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How to Choose the Correct Sensor- Online Nutrient Monitoring

Ben Barker
Applications Engineer

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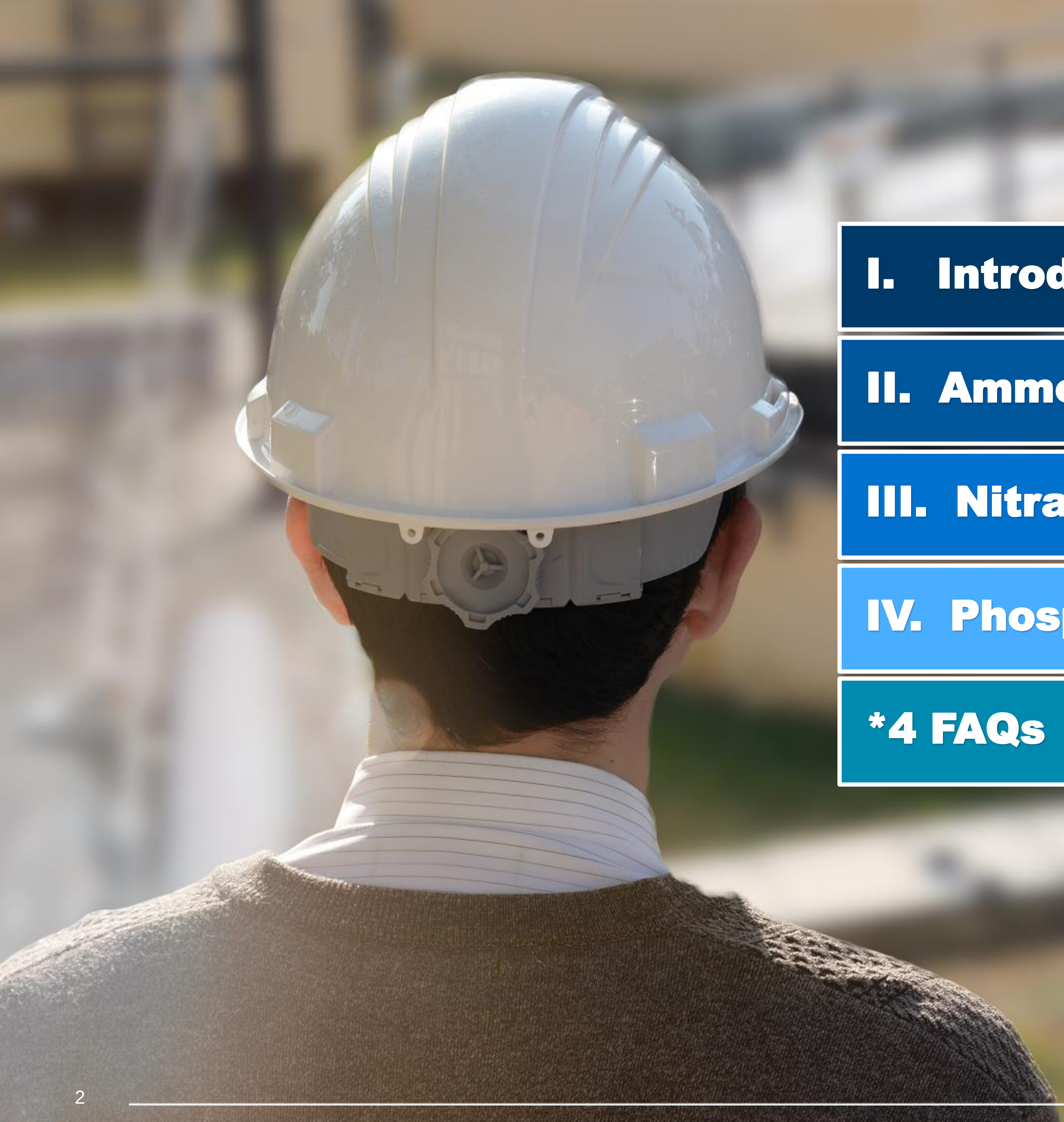

I. Introduction to Nutrient Monitoring

II. Ammonium (ISE vs Wet Chemistry)

III. Nitrate (ISE vs UV)

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

*4 FAQs

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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

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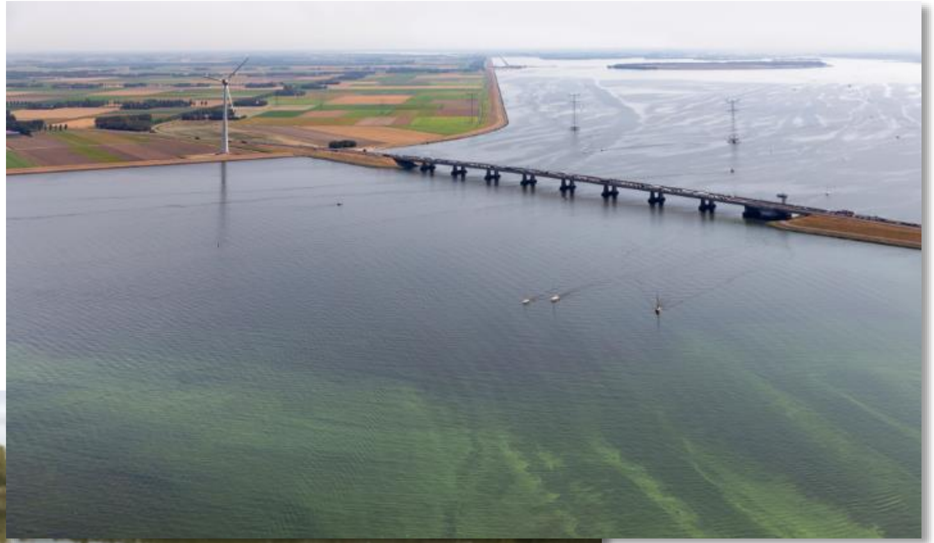
Why do we monitor nutrients?

- 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

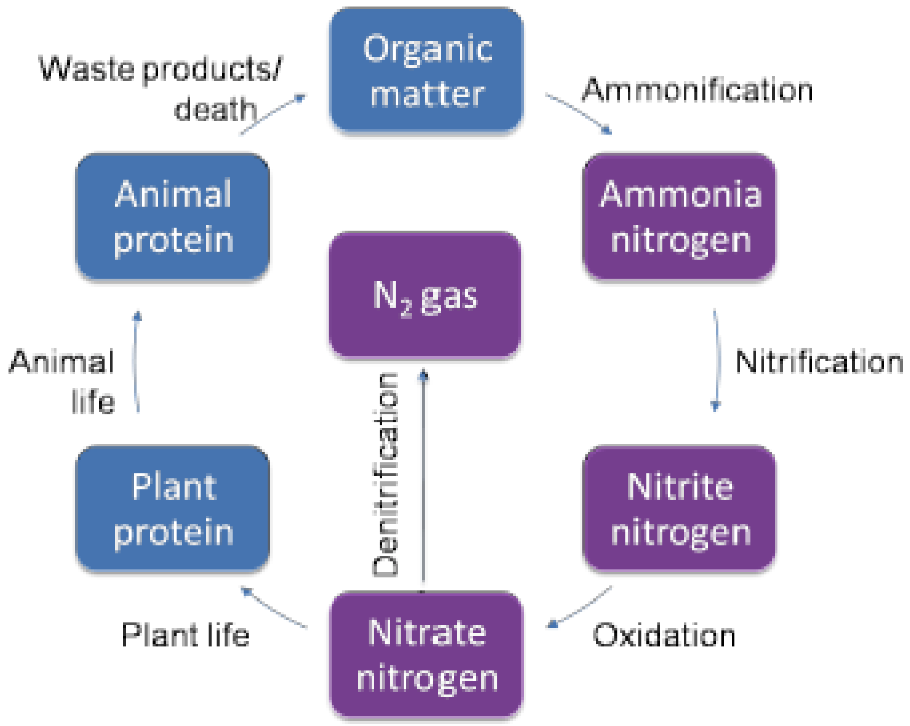


Nitrogen Removal

- 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

NH_4^+ NO_3^-

- 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

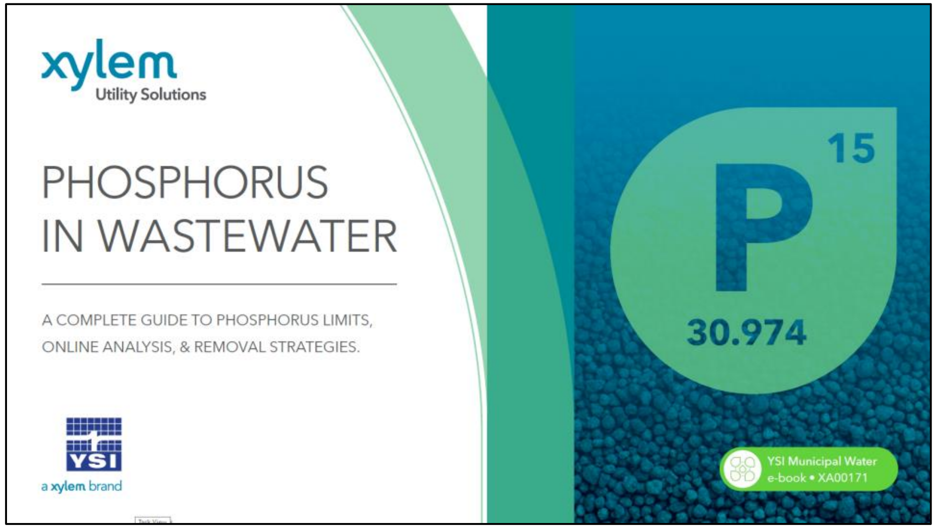


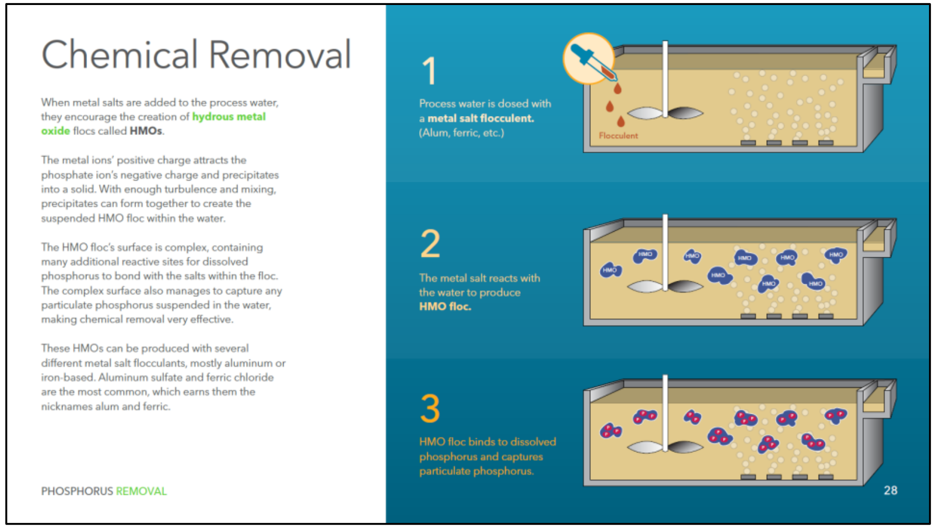
Phosphorus Removal

- 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



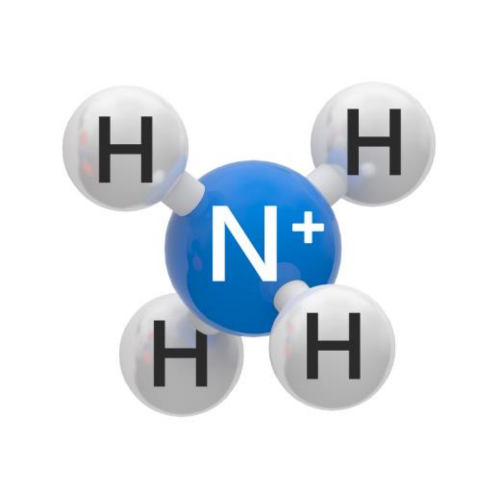


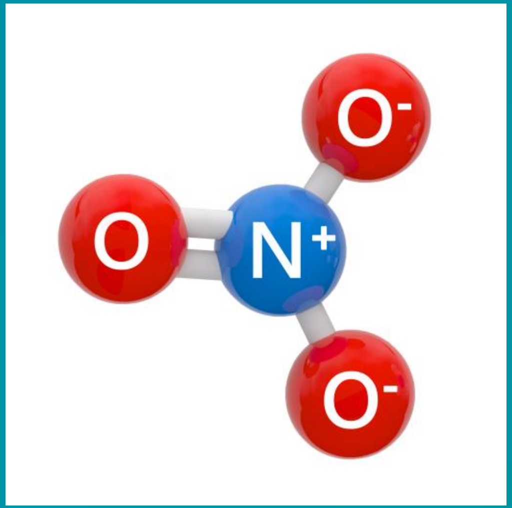
FAQ #1

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

NH_4-N:
1 to 2000 mg/L / 1 mg/L
0.1 to 100 mg/L / 0.1 mg/L
NH_4:
1 to 2580 mg/L / 1 mg/L
0.1 to 129.0 mg/L / 0.1 mg/L

NO_3-N:
1 to 1000 mg/L / 1 mg/L
0.1 to 100 mg/L / 0.1 mg/L
NO_3:
5 to 4500 mg/L / 1 mg/L
0.5 to 450.0 mg/L / 0.1 mg/L





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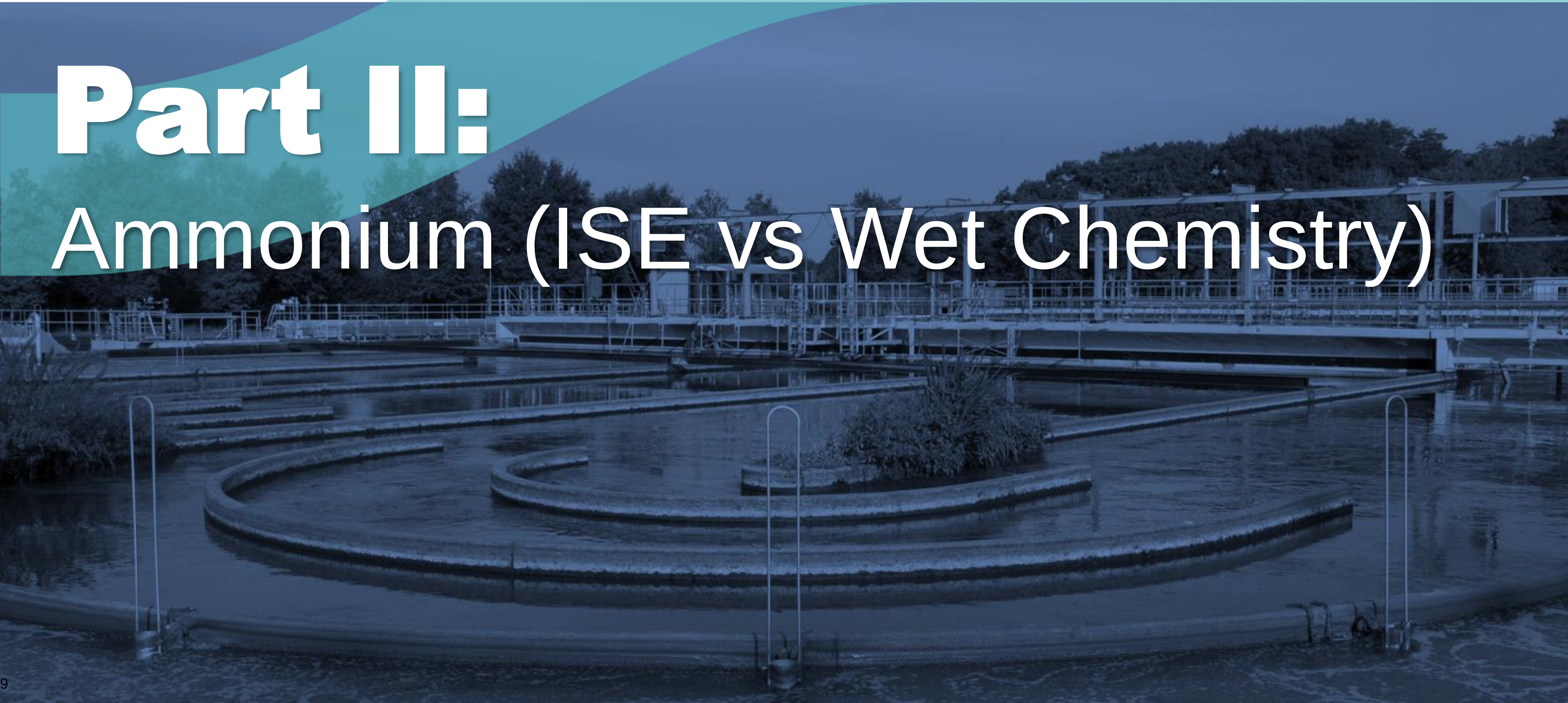
Part II:

Ammonium (ISE vs Wet Chemistry)



Ion-Selective Electrode (ISE) Technology

NH_4^+

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

Ion-Selective Electrode (ISE) Technology

NH_4^+

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

NH_4^+

- 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

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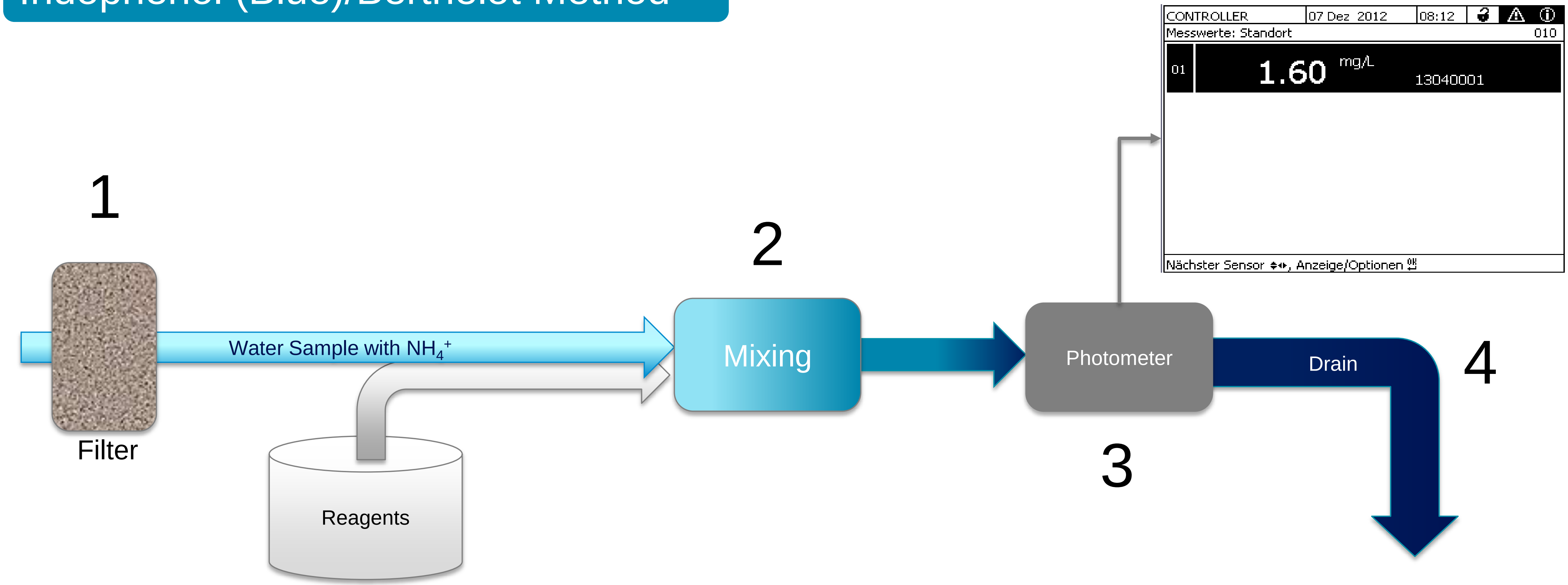
Wet Chemistry Technology

NH_4^+

Indophenol (Blue)/Berthelot Method



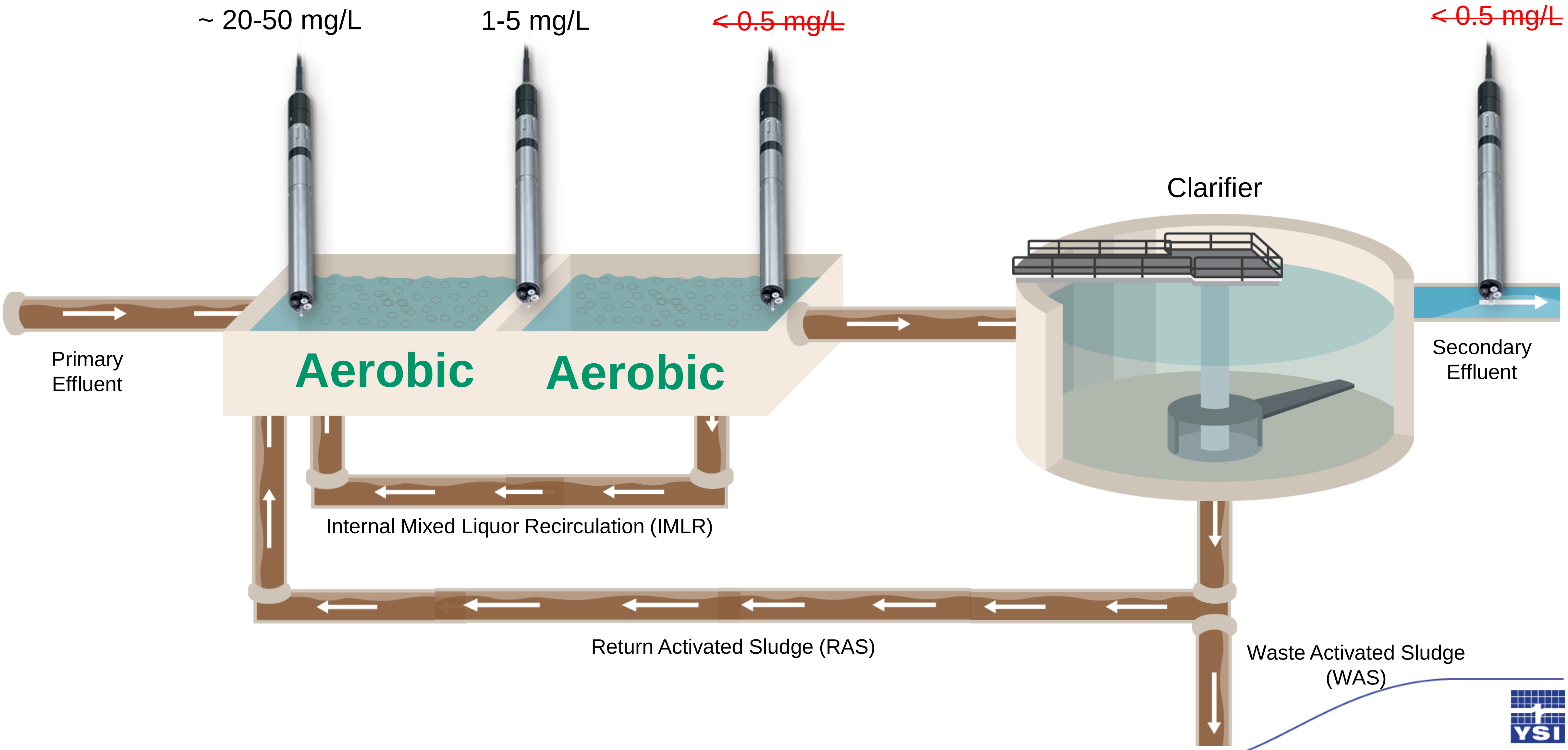
Installation/Maintenance Comparison

NH_4^+

	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^+

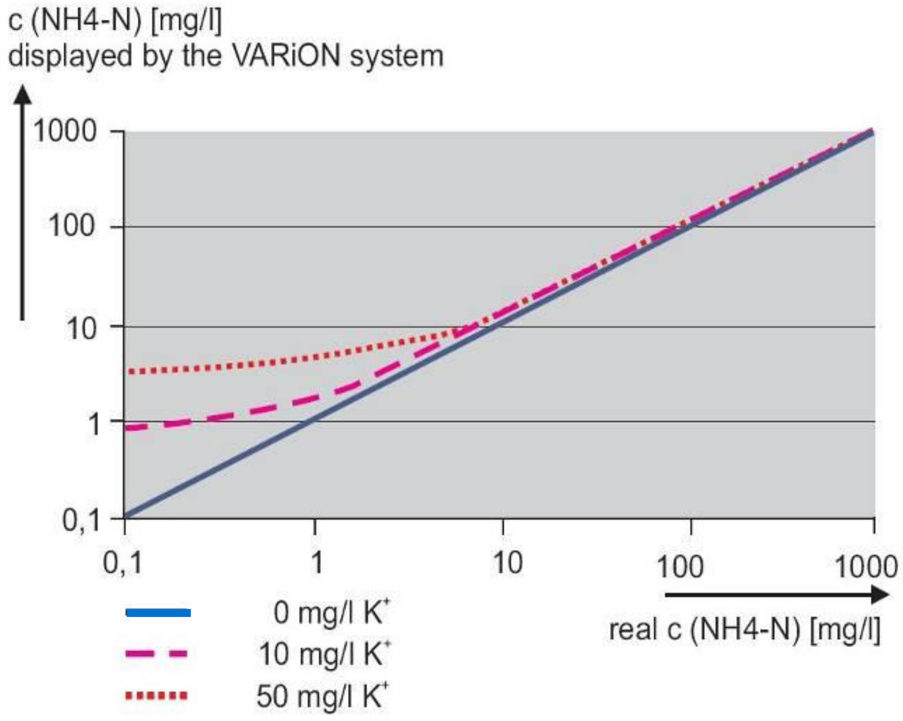


Application Comparison- ISE

NH_4^+

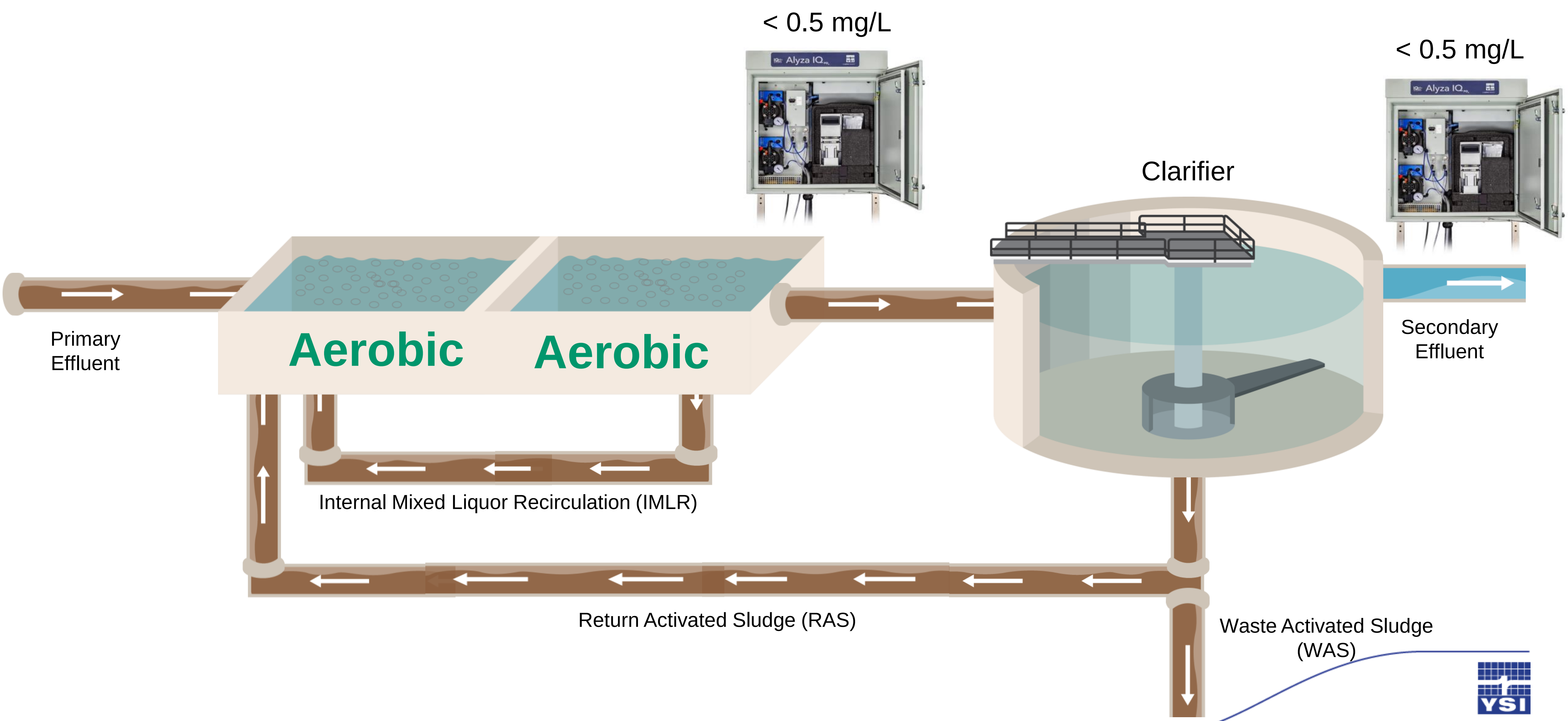
Difficulty consistently measuring below 1.0 mg/L NH4-N

- 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^+

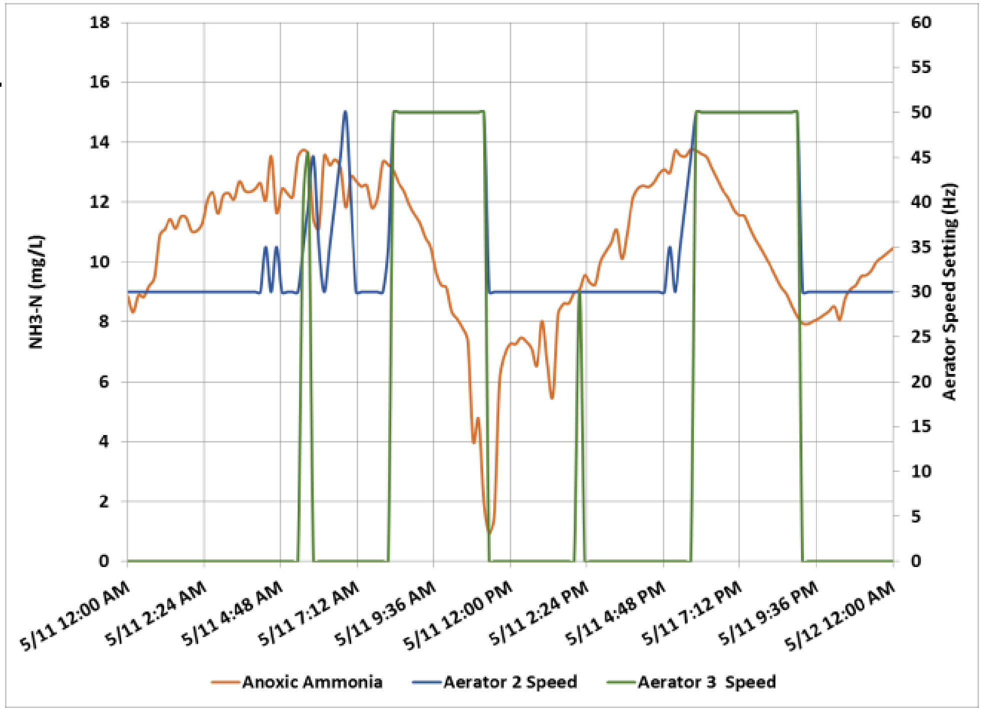


NH_4^+

Application Comparison

Ammonia-Based Aeration Control (ABAC)

- Uses an online ammonium measurement to control blowers and maintain a preferred ammonium setpoint. T 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 mg/L NH4-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?

NH_4^+

- 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 mg/L NH4-N

FAQ #2

NH_4^+

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

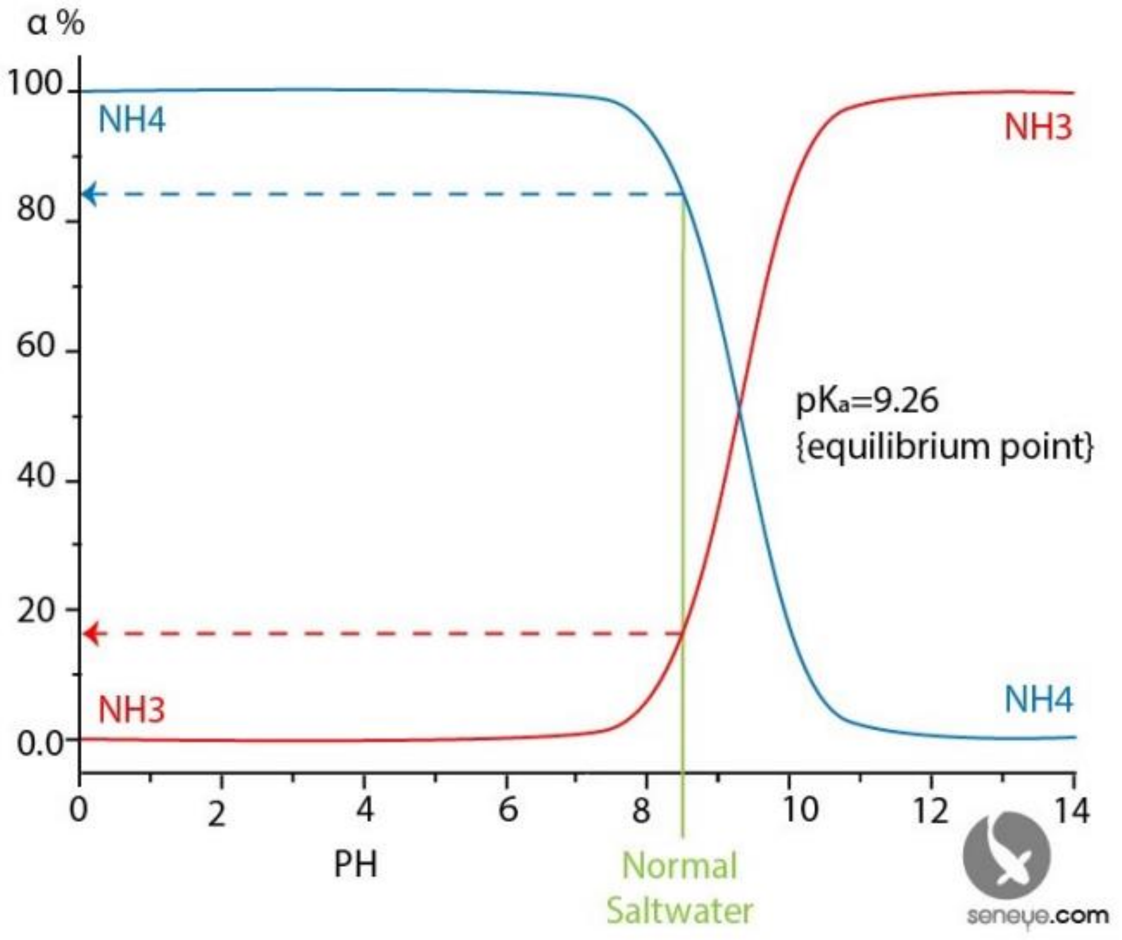
They are the SAME MOLECULE

The extra H^+ is dependent on pH

FAQ #2

NH_4^+

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



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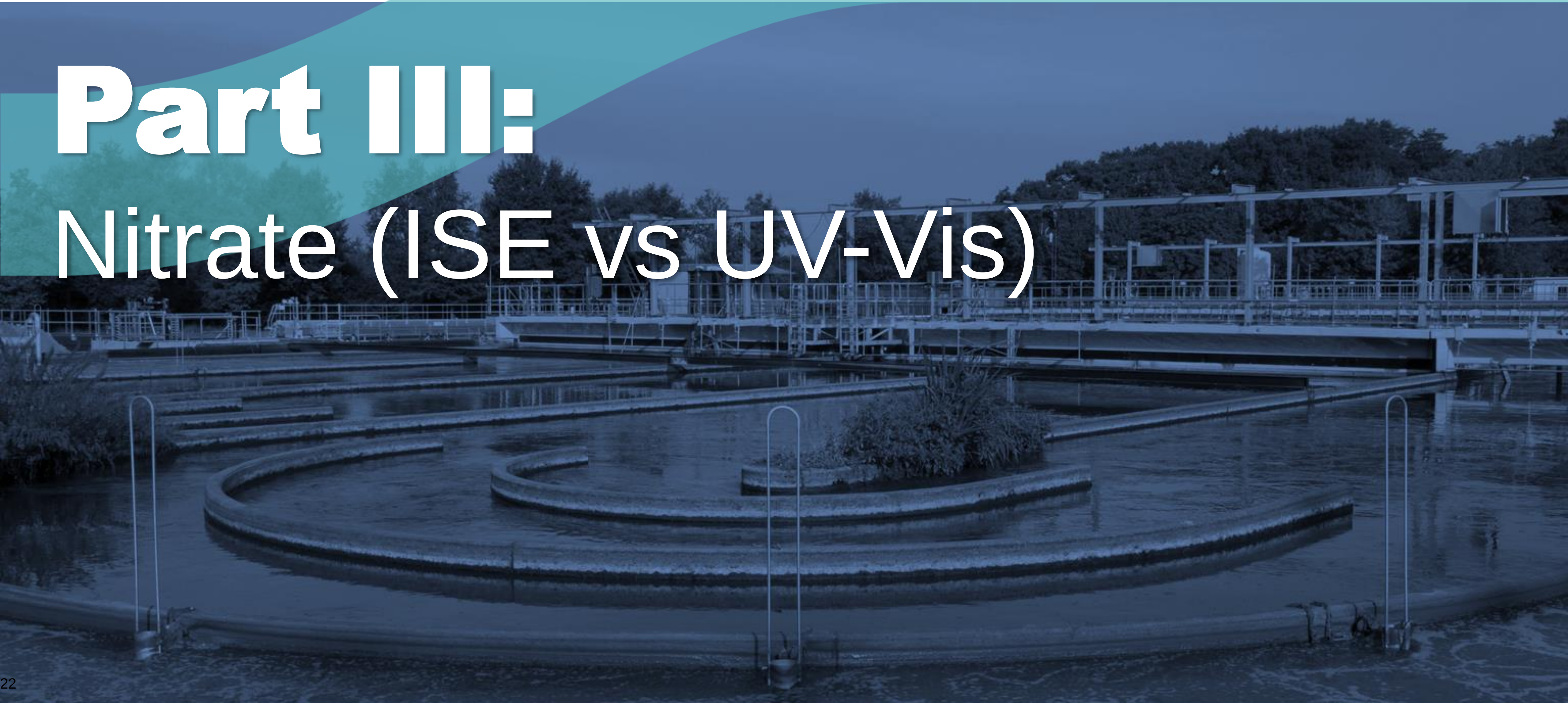
Part III:

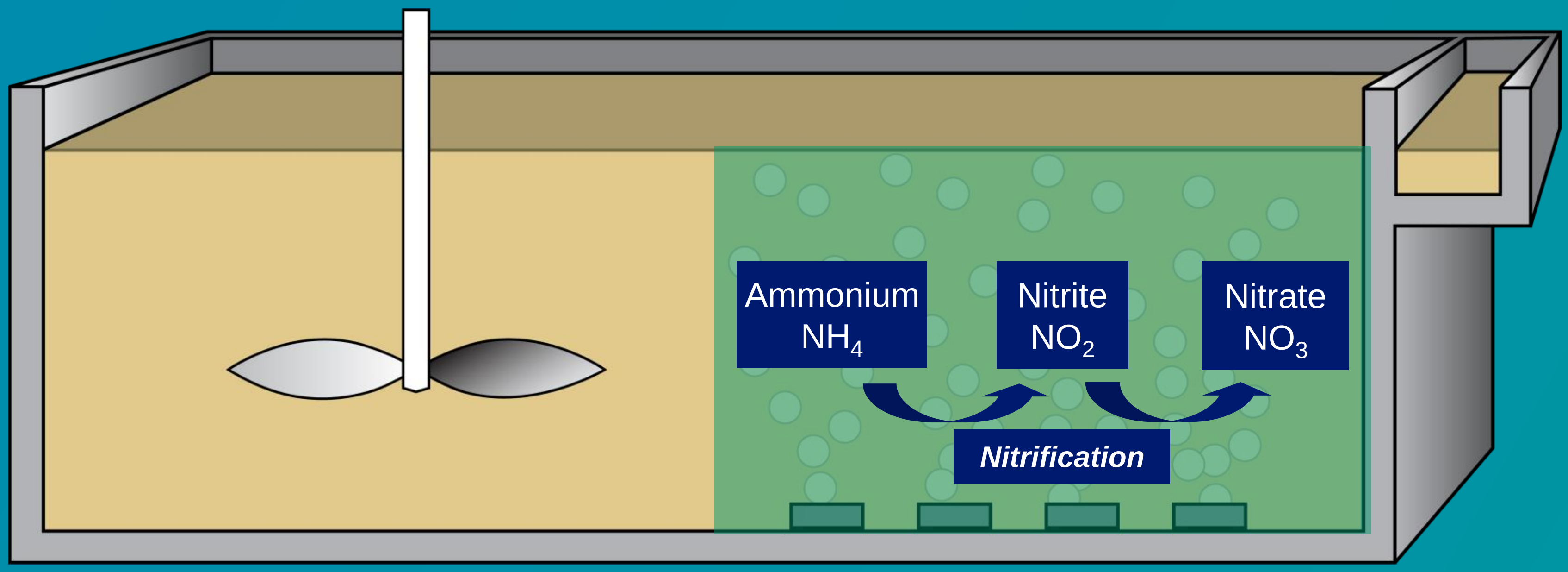
Nitrate (ISE vs UV-Vis)



FAQ #3

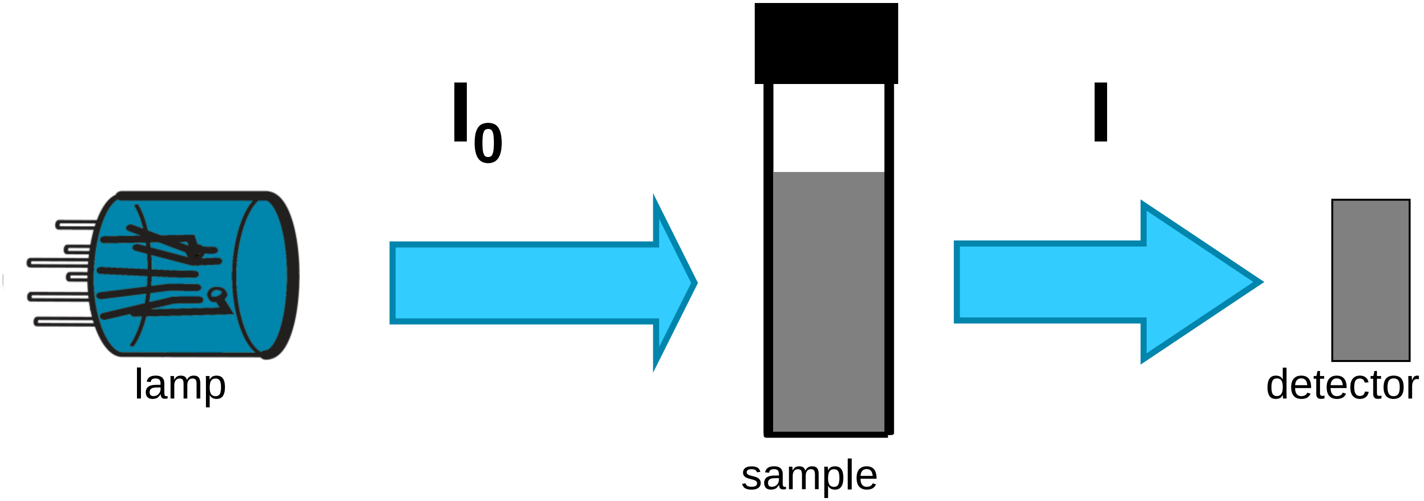
NO_3^-

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



UV-Vis Technology

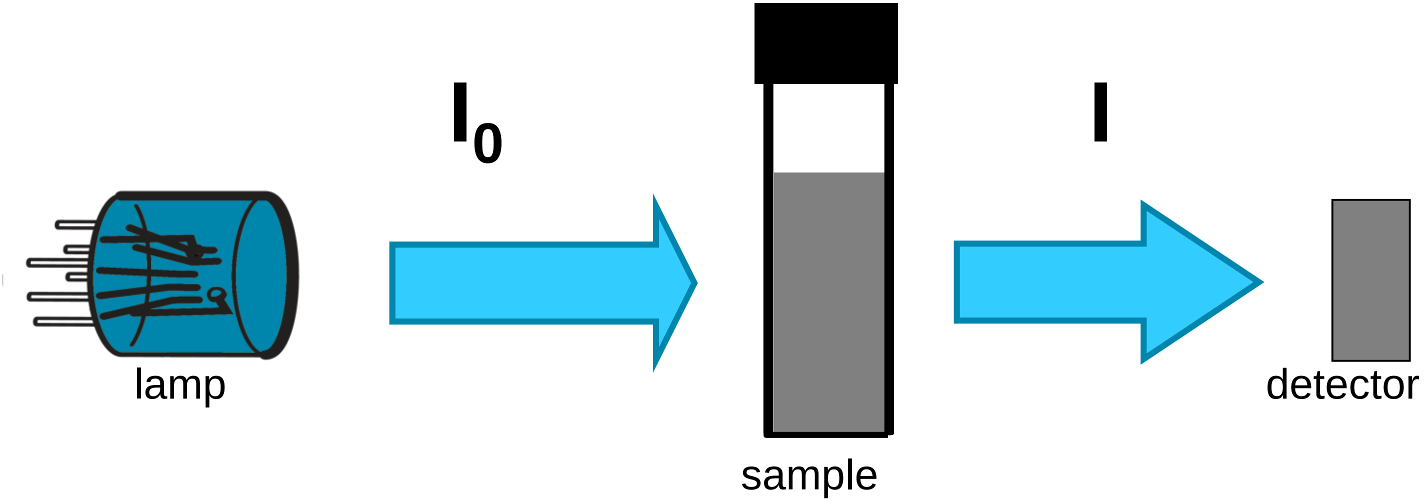
NO_3^-



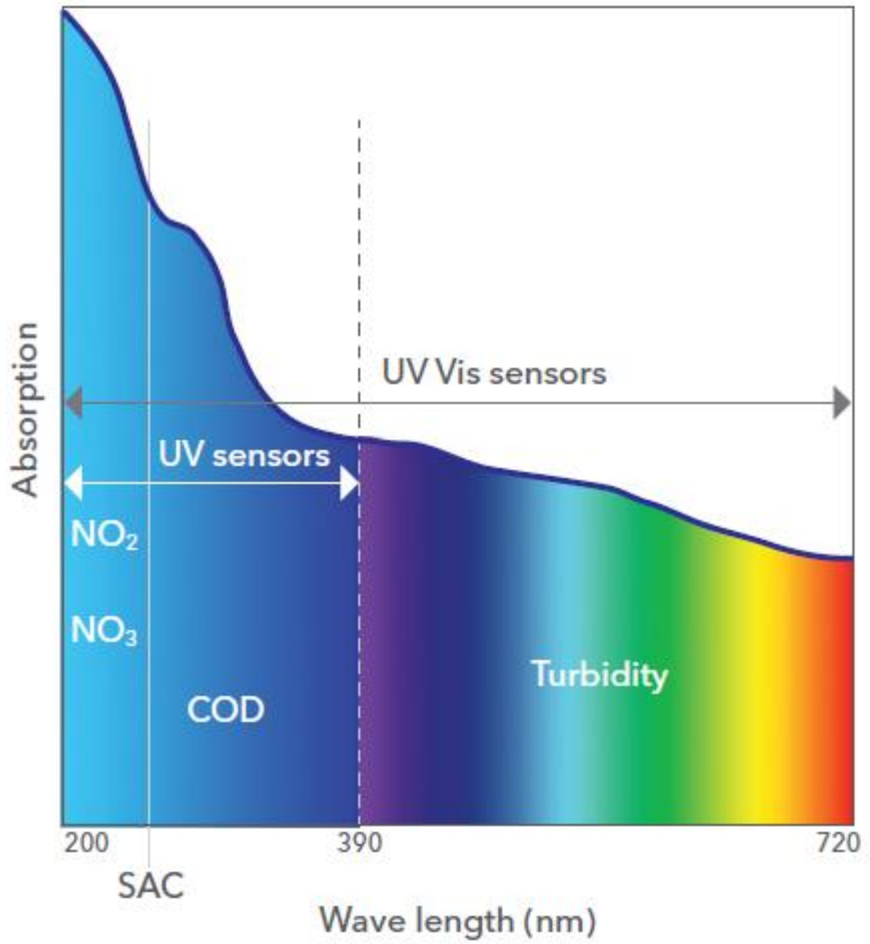
$$\%T = \frac{I}{Io} \times 100$$

UV-Vis Technology

NO_3^-



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



UV-Vis Technology

NO_3^-

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

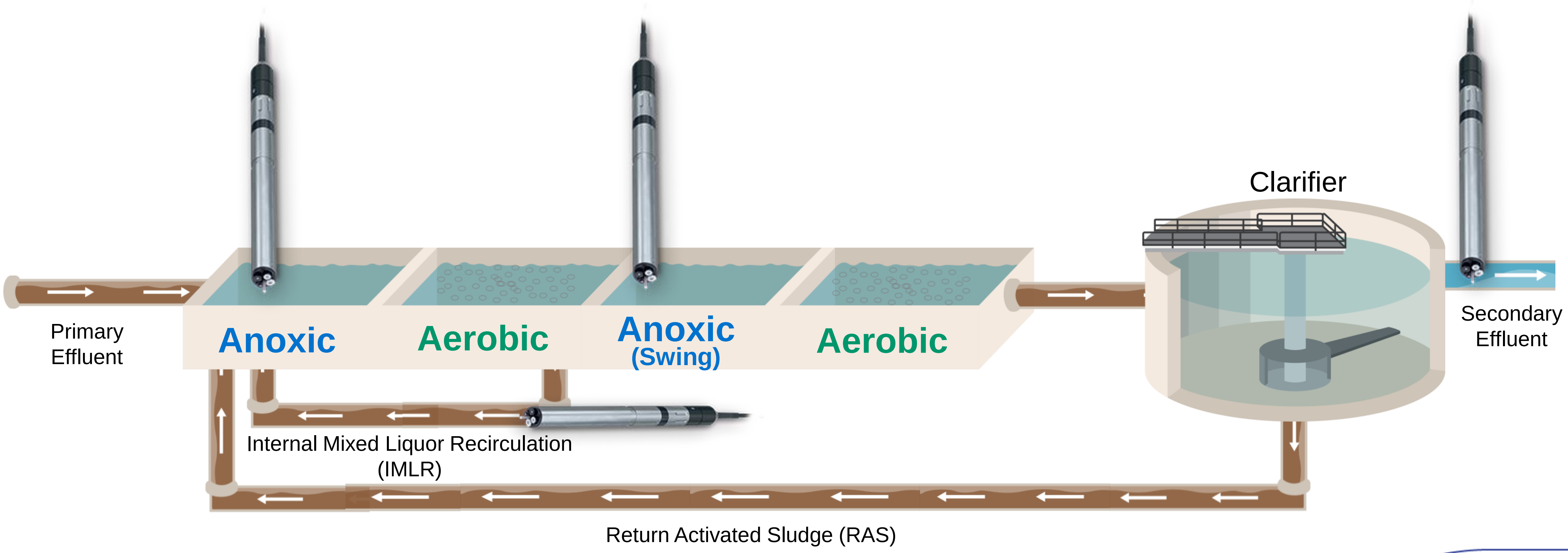
Installation/Maintenance Comparison

NO_3^-

	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

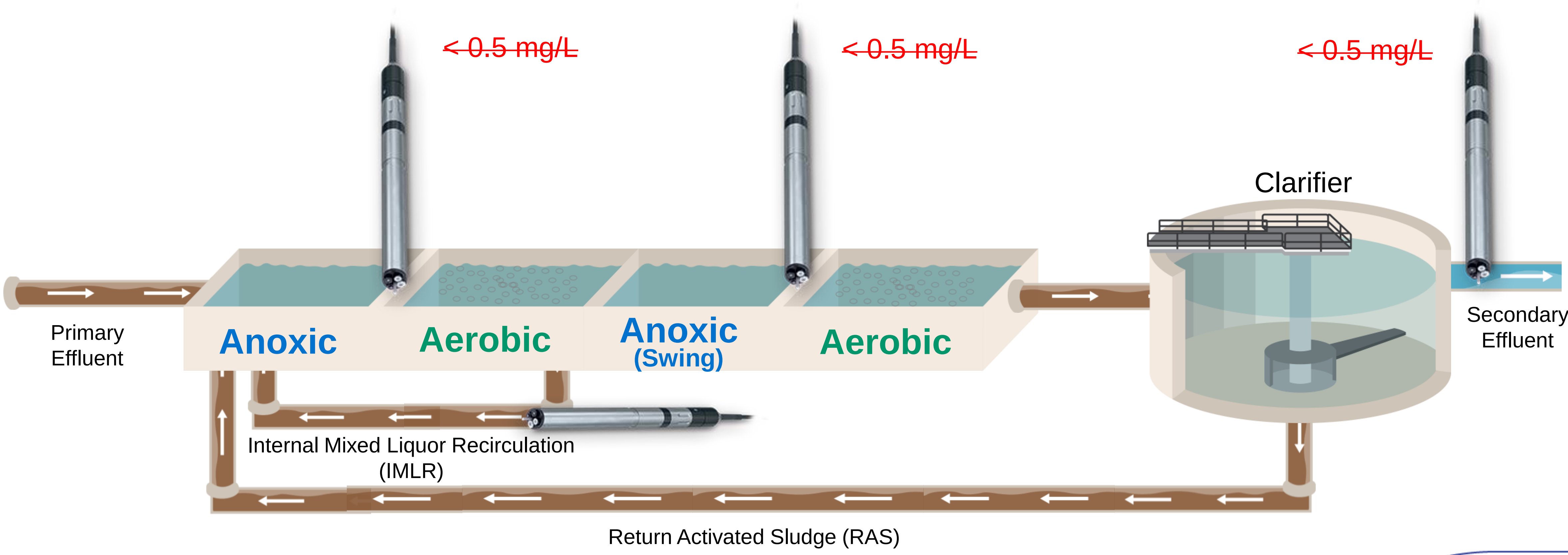
Application Comparison-ISE

NO_3^-



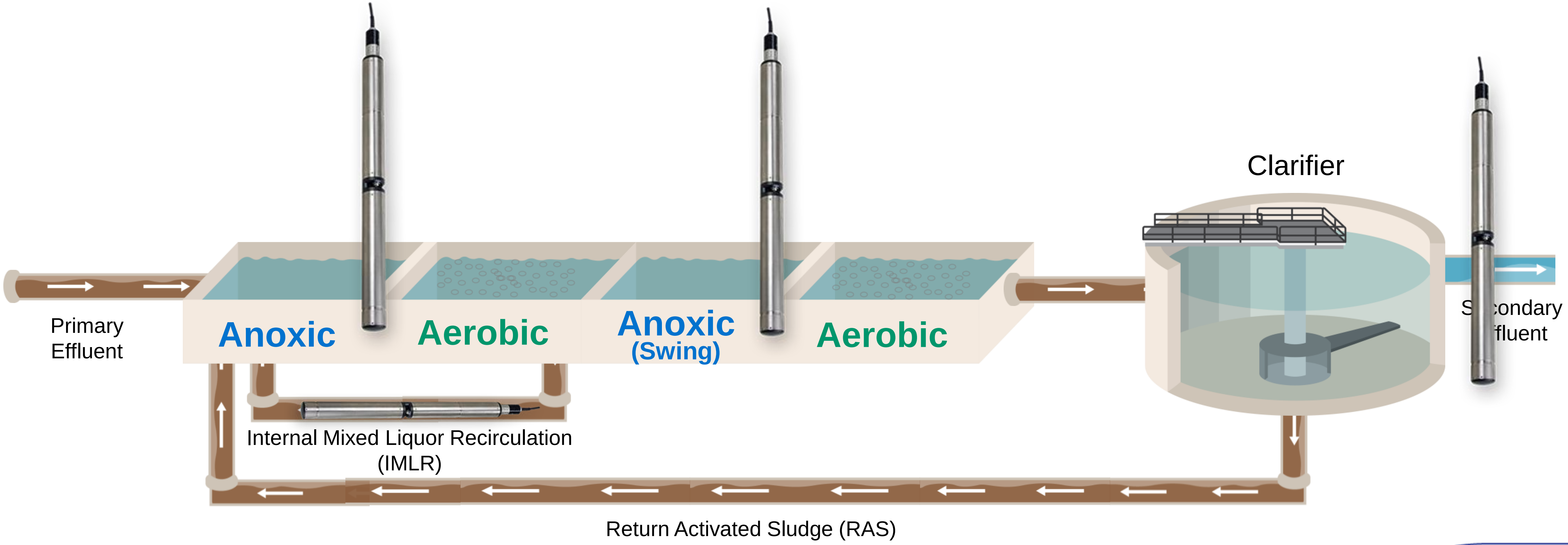
Application Comparison-ISE

NO_3^-



Application Comparison-UV/Vis

NO_3^-



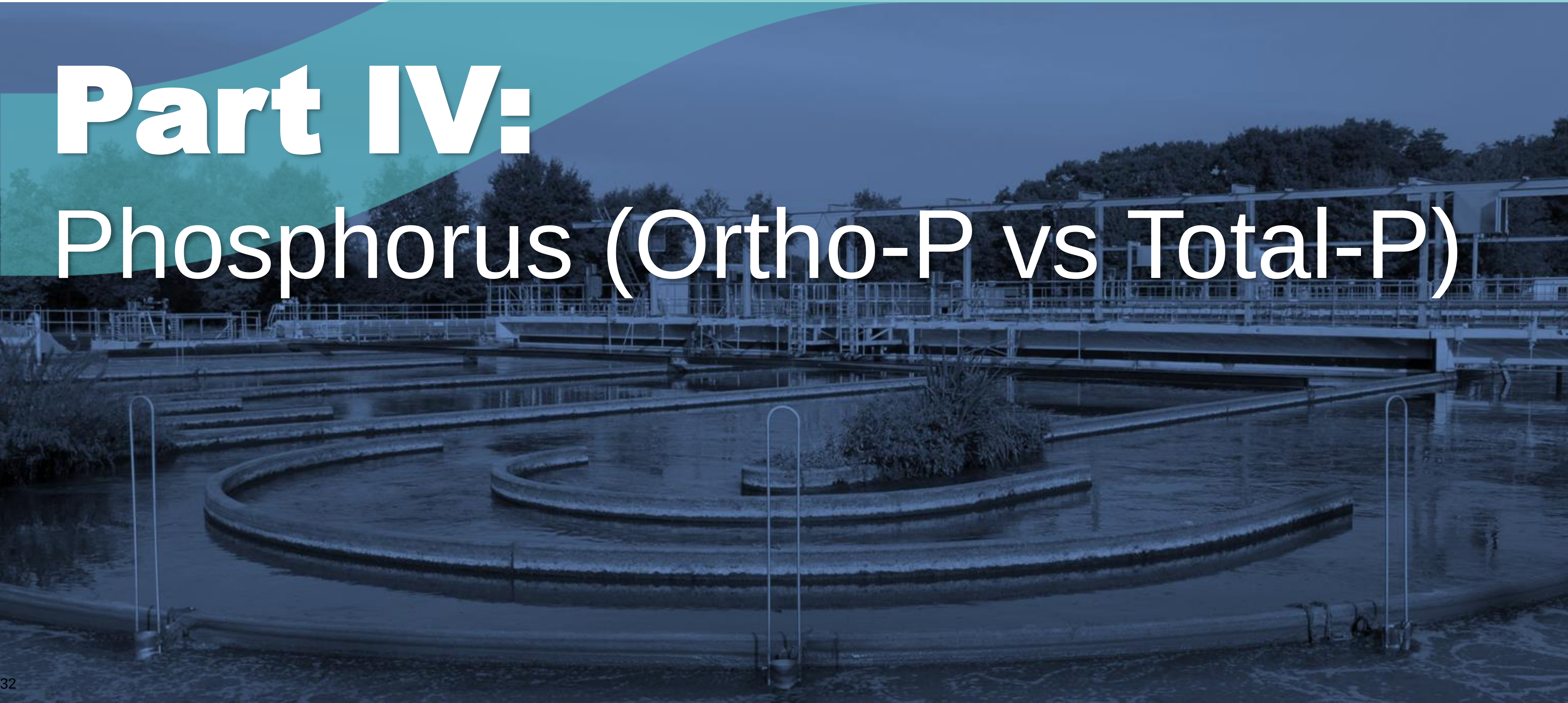
Which should you choose for Nitrate measurement? NO_3^-

- 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:

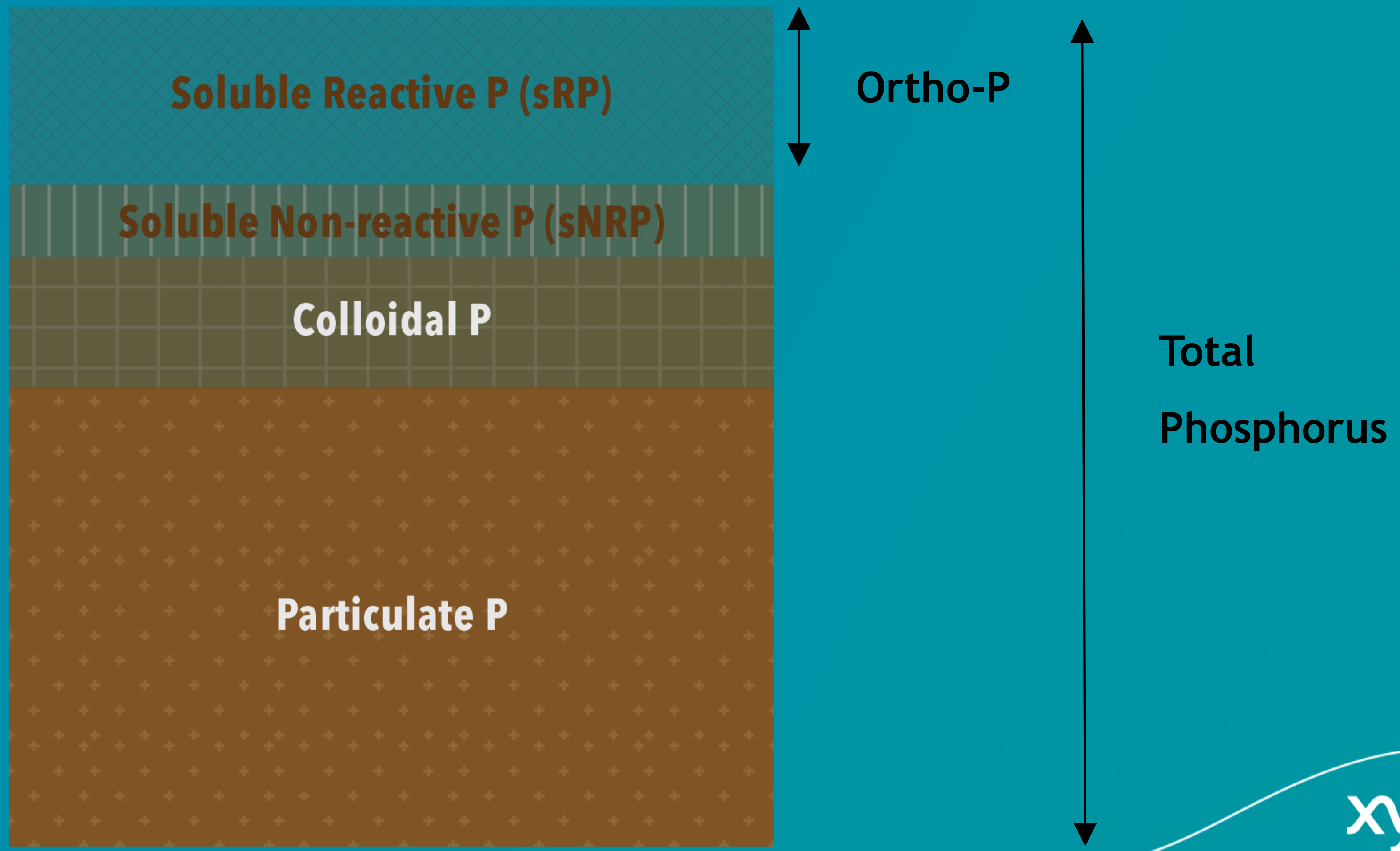
Phosphorus (Ortho-P vs Total-P)



FAQ #4

P

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



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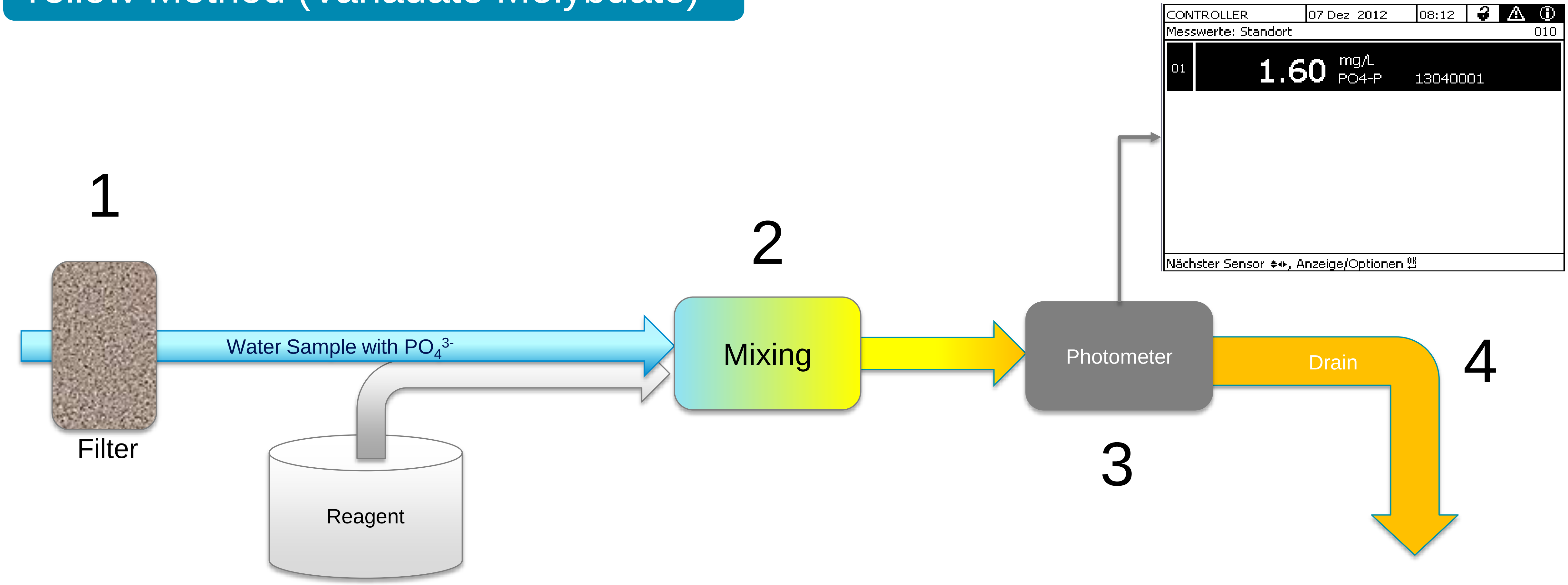
Technology Comparison: Ortho-P

P

Yellow Method (Vanadate Molybdate)



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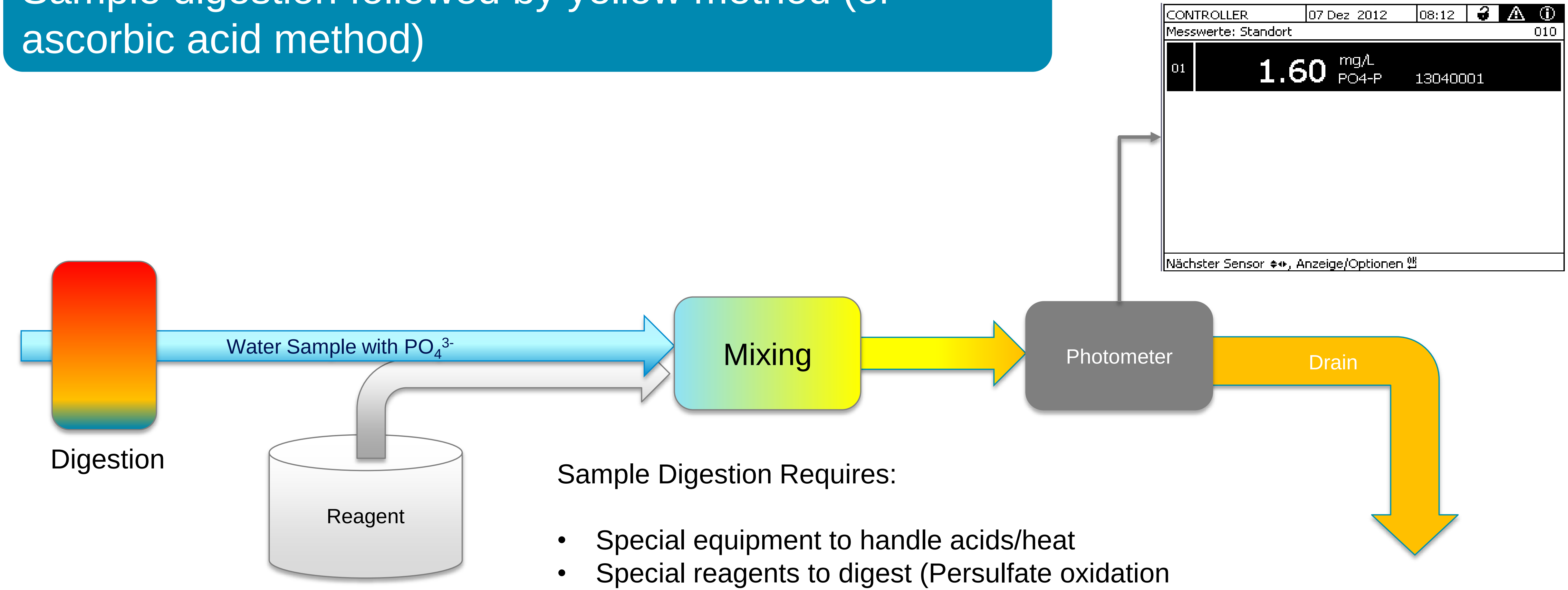
Technology Comparison: Total P

P

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



Sample Digestion Requires:

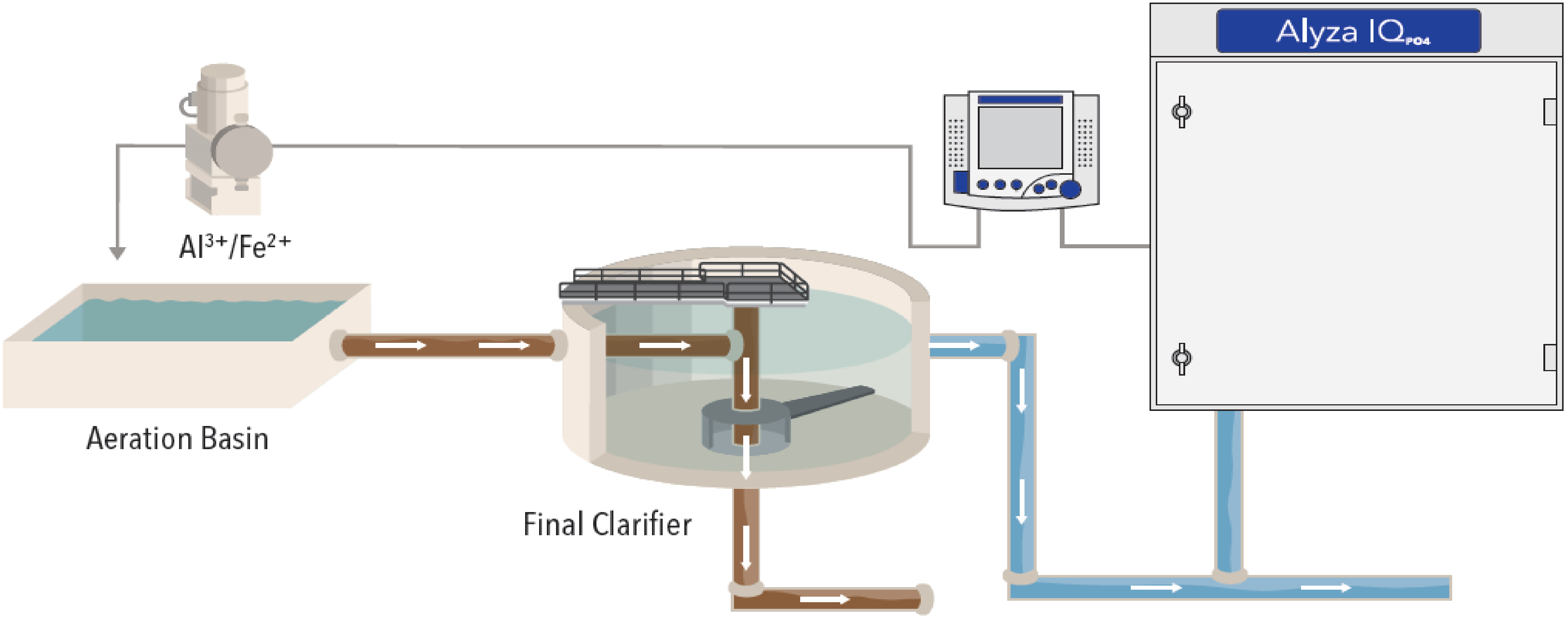
- Special equipment to handle acids/heat
- Special reagents to digest (Persulfate oxidation OR Nitric/Sulfuric Acid
- More sample processing time

= Difficult to run as Online Wet Chemistry Analyzer

Application Comparison: Ortho-P

P

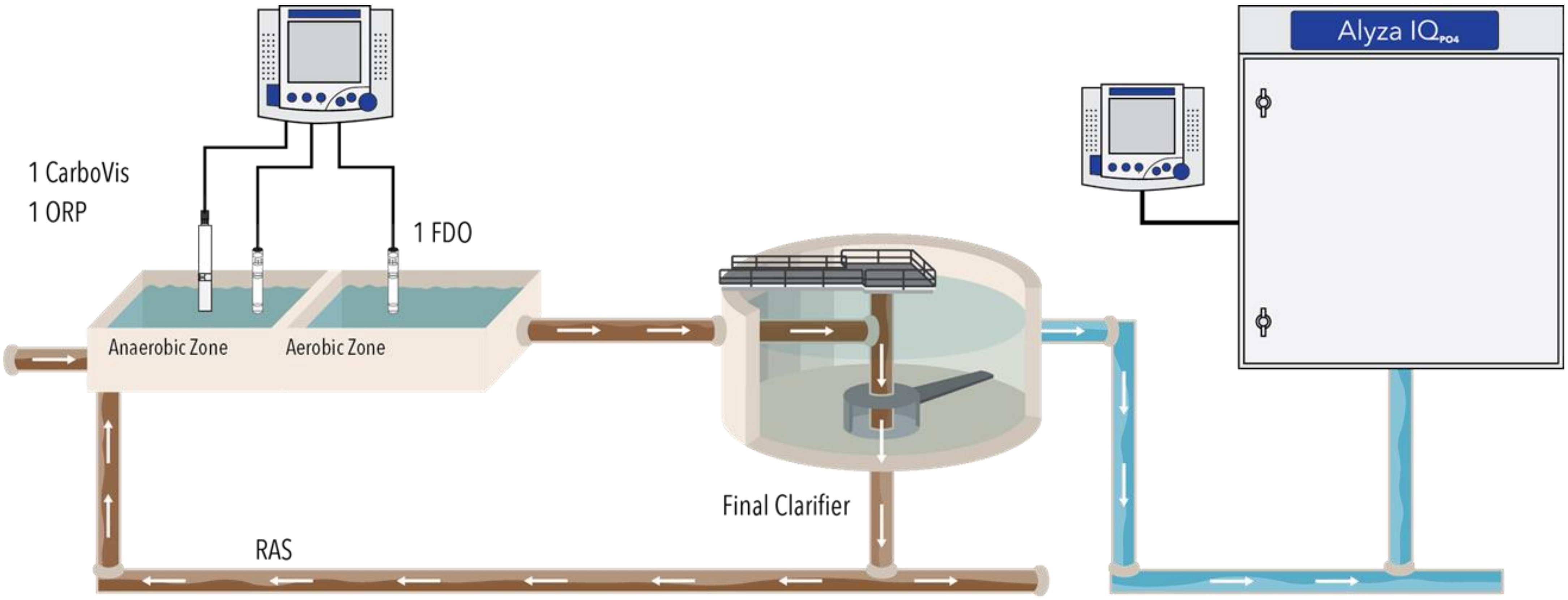
Alum/Ferric Dosing Control



Application Comparison: Ortho-P

P

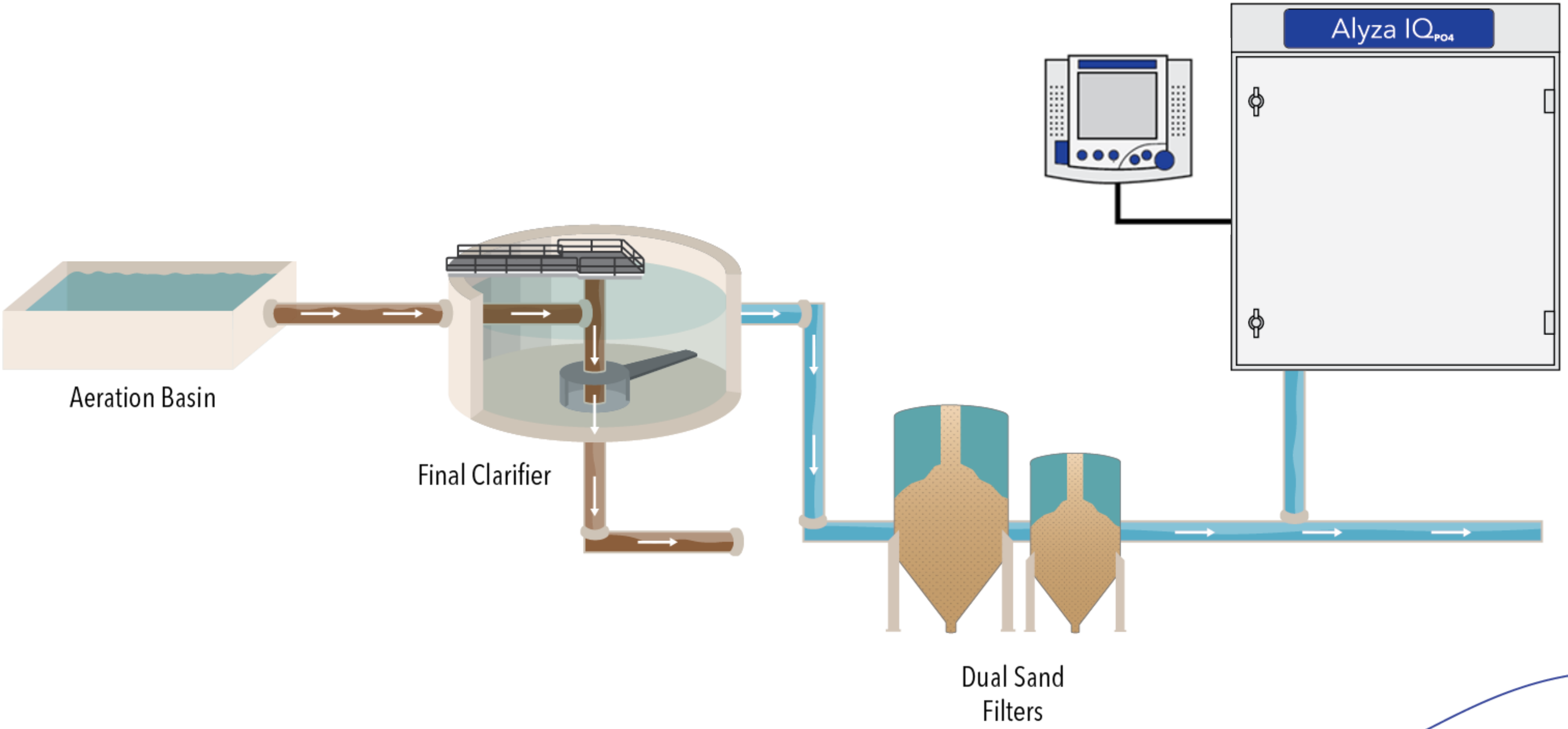
Enhanced Biological Phosphorus Removal Monitoring



Application Comparison: Ortho-P

P

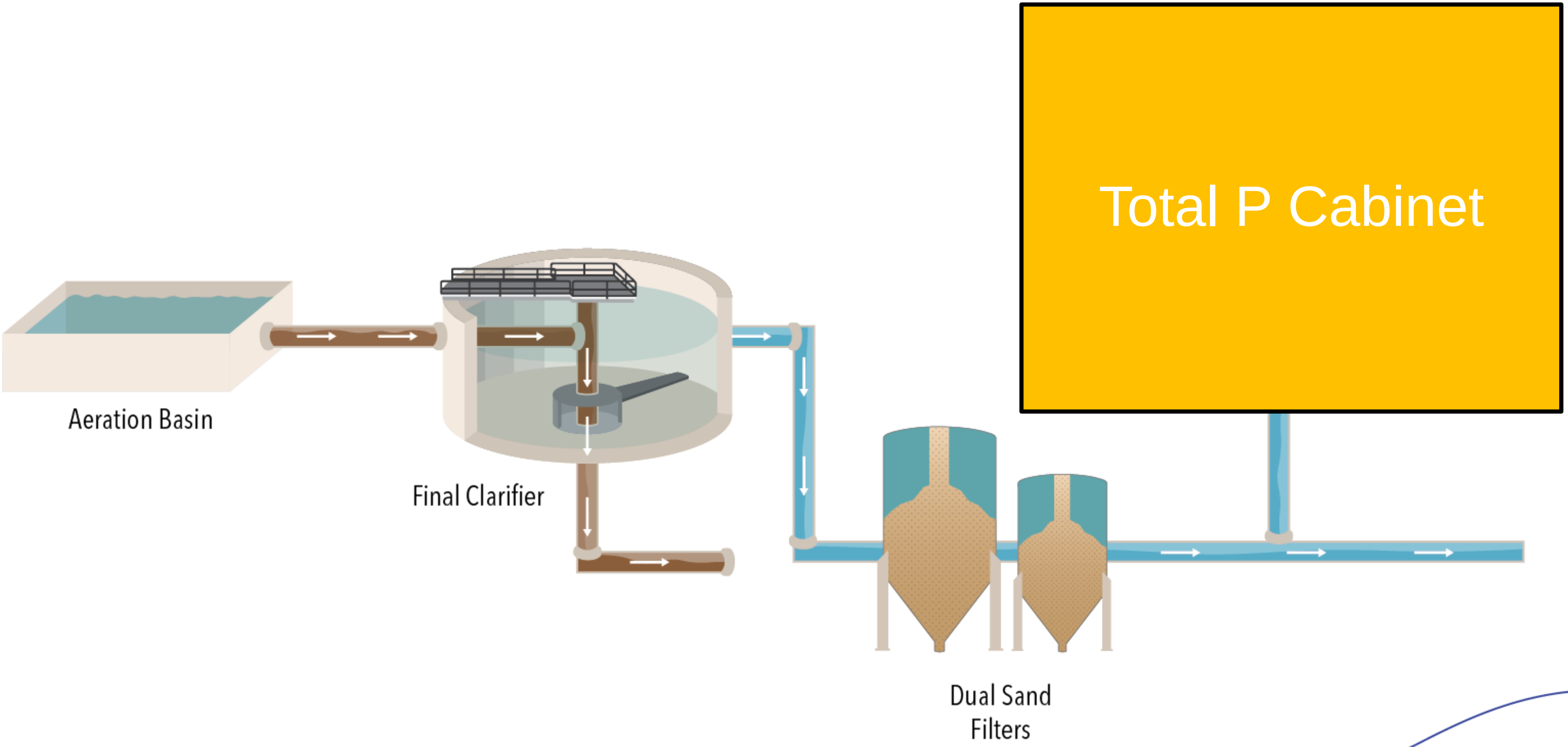
Final Effluent Monitoring



Application Comparison: Total P

P

Final Effluent Monitoring



Which should you choose for phosphorus monitoring?

P

- 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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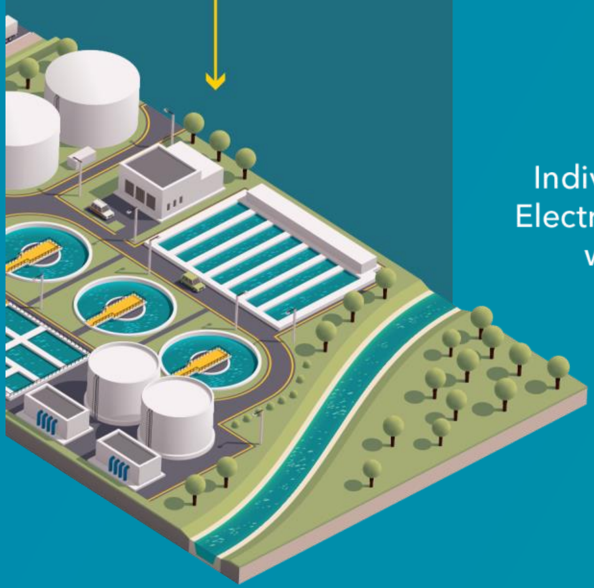
Control Confidently with YSI

Process control of wastewater treatment

Ammonium and Nitrate measurements that you can depend on.

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



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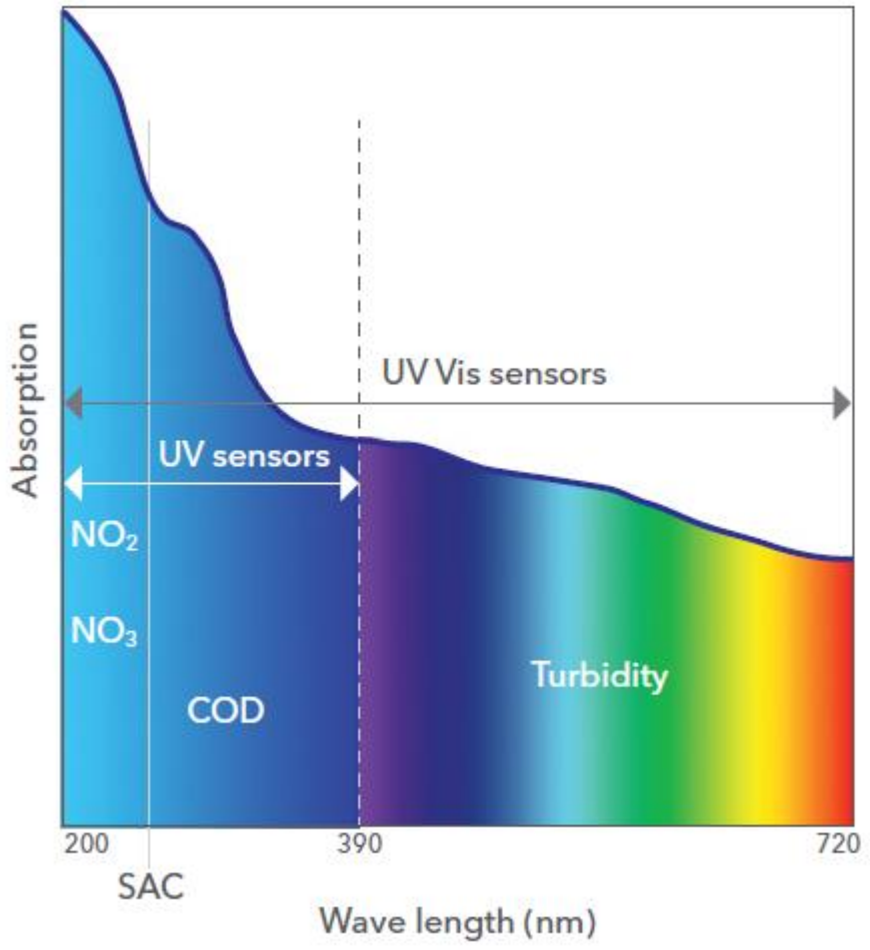
UV and UV-Vis Spectrophotometer Sensors

Parameters: NO_3, NO_2, 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

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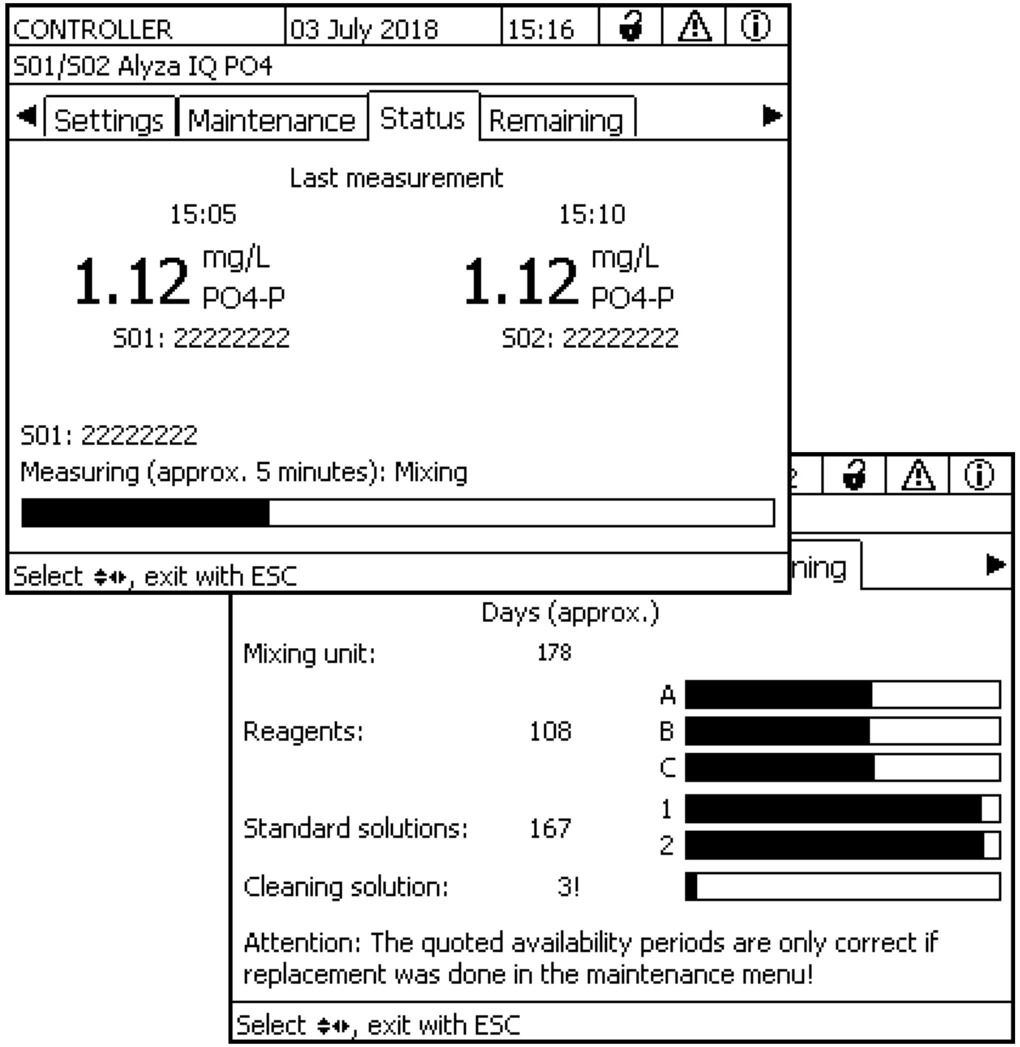
Alyza

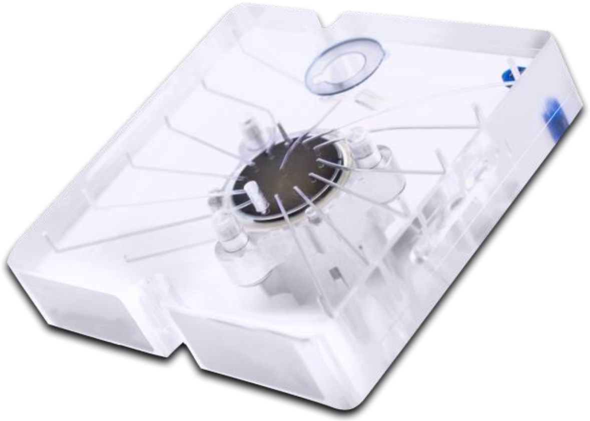
New YSI Analyzer Platform

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 ºF	
Warranty:	2 years	

Alyza’s Improvements to Online Analyzer Technology





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Q&A