

October 17, 2018



Orthophosphate Monitoring and Phosphorus Removal Control

WISCONSIN WASTEWATER OPERATORS' ASSOCIATION
52ND ANNUAL CONFERENCE



Today's Topics

Process monitoring of phosphorus

- Chemistry
- Removal mechanism
- Analyzers
- Treatment
- Case studies

Chemical and biological removal of phosphorus from wastewater



Phosphorus Chemistry

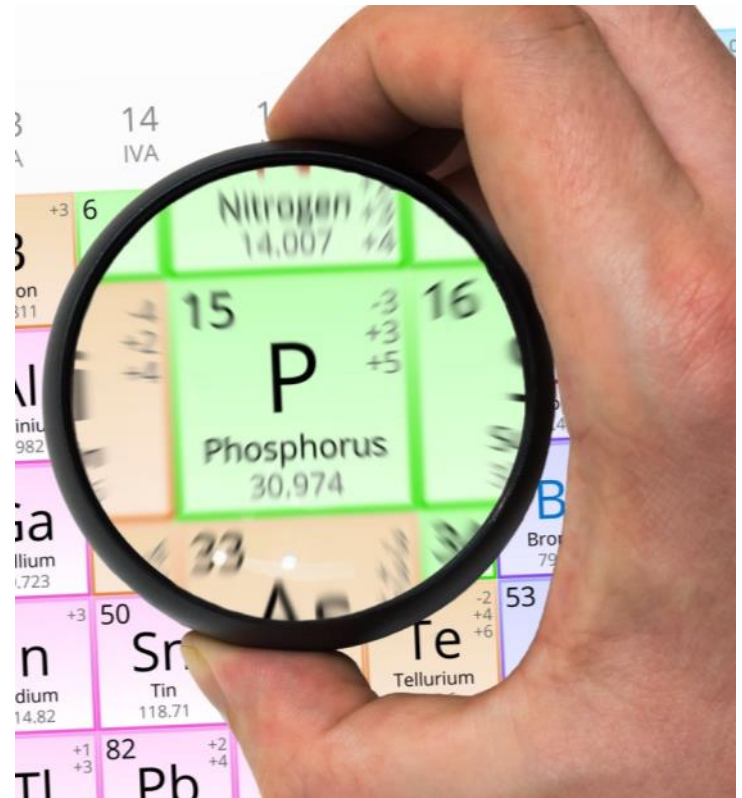
PO_4^{3-} (+5) most common occurrence
in environment

1 of 5 main elements of living
organisms (CHONP)

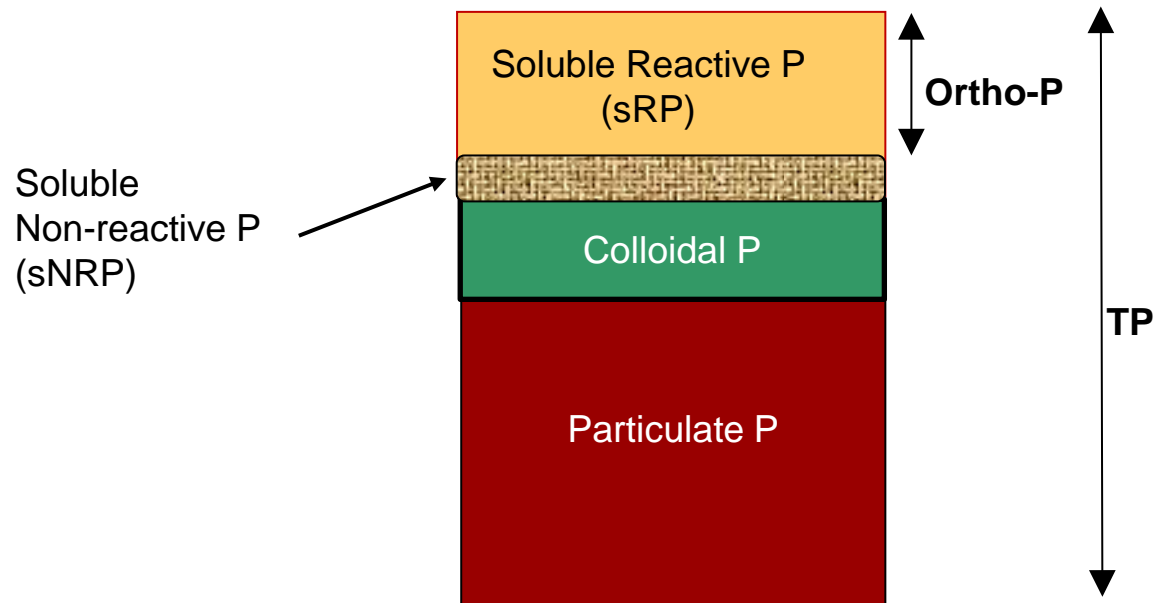
Major component of fertilizers

Limiting nutrient in fresh water

What goes in, must come out



Phosphorus Forms in WW*



*All are PO_4^{3-}

How is 'P' Removed?

1. Biological
2. Chemical

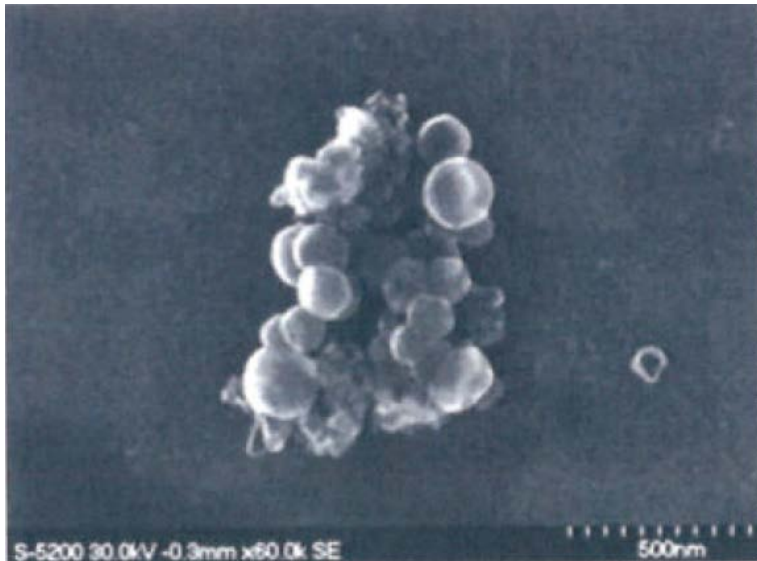
Basic concept:

'P' dissolved \longrightarrow 'P' Particulate



Particulate Forms of P in Treated WW

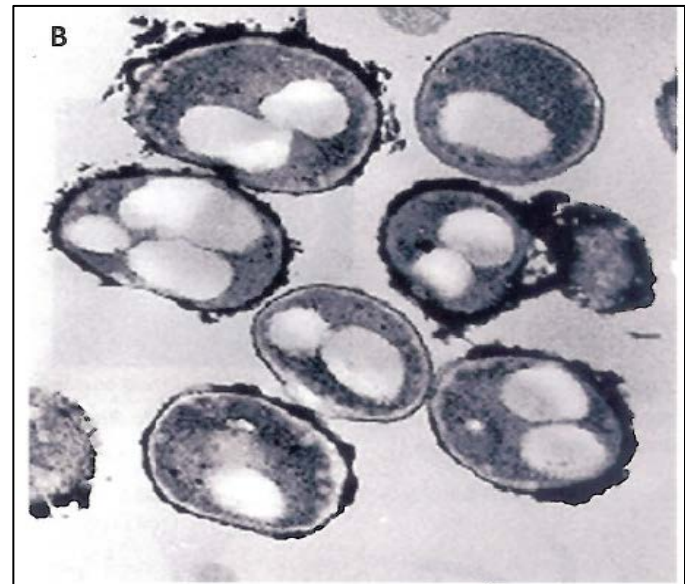
Surface Complexation



SEM image of 1-minute old (FeOH_3) floc, Dr. Vladimir Kitaev, Wilfred Laurier University

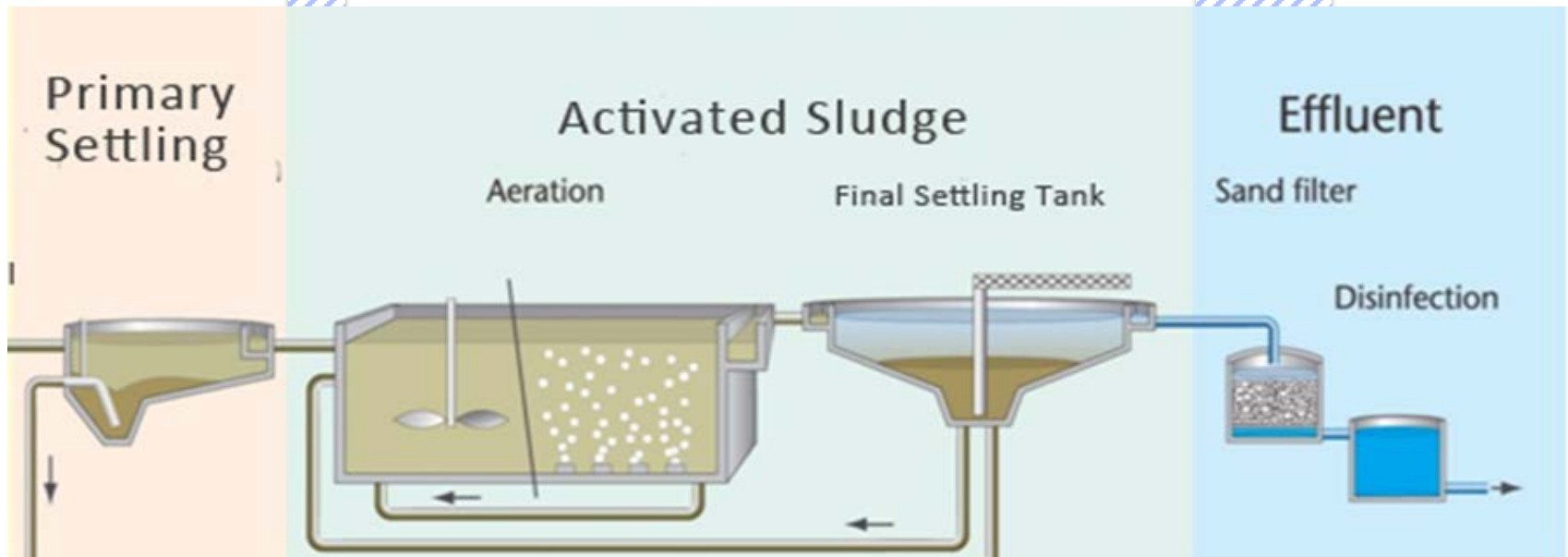
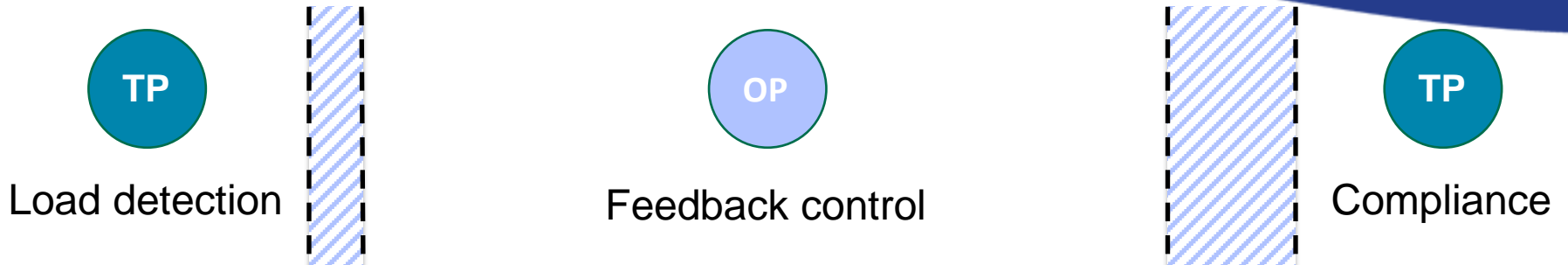
HMO floc w/ adsorbed P

Enhanced Biological P Removal (EBPR)



Polyphosphate granules in bacteria

Phosphorus Monitoring Applications



TP

Total Phosphorus

OP

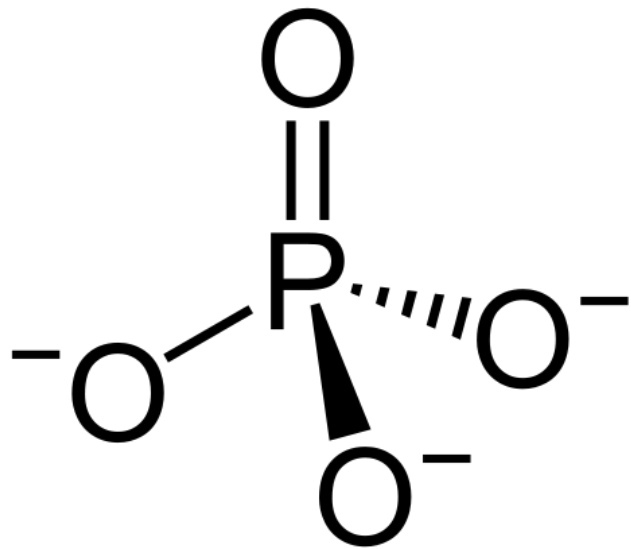
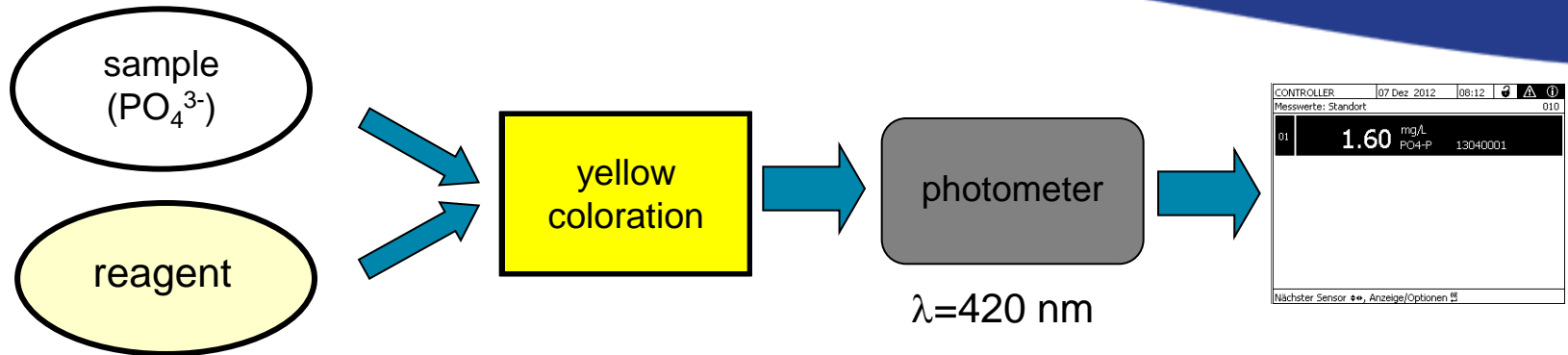
Orthophosphate



a xylem brand

Phosphorus Analyzers

Colorimetric Measurement of P



- Measures ortho-P
- Sample processing required for sNRP or TP (additional step)
- **Yellow** method
 - Detection limit = 0.05 mg P/L
 - Used in most online analyzers
- **Blue** method used in lab for compliance monitoring

Orthophosphate Cabinet Analyzers

Wet chemistry

4 main components



- Electronics
- Photometer & tubing
- Sample transport
- Reagent & solutions

Analyzer Mounting



Sampling System





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P Removal Treatment

Effect of P Removal on WRRF Operations

	Chemical Removal	EBPR
Nitrogen removal	⬇️	⬇️
Energy usage		⬆️
Supplemental carbon requirements		⬇️
Dewatering	⬆️	●
Biogas production	⬆️	⬇️
Sludge production	⬇️	
Operating cost	●	⬆️
Operating Complexity		⬇️

● - Strong positive impact

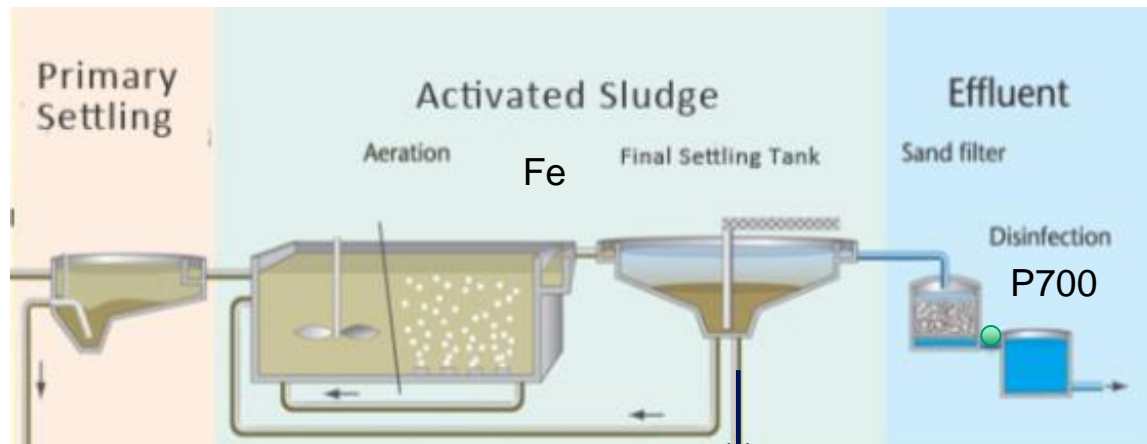
⬆️ - Positive

⬇️ - Negative

● - Strong negative impact

Adapted from Dube, P. (2018), Understanding the Effects of Nutrient Removal on Dewatering, wefhq update appearing in The Conduit magazine

Chemical Removal - Simultaneous Precipitation



'P'

Floating Point Control

P-701

Run
 Phos Analyzer Manual

Manual Setpoint
 Output To Pump

OUTPUT TO PUMP ONLY VALID WHEN IN AUTO

P-703

Run
 Phos Analyzer Manual

Manual Setpoint
 Output To Pump

OUTPUT TO PUMP ONLY VALID WHEN IN AUTO

P-702

Run
 Phos Analyzer Manual

Manual Setpoint
 Output To Pump

OUTPUT TO PUMP ONLY VALID WHEN IN AUTO

P-704

Run
 Phos Analyzer Manual

Manual Setpoint
 Output To Pump

OUTPUT TO PUMP ONLY VALID WHEN IN AUTO

Total Influent

Total Effluent

Excess Flow

Phos Analyzer Read Out

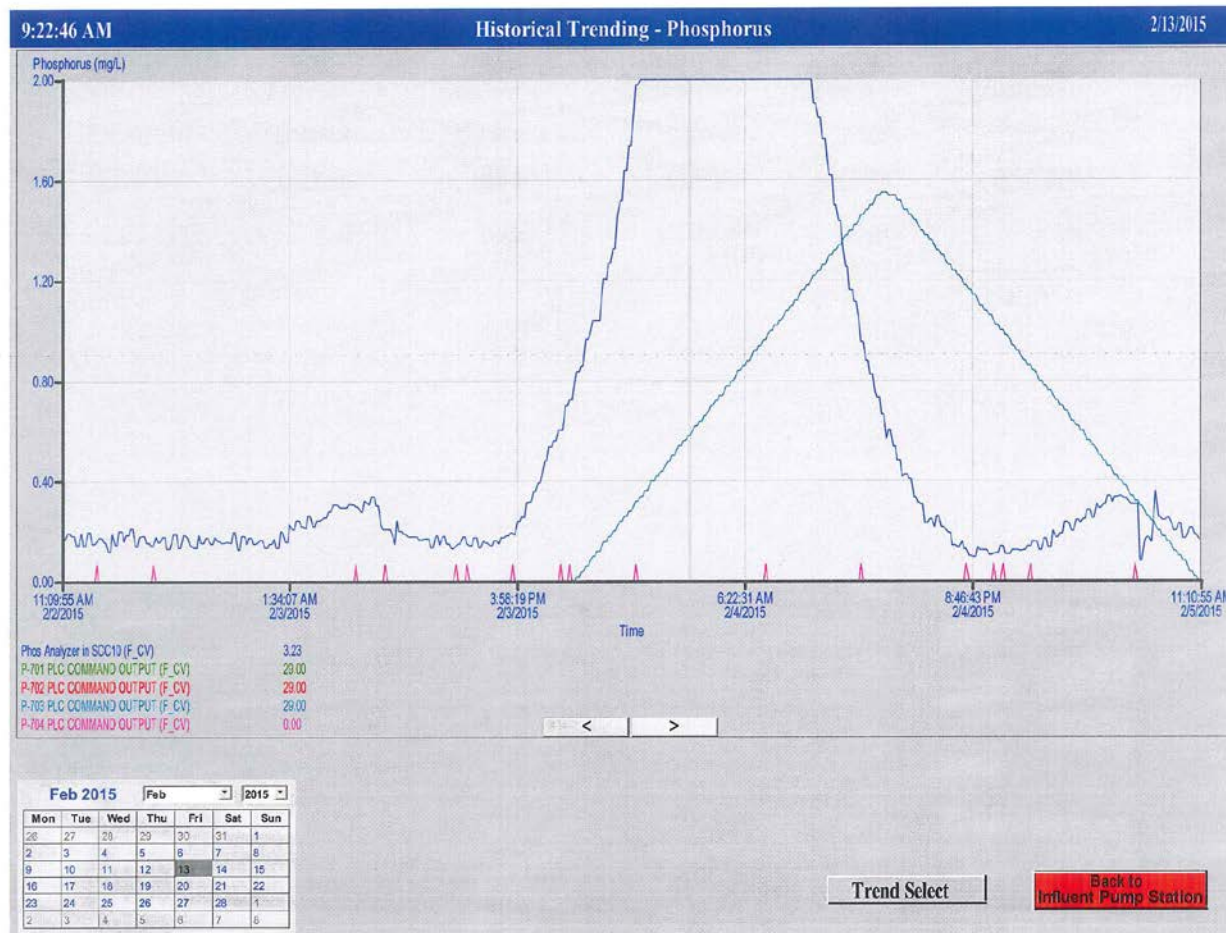
0.61 mg/l

FCL Pump Step Control Setpoints

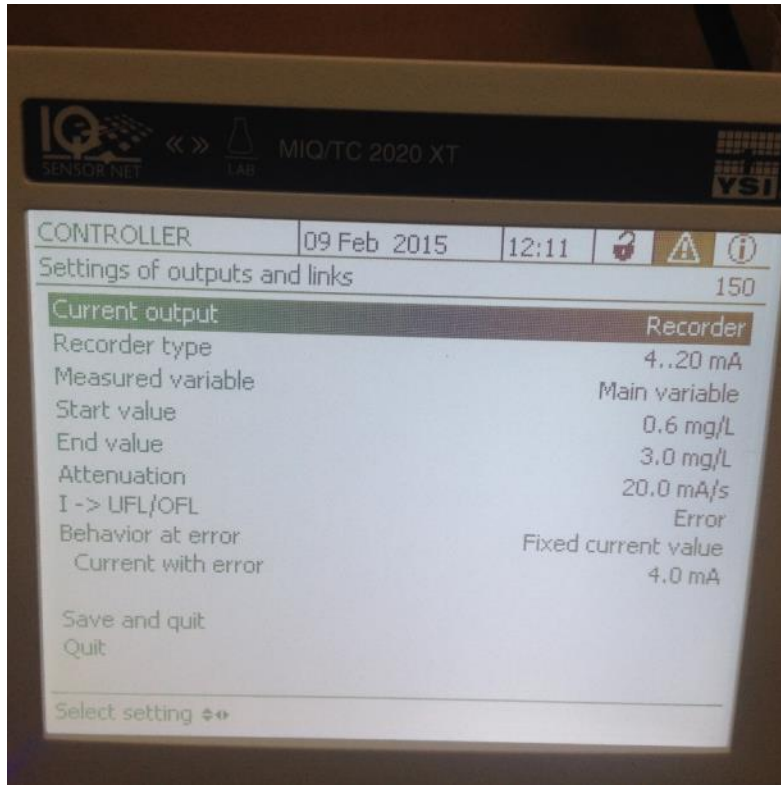
Phos Control Setpoint	<input type="text" value="0.65 MGL"/>	Phos Control Hold Setpoint	<input type="text" value="0.05 MGL"/>
Pump Large Adj Setpoint	<input type="text" value="2.00 %"/>	Pump Large Adj Delay	<input type="text" value="900 Sec"/>
Pump Small Adj Setpoint	<input type="text" value="0.50 %"/>	Pump Small Adj Delay	<input type="text" value="900 Sec"/>
Pump Small To Large Adj Up	<input type="text" value="0.10 MGL"/>	Pump Large To Small Adj Dwn	<input type="text" value="0.10 MGL"/>

FCL Pump Step Control Output Status

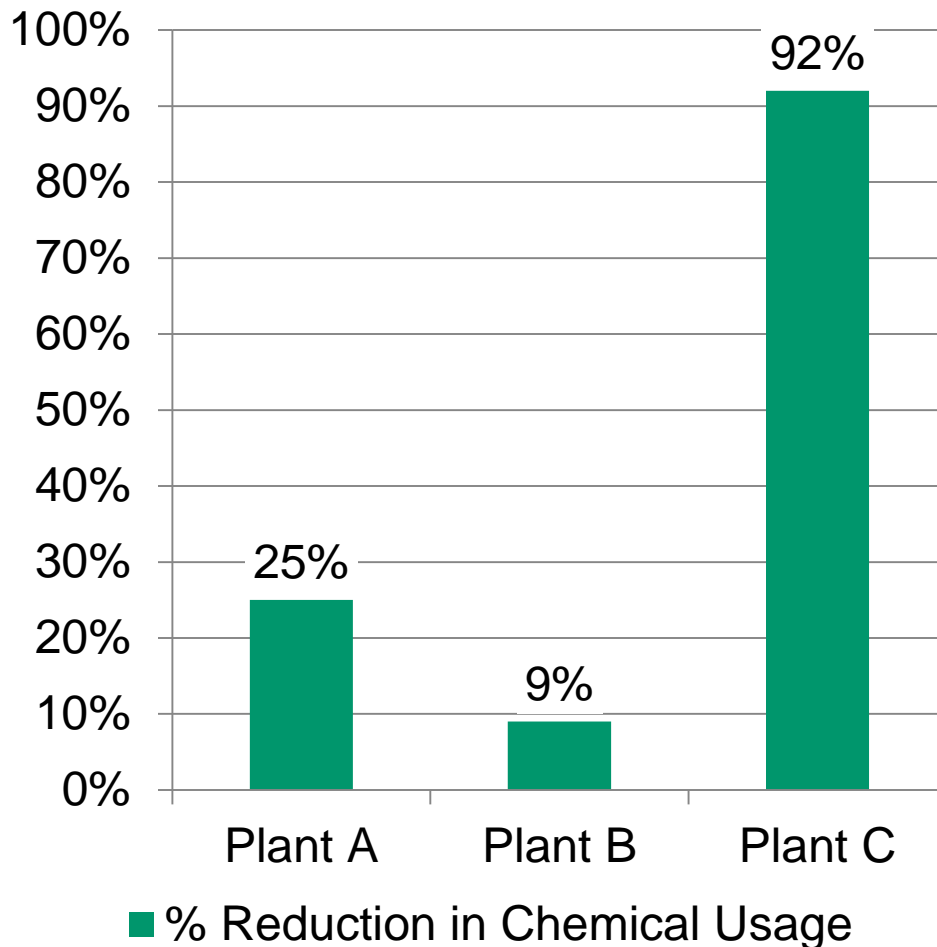
Chemical Dosing System Operation



Analog Signal Directly to Feed Pump



Wisconsin WRRF Chemical Usage

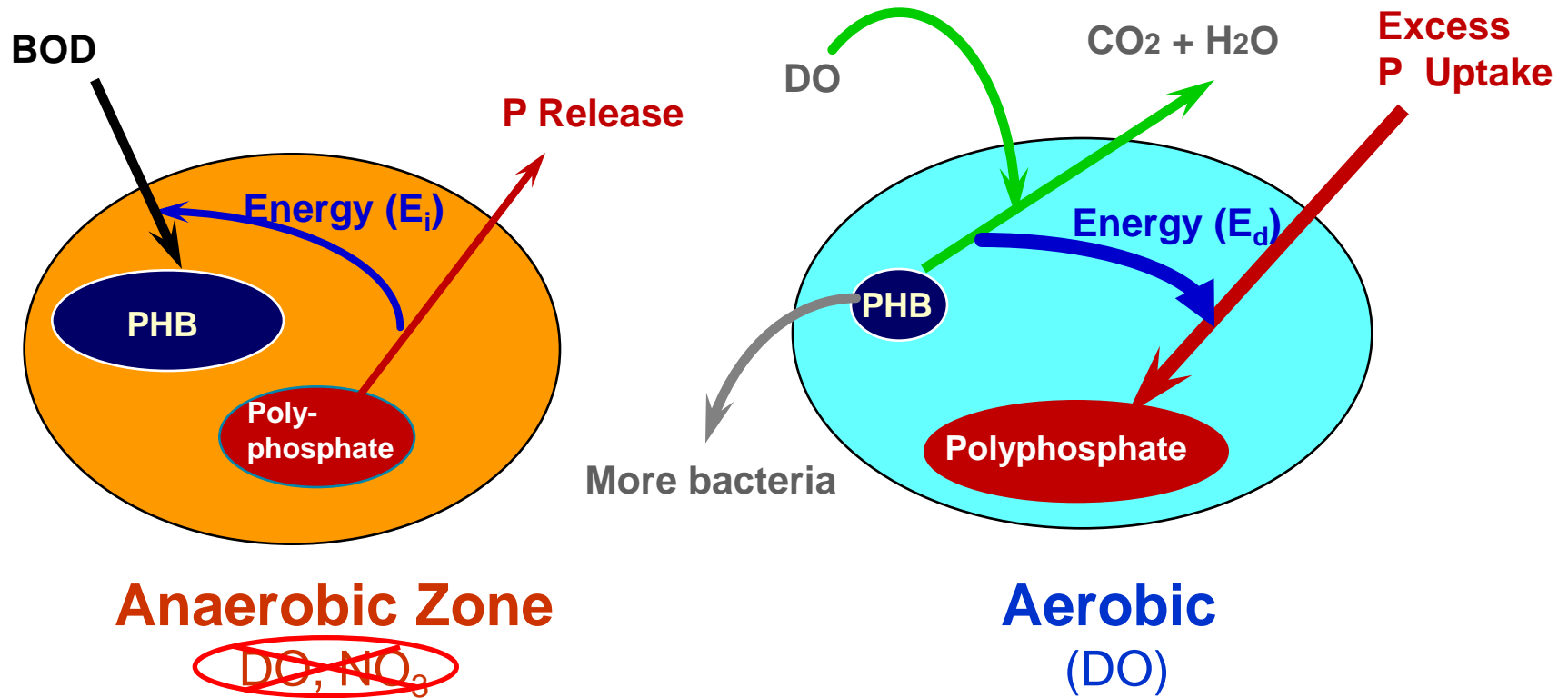


Chemical usage easy to track

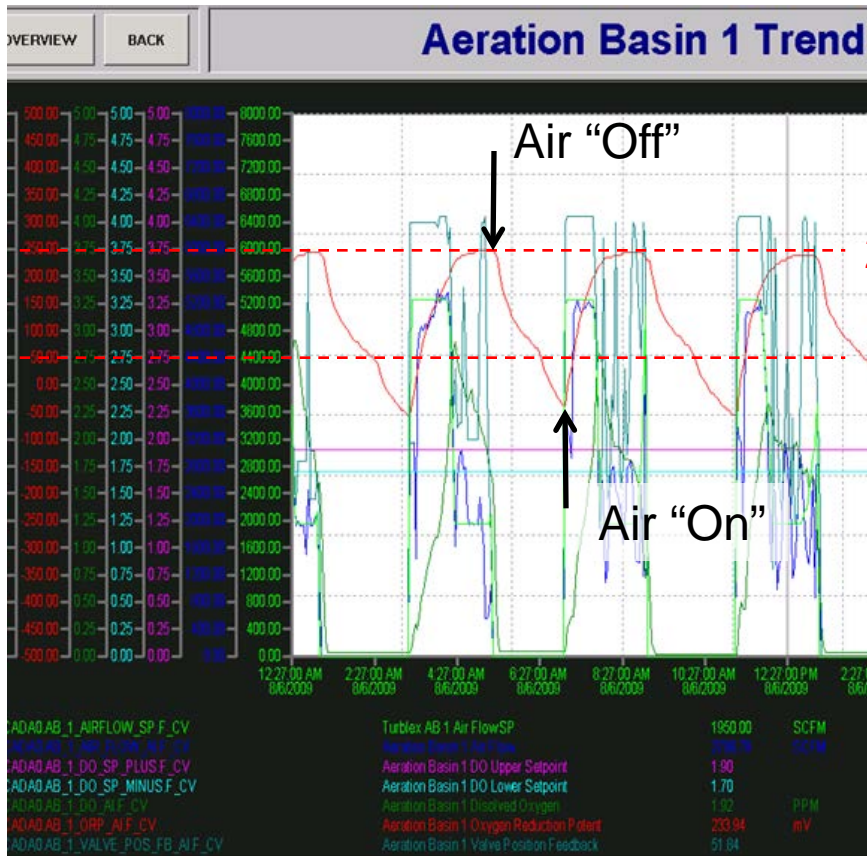
Simple payback is 1 year or less

Other benefits like less sludge production not quantified

Enhanced Biological Phosphorus Removal



ORP Control of EBPR



ORP high / air "off": ~250 mV

- Anaerobic to Oxidic
- DO SP: 1.7 to 1.9 mg/L
- Nitrification
- P uptake

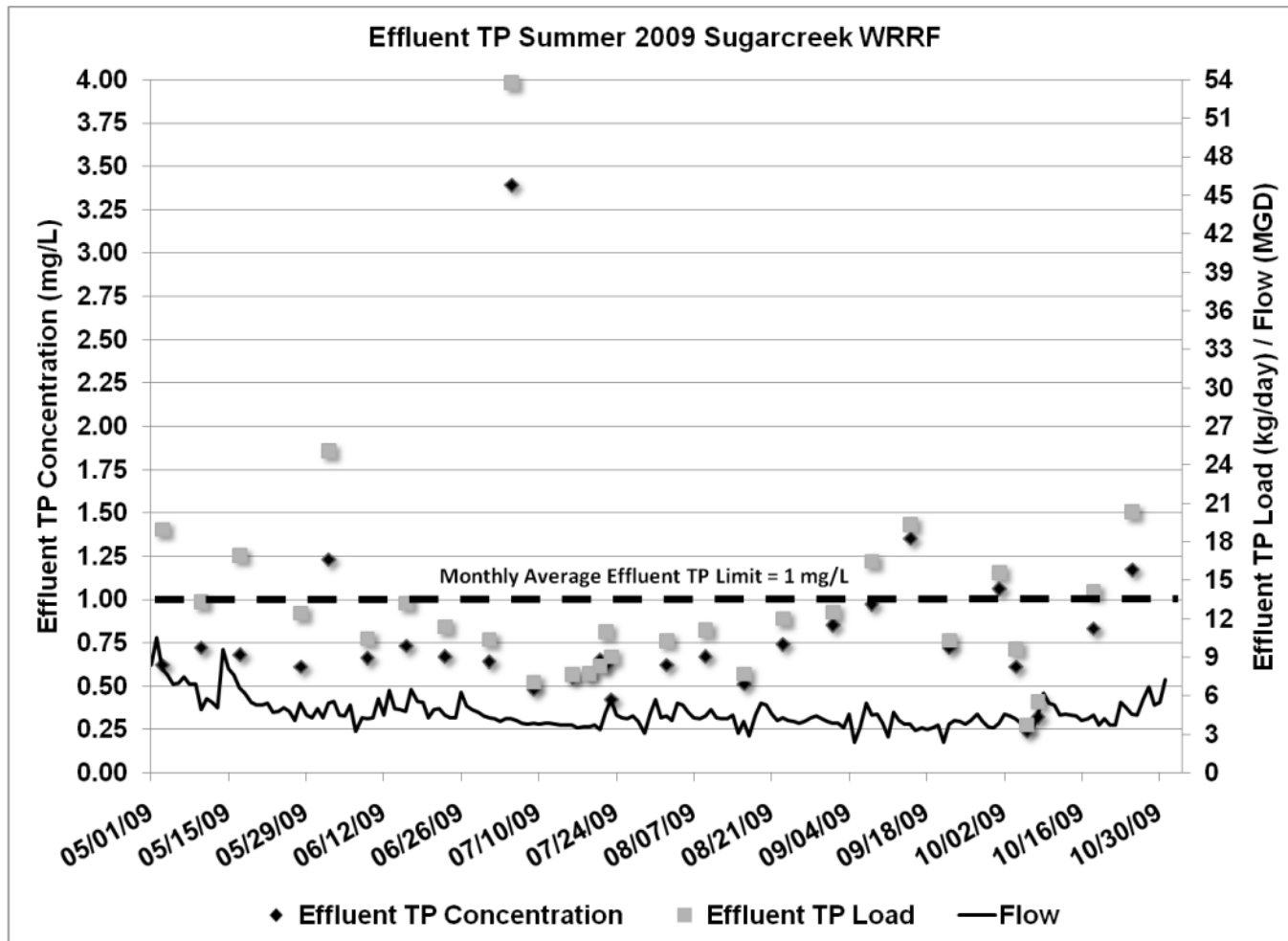
ORP low / timer start: ~50 mV

- Oxidic to Anoxic
- Denitrification
- Timer start

Anaerobic Timer: 40 min.

- Anaerobic
- P release
- Air "on"

2009 – 1 mg/L TP Limit with EBPR



Smith, R.C., Goble, L, "To Everything There is a Season: Lessons from Four Seasons of Phosphorus Removal at Greene County Sugarcreek WRRF", WEFTEC 2010

Summary

Phosphorus in wastewater occurs as PO_4^{3-} and is either dissolved or particulate

Chemical and biological P processes convert soluble P to particulate P which can be removed from ww by sedimentation

It is important to consider the impact of P removal on WRRF operations when selecting between chemical and biological P removal

Monitoring of dissolved P, which is mostly orthophosphate, is useful for process control of P removal processes

- Minimizing chemical usage

- Status of release/uptake (EBPR)

Oxidation-Reduction Potential (ORP) can be used to optimize the conditions for EBPR

Questions? Comments? Clarifications?

www.YSI.com

E-mail

robert.smith@xylem.com

tmulcahy@mulcahyshaw.com

mduerr@mulcahyshaw.com

Twitter

@YSIinc

@DrRobYSI

YouTube

<https://www.youtube.com/user/YSIinc>

