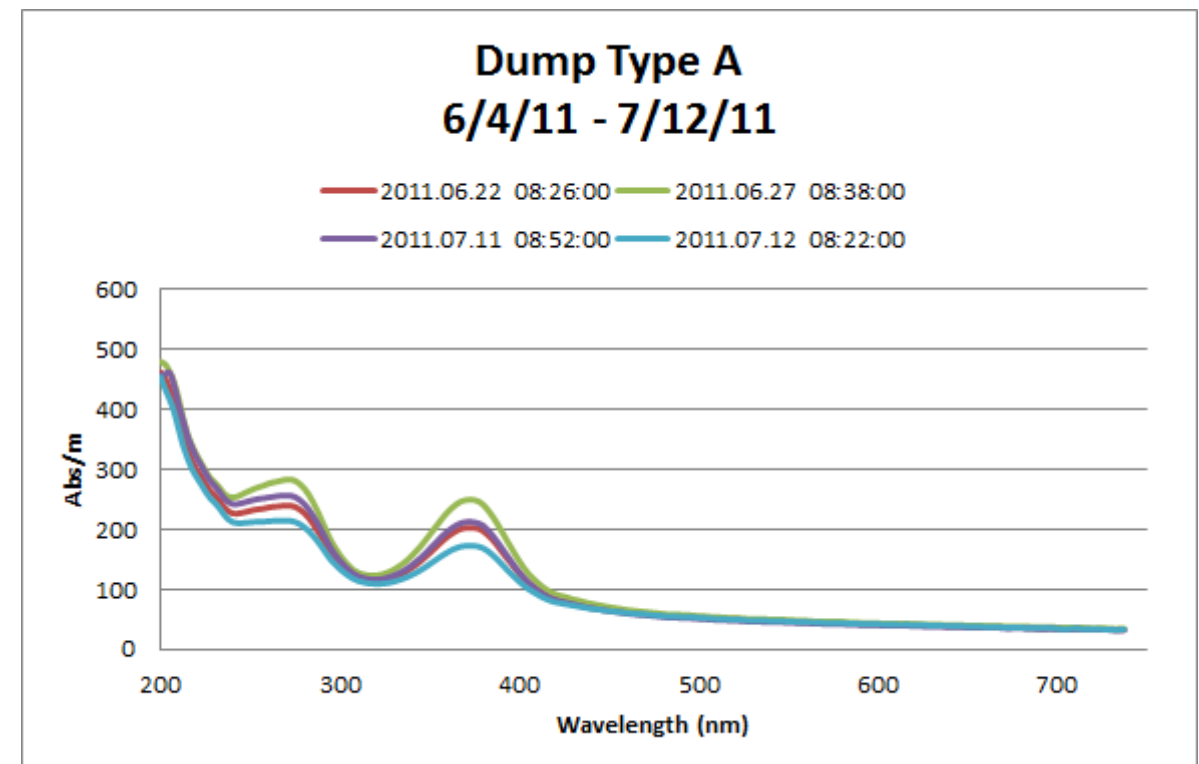
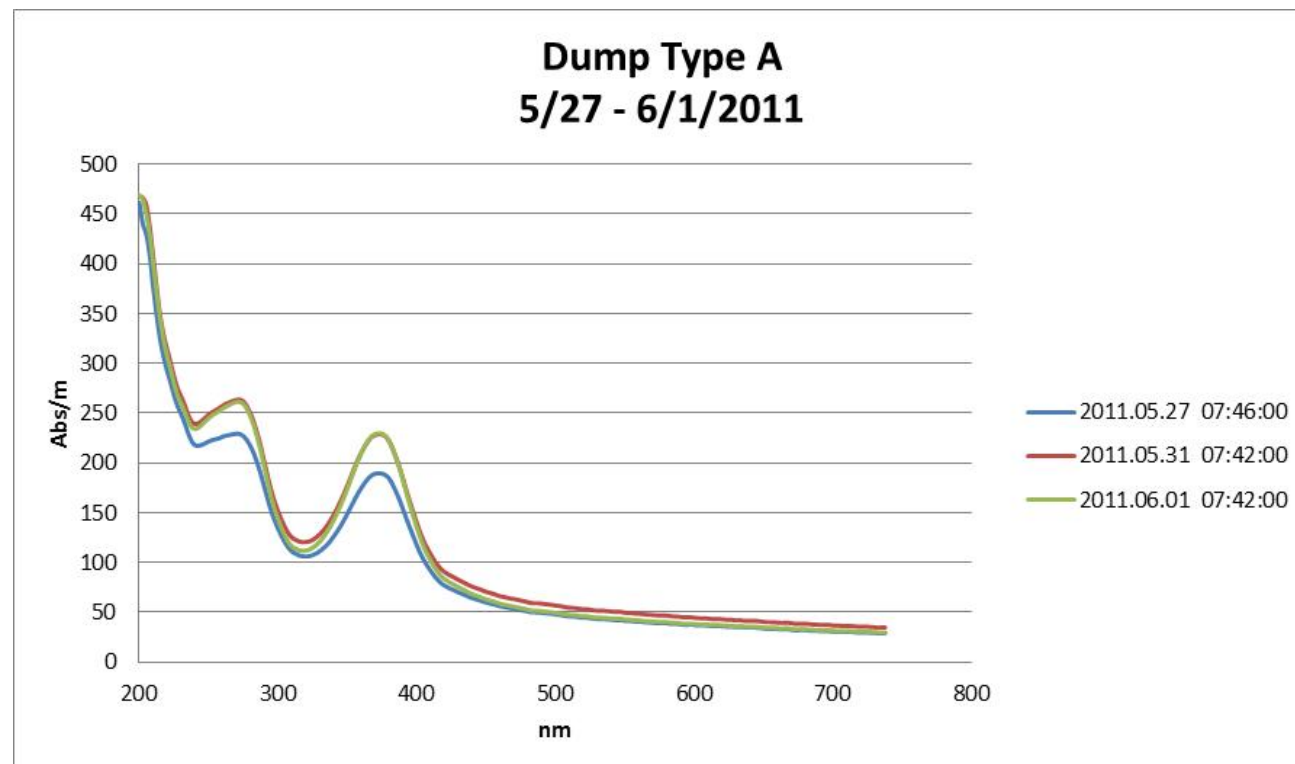


Industrial Wastewater Alarms

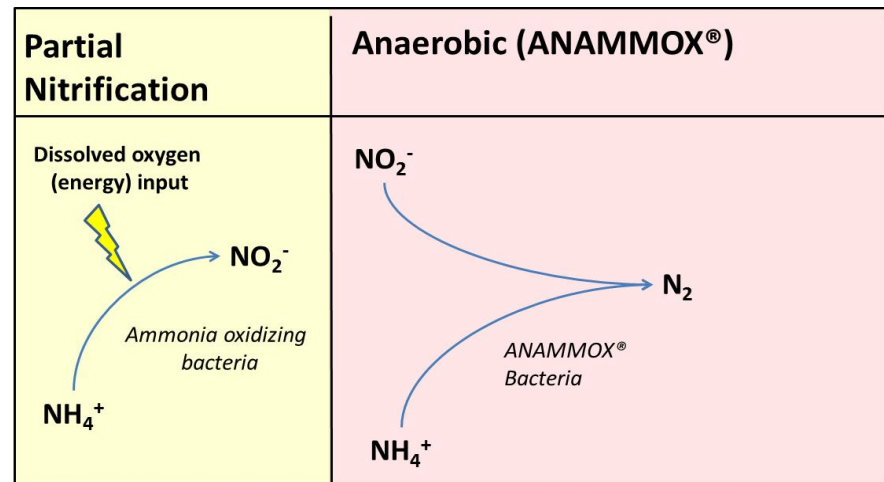
- The spectro::lyser was able to detect and differentiate various industrial loads over a 2-year period of continuous operation
- Aeration basin sensors have detected changes in NO_2/NO_3 following these discharge events indicating biological inhibition
- The city has been able to track down offenders and plan to install a network of sensors in their collection system

Industrial Wastewater Alarms

- A closer investigation of the raw spectral data revealed that distinct, abnormal UV-Vis peaks were visible during a number of these alarms
- The alarms occurred at approximately the same time on different days



In-situ Nitrate and Nitrite Monitoring



- Some U.S. POTW's are beginning to consider side stream or mainstream de-ammonification
- Many questions remain about how to properly control this new process
- NO_3 monitoring may be sufficient for conventional nitrification/denitrification
- Differentiation of the NO_2/NO_3 species can be essential in these new process schemes

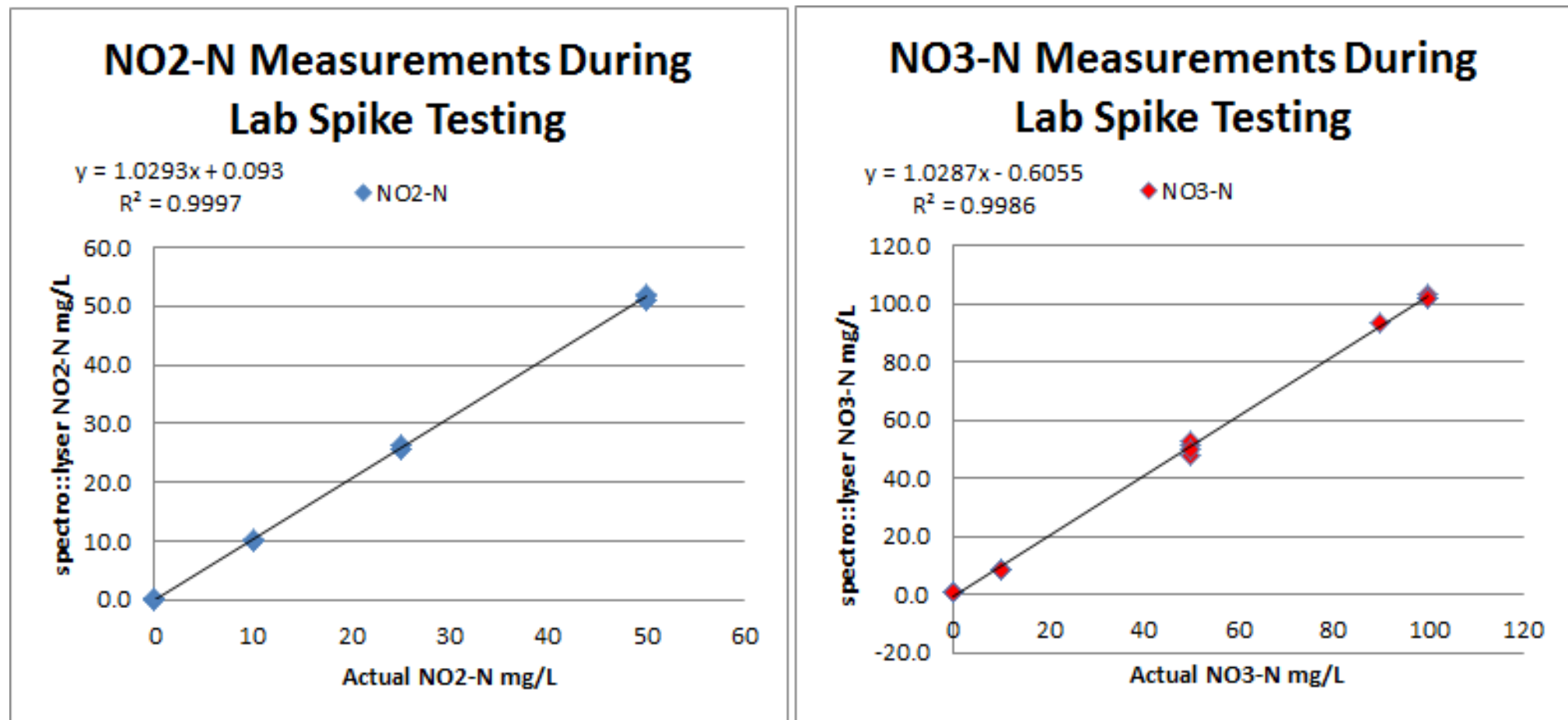
NYCDEP 26th Ward ANAMMOX Pilot

- MBBR ANAMMOX process for centrate treatment
- A pilot study has been on-going for ~ 2 years with continuous NO_2 , NO_3 , and NH_4 data from the scan spectrolyser and ammo::lyser
- Matrix characteristics:
 - TSS: 400 – 1,000 mg/L
 - $\text{NH}_4\text{-N}$: 500 – 900 mg/L
 - $\text{NO}_2\text{-N}$: 5 – 70 mg/L
 - $\text{NO}_3\text{-N}$: 0 – 50 mg/L
 - COD: 100 – 600 mg/L

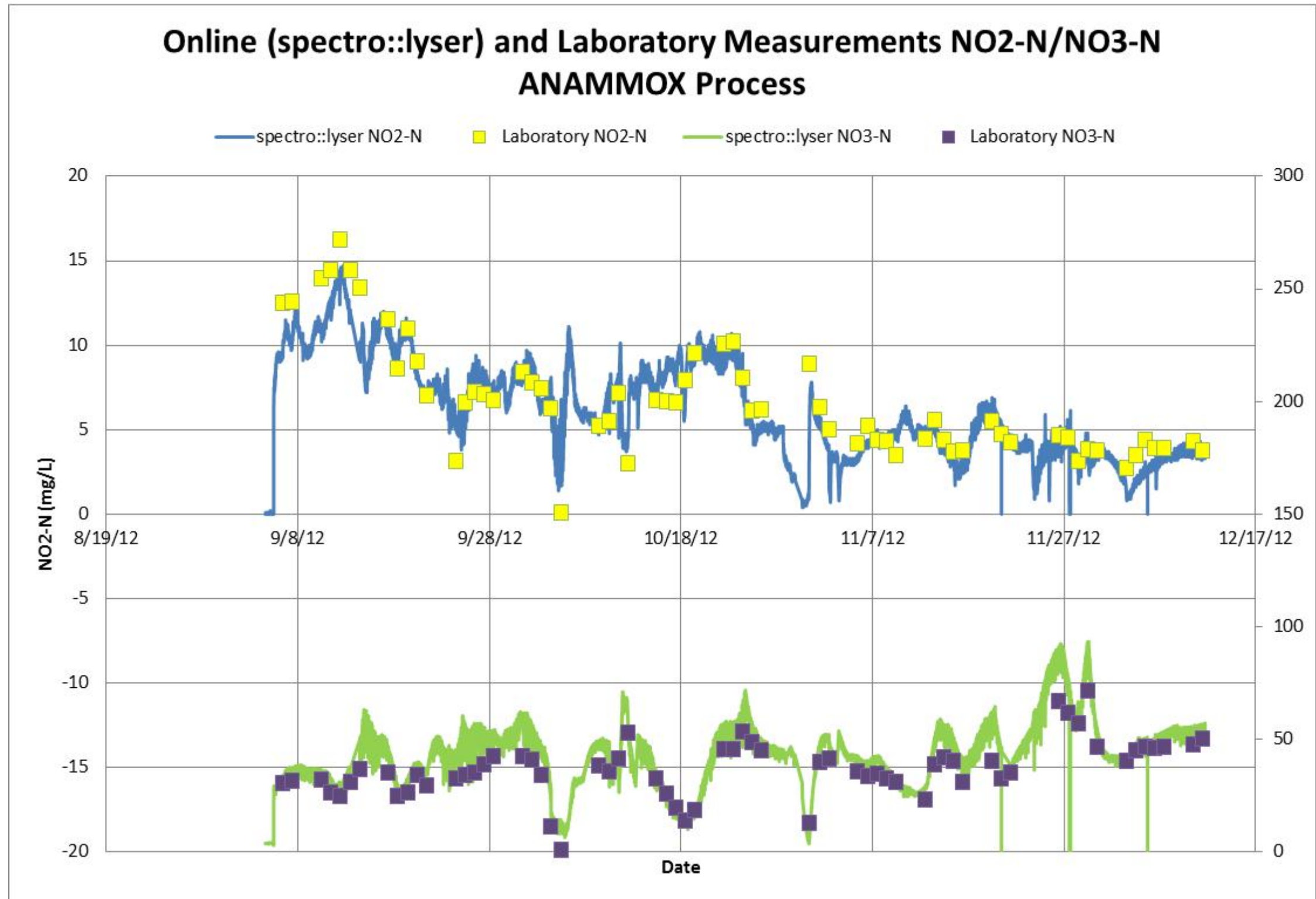


NYCDEP 26th Ward ANAMMOX Pilot

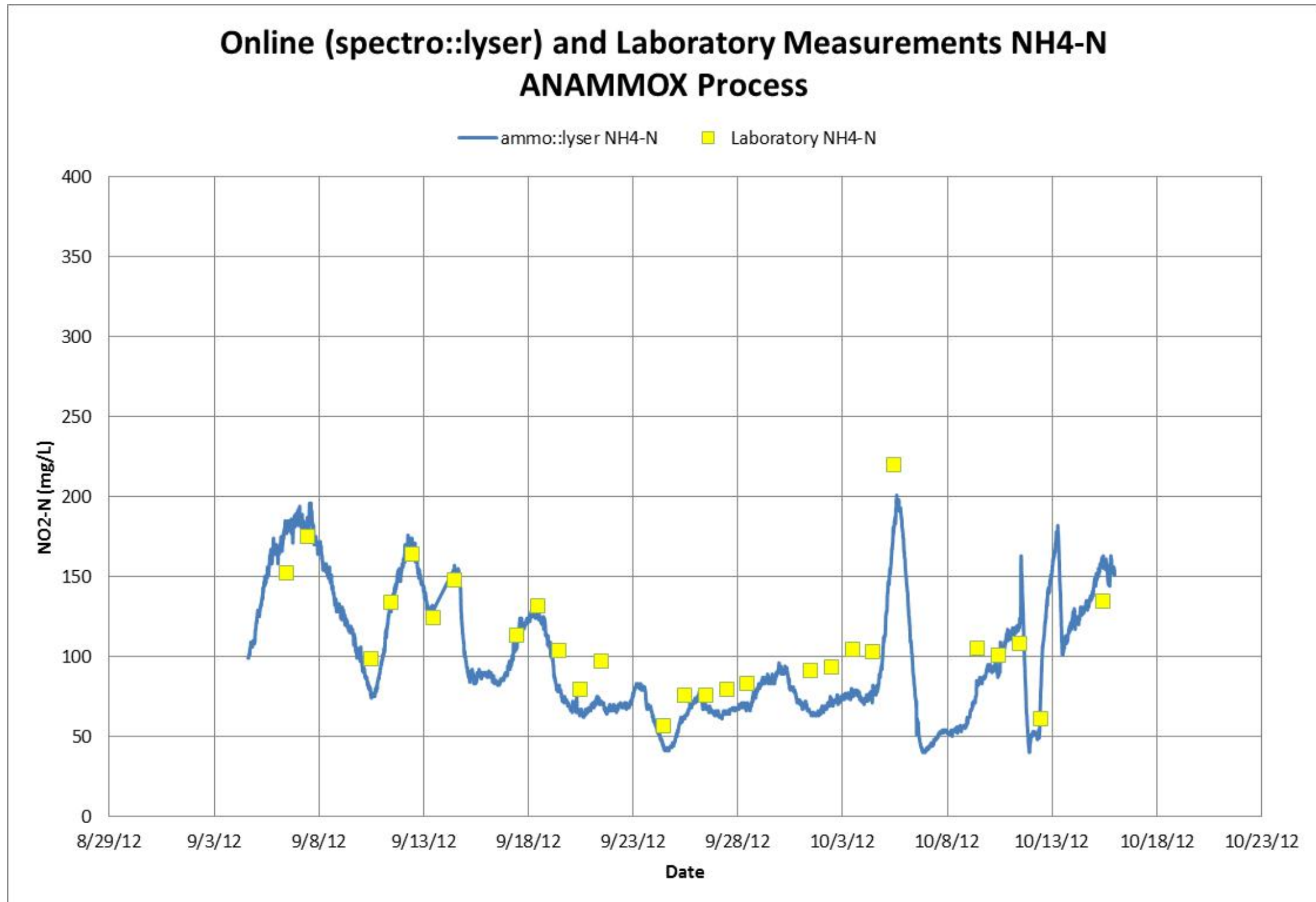
- Results
 - Initial spike testing conducted in the lab indicated that the simultaneous measurement of NO₂/NO₃ functioned well over the full range with little cross-sensitivity



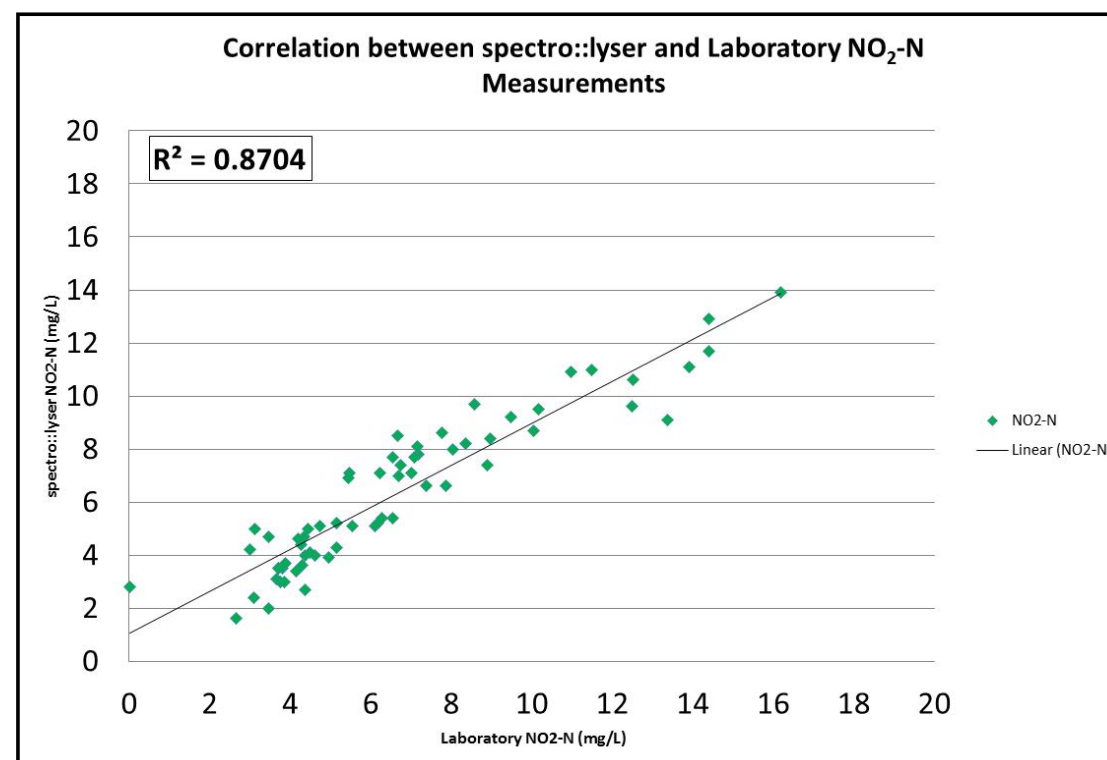
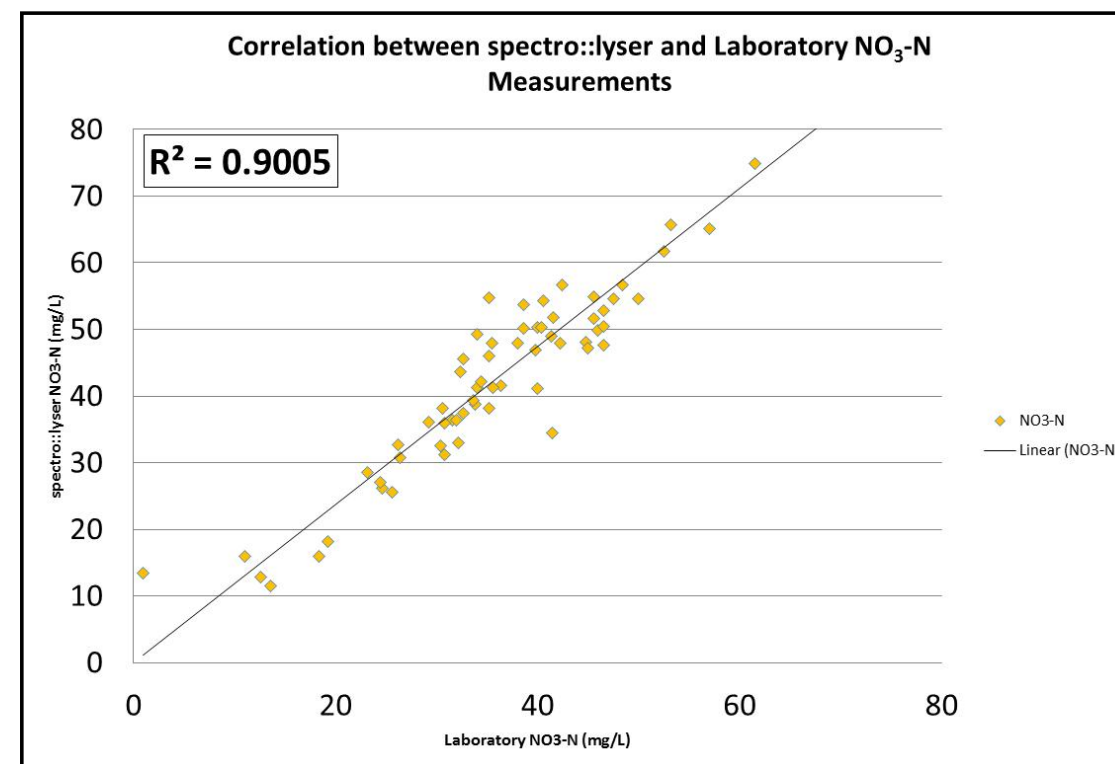
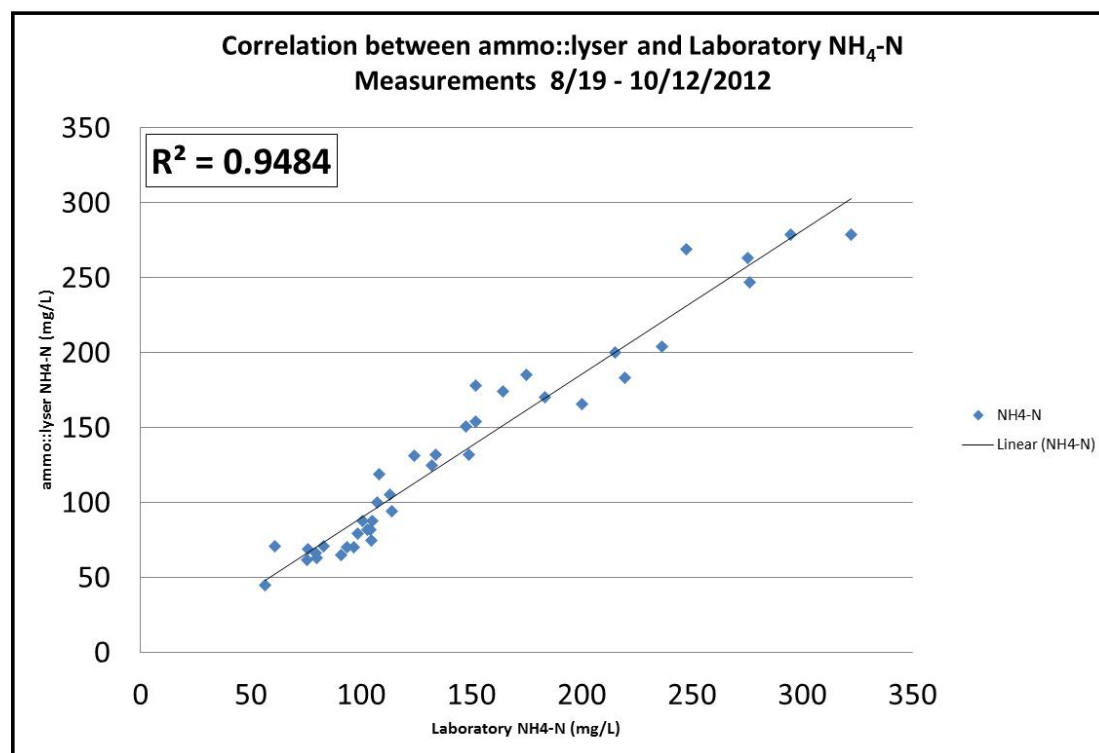
NYCDEP 26th Ward ANAMMOX Pilot



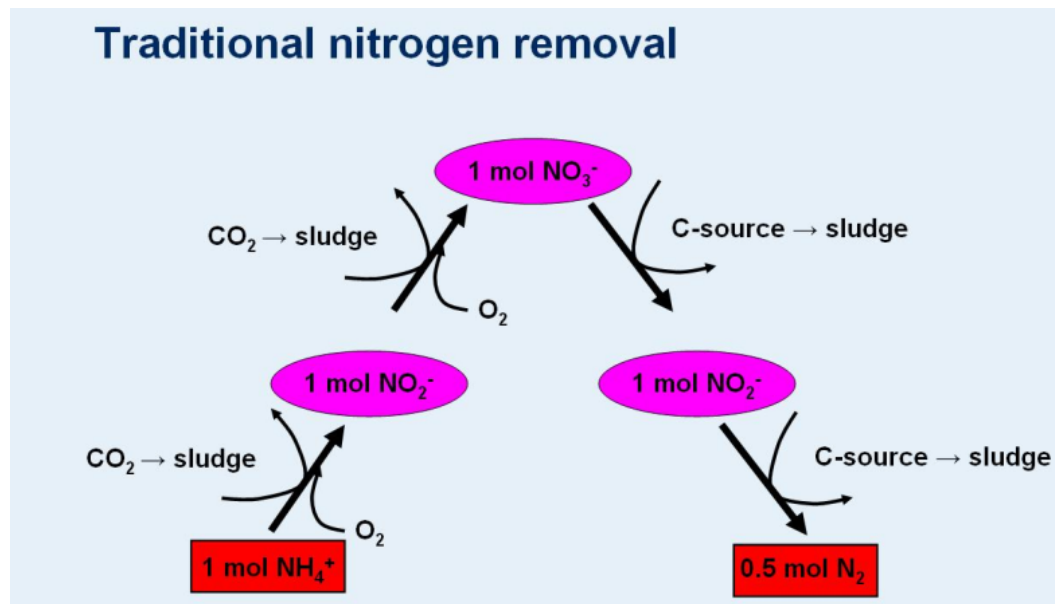
NYCDEP 26th Ward ANAMMOX Pilot



NYCDEP 26th Ward ANAMMOX Pilot



Nitrate and Ammonia



- For conventional nutrient removal NO_3 and NH_4 monitoring are important process parameters
- As more smaller plants are required to perform nutrient removal, operating costs and maintenance become more important

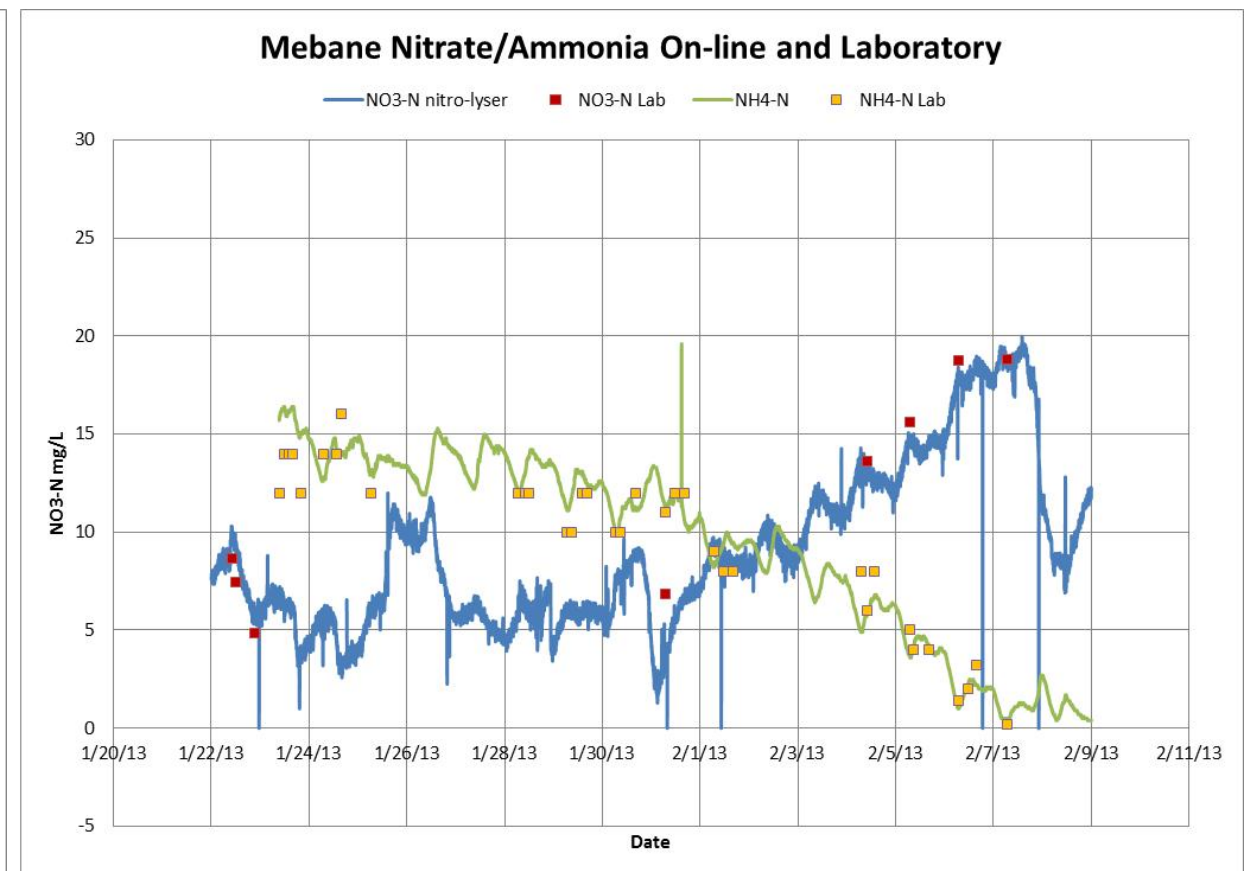
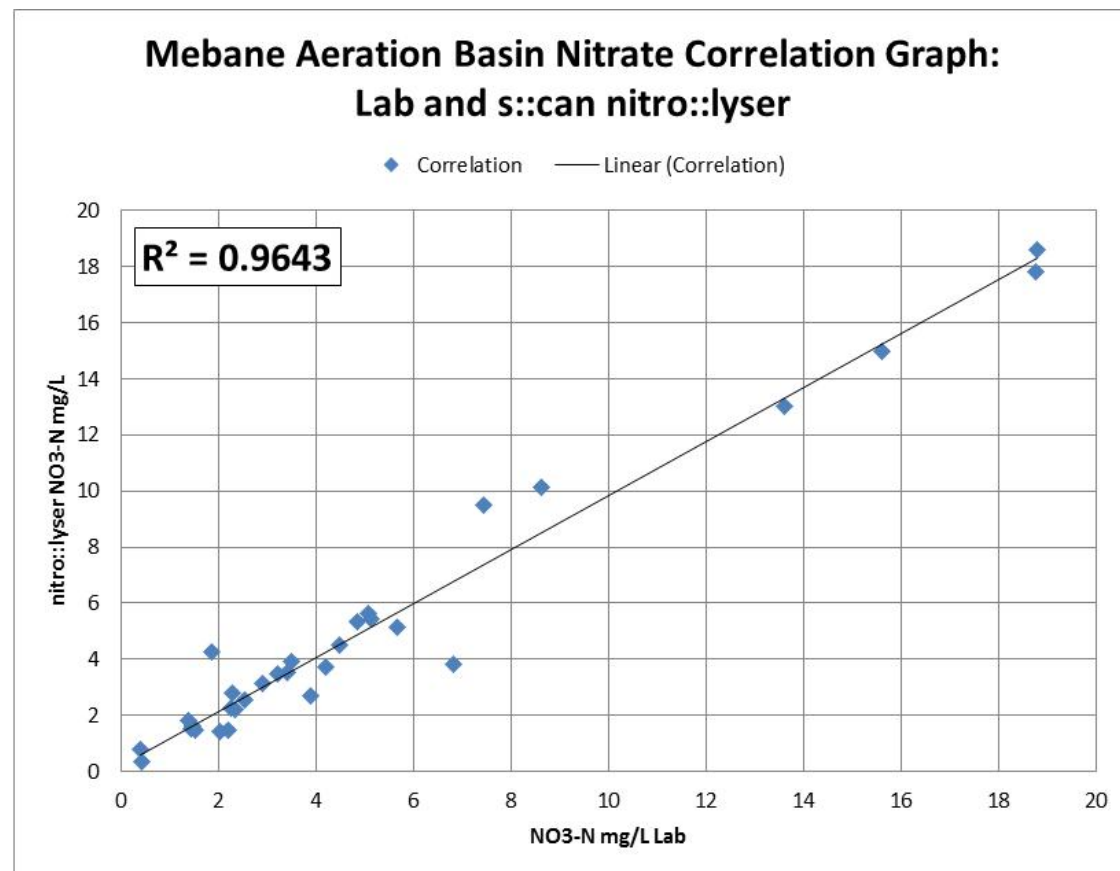
Mebane WWTP

- Mebane is a small WWTP with approximately 2.5 MGD max flow
- Needed a cost effective, low-maintenance solution for enhanced control of their biological nutrient removal process
- Capital costs and life-cycle costs are both important factors in equipment selection



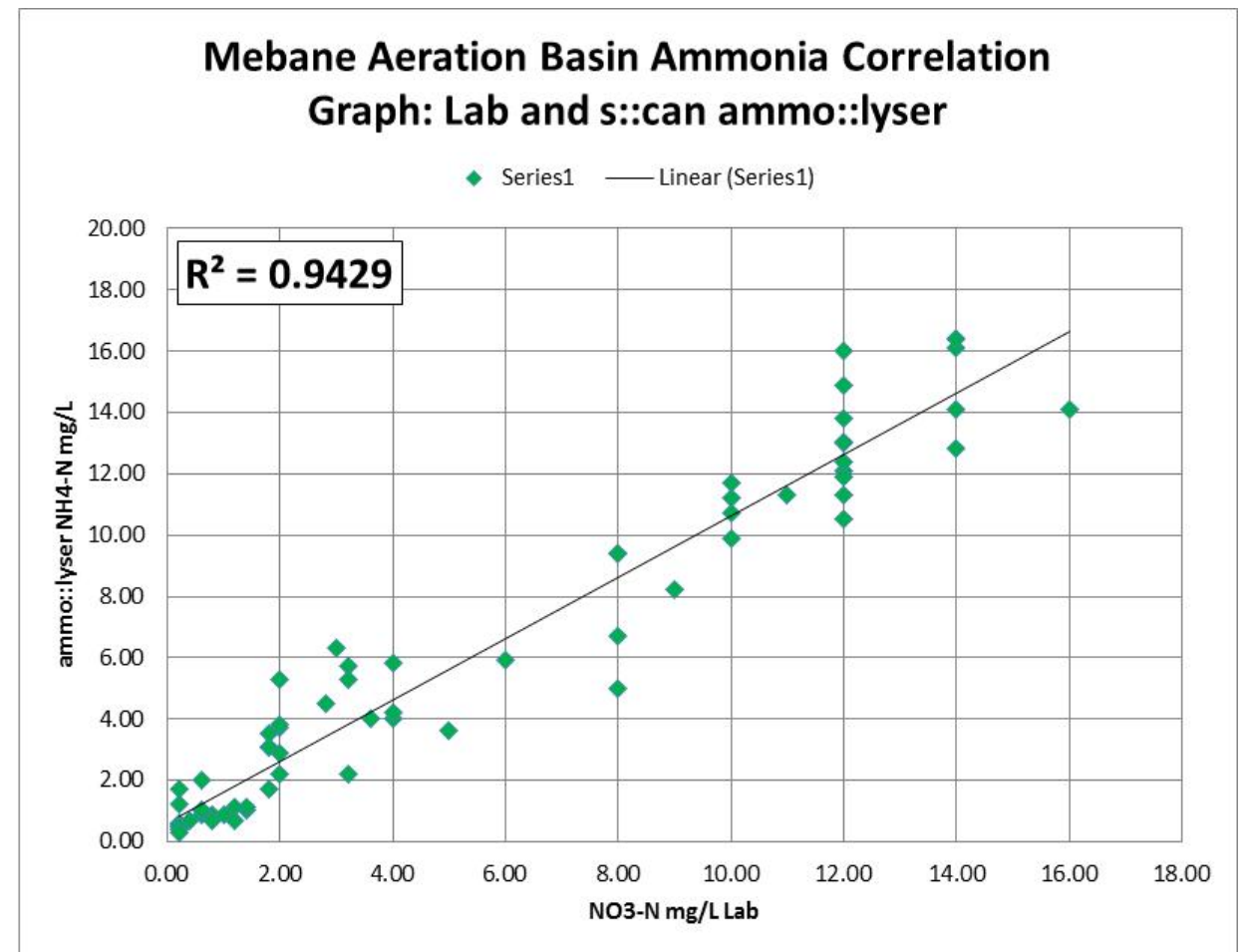
Mebane WWTP

- Mebane obtained consistent, accurate results with little to no maintenance
- Laboratory ammonia measurements were estimated with a color wheel



Mebane WWTP

- The data has provided operations staff with important real-time information for process adjustments
- Allowed for enhanced nitrogen removal and cost savings



Questions?