

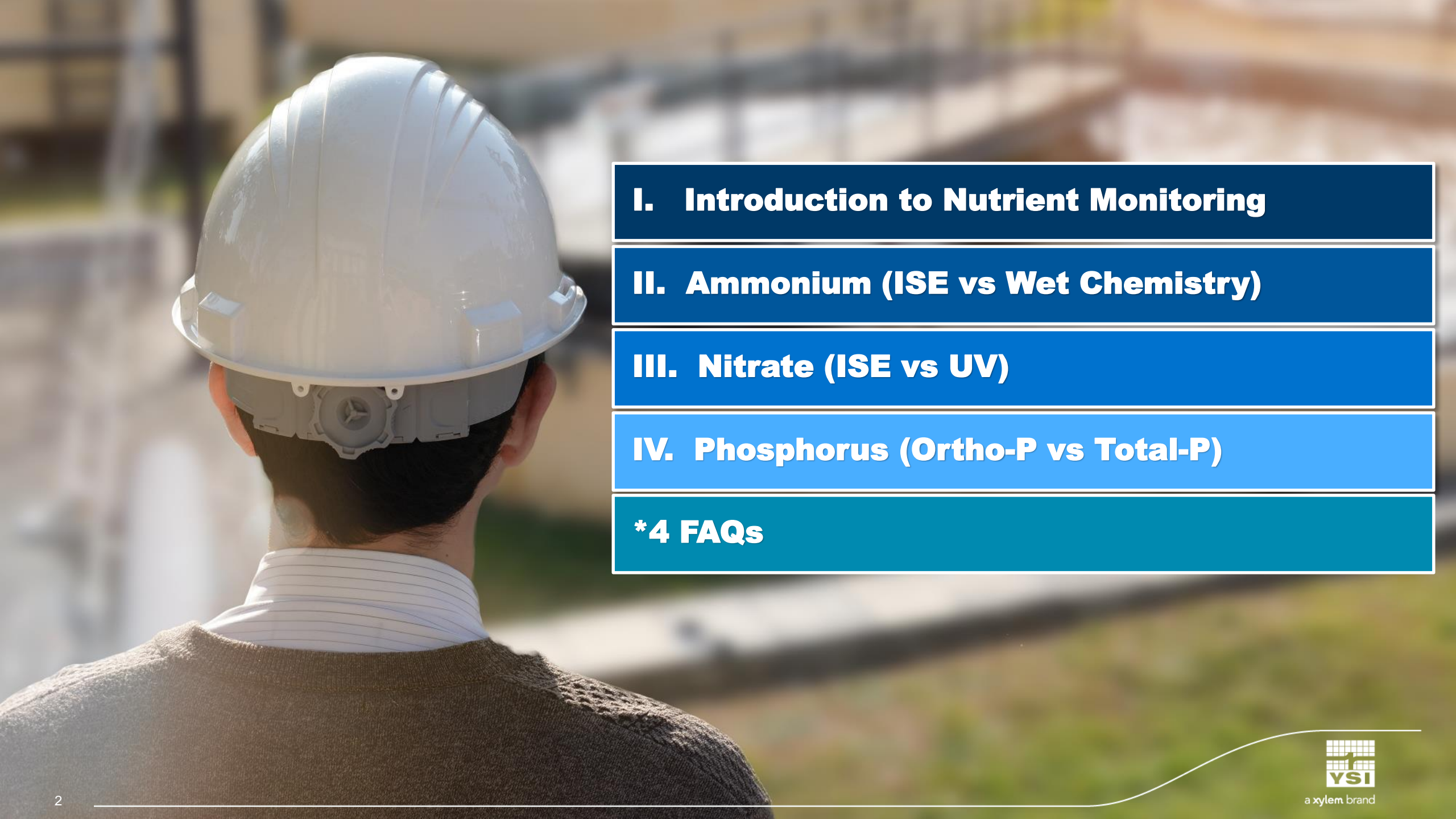
How to Choose the Correct Sensor-Online Nutrient Monitoring



Ben Barker
Applications Engineer



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I. Introduction to Nutrient Monitoring

II. Ammonium (ISE vs Wet Chemistry)

III. Nitrate (ISE vs UV)

IV. Phosphorus (Ortho-P vs Total-P)

***4 FAQs**

Part I:

Introduction to Nutrient Monitoring in Wastewater

What is Nutrient Monitoring in wastewater?

- Nutrient monitoring is the quantification of nutrients within various water systems that may cause harm to humans or the environment
- Nitrogen and Phosphorus
- Tools for nutrient monitoring in wastewater
 - Online sensors & analyzers
 - Handheld sensors
 - Grab samples and lab equipment
 - Samplers



Why do we monitor nutrients?

- Excess nutrients= Eutrophication
 - Harmful algal blooms (HABs)
 - Can be toxic
 - Oxygen dead zones
 - Fish kills
 - <https://www.ysi.com/habs>
- Phosphorus and Nitrogen are limiting nutrients
- 1972 Clean Water Act
 - Instituted NPDES limits to reduce nutrient pollution
 - <https://www.ysi.com/ysi-blog/water-blogged-blog/2022/06/the-clean-water-act-how-a-small-fire-sparked-big-changes>

Clean Water Act



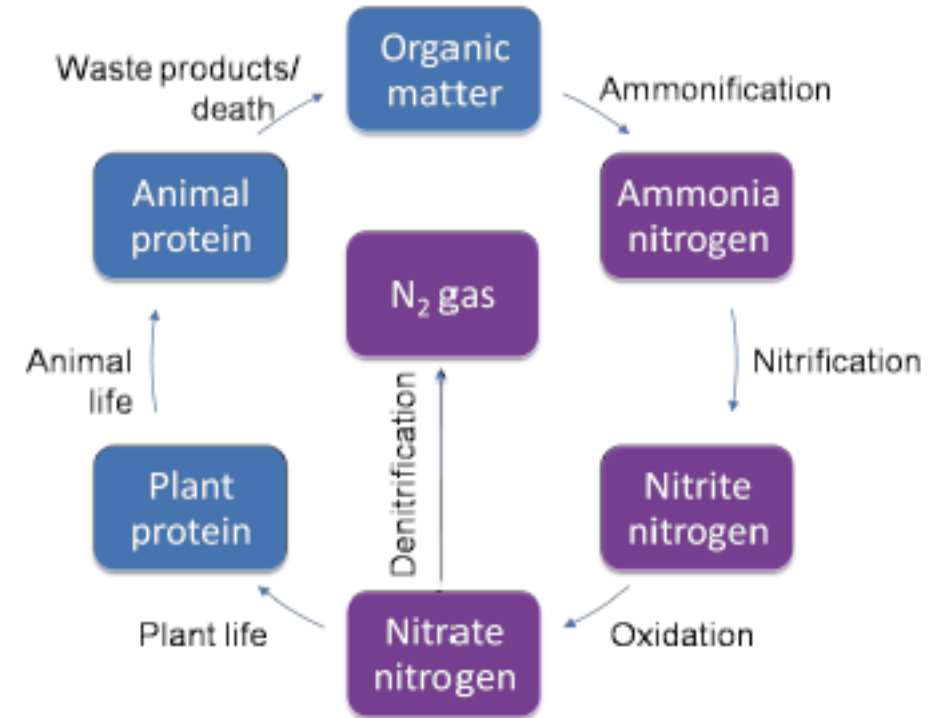
Nitrogen Removal

- Nitrogen enters wastewater as:
 - Urea: excreted form of waste N from humans/animals (urine)
 - Organic N: fecal waste or any decomposing organic matter
 - Fertilizers: runoff of N-rich fertilizer back into waterways

- There are several forms of nitrogen in wastewater

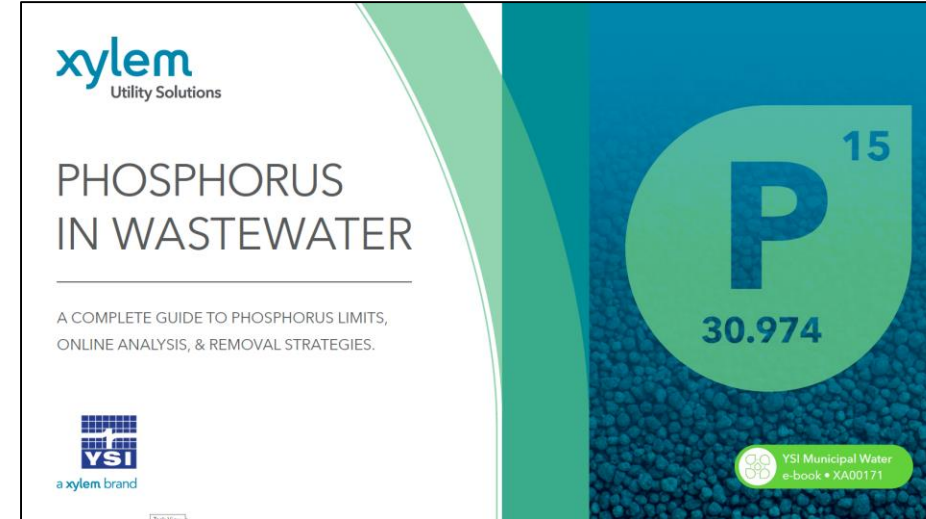


- Nitrogen is removed through biological nutrient removal (BNR):
 - An activated sludge process that simulates the nitrification/denitrification portion of the nitrogen cycle to return nitrogen to the atmosphere



Phosphorus Removal

- Phosphorus enters wastewater from fertilizers, manufactured products, and human and animal waste
- Phosphorus can be removed chemically or biologically
 - Chemical removal requires dosing a coagulant (Ferric/Alum) which binds to dissolved phosphorus and then settled out
 - Biological removal requires phosphorus uptake by anaerobic microorganisms and are then settled out
- <https://www.ysi.com/phosphorus-in-wastewater>



Chemical Removal

When metal salts are added to the process water, they encourage the creation of **hydrous metal oxide** flocs called **HMOs**.

The metal ions' positive charge attracts the phosphate ion's negative charge and precipitates into a solid. With enough turbulence and mixing, precipitates can form together to create the suspended HMO floc within the water.

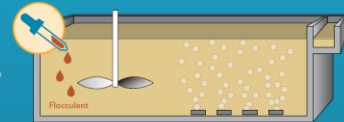
The HMO floc's surface is complex, containing many additional reactive sites for dissolved phosphorus to bond with the salts within the floc. The complex surface also manages to capture any particulate phosphorus suspended in the water, making chemical removal very effective.

These HMOs can be produced with several different metal salt flocculants, mostly aluminum or iron-based. Aluminum sulfate and ferric chloride are the most common, which earns them the nicknames alum and ferric.

PHOSPHORUS REMOVAL

1

Process water is dosed with a **metal salt flocculent**. (Alum, ferric, etc.)



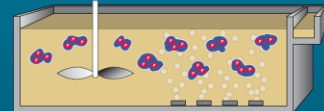
2

The metal salt reacts with the water to produce **HMO floc**.



3

HMO floc binds to dissolved phosphorus and captures particulate phosphorus.



28

FAQ #1

Why do sensor specifications for nutrients list the parameters as both NH₄-N and NH₄?

NH₄-N:

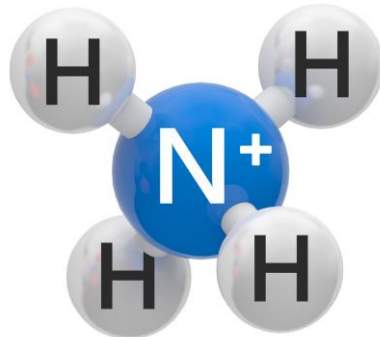
1 to 2000 mg/L / 1 mg/L

0.1 to 100 mg/L / 0.1 mg/L

NH₄:

1 to 2580 mg/L / 1 mg/L

0.1 to 129.0 mg/L / 0.1 mg/L



NO₃-N:

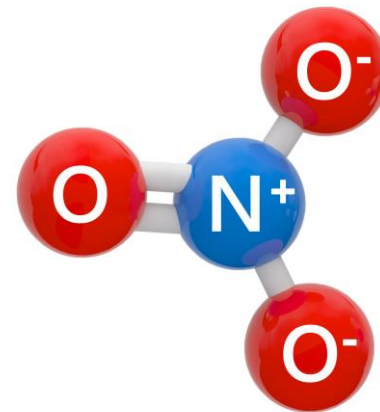
1 to 1000 mg/L / 1 mg/L

0.1 to 100 mg/L / 0.1 mg/L

NO₃:

5 to 4500 mg/L / 1 mg/L

0.5 to 450.0 mg/L / 0.1 mg/L



Part II: Ammonium (ISE vs Wet Chemistry)

Ion-Selective Electrode (ISE) Technology



- Measuring Electrodes
 - Ammonium
 - Nitrate
- Reference Electrode
- Compensating Electrodes
 - Potassium (NH4 Comp)
 - Chloride (NO3 Comp)

Ion-Selective Electrode (ISE) Technology



1. Measuring electrode and reference electrode produce mV values
2. The difference is calculated and input into the Nernst equation

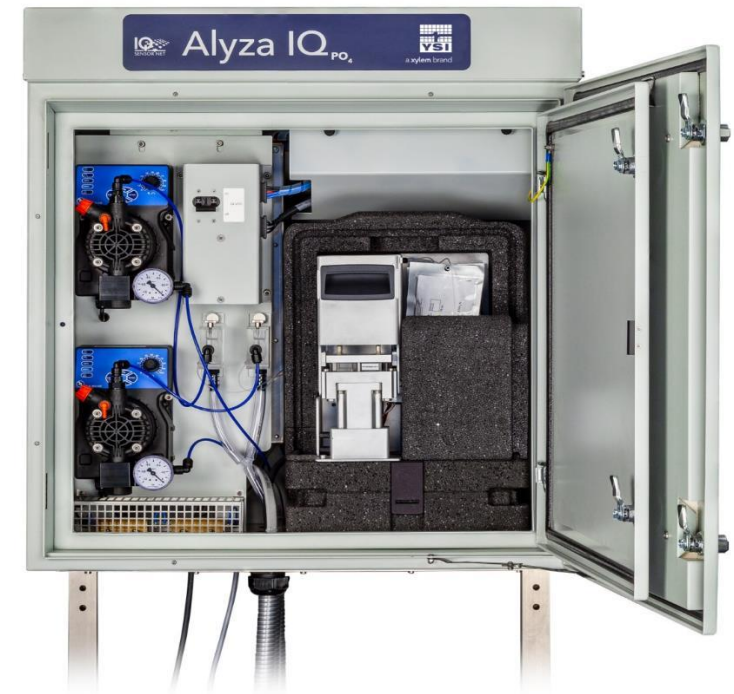
$$U_{ion} = U^0_{ion} \pm S \cdot \log(a_{ion})$$

3. The value created can be calibrated to produce a slope based on the concentration of the ammonium or nitrate

Wet Chemistry Technology

NH₄⁺

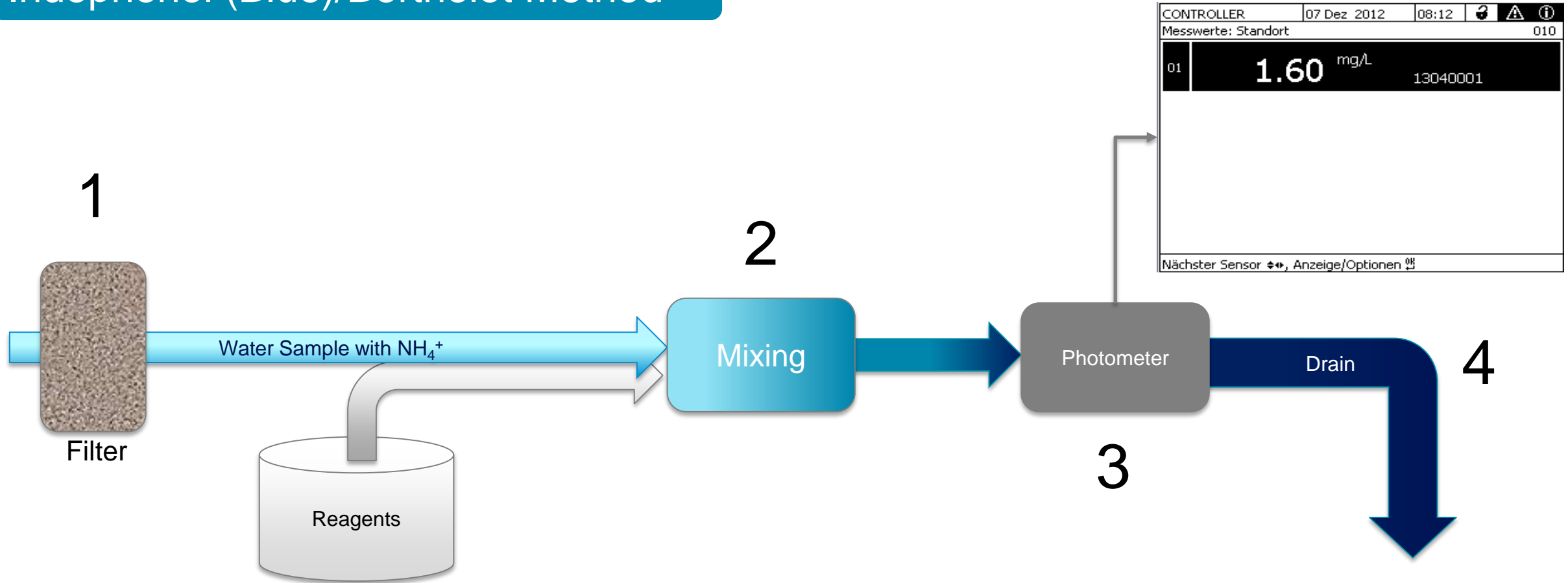
- Wet chemistry analyzers are automated instruments that perform “lab” analyses
- Involves the use of reagents
- Often requires filtration to eliminate solids
- Runs continuously to get 24/7 readings



Wet Chemistry Technology

NH_4^+

Indophenol (Blue)/Berthelot Method



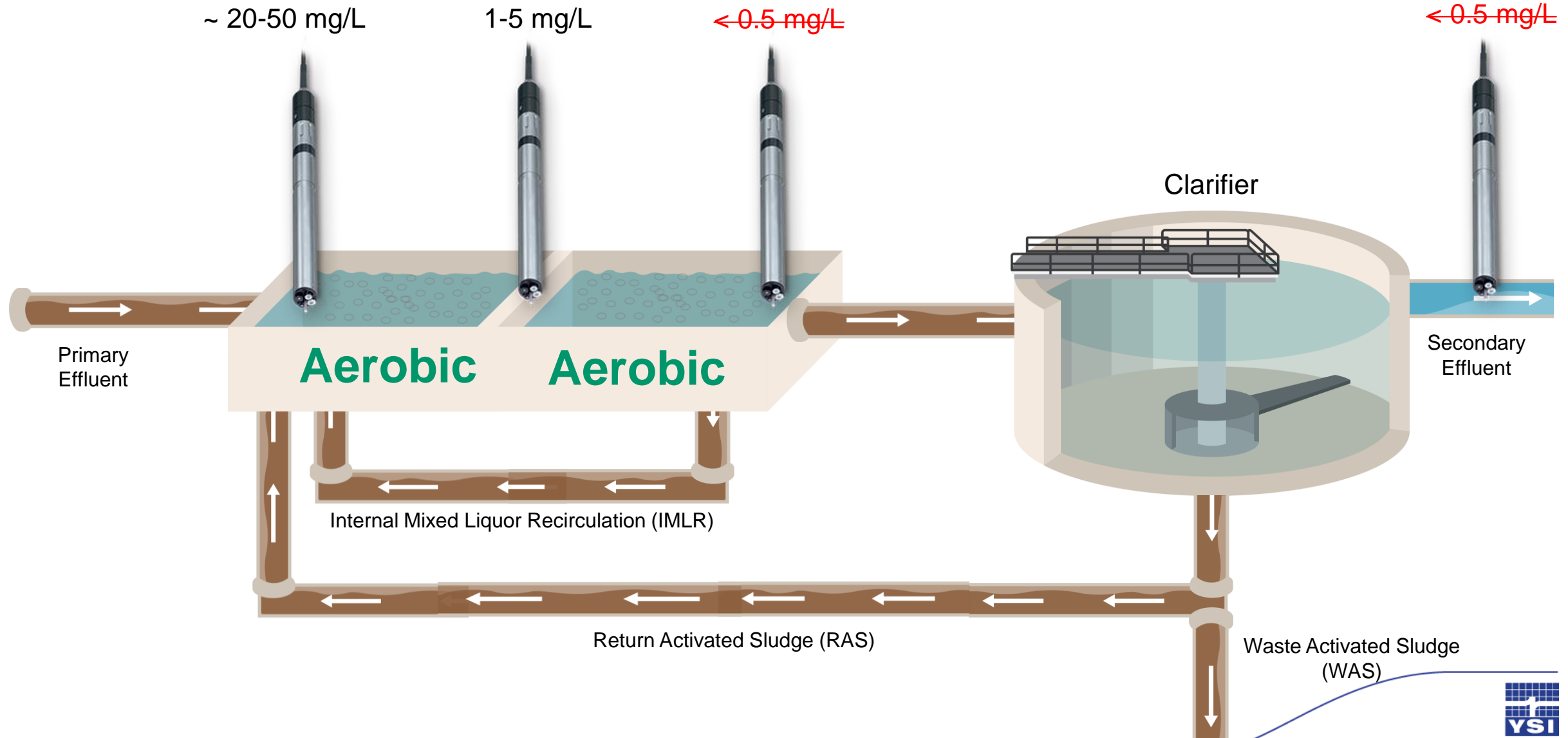
Installation/Maintenance Comparison

NH₄⁺

	ISE Sensor	Wet Chem Analyzer
Cleaning Frequency	Biweekly	Analyzer: Automatic Filter: Biweekly
Calibration Frequency	Monthly	Automatic
Consumable Replacement	Electrodes: 12-24 months	Reagents: 3 months MPV: 6-12 months Filter: 12-24 months
Space Requirements	Lower	Higher
Cost	Lower	Higher

Application Comparison- ISE

NH_4^+

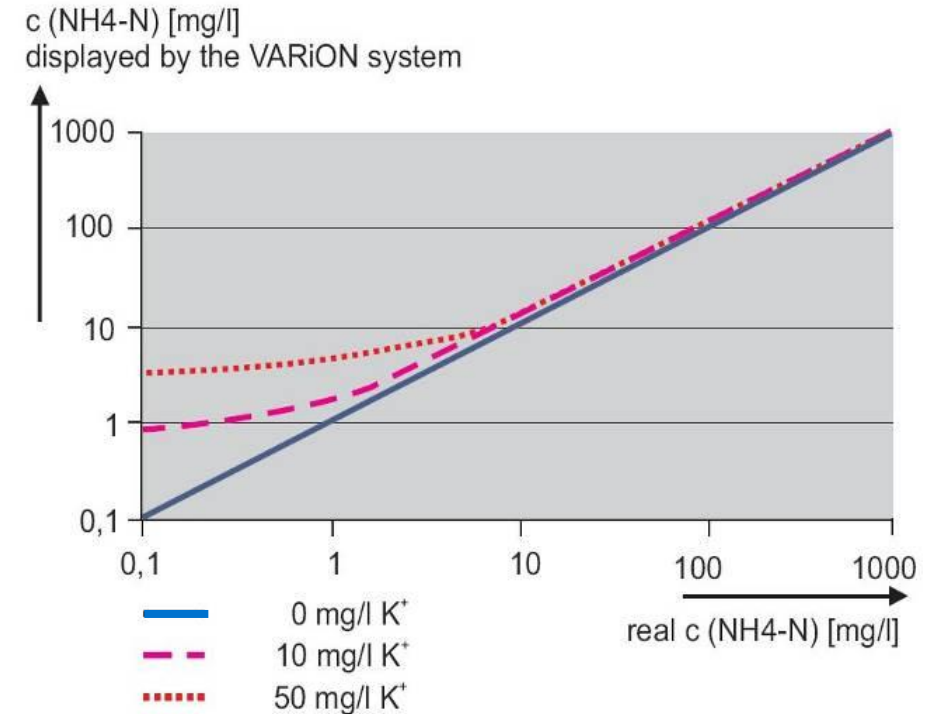


Application Comparison- ISE



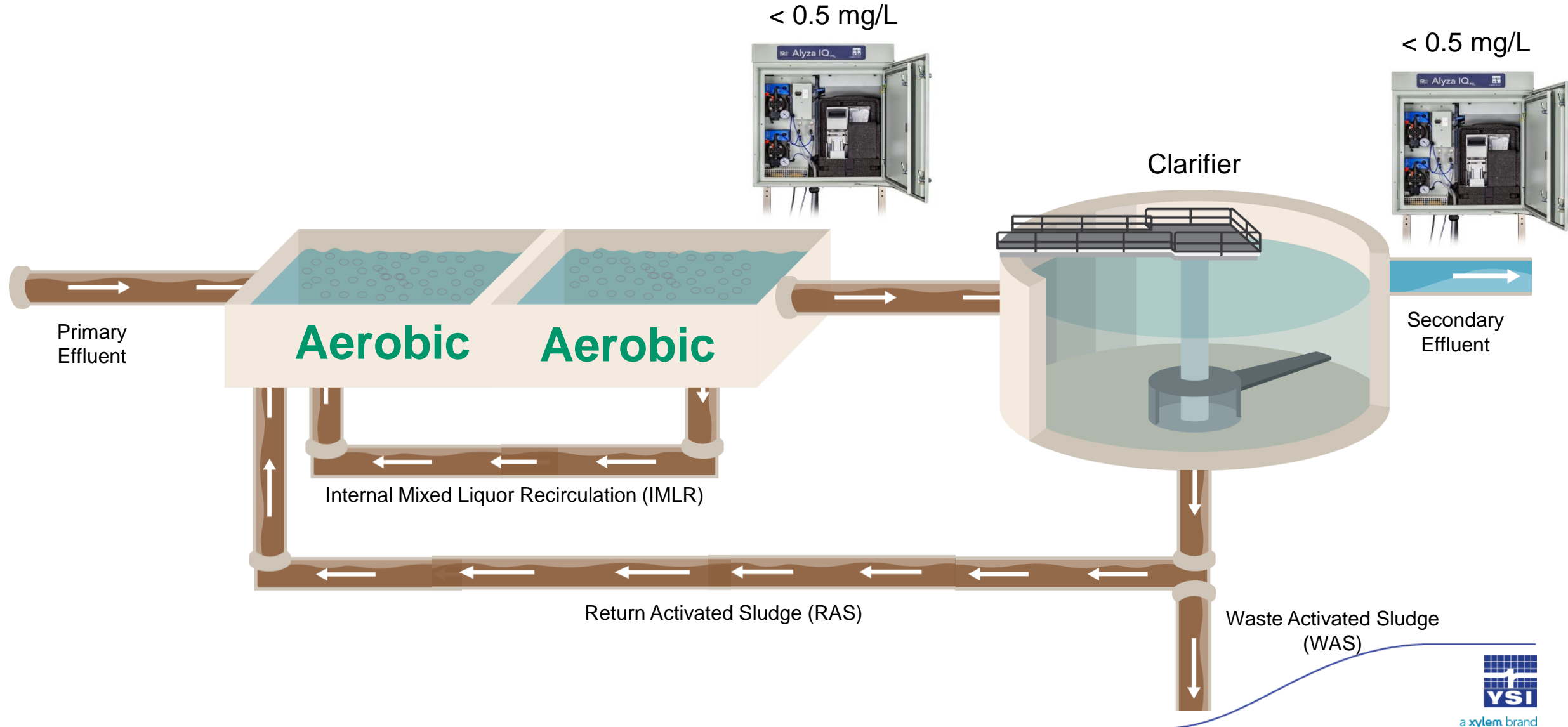
Difficulty consistently measuring below 1.0 mg/L NH₄-N

- If an ISE is continually reading near 0.0 mg/L...
- Occasional spikes in ammonium will NOT be detected
- Calibration will drift sooner
- Electrodes will need to be replaced more often
- Interferences will be much more prevalent



Application Comparison- Wet Chemistry

NH_4^+

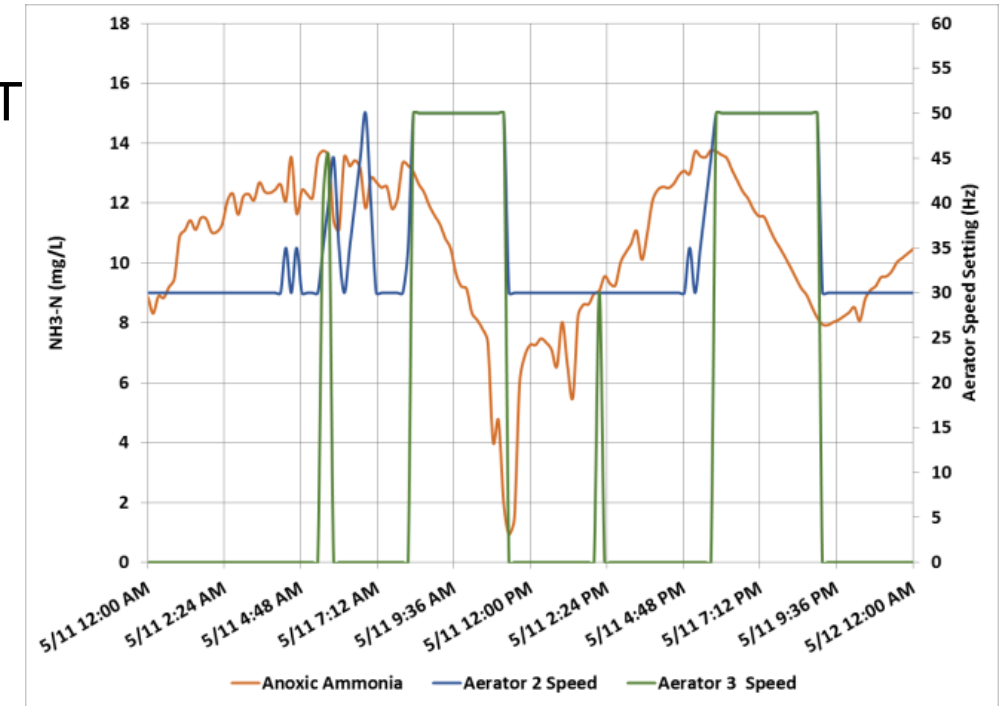


Application Comparison

NH_4^+

Ammonia-Based Aeration Control (ABAC)

- Uses an online ammonium measurement to control blowers and maintain a preferred ammonium setpoint. This saves energy by reducing over-aeration
- Ammonium ISE
 - + Immediate response time
 - + Easier to locate, Easier to maintain multiple, lower cost
 - Must be in a location $> 0.5 \text{ mg/L NH}_4\text{-N}$
- Ammonium Wet Chemistry
 - + Accurate at low levels for feedback control
 - 10- minute measuring intervals
 - Difficult to locate and maintain several Wet Chemistry cabinets



Which should you choose for Ammonium measurement?



- Maintenance overall is comparable but different
- ISEs require much less space and lower cost
- If controlling aeration, use the ISE sensor UNLESS the concentration stays at low values
- Wet Chemistry Ammonium should be used when sample concentration is mostly $< 0.5 \text{ mg/L NH}_4\text{-N}$

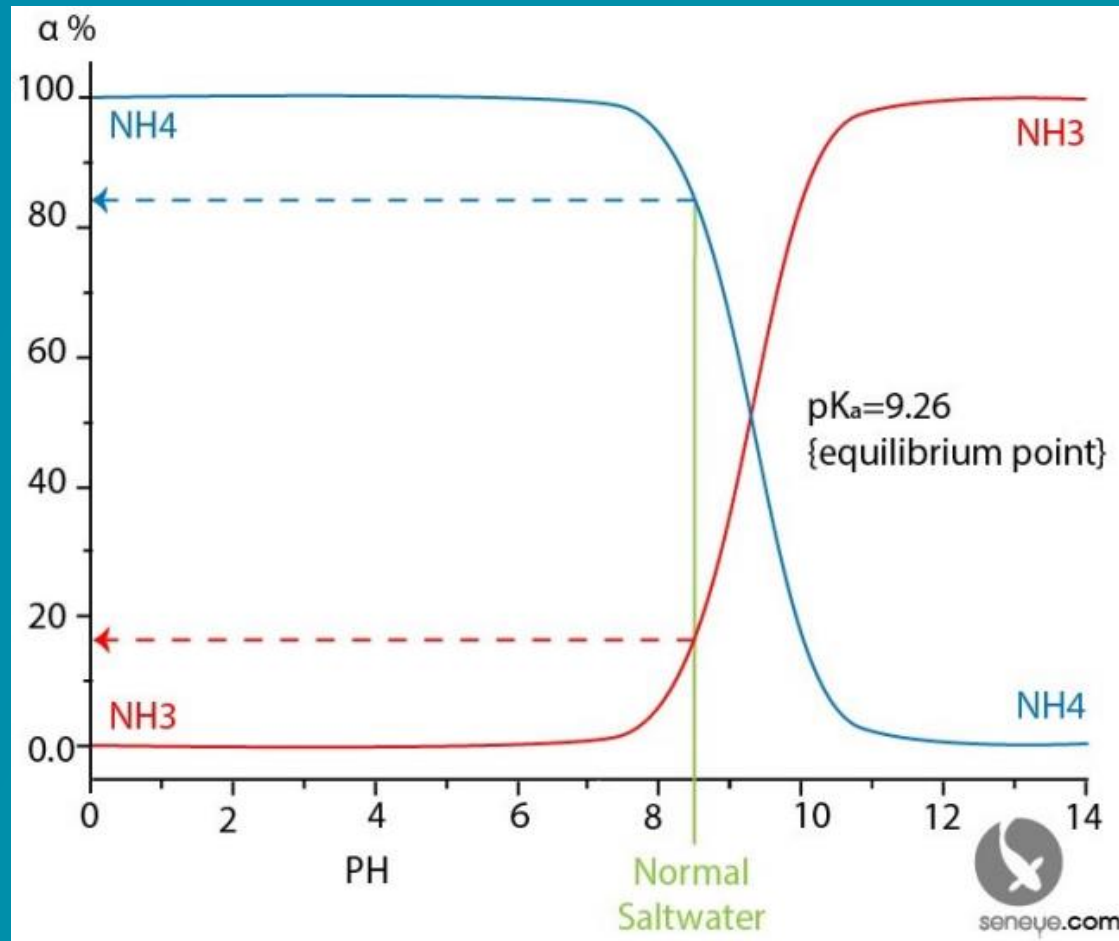


What is the difference between Ammonium (NH_4^+) and Ammonia (NH_3)?

They are the SAME MOLECULE

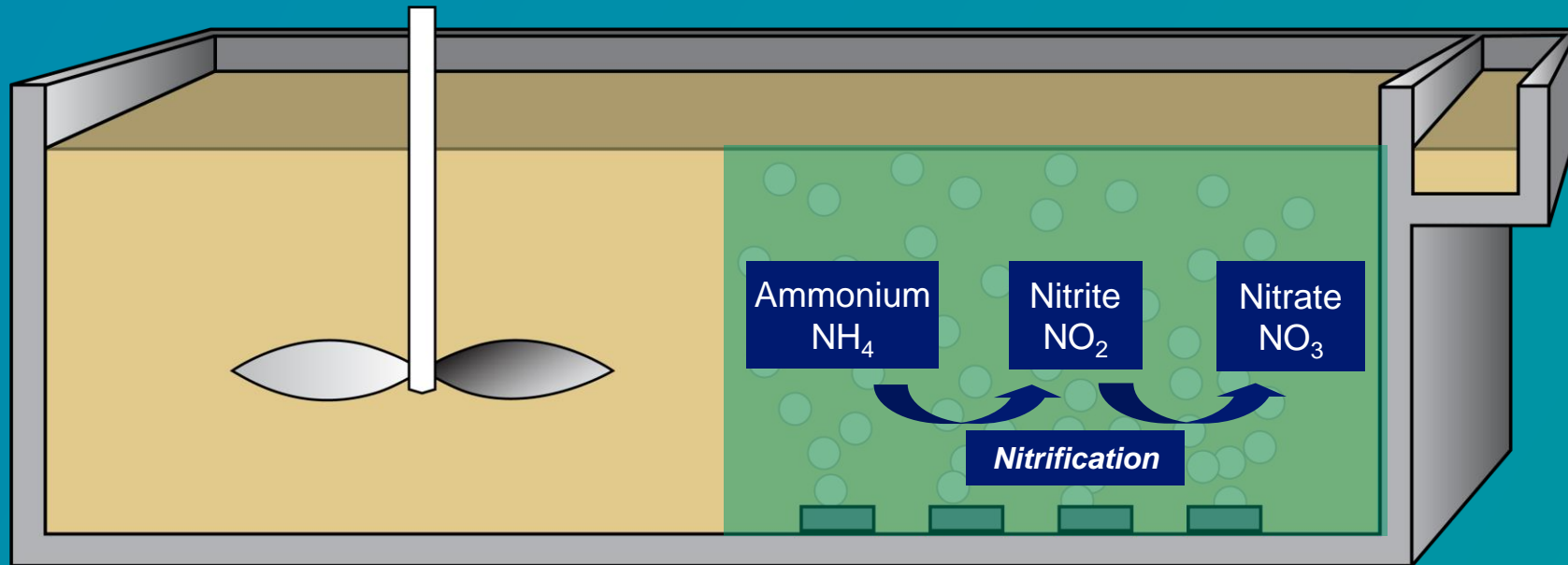
The extra H^+ is dependent on pH

What is the difference between Ammonium (NH₄⁺) and Ammonia (NH₃)?



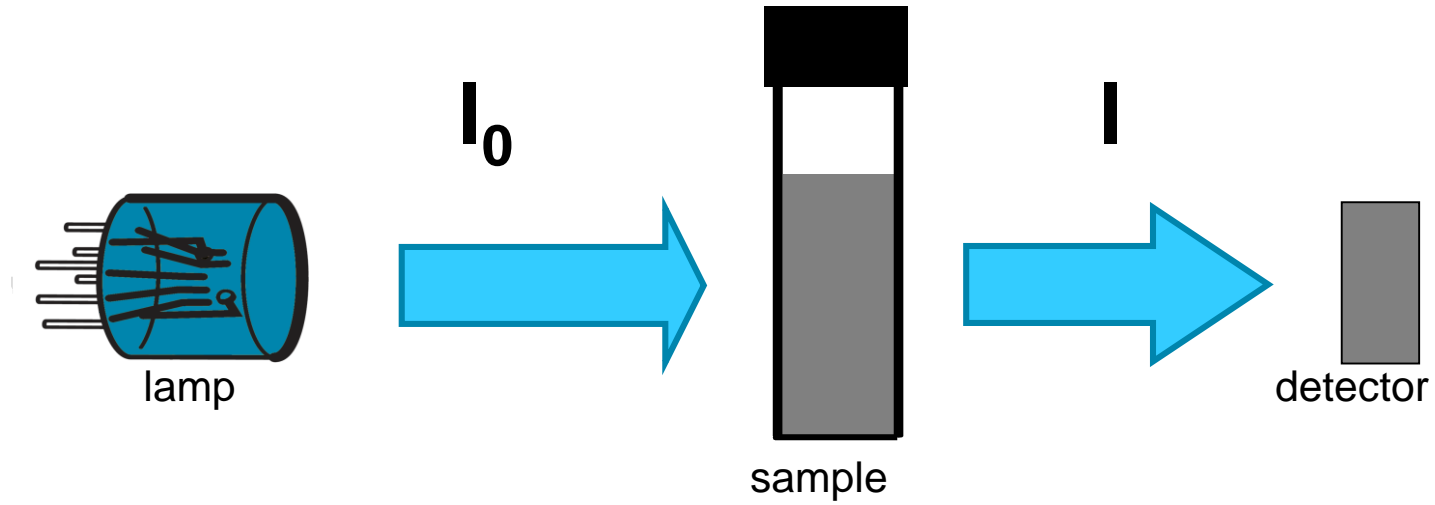
Part III: Nitrate (ISE vs UV-Vis)

What is the difference between Nitrate (NO_3^-) and Nitrite (NO_2^-)?



UV-Vis Technology

NO₃⁻

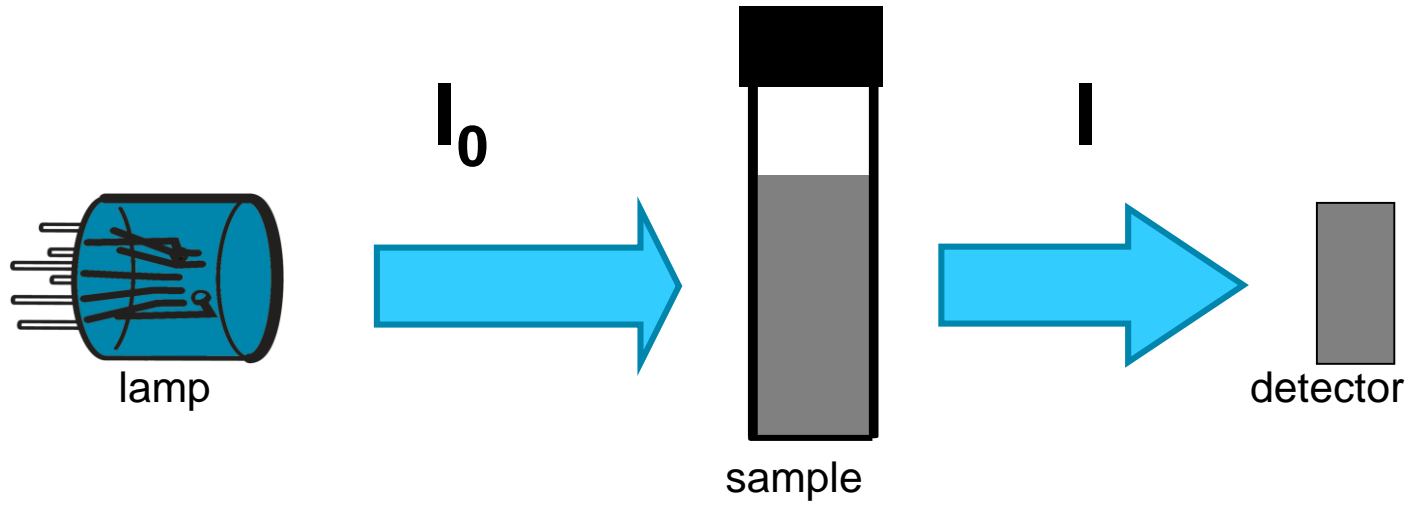


$$\%T = \frac{I}{I_0} \times 100$$

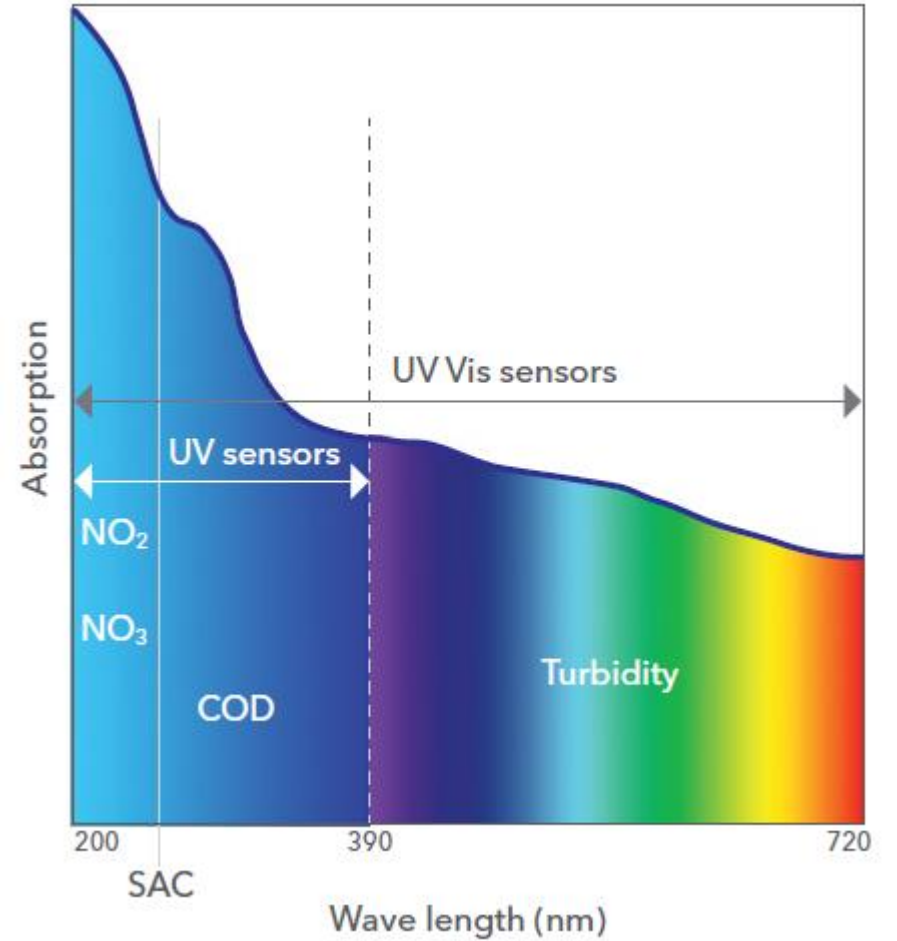


UV-Vis Technology

NO₃⁻



$$\%T = \frac{I}{I_0} \times 100$$



- Number of wavelengths measured
- The parameters available
- Gap size
- Programmed calibrations
- Cleaning technology



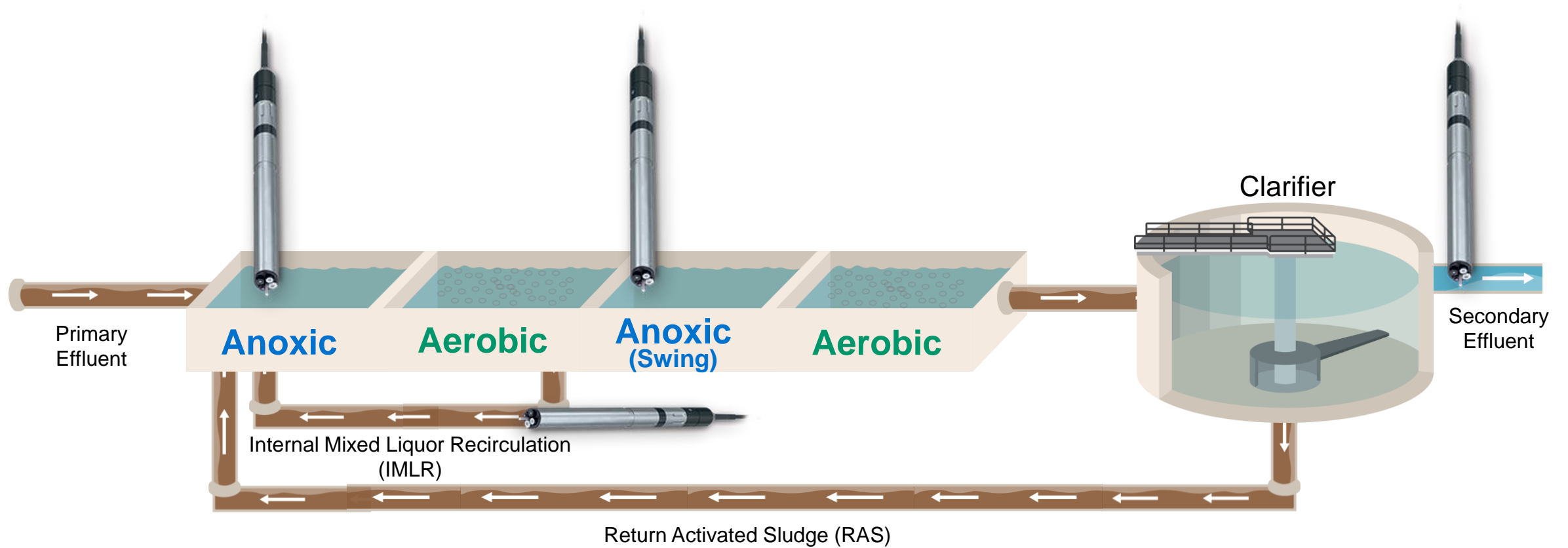
Installation/Maintenance Comparison

NO₃⁻

	ISE Sensor	UV-Vis Sensor
Cleaning Frequency	Biweekly	Monthly
Calibration Frequency	Monthly	As needed
Consumable Replacement	Electrodes: 12-24 months	None
Space Requirements	Similar	Similar
Cost	Lower	Higher

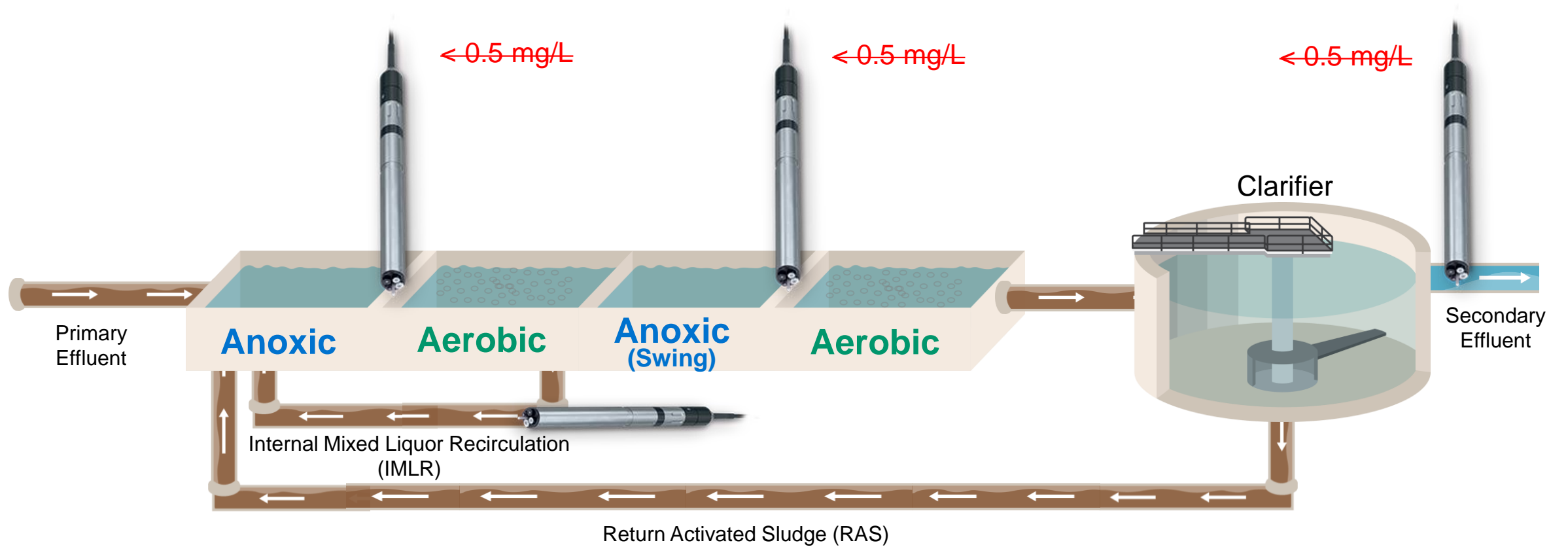
Application Comparison-ISE

NO_3^-



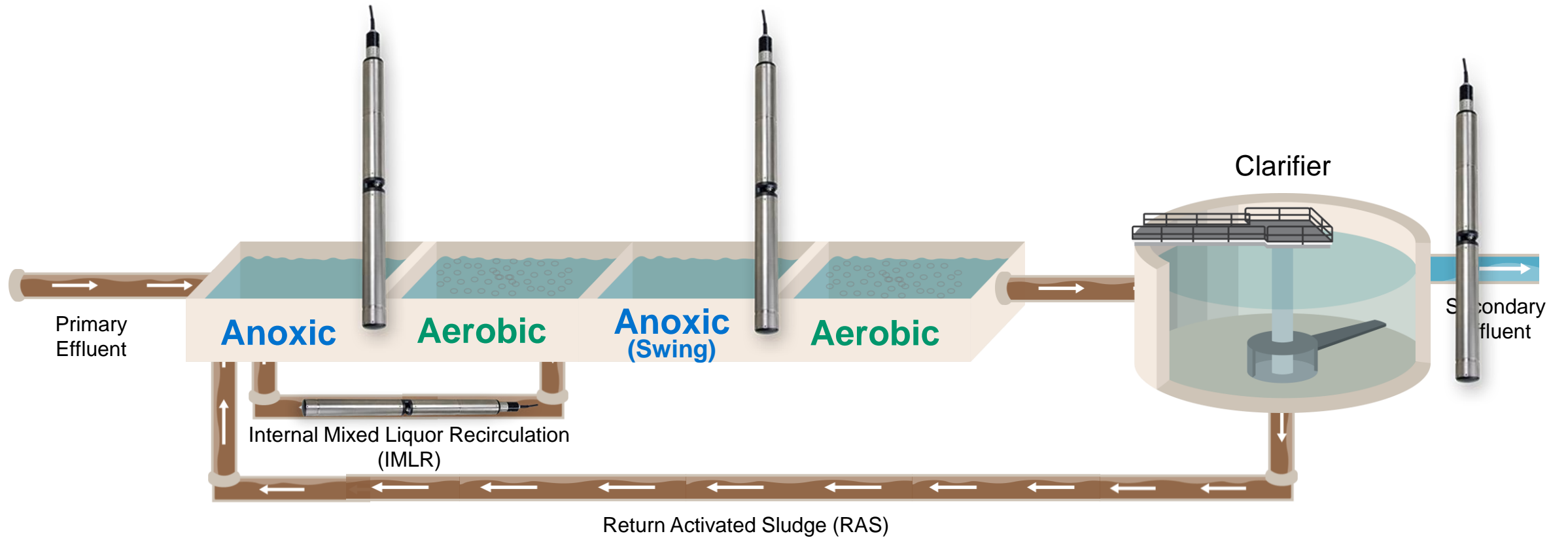
Application Comparison-ISE

NO_3^-



Application Comparison-UV/Vis

NO_3^-



Which should you choose for Nitrate measurement?

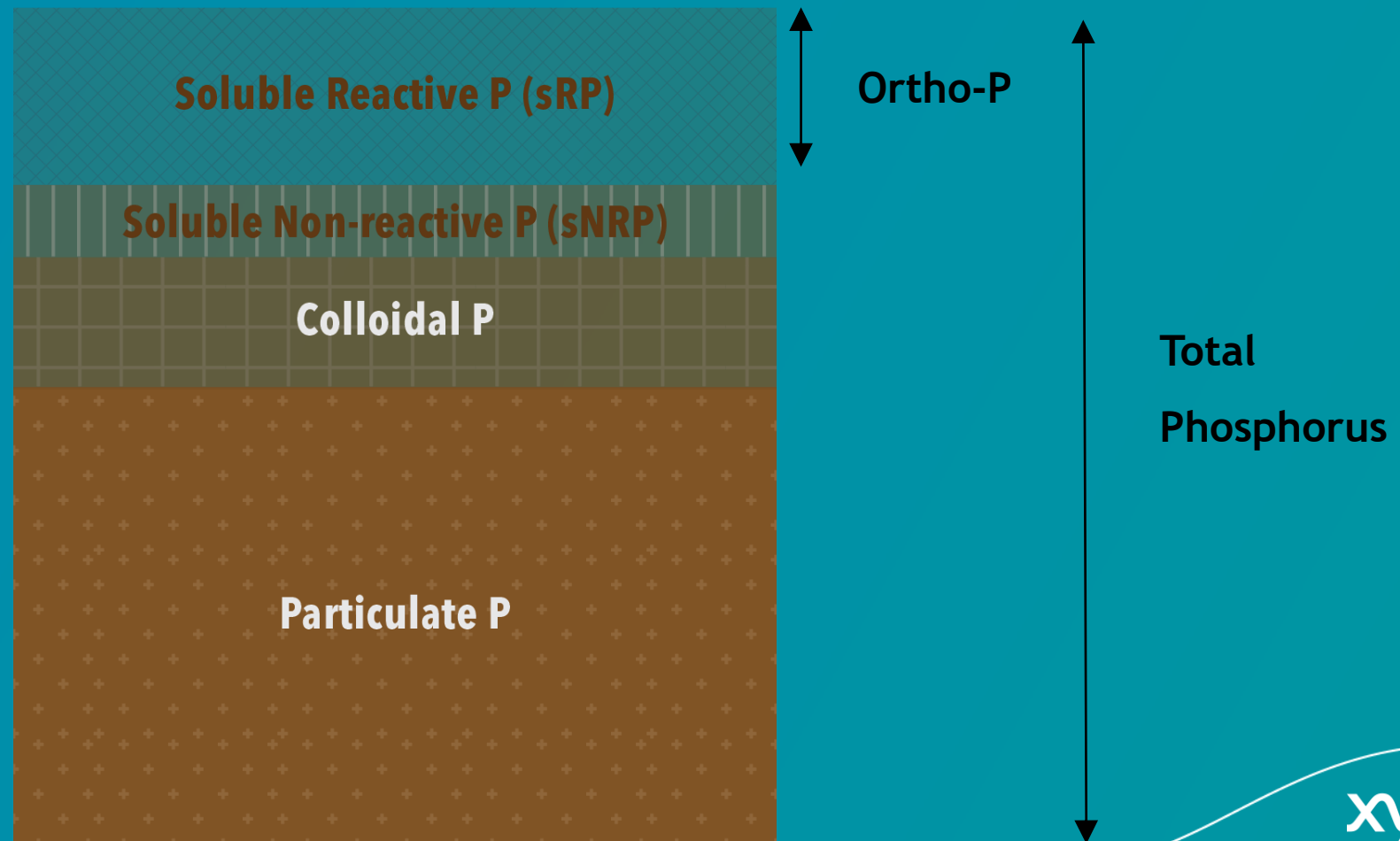


- Choose the UV/Vis sensor if...
 - Less overall maintenance
 - Measure below 1.0 mg/L NO₃-N
 - Controlling carbon dosing
 - Want to ALSO measure..
 - NO₂-, COD, BOD, TOC, UVT, TSS
- Choose the ISE sensor if...
 - Lower budget
 - Want to ALSO measure NH₄⁺



Part IV: Phosphorus (Ortho-P vs Total-P)

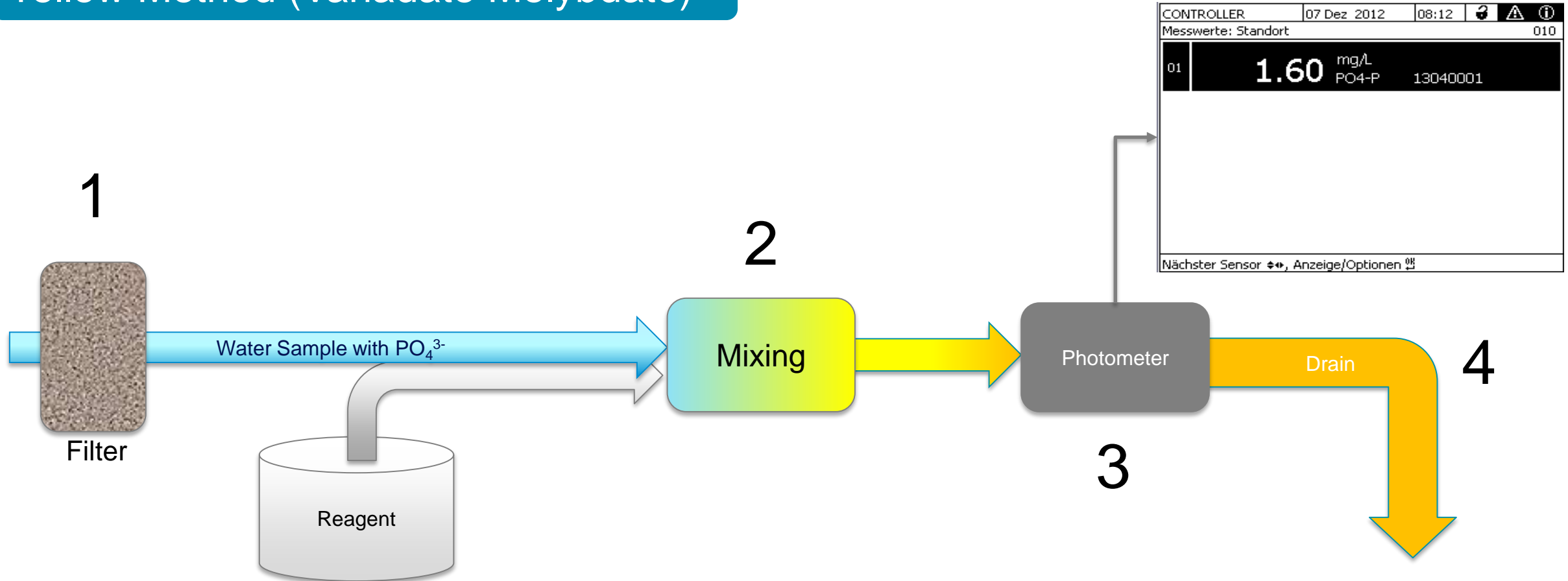
What is the difference between Orthophosphate (PO_4^{-3}) and Total Phosphorus (TP)?



Technology Comparison: Ortho-P



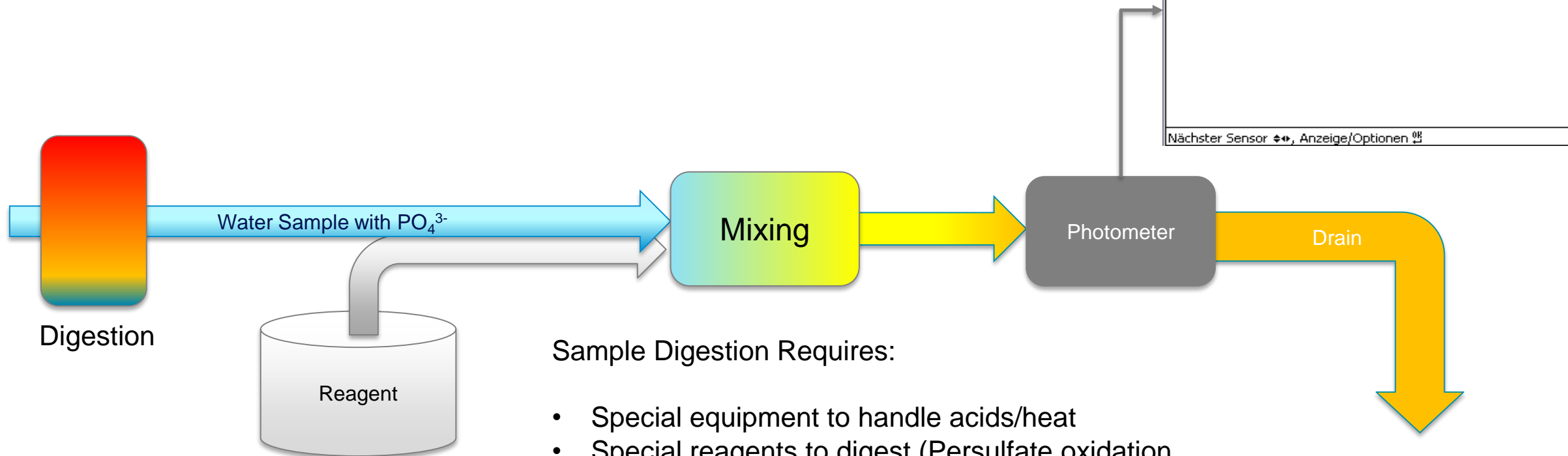
Yellow Method (Vanadate Molybdate)



Technology Comparison: Total P



Sample digestion followed by yellow method (or ascorbic acid method)



Sample Digestion Requires:

- Special equipment to handle acids/heat
- Special reagents to digest (Persulfate oxidation OR Nitric/Sulfuric Acid)
- More sample processing time

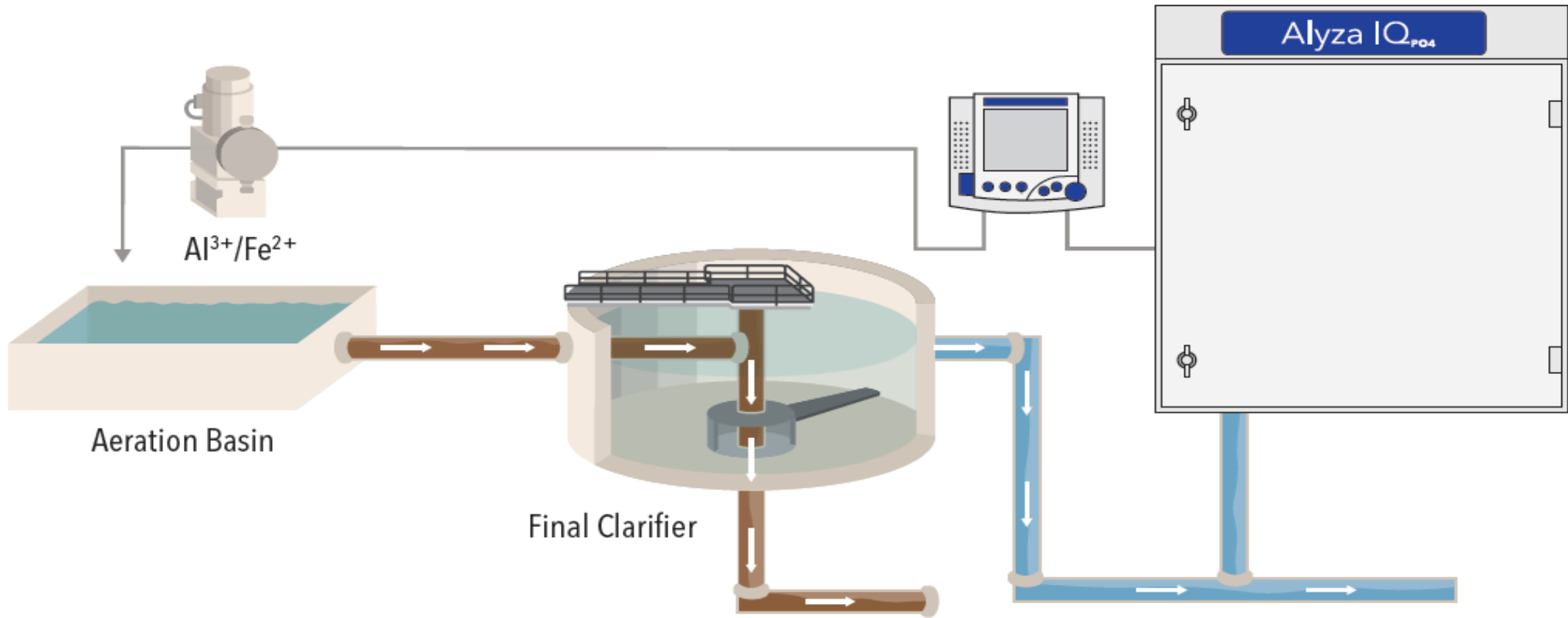
= Difficult to run as Online Wet Chemistry Analyzer



Application Comparison: Ortho-P



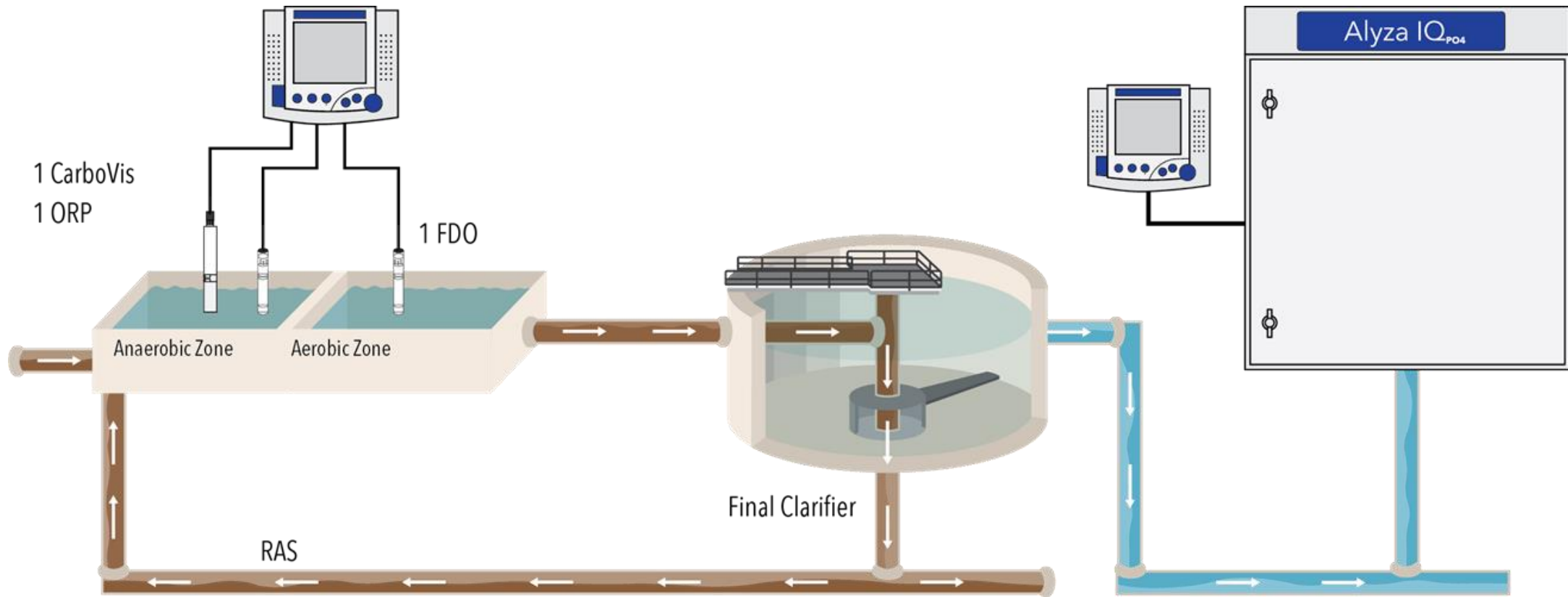
Alum/Ferric Dosing Control



Application Comparison: Ortho-P



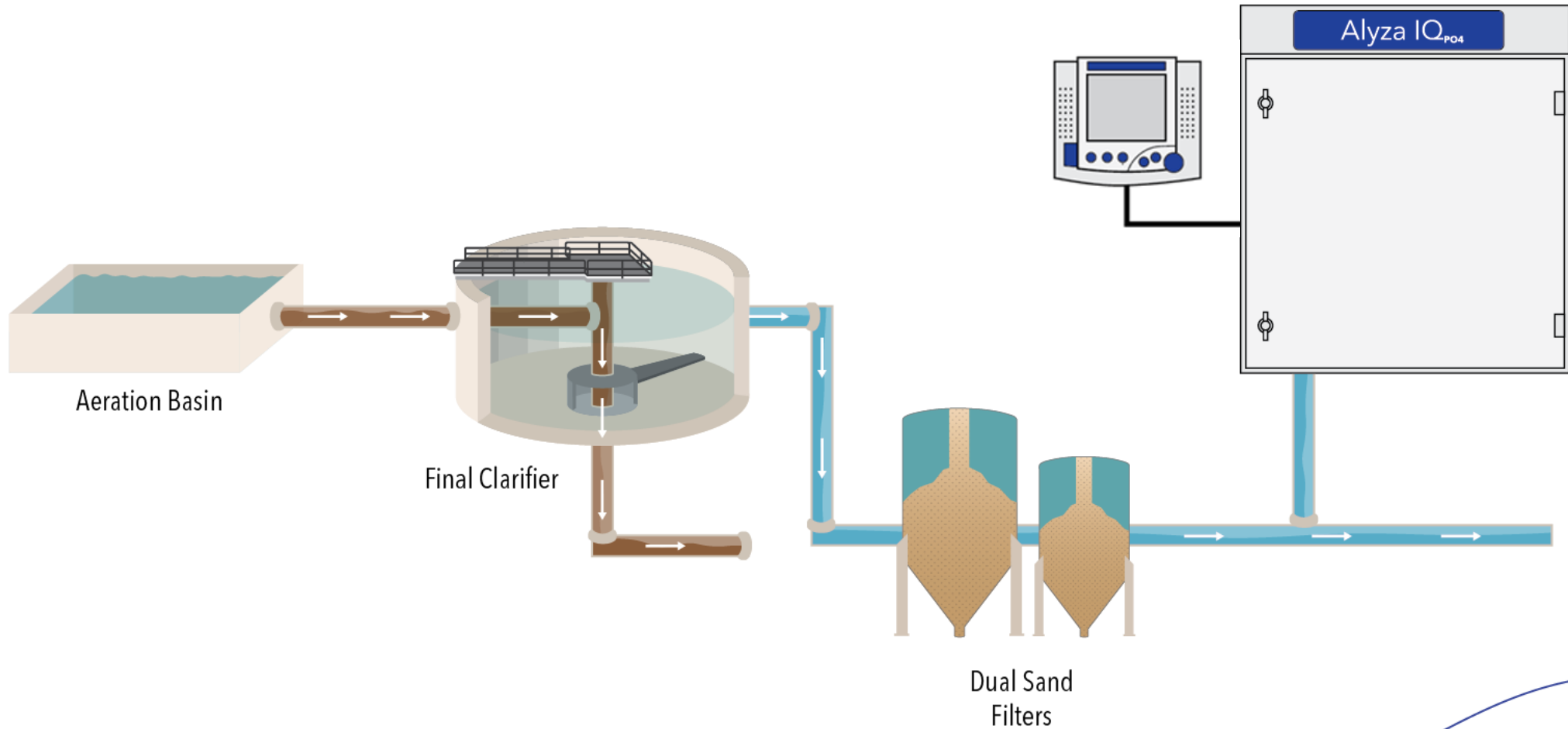
Enhanced Biological Phosphorus Removal Monitoring



Application Comparison: Ortho-P



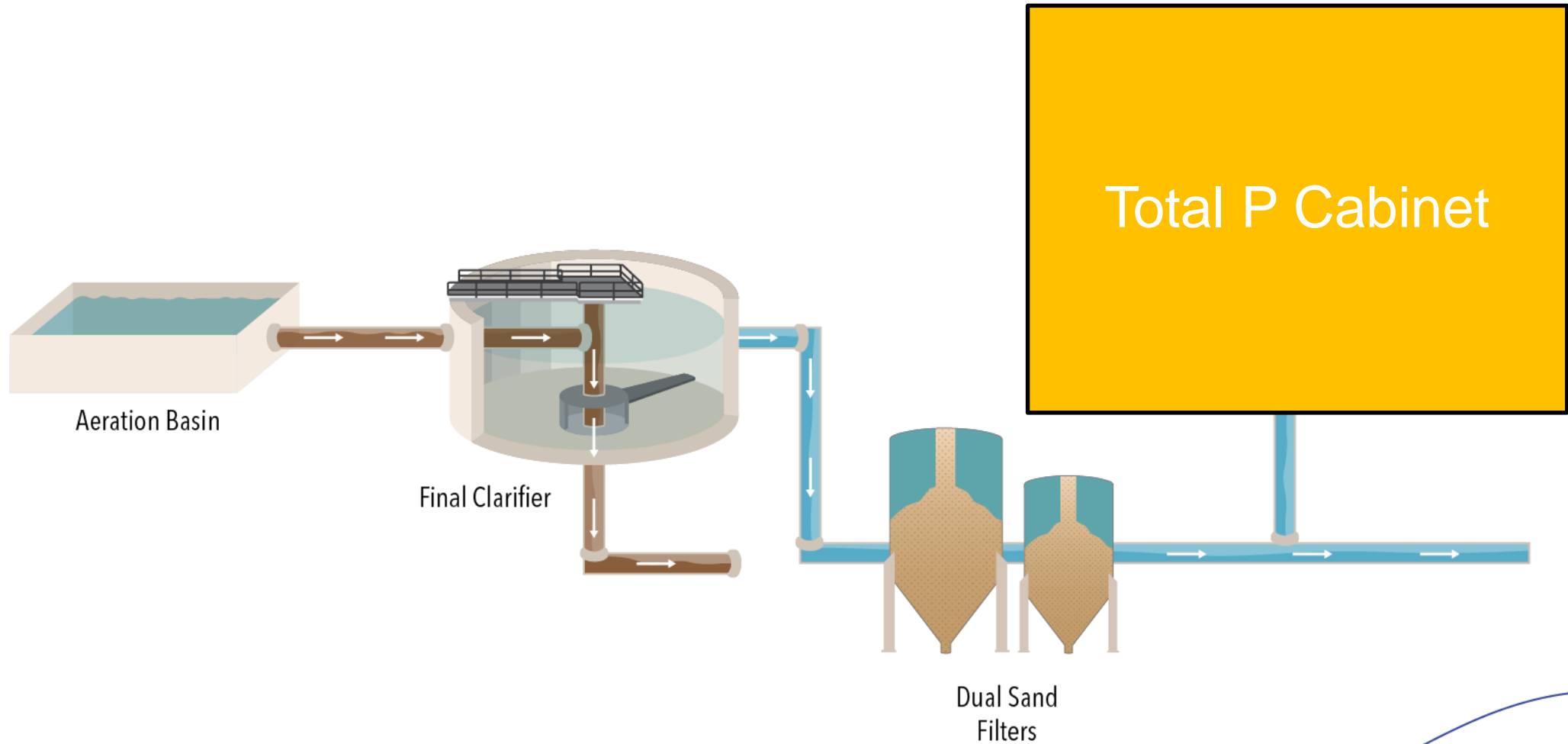
Final Effluent Monitoring



Application Comparison: Total P



Final Effluent Monitoring



Which should you choose for phosphorus monitoring?

- You should choose a Total P Analyzer if...
 - Absolutely NEED TP measurements at the final effluent
- You should choose an Orthophosphate Analyzer if...
 - In every other application.
 - For chemical dosing control or EBPR, orthophosphate gives the remaining dissolved-P
 - For Final Effluent, Ortho-P will give great dissolved-P measurement leaving the facility. This





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You Always Have a Choice Partner with YSI



Disinfection / Effluent:
Ammonium, Nitrate, Nitrite, UVT-254, Orthophosphate, pH, Conductivity, Dissolved Oxygen, Turbidity, ORP, COD, TOC, DOC, BOD, SAC

Parameter	Value	Unit	Alarm
12.39	mg/L	13.20 #	12110360
249.9	mg/L	30.0 #	16072183
0.18	mg/L	3 Bchrs	
21.4	mg/L	131.0360	

IQ 2020 Controller
Can be docked in the control room or at any point along the system network.

Control Room

Influent:
pH, Conductivity, Ammonium, COD, TOC, BOD, SAC

Aeration:
Dissolved Oxygen, BOD, ORP, Ammonium, Nitrate, Nitrite, NOx, TSS, pH, Orthophosphate

Final Settling:
Turbidity, TSS, Sludge Level

Portable Display Units
Additional controllers can be docked anywhere in the system.



IQ SensorNet is a monitoring and control system of analytical instrumentation that assures compliance, improves treatment reliability, and minimizes energy and chemical usage. Display and report on up to 20 water quality sensors within a single network.



Benefit from our 70+ years experience with monitoring instrumentation & analytics.

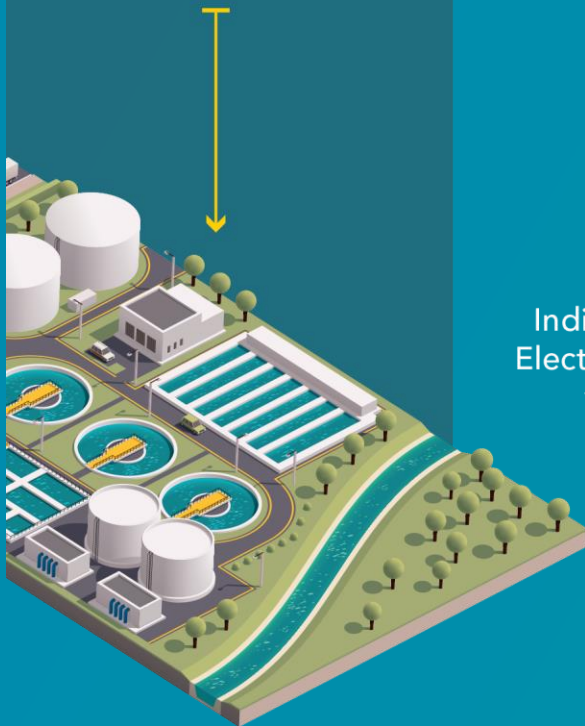
Contact us: info@ysi.com



Control Confidently with YSI

Process control of wastewater treatment

YSI's electrodes allow you to effectively monitor and control activated sludge aeration and nitrogen removal.



Ammonium and Nitrate measurements that you can depend on.

Ammonium and nitrate electrodes with onboard compensation

Temperature Thermistor

Individually Replaceable Electrodes with 12-month warranty (18+ month expected life)

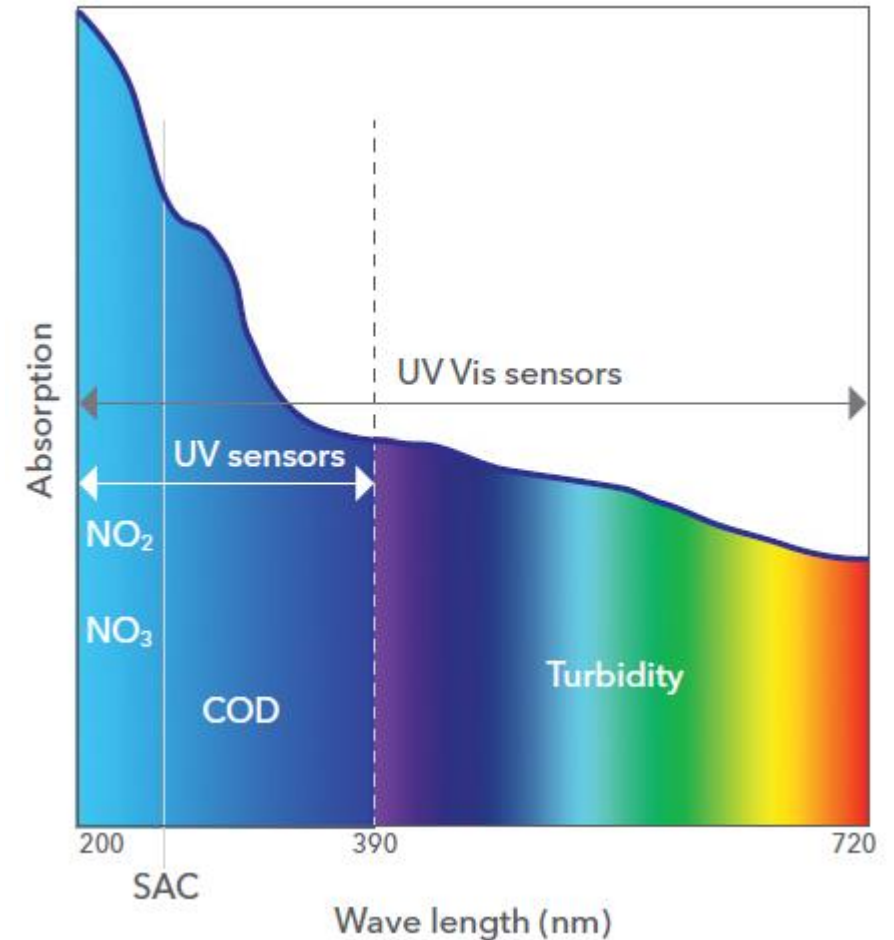


UV and UV-Vis Spectrophotometer Sensors

Parameters: NO₃, NO₂, COD, BOD, TOC, DOC, UVT-254, SAC-254, TSS

256 wavelengths scanned each measurement

- Better correlation
- Better turbidity correction
- Allows us to differentiate between Nitrate and Nitrite
- Better compensation for a continually changing wastewater process



*Single wavelength sensors also available

Alyza

New YSI Analyzer Platform

1. Alyza-PO4
2. Alyza-NH4



	Alyza-PO4	Alyza-NH4
Ranges:	0.02 – 5 mg/L PO ₄ -P 0.2 – 50 mg/L PO ₄ -P	0.02 – 5.00 mg/L NH ₄ -N 0.10 – 20 mg/L NH ₄ -N
Method:	Yellow Method (VanMo)	Berthelot Method (Indophenol)
Reagent per measurement:	5 µL	10 µL
Channels:	1 & 2 channel	
Auto-functions:	Auto-Cleaning and Auto-Calibration (1 & 2 point)	
Filtration:	0.45µ filter (In-situ & flow-thru options available)	
Operation Temperature:	-4 – 104 °F	
Warranty:	2 years	

Alyza's Improvements to Online Analyzer Technology

CONTROLLER 03 July 2018 15:16 [Lock] [Warn] [Info]

S01/S02 Alyza IQ PO4

◀ Settings Maintenance Status Remaining ▶

Last measurement

15:05	15:10
1.12 mg/L	1.12 mg/L
PO4-P	PO4-P
S01: 22222222	S02: 22222222

S01: 22222222

Measuring (approx. 5 minutes): Mixing

Select ⇐⇒, exit with ESC

Days (approx.)	
Mixing unit:	178
Reagents:	108
Standard solutions:	167
Cleaning solution:	3!

Attention: The quoted availability periods are only correct if replacement was done in the maintenance menu!

Select ⇐⇒, exit with ESC



Contact Us for More Information!

EMAIL:

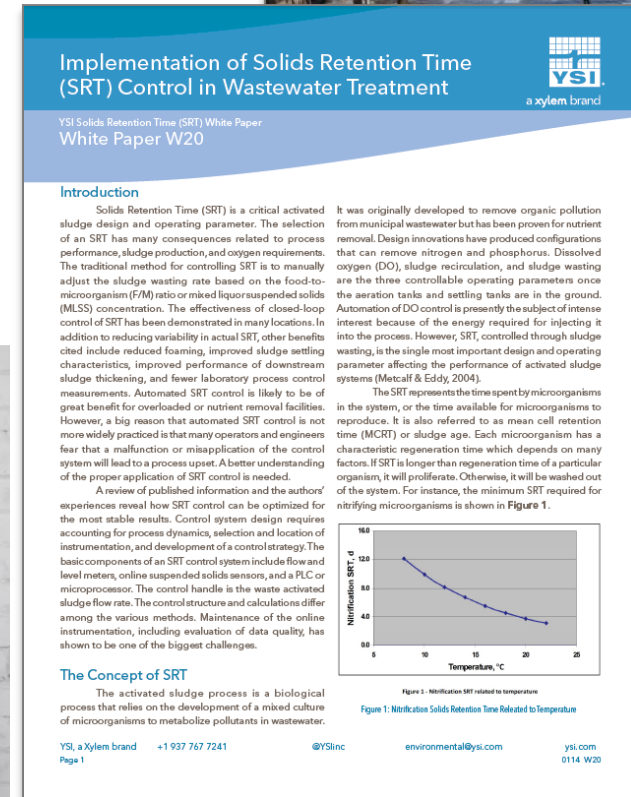
benjamin.barker@xylem.com

info@ysi.com

ONLINE:

YSI.com/IQSN

YouTube.com/YSIInc



Implementation of Solids Retention Time (SRT) Control in Wastewater Treatment

YSI Solids Retention Time (SRT) White Paper
White Paper W20

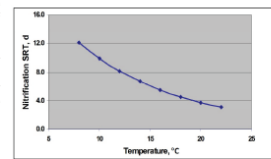
Introduction

Solids Retention Time (SRT) is a critical activated sludge design and operating parameter. The selection of an SRT has many consequences related to process performance, sludge production, and oxygen requirements. The traditional method for controlling SRT is to manually adjust the sludge wasting rate based on the food-to-microorganism (F/M) ratio or mixed liquor suspended solids (MLSS) concentration. The effectiveness of closed-loop control of SRT has been demonstrated in many locations. In addition to reducing variability in actual SRT, other benefits cited include reduced foaming, improved sludge settling characteristics, improved performance of downstream sludge thickening, and fewer laboratory process control measurements. Automated SRT control is likely to be of great benefit for overloaded or nutrient removal facilities. However, a big reason that automated SRT control is not more widely practiced is that many operators and engineers fear that a malfunction or misapplication of the control system will lead to a process upset. A better understanding of the proper application of SRT control is needed.

A review of published information and the authors' experiences reveal how SRT control can be optimized for the most stable results. Control system design requires accounting for process dynamics, selection and location of instrumentation, and development of a control strategy. The basic components of an SRT control system include flow and level meters, online suspended solids sensors, and a PLC or microprocessor. The control handle is the waste activated sludge flow rate. The control structure and calculations differ among the various methods. Maintenance of the online instrumentation, including evaluation of data quality, has shown to be one of the biggest challenges.

It was originally developed to remove organic pollution from municipal wastewater but has been proven for nutrient removal. Design innovations have produced configurations that can remove nitrogen and phosphorus. Dissolved oxygen (DO), sludge recirculation, and sludge wasting are the three controllable operating parameters once the aeration tanks and settling tanks are in the ground. Automation of DO control is presently the subject of intense interest because of the energy required for injecting it into the process. However, SRT, controlled through sludge wasting, is the single most important design and operating parameter affecting the performance of activated sludge systems (Metcalf & Eddy, 2004).

The SRT represents the time spent by microorganisms in the system, or the time available for microorganisms to reproduce. It is also referred to as mean cell retention time (MCRT) or sludge age. Each microorganism has a characteristic regeneration time which depends on many factors. If SRT is longer than regeneration time of a particular organism, it will proliferate. Otherwise, it will be washed out of the system. For instance, the minimum SRT required for nitrifying microorganisms is shown in Figure 1.



Temperature (°C)	Nitrification SRT (hr)
5	120
10	100
15	80
20	60
25	40

The Concept of SRT

The activated sludge process is a biological process that relies on the development of a mixed culture of microorganisms to metabolize pollutants in wastewater.

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When / Vis Sensor



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Wastewater ISE Sensors

6 Tips for Accurate, Reliable Data



TECHNOLOGY COMPARISON

ISE vs. Analyzer for Ammonium Monitoring



Q&A

