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Phosphorus Removal

**Bench Scale and Full Scale Pilots that Result in
Improved Phosphorus Removal**

May, 2015

**Central States Water Environment Association
Annual Conference**



**Presented By:
Troy A. Larson**

Strand Associates, Inc.®

Discussion Points

- *Chemical Phosphorus Removal (CPR) Jar Testing*
 - *Case Studies*
- *CPR Full Scale Test(s)*
- *Biological Phosphorus Removal (BPR) Jar Testing*
- *BPR Full Scale Pilot*
- *BPR Control Strategies (If Time Allows)*

■ Presentation Will Not Focus on Emerging Technologies

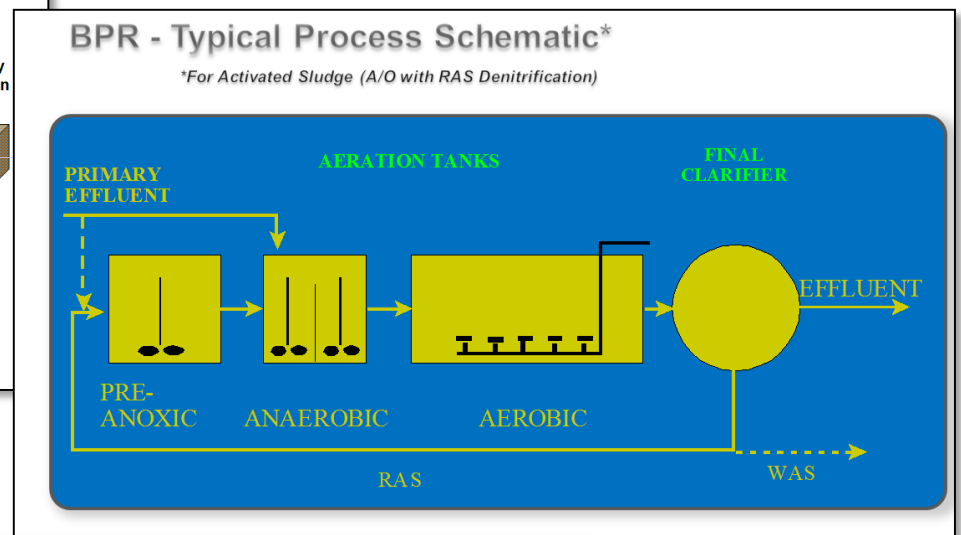
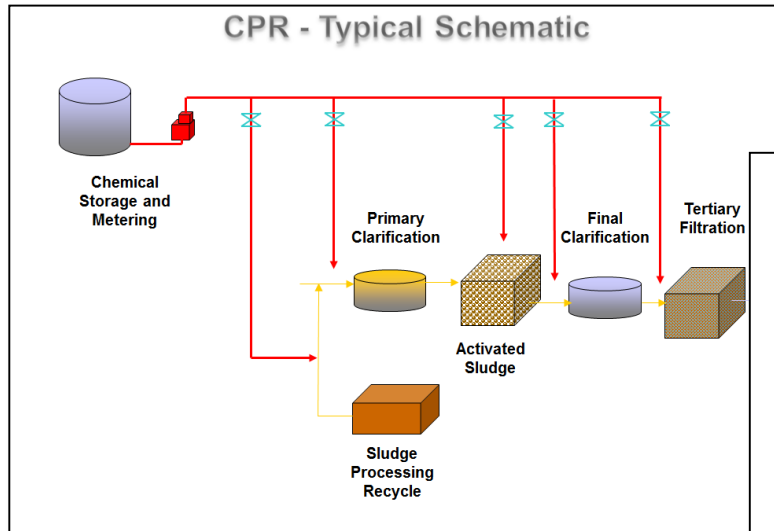


Parkson Pilot - Manitowoc



CoMag Pilot – Fond du Lac

■ Presentation Will Focus on Optimizing Current Technologies



Necessity... the mother of invention.

Plato

Jar Testing Should Provide Lab Scale Simulations of Full Scale Considerations



■ Jar Testing in Proper Context Provides Value

- Strengths of jar testing include:
 - Low cost
 - Easy comparison of many conditions
 - Provides proof of concept
 - Allows communication and training
- Limitations of jar testing include:
 - Jar tests do not always scale-up
 - Long term operation not always reflected
 - Full scale conditions can not always be mimicked

■ Bench Scale Testing for CPR Determines Key Parameters

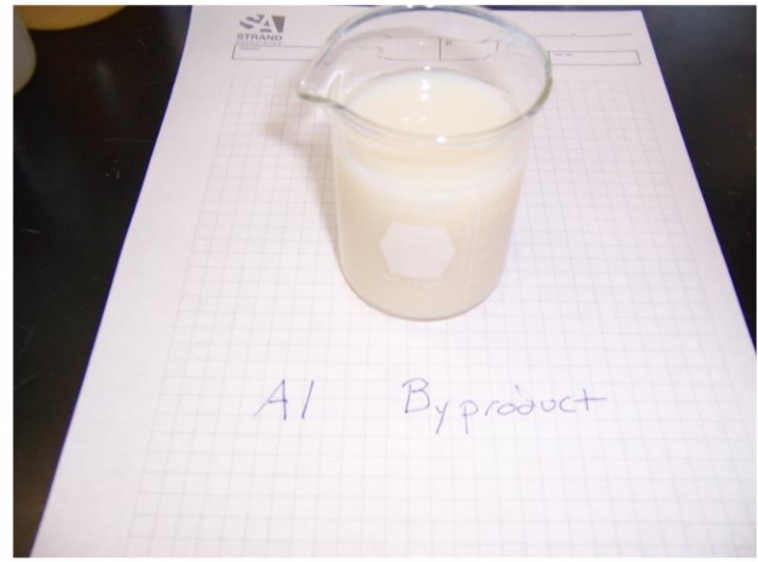
- Precipitation/Adsorption Reactions
- Dose Rates and Costs
- Side Effects
 - pH Depression
 - Alkalinity Loss



■ Jar Testing Allows Low Cost Comparisons

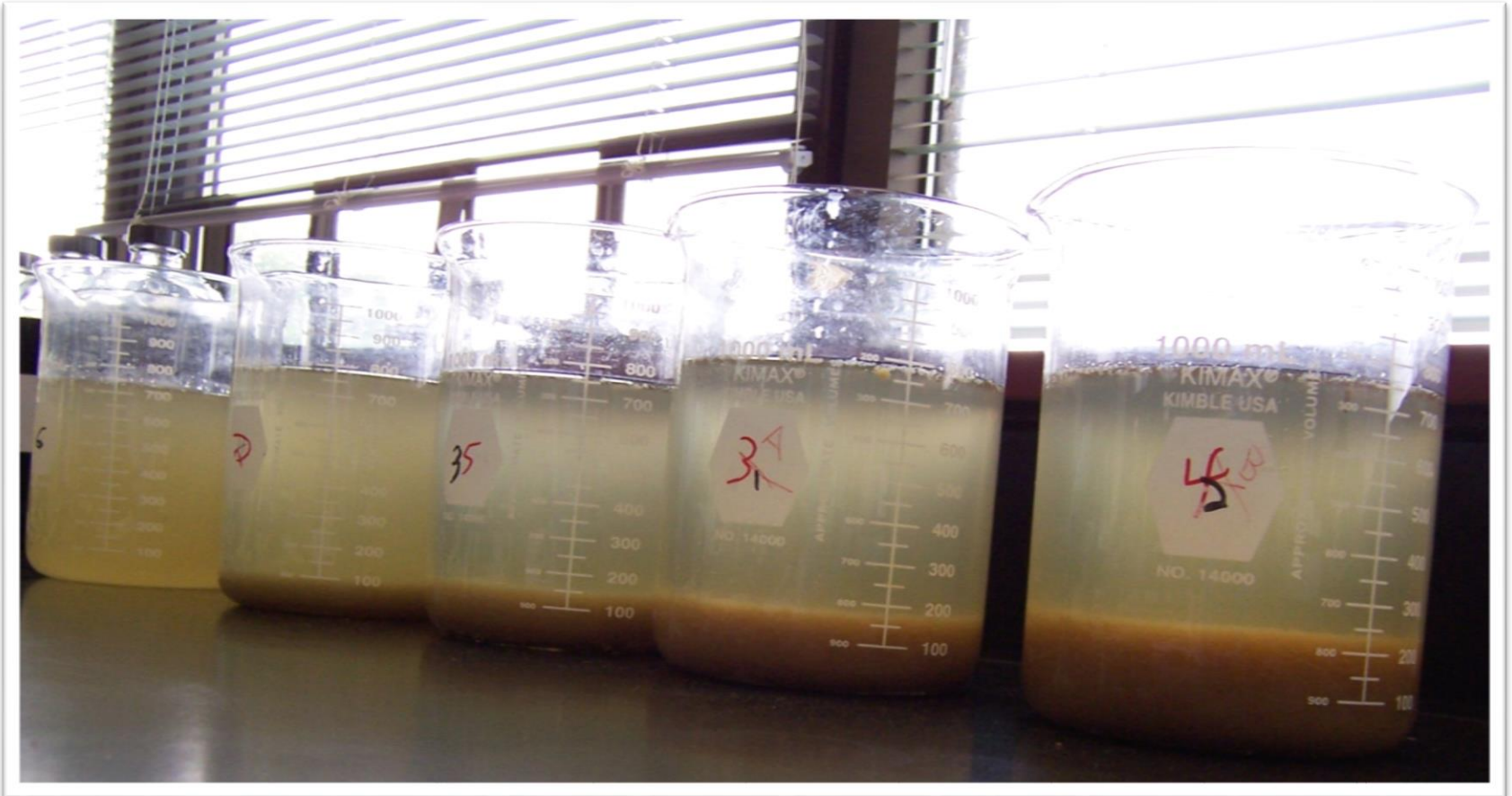


Left to Right – Ferric Chloride, Alum, SorbX



Aluminum Byproduct

Jar Testing Provides Visual Comparisons



Impacts on Sludge Production

Jar Testing Provides Visual Comparisons



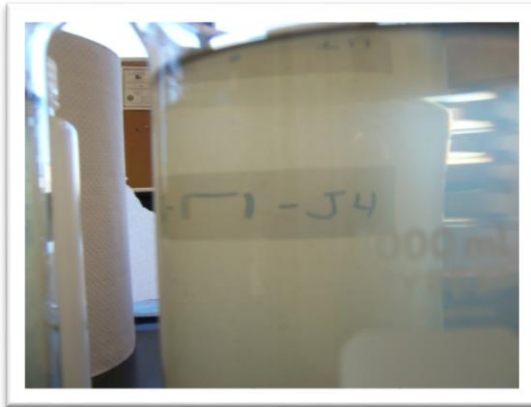
Jar 1



Jar 2



Jar 3



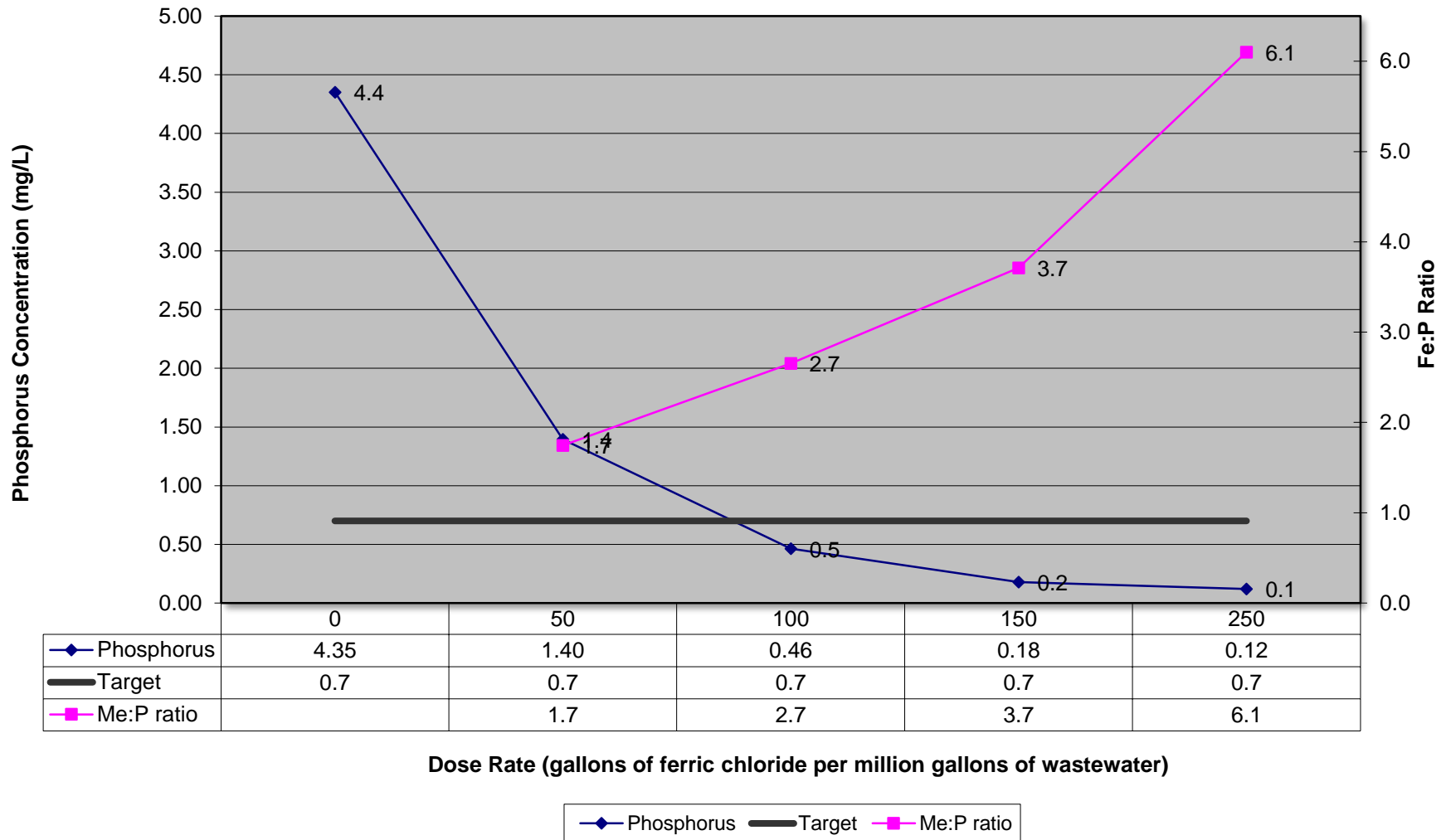
Jar 4



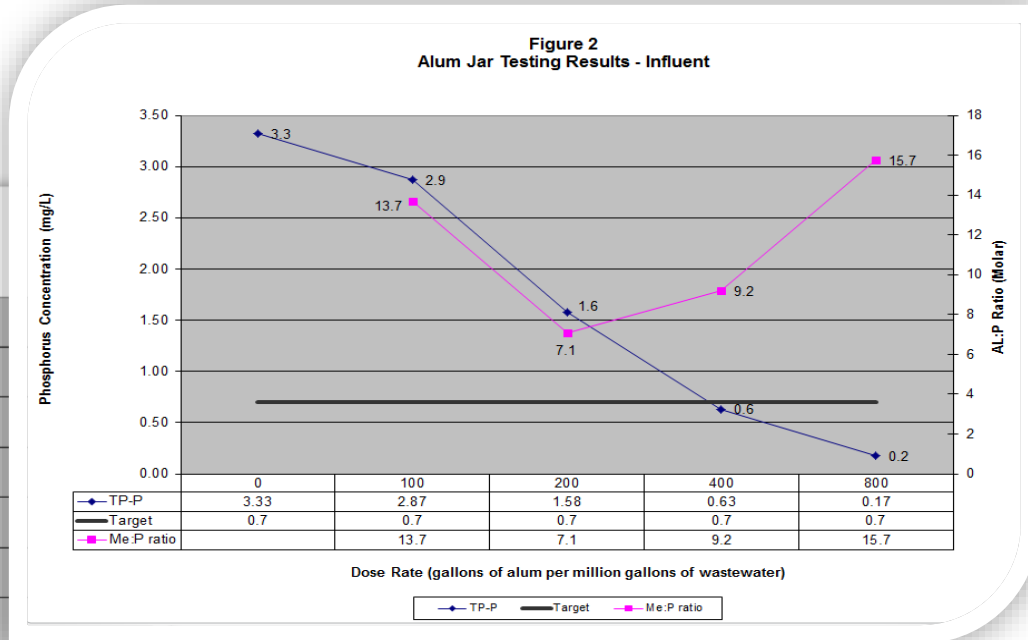
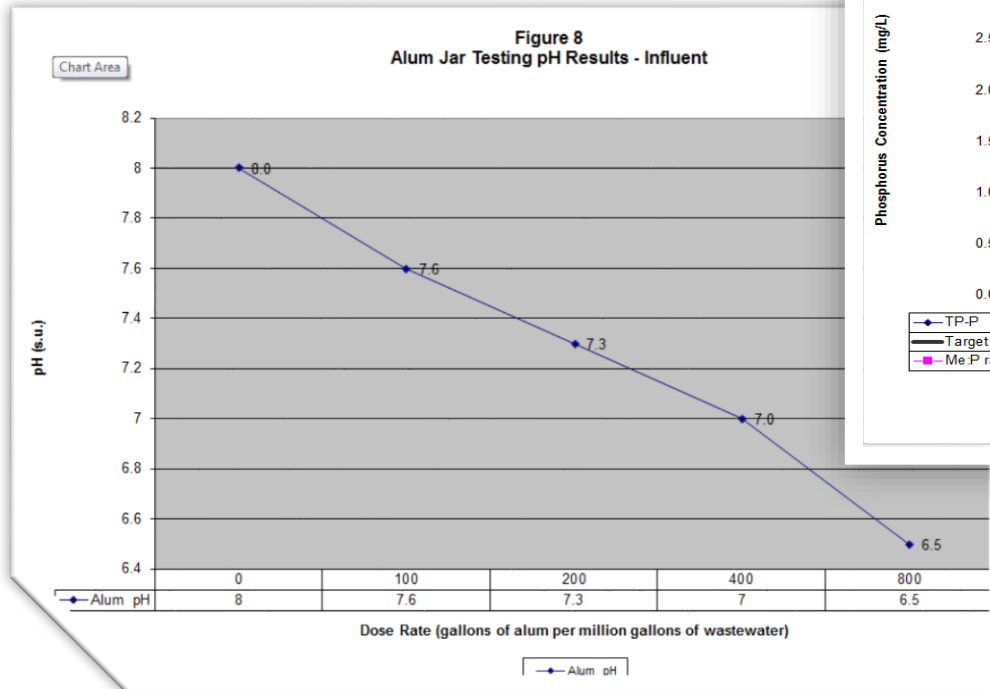
Jar 5

Typical Jar Test Result

Ferric Jar Testing Results

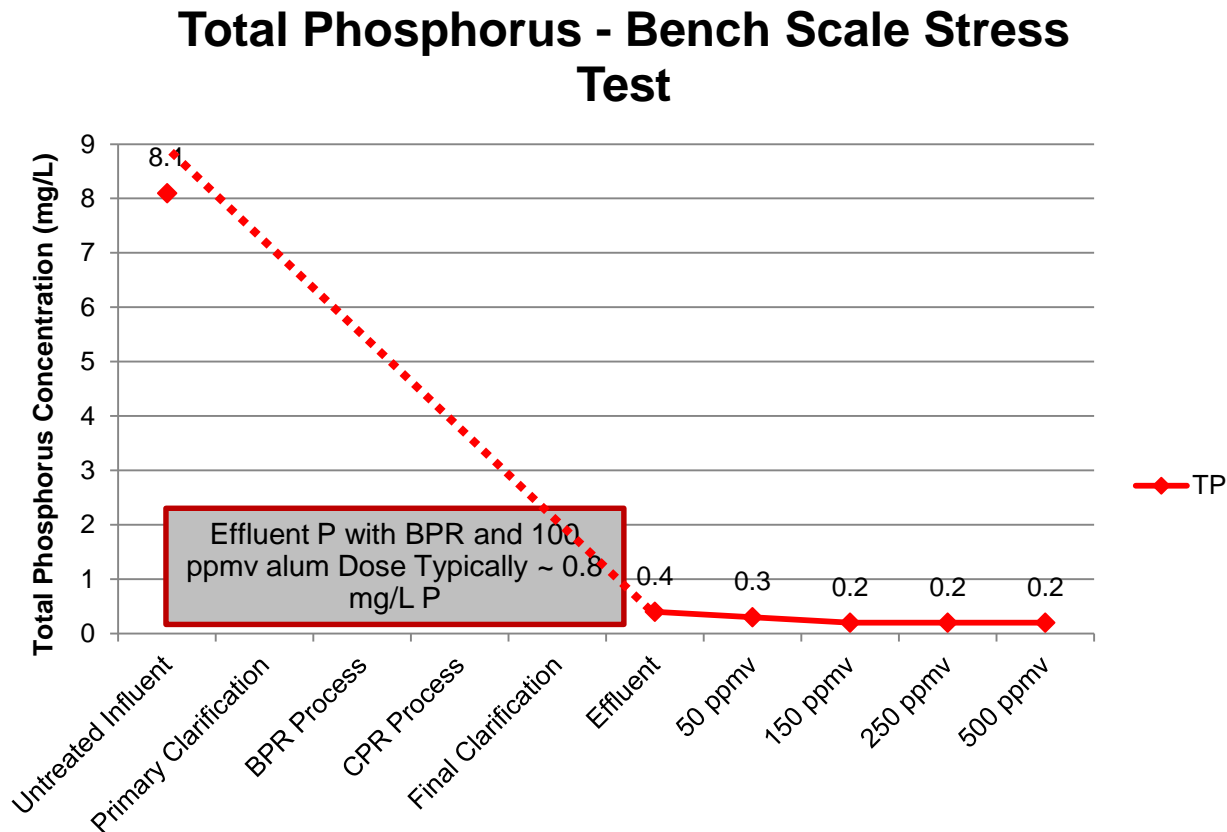


High pH Results in High Chemical Needs



Jar Stress Tests Can Isolate Performance

- Samples Filtered
- Lowest P level achievable

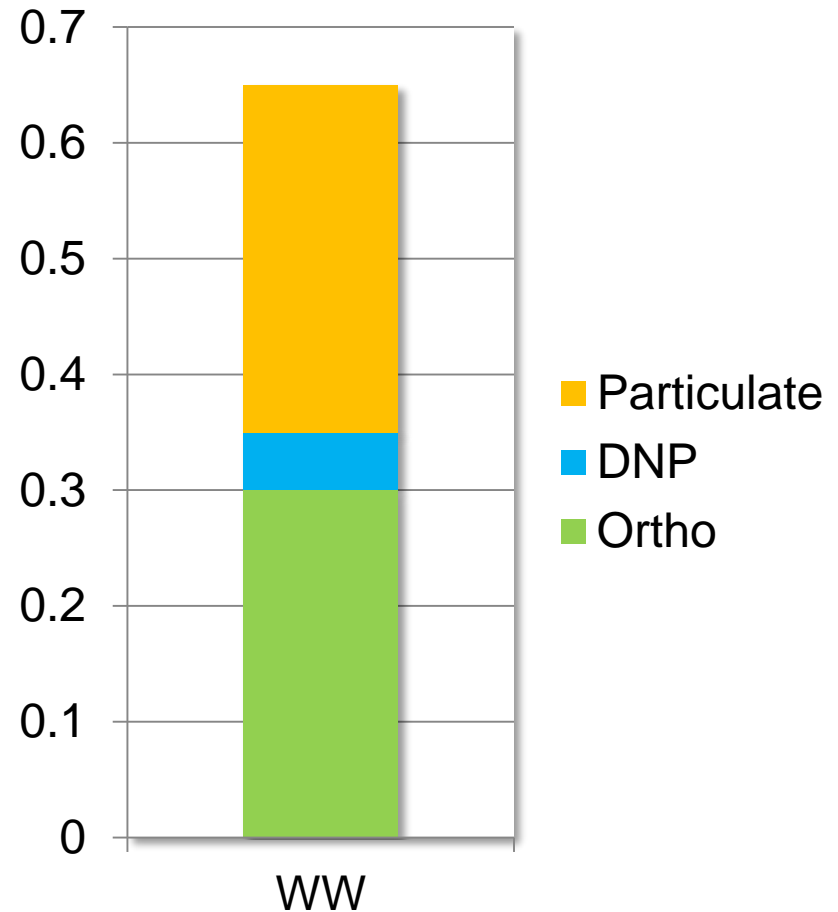


■ Proper Phosphorus Characterization Provides Targeted Actions

Particulate P = TSS Removal

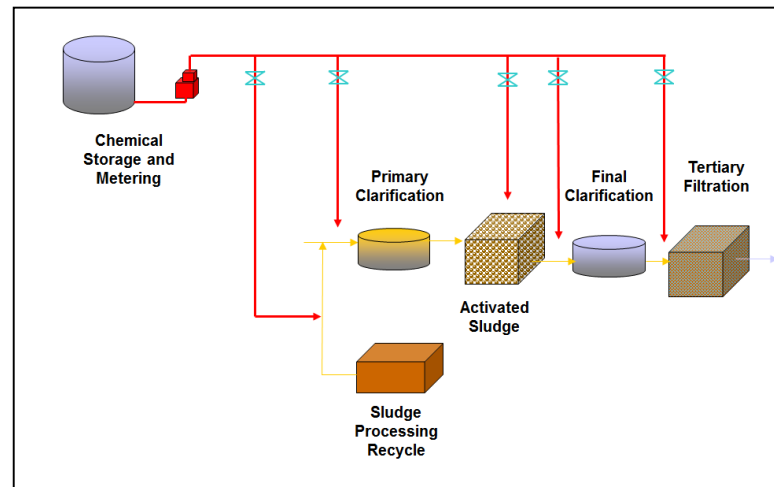
**Dissolved Non-reactive P =
Source Control**

**Ortho P = Create Particulate
P (BPR or CPR)**



CPR Pilot – Multiple Application Points

- Multiple Application Points
 - Reduce losses to competing reactions
 - Potentially develop residual value in multiple systems
 - Inherent redundancy



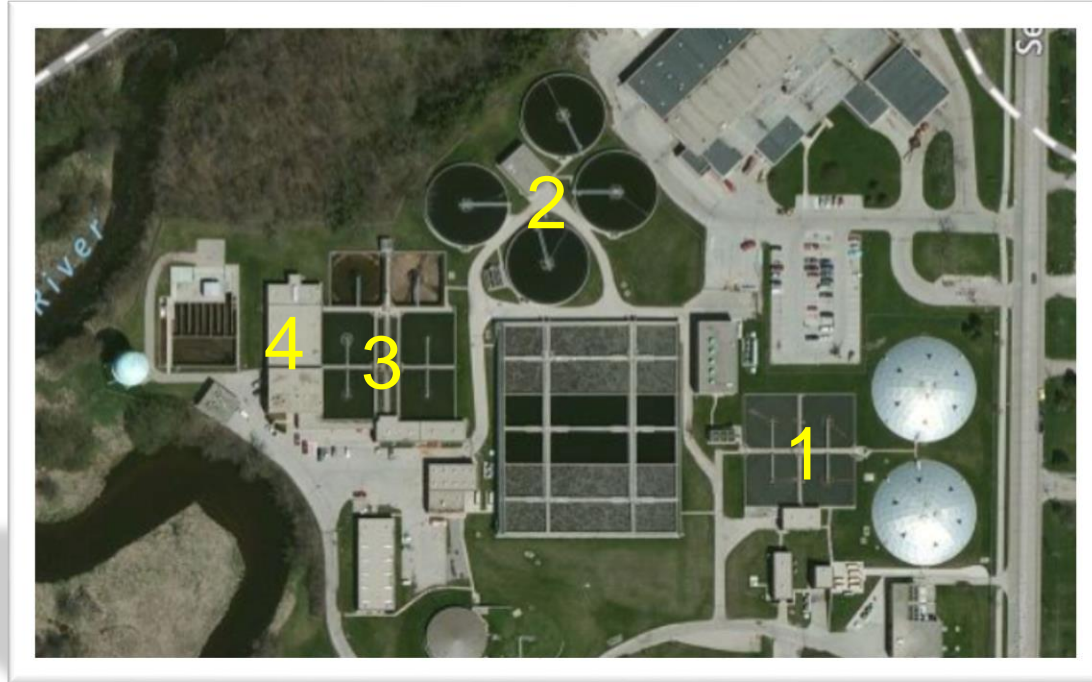
Pilot Considerations

- Cost Considerations
 - Consumables such as chemical
 - Engineering
 - Lab
 - Manpower
 - Utilities
 - Capitol Improvements
- Repeatability and/or Isolation
- Full Scale or Full Time Implementation
- Effluent Quality
 - Reliability
 - Exit/Termination Planning

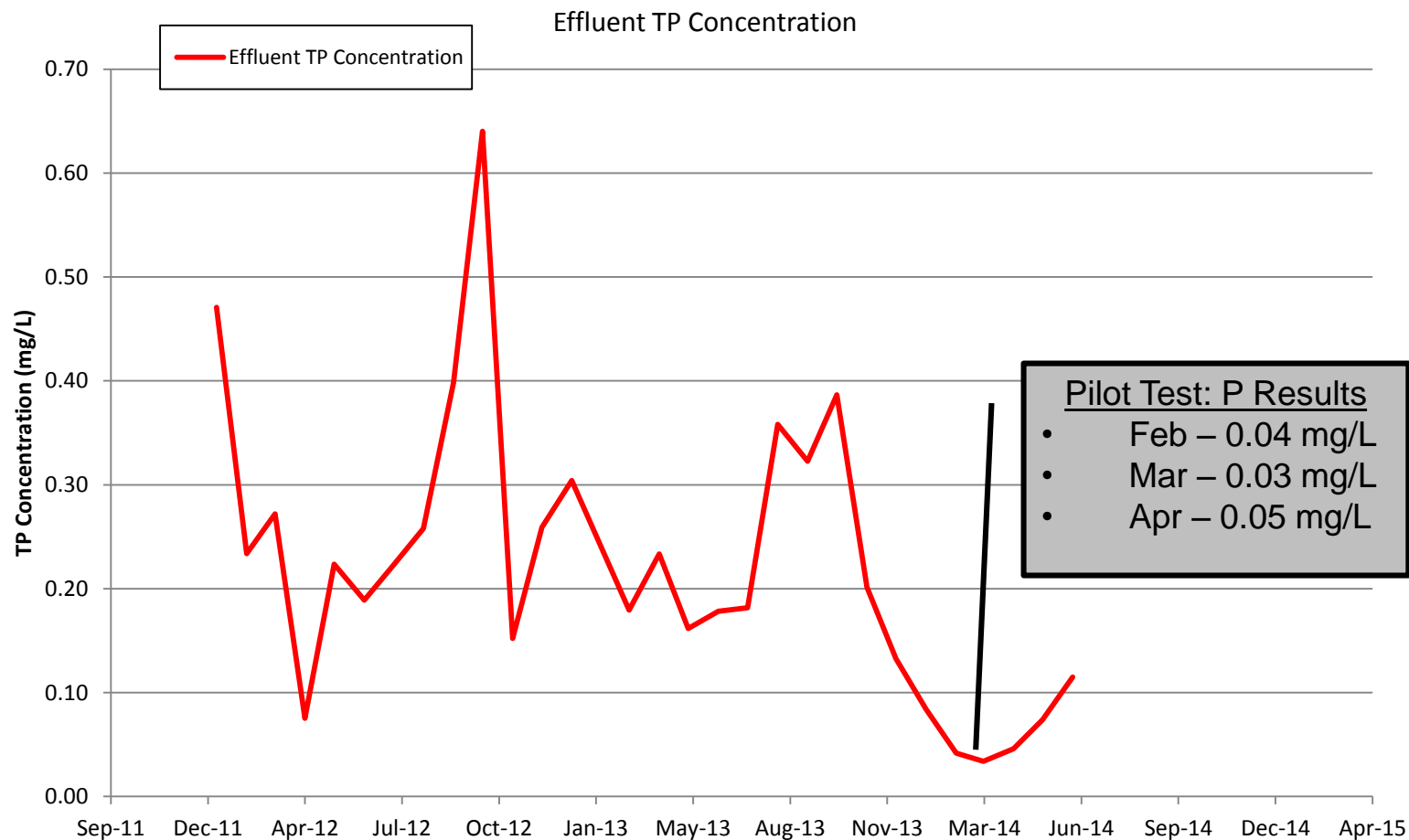
■ Each Facility Offers Unique Opportunities

Phosphorus is removed where solids are removed, such as:

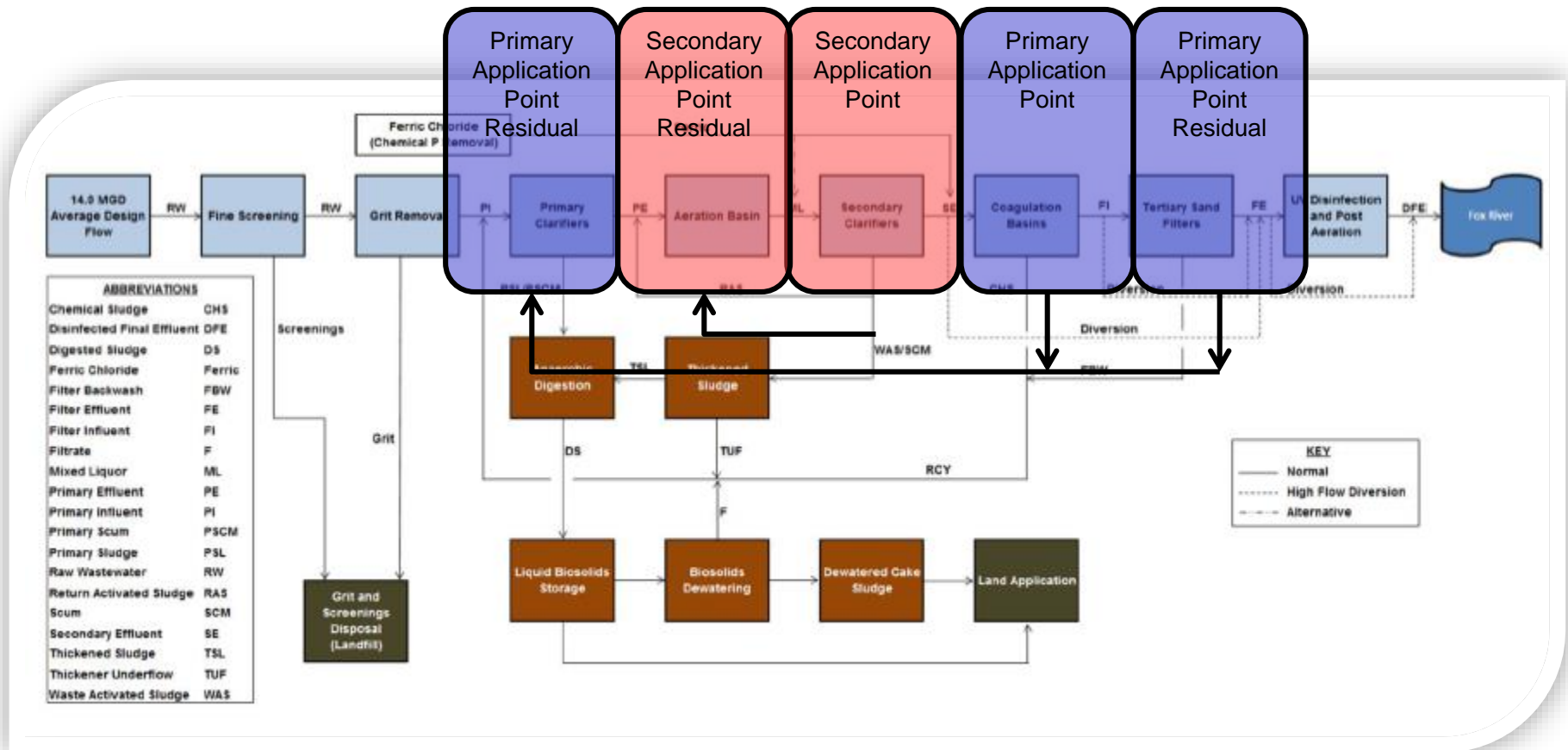
1. Primary clarifiers
2. Secondary clarifiers
3. Tertiary clarifiers
4. Filters



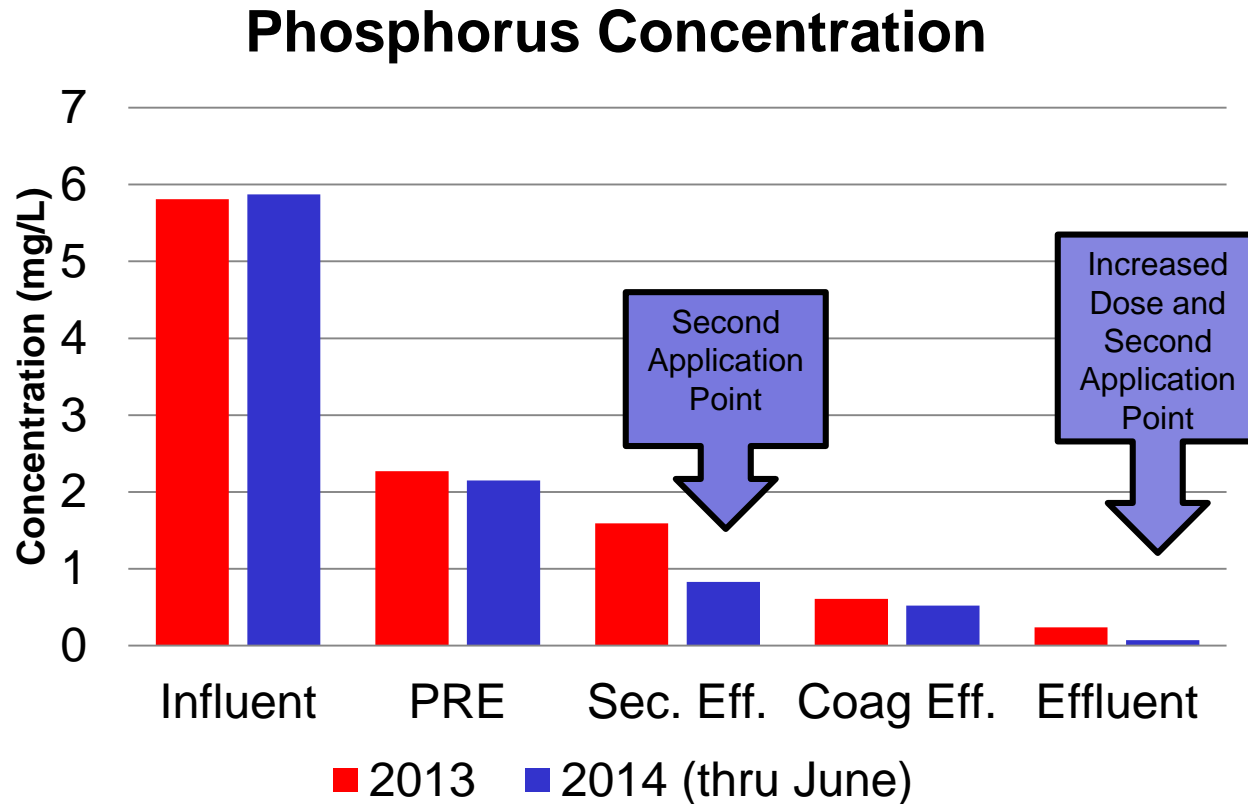
Baseline Data



Multiple Application Points Result in Multiple P Removal Mechanisms



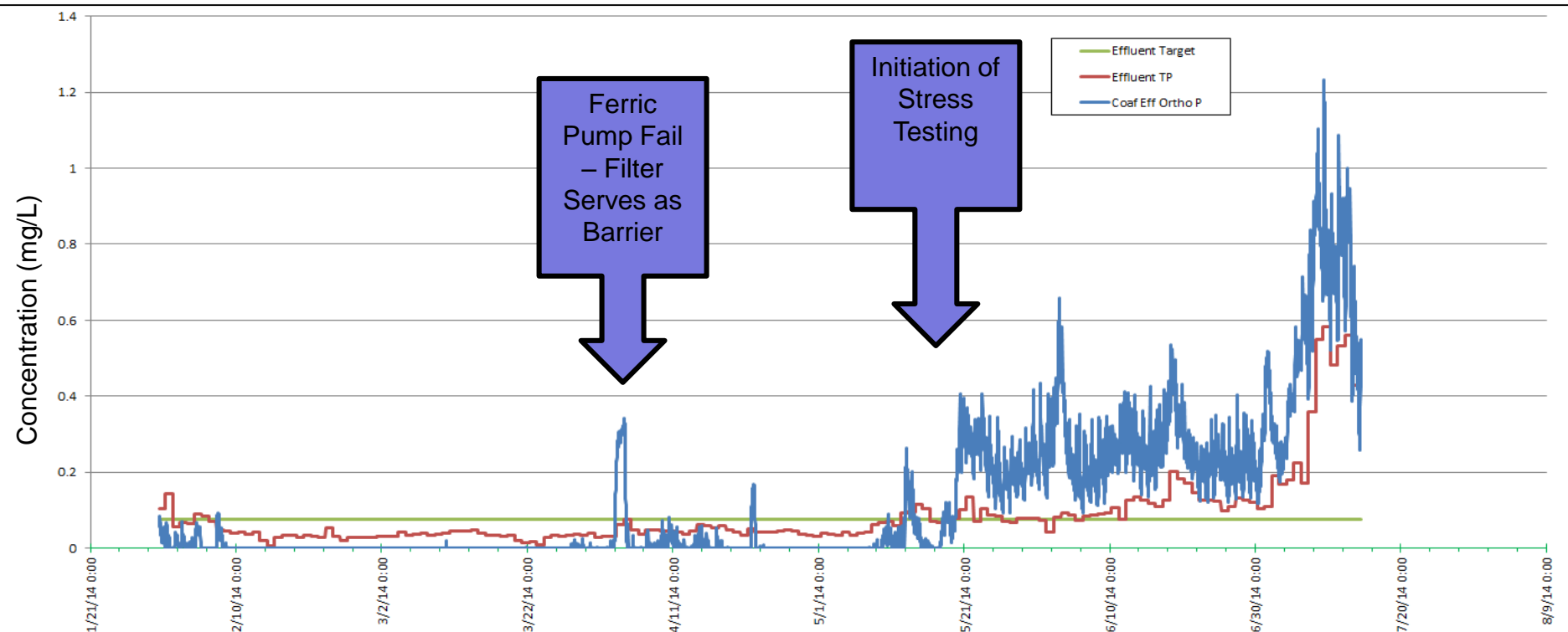
Understanding Removal Mechanisms Improves Process Understanding



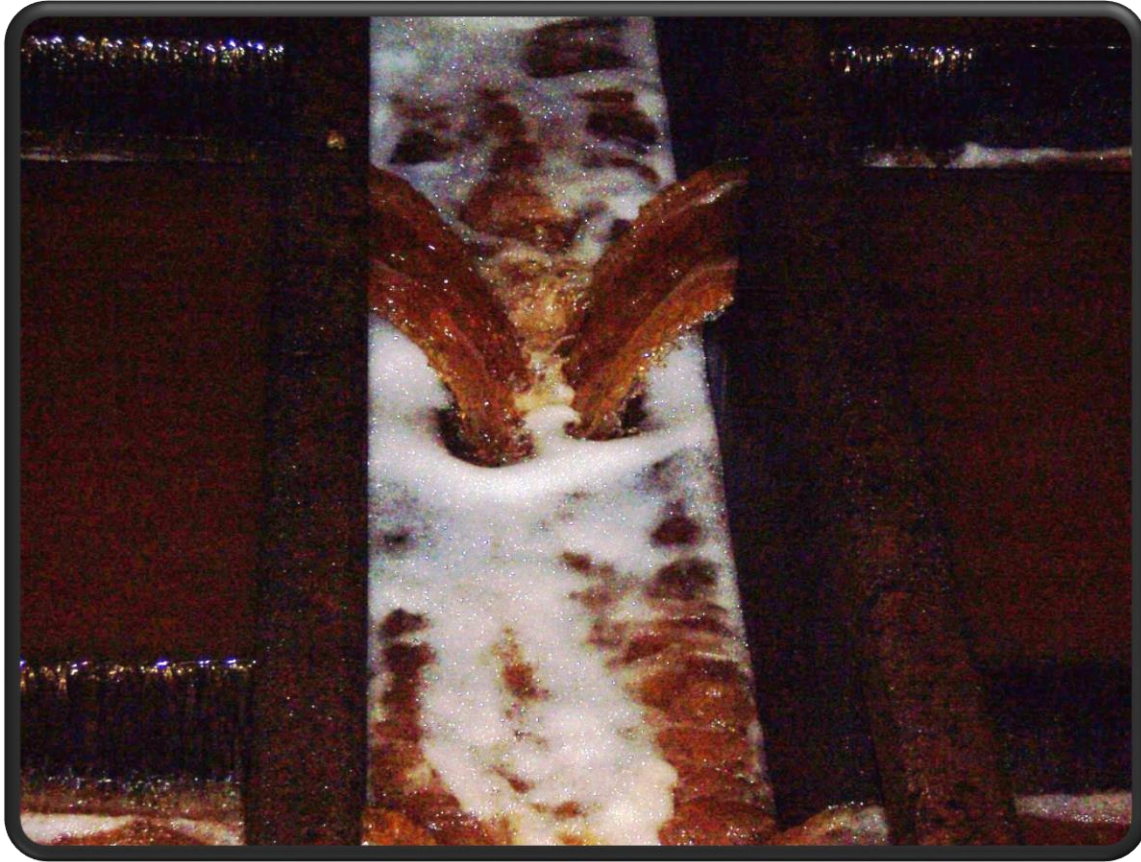
■ Waukesha – Monitoring: Upstream of Filter



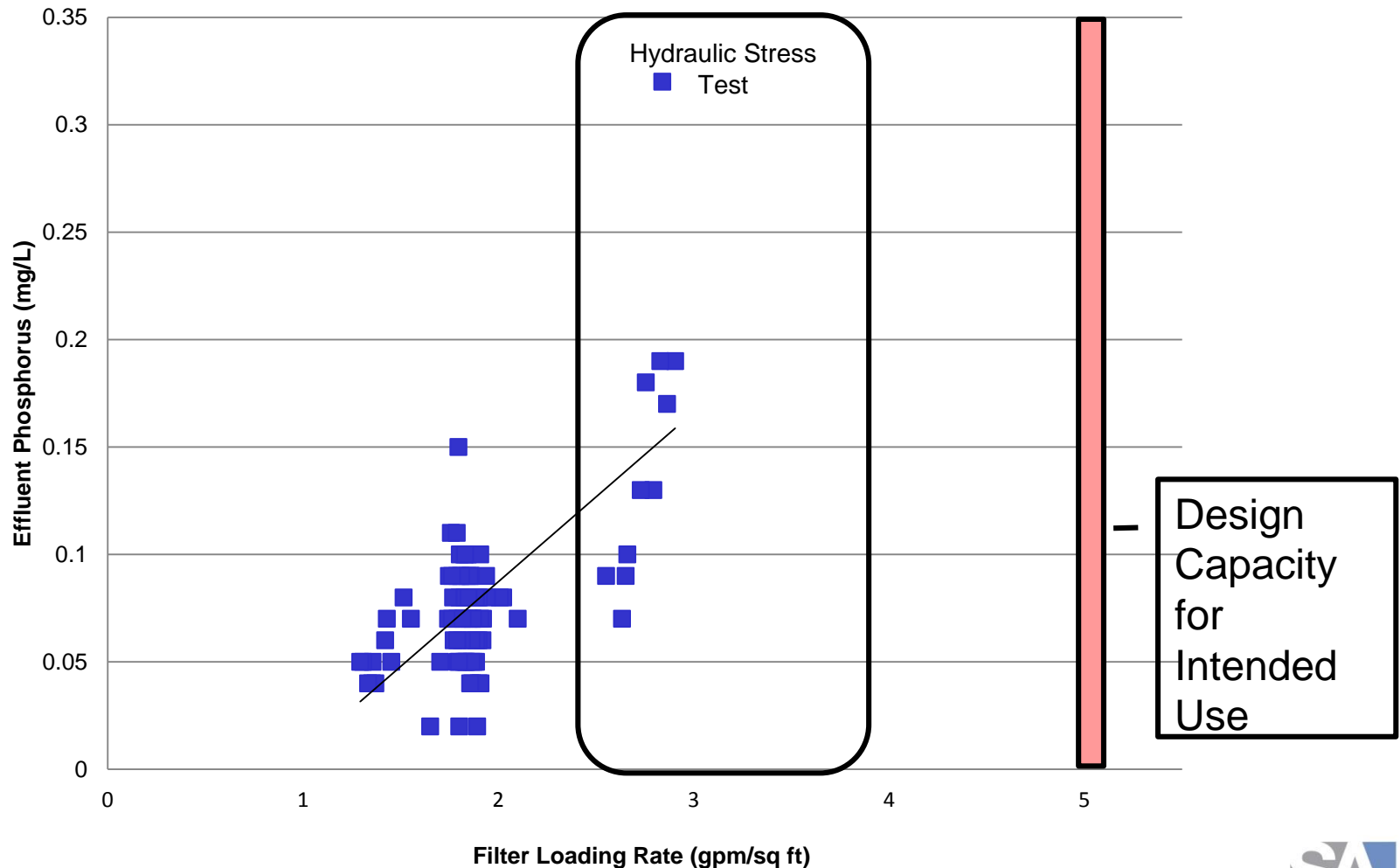
Full Scale Test and Stress Test



■ Filter (Backwash)

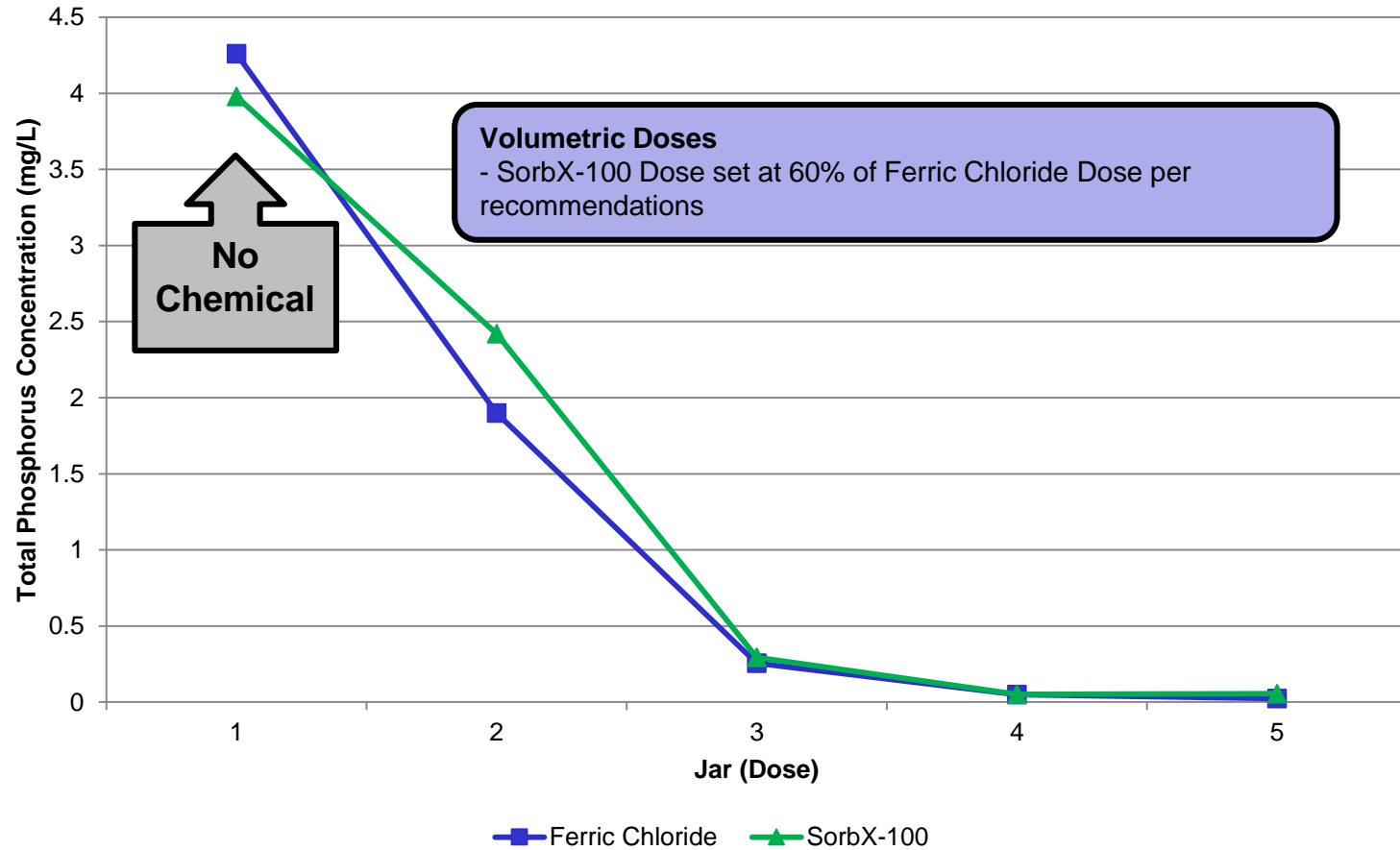


Filter Loading Impacts Performance Reliability

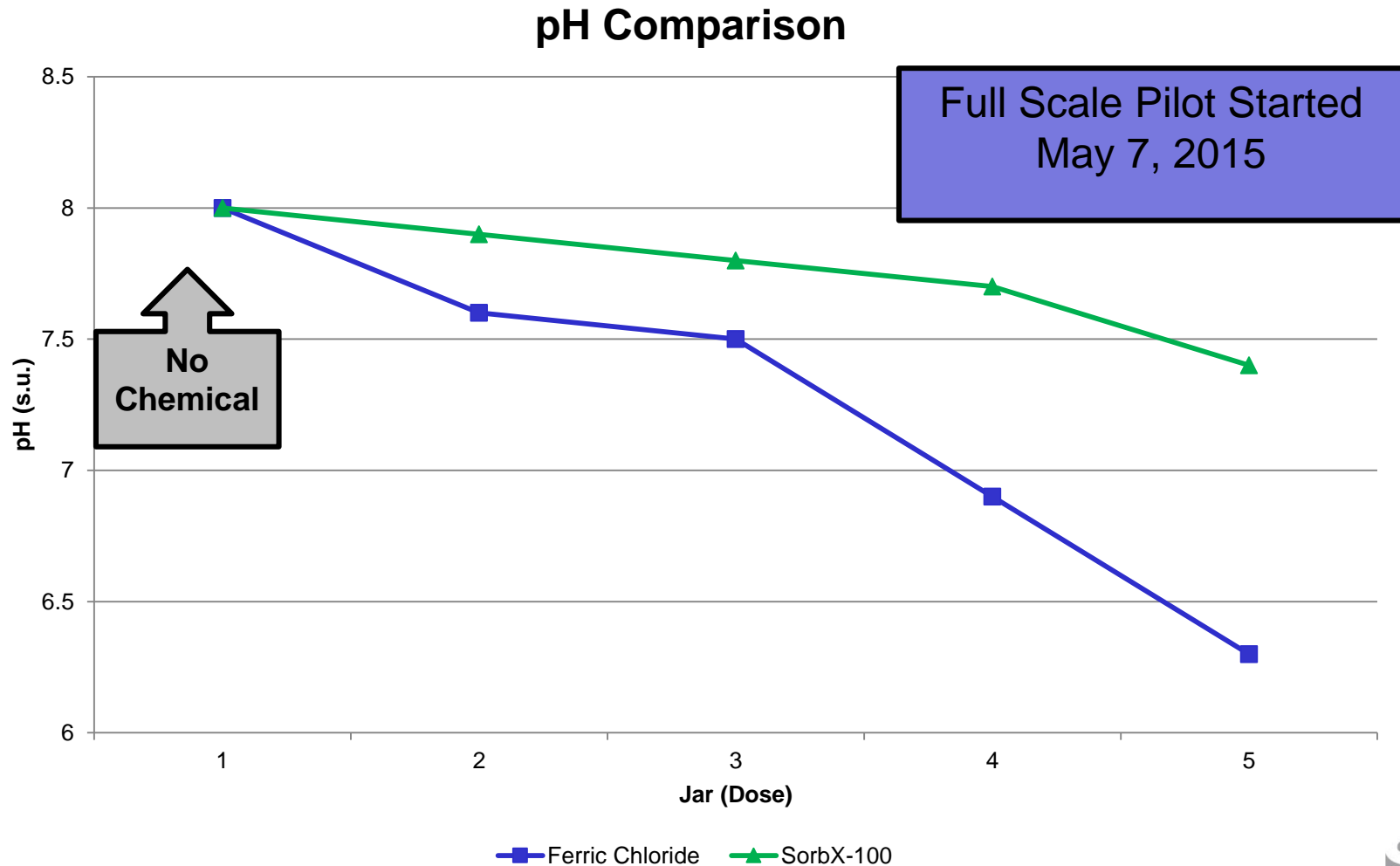


Jar Test Validates Interest In Full Scale Pilot

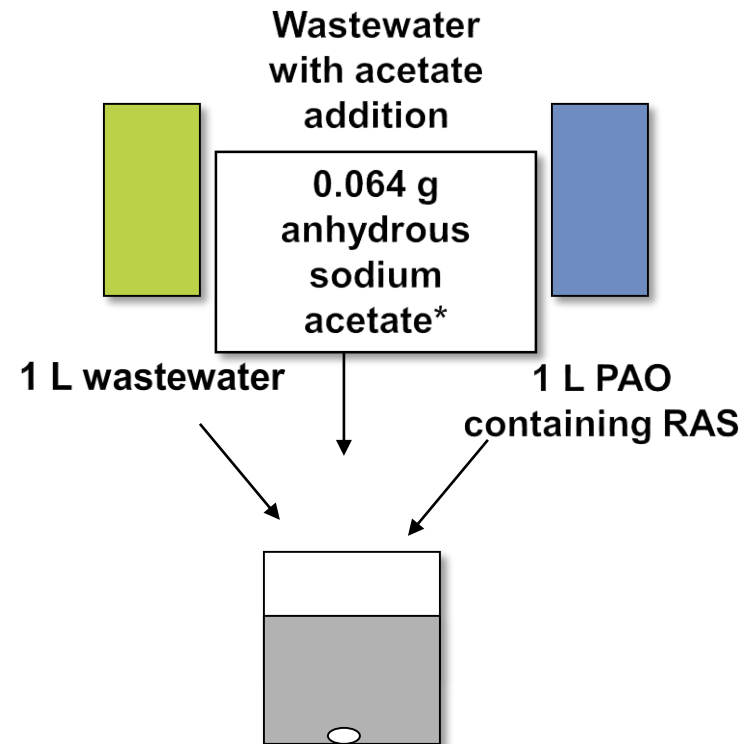
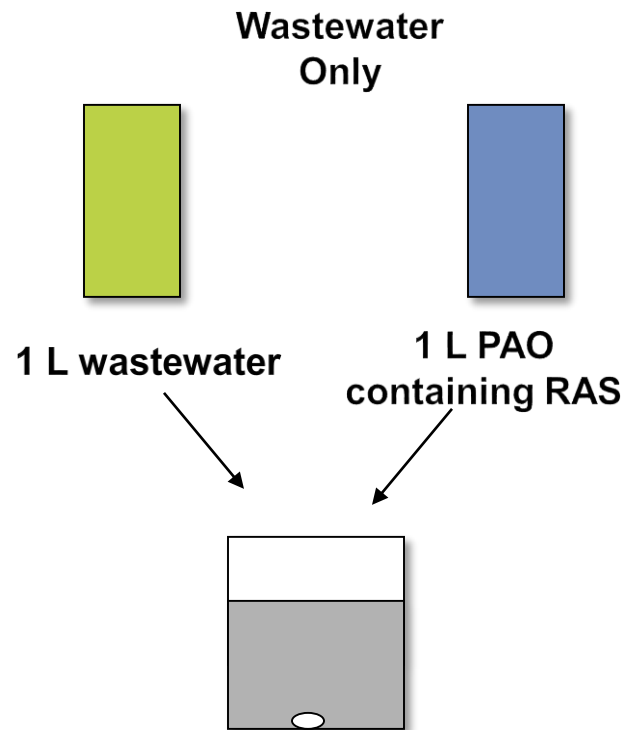
Chemical Jar Test



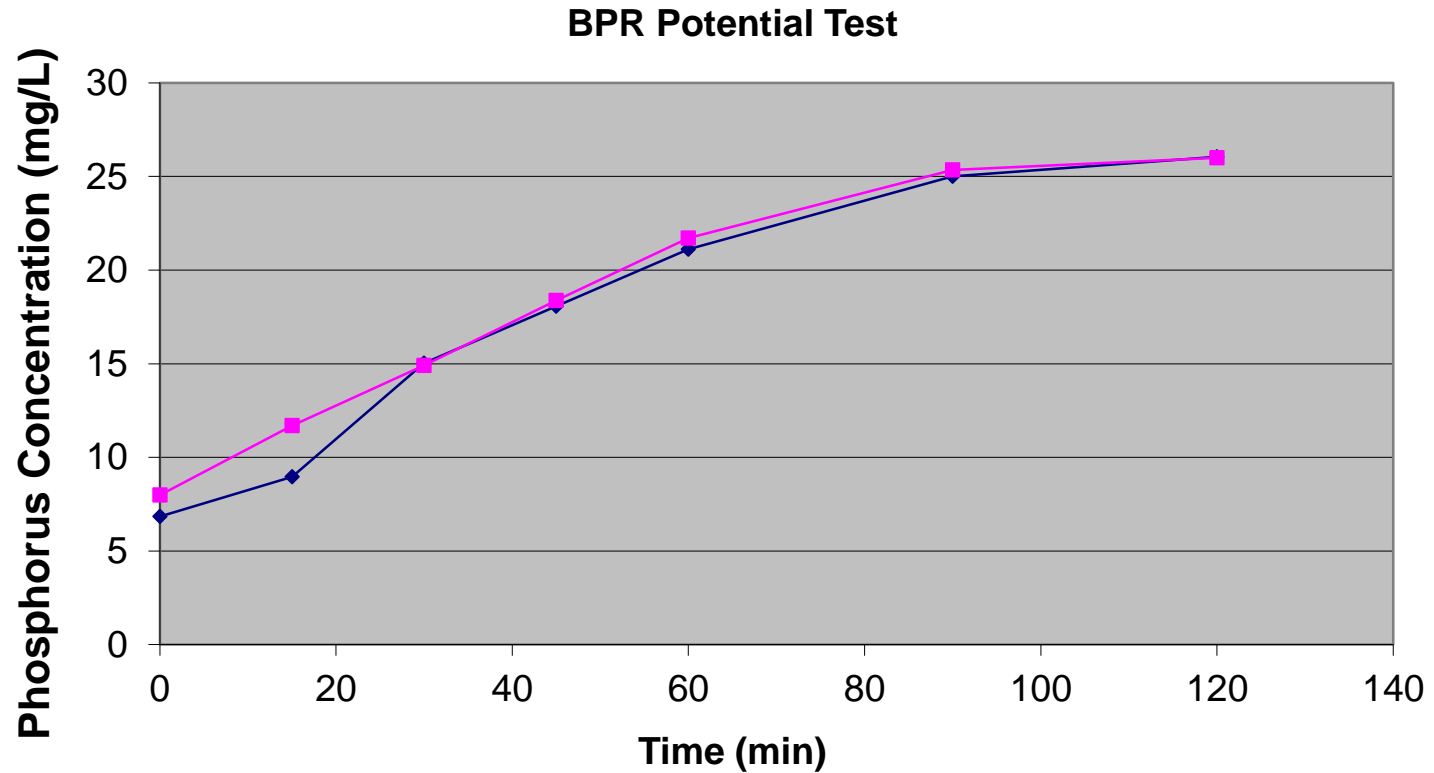
Jar Test Validates Interest In Full Scale Pilot



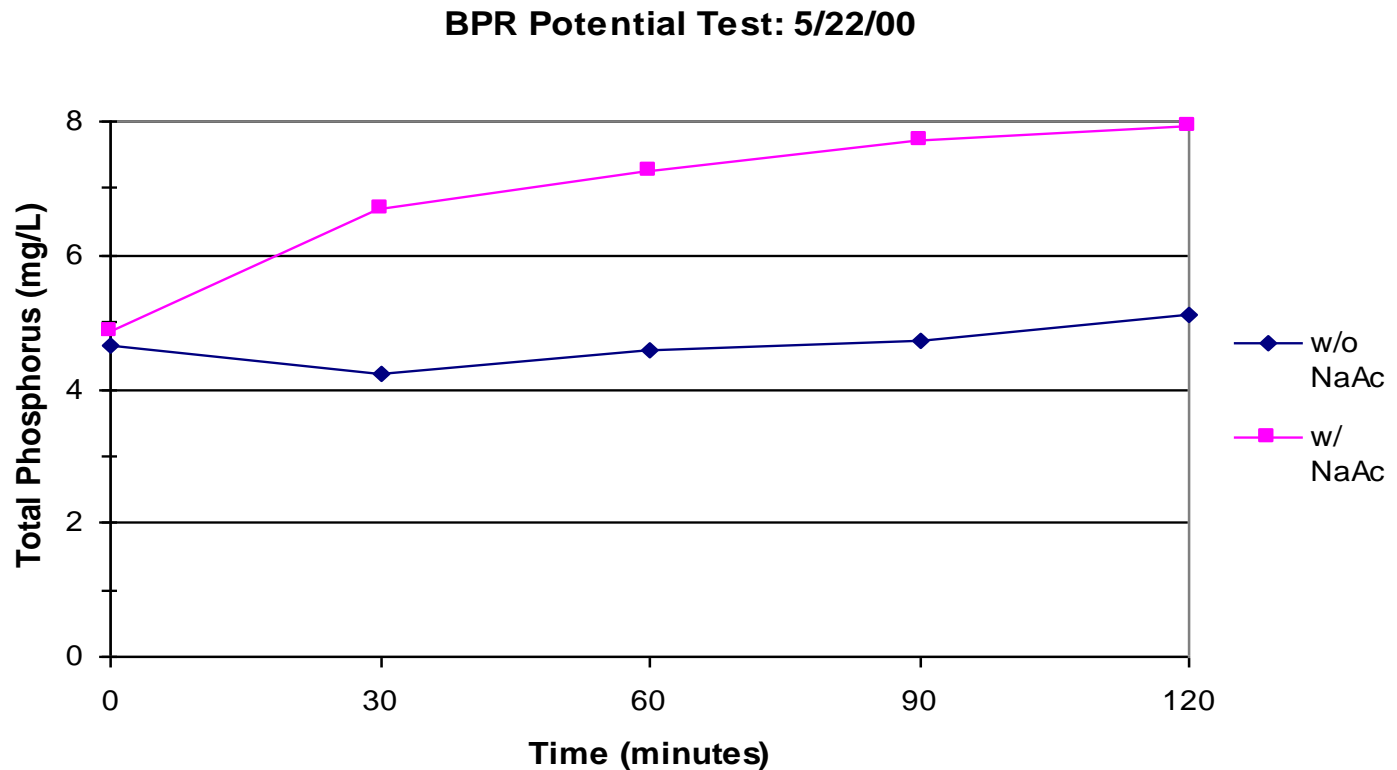
Biological Systems Can be Tested at a Bench Scale



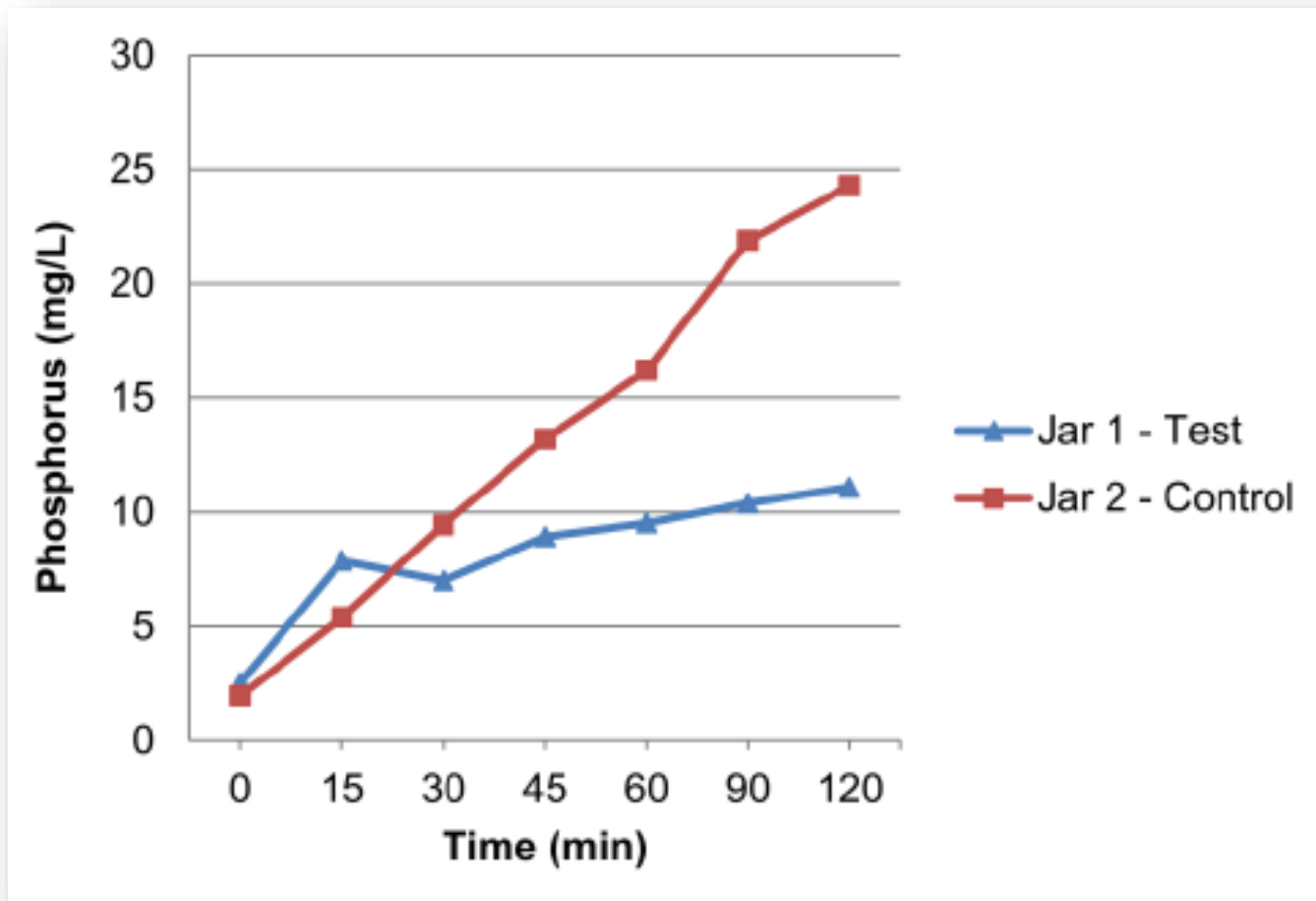
BPR Bench Scale Testing Results



Wastewater Characterizations - BPR Not Recommended



■ Wastewater Characterizations – BPR Recommended, Side Benefits Desired



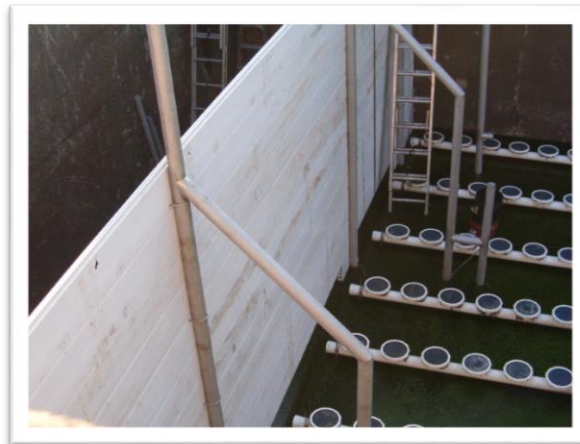
BPR Pilot Tests Can Focus on Full Scale Trials With Little Capital Expenditure



■ Full Scale Testing

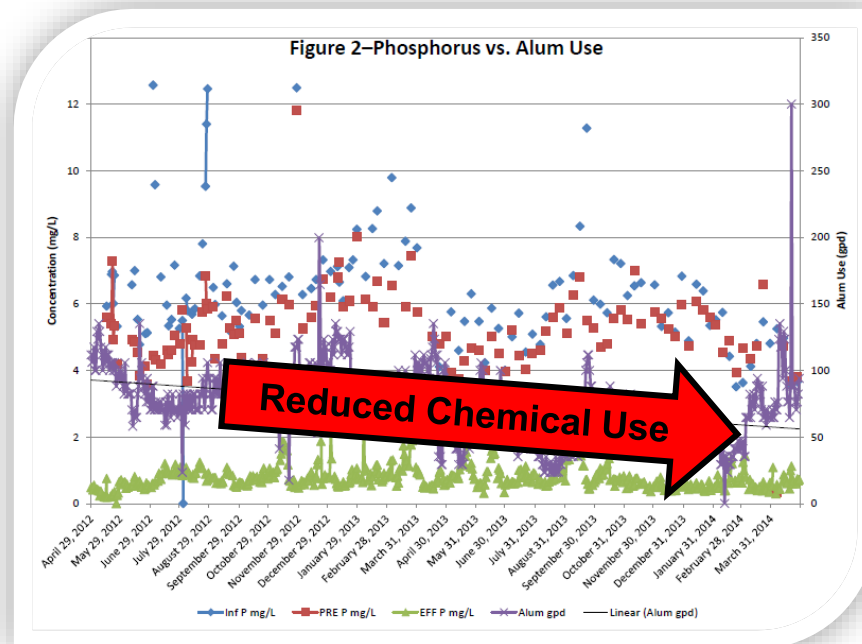
Full Scale BPR Testing in Conventional AS Plants

- Install cloth, wood, or block baffle walls and submersible mixers for ~2 zones; turn off air to zones
- Install temporary or permanent gates/piping as needed to route PRE/RAS where needed
- Measure SBOD, PO_4 , nitrate, and DO at various locations
- Monitor changes in sludge production and settleability/dewaterability



Pilot Goal – Reduce Chemical Use

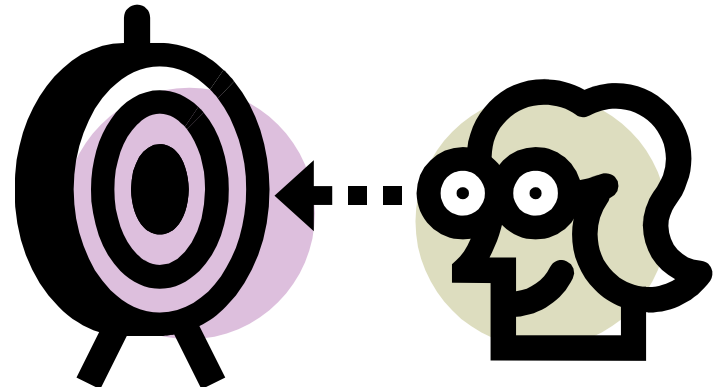
	Alum	Caustic
Pre-Pilot	80 to 120 gpd	20 to 30 gpd
Post-Pilot	20 to 80 gpd (Occasionally 0)	0 to 5 gpd (Typically 0)
Typical Observed Chemical Use		



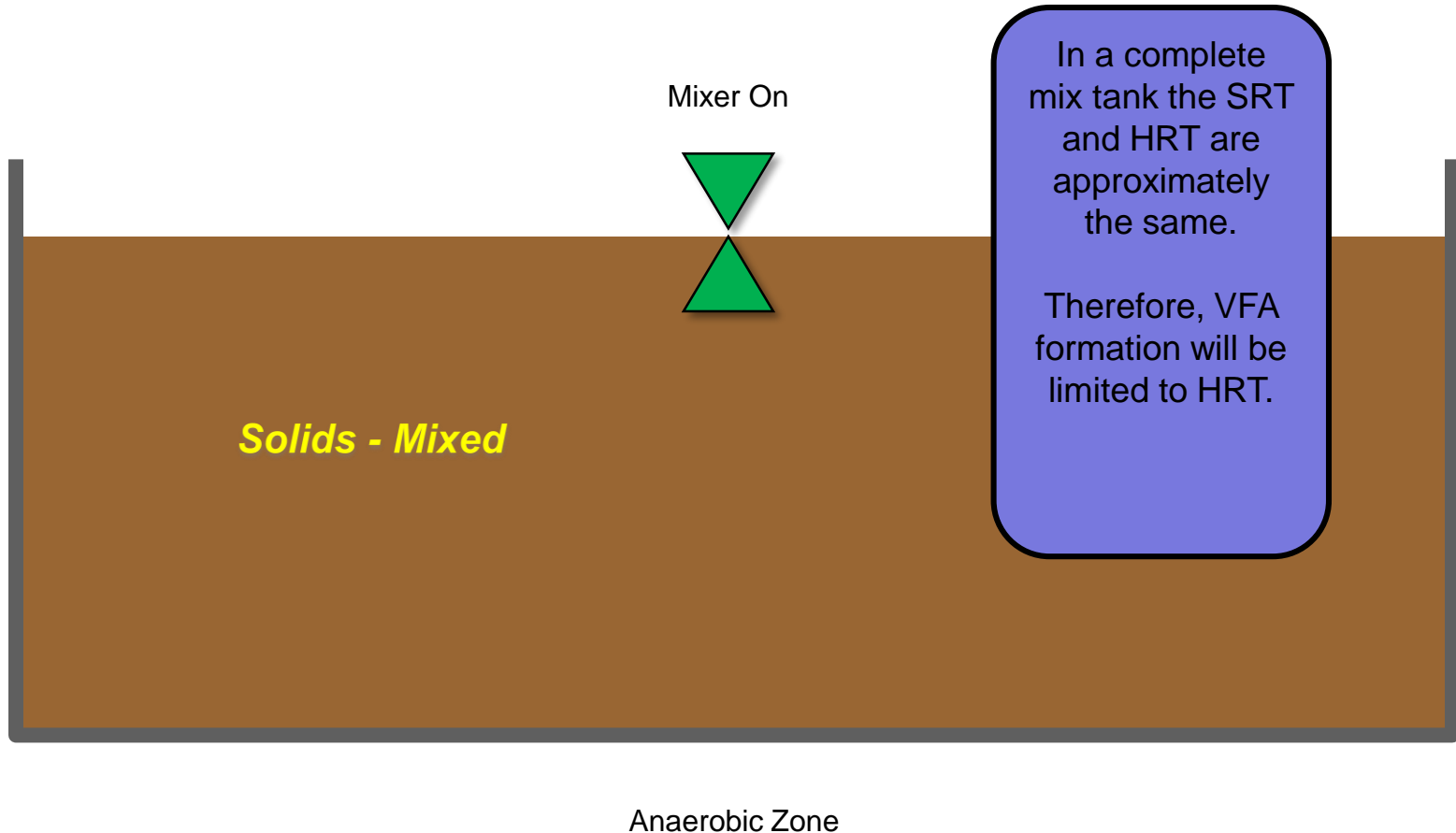
Target Key Process Mechanisms by Piloting Operational Adjustments

Control Parameters

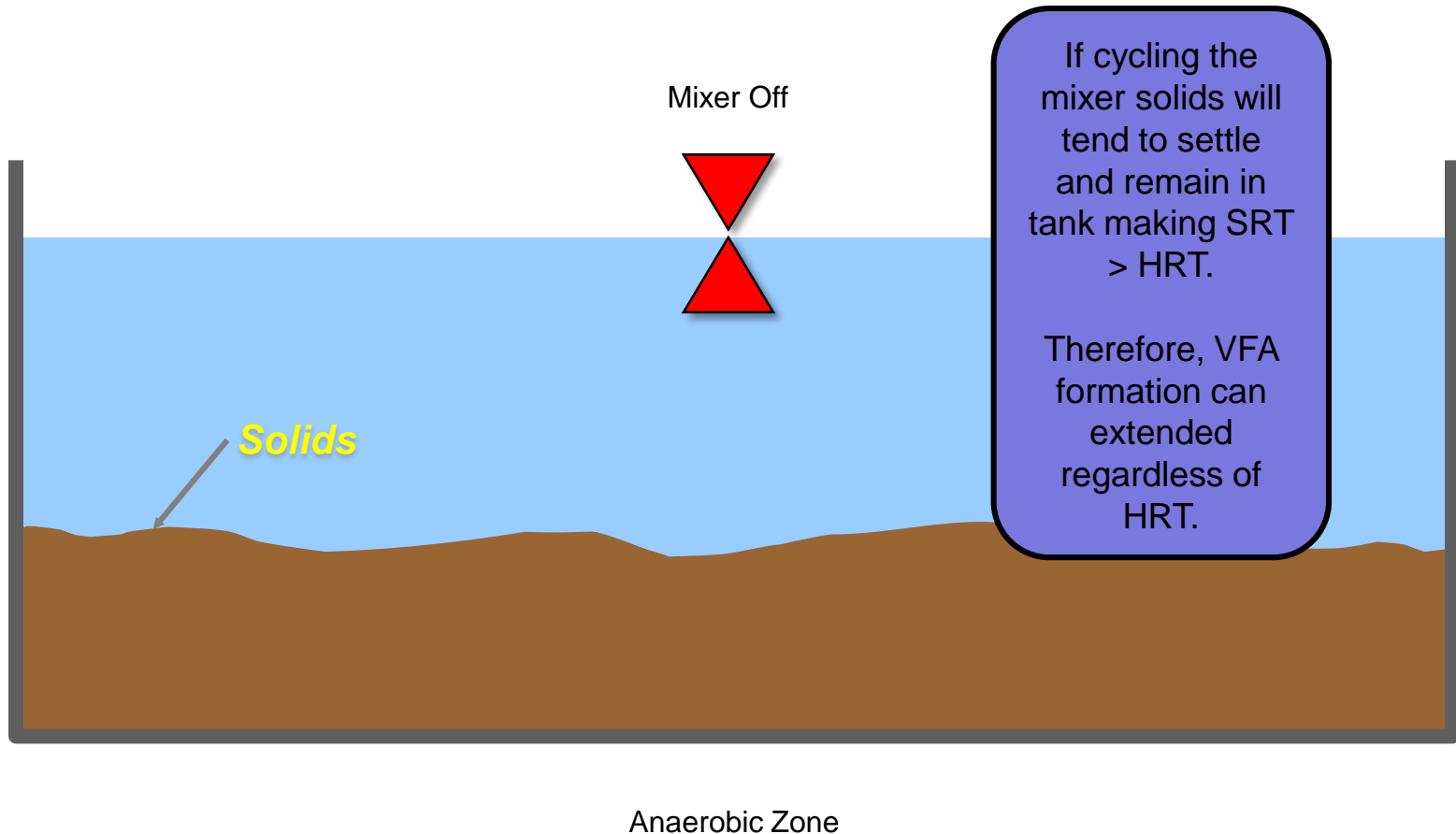
- Aeration
- Return Activated Sludge
- Wasting
- Internal Recycles



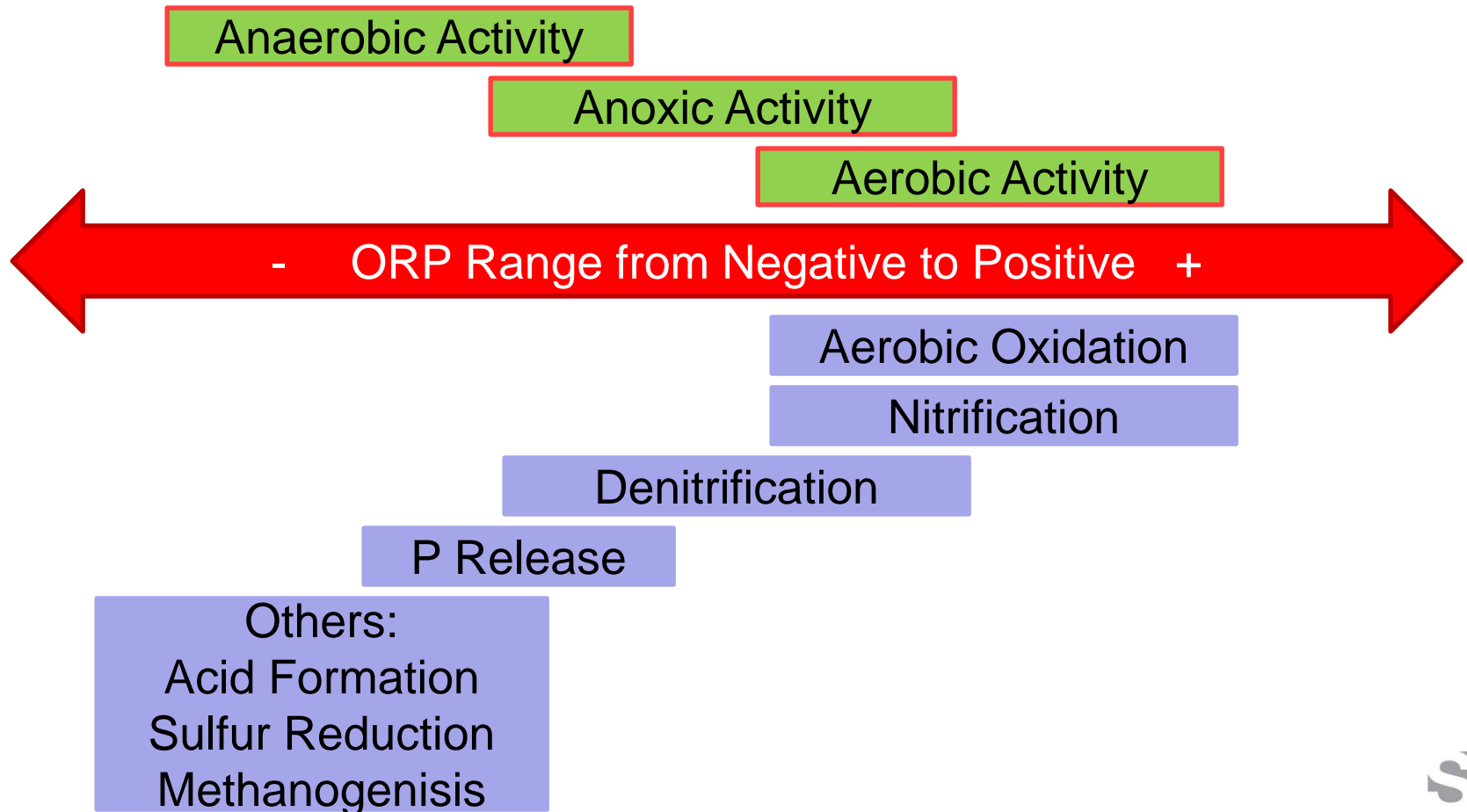
■ BPR Pilot Element – Mixer Cycling



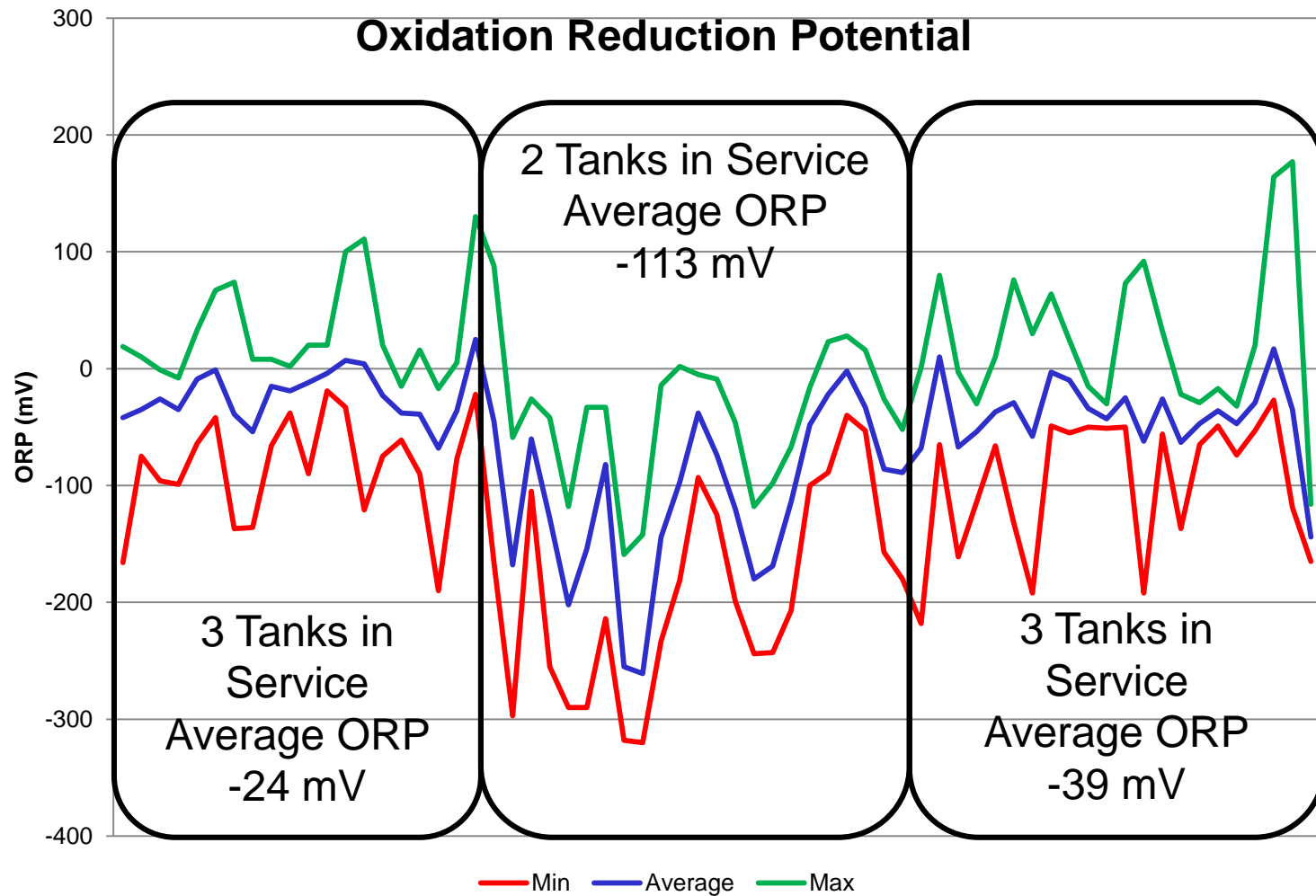
■ BPR Pilot Element – RAS Rate Control



■ ORP Provides a Spectrum of Biological Activity



Capacity Impacts Environments



Acknowledgements

- Rachel Lee – Strand Associates
- Ken Bloom – Marathon City, WI
- Jeremy Cramer (and staff) - Fond du Lac, WI
- Jeff Harenda, Randy Thater - Waukesha, WI
- Terry Vanden Heuvel – Merrill, WI

Summary

- Piloting operational changes can provide greater understanding of facility and improved performance.
- Jar scale testing can aid in training and proof of concept analysis.
- Impending phosphorus limits has contributed to improvements and increased knowledge base...
- ...you wont know if you don't try.



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