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A Phosphorus Deficit? – Impacts of Substrate Composition and Nutrient Supply on a Municipal/Industrial Activated Sludge System

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Outline

- Background Information
- Description of Problem and Potential Causes
- Potential Solutions
- Proof of Concept Pilot

Background Information



Background Information: Treatment Train

Forward Flow

- Screening
- Grit Removal
- Primary Clarification
- Moving Bed Bioreactor
- Activated Sludge
- ***Final Clarification***
- UV Disinfection

Biosolids Flow

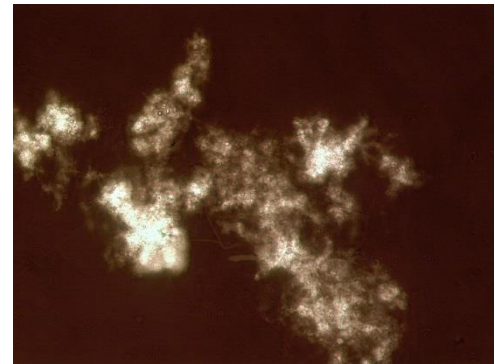
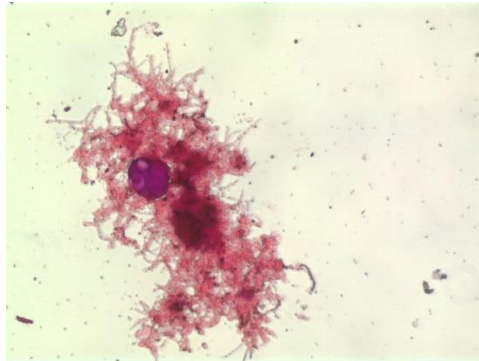
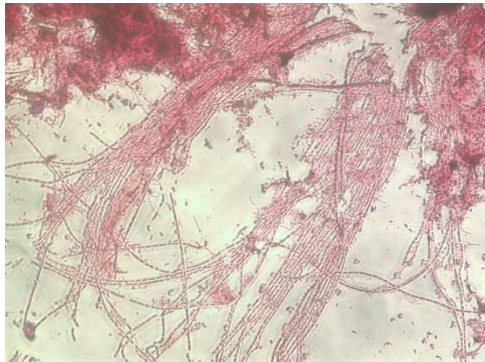
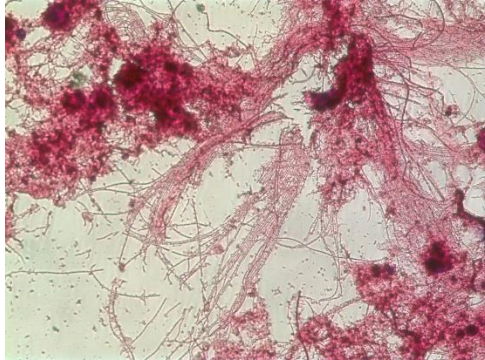
- Primary Sludge Pumping
- ***WAS Thickening***
- TPAD Anaerobic Digestion
- Biosolids Dewatering

Background Information: Industry

- Industry owns capacity at WWTP
 - Multiple companies with similar wastewater characteristics
- Industry has been a responsible partner (with confidentiality requirements)
- Industry has grown (correlating with stress at WWTP)
- Previous studies (others) have identified
 - High soluble BOD loads (VFAs)
 - Low nutrient Contributions

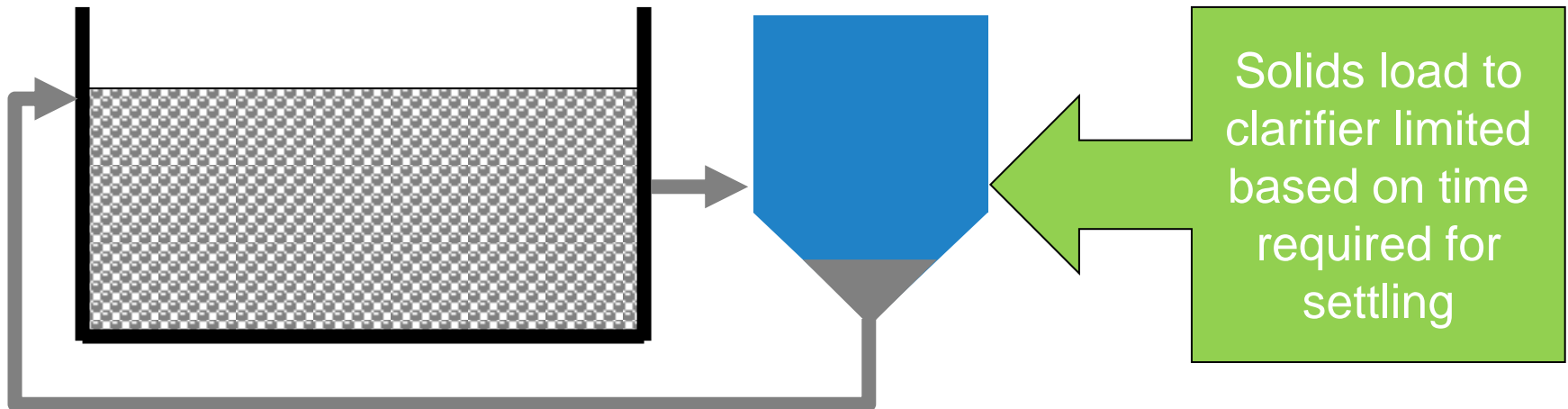
Study confirmed previously identified stress while estimating efforts associated with addressing the stress.

Description of Problem and Potential Causes



Understanding the Problems Allow Informed Discussions Related to the Potential Causes

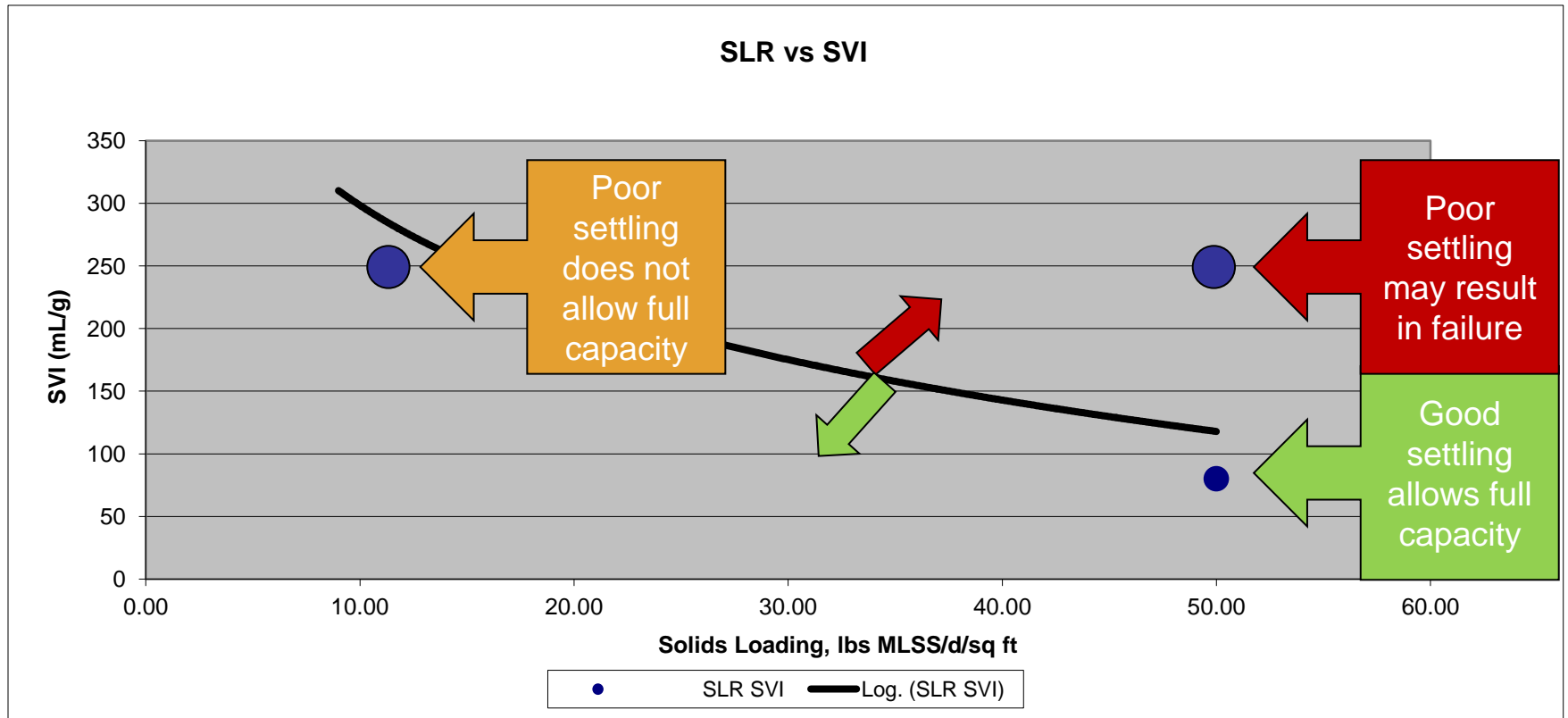
Problem 1.) Bulking Clarifier – Effluent Violations



Problem 2.) Additional Polymer Use - Costs

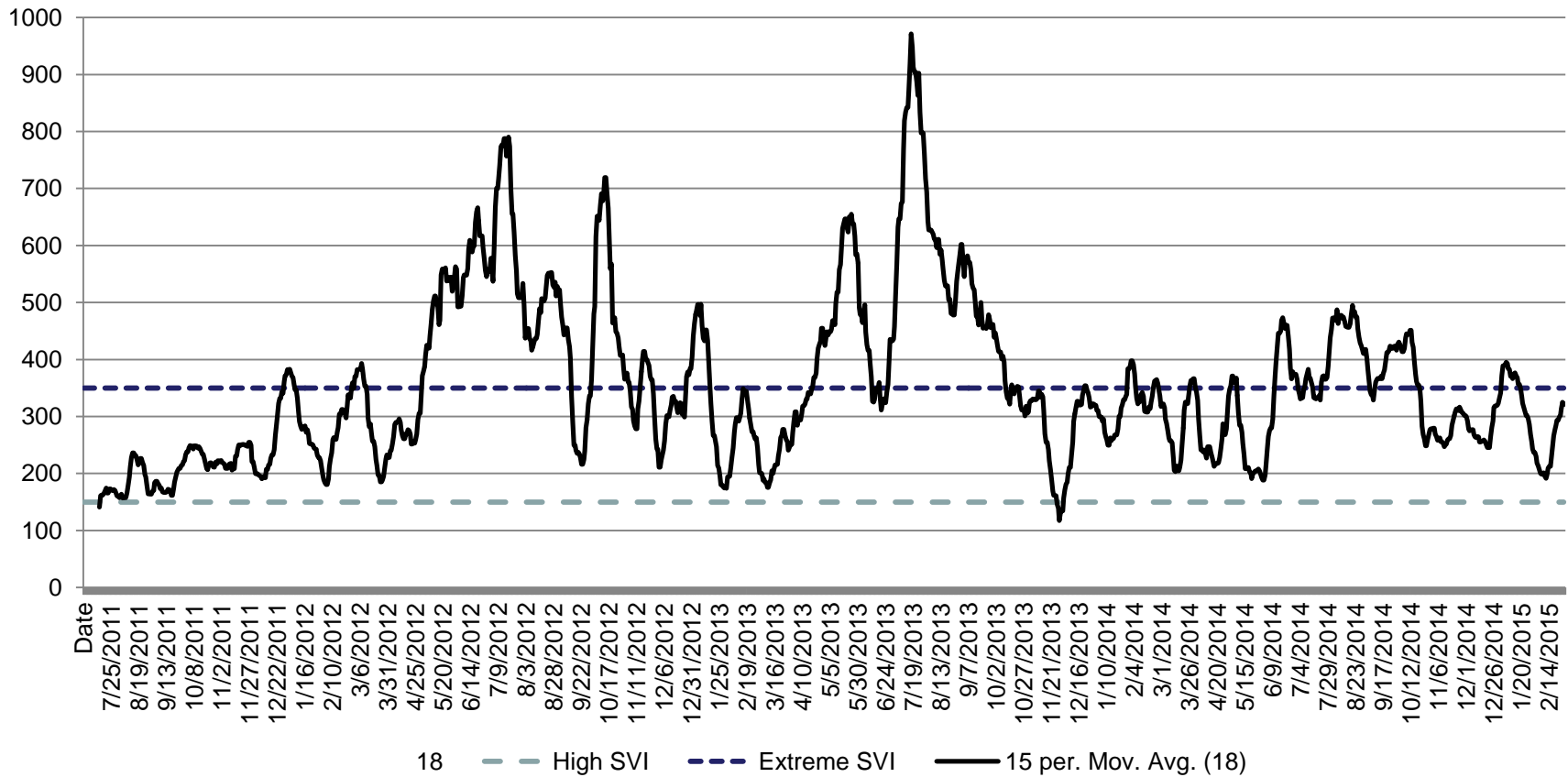
Problem 3.) Labor and Effort

Poor Settling Conditions Erode Facility Capacity



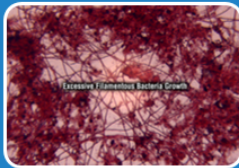
SVI Data Demonstrates Continuous Treatment Pressure

Figure 1 - SLUDGE VOLUME INDEX



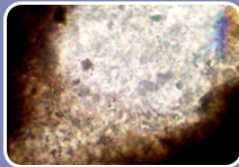
Project Activities Geared Towards Review of All Potential Triggers

Evaluation of All Potential Causes Allows the Actual Problem to be Addressed



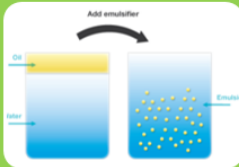
Filamentous Bacteria

- Slows settling by adding unwanted structure to floc
- Opportunistic growth (low DO, low nutrient, VFAs etc.)



Slime Bulking

- Unwanted biological secretions “gum-up” the floc
- Side effect of “good” bacteria



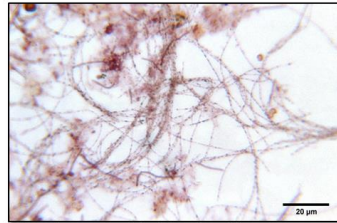
Emulsifiers/Outside Influence

- Physical/chemical interference
- Generally an industrial impact

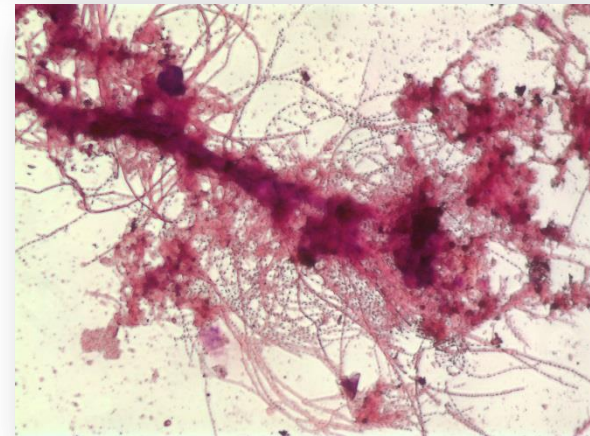
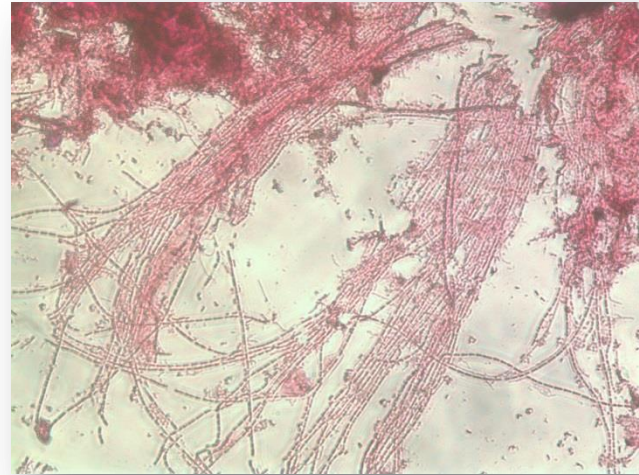
Filaments Were Observed To Address the Original Premise of the Project

Filamentous Bacteria Take Advantage of Environmental Conditions

- Triggers
 - Low dissolved oxygen
 - Low nutrients
 - Long sludge ages
 - Sulfides
 - VFAs
- ~ 20 Types common to wastewater



Structure provided by the filamentous bacteria impacts settling.



Filamentous stress was confirmed and species were consistent with previous findings. Watch areas remain:

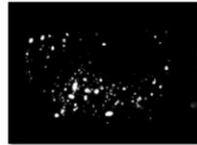
- VFAs
- Limited Nutrient Supplies

Slime Bulking Related To Readily Degradable Substrate and Low Nutrients Remains a Concern

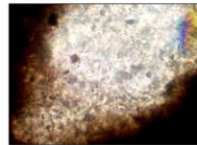
Slime Bulking is a Side Effect Associated with Stress in an Activated Sludge System

- Triggers

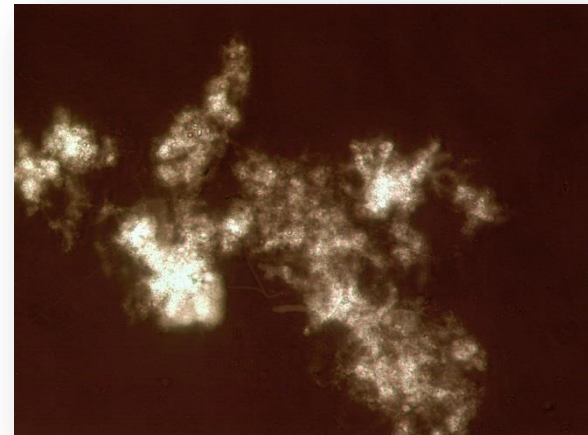
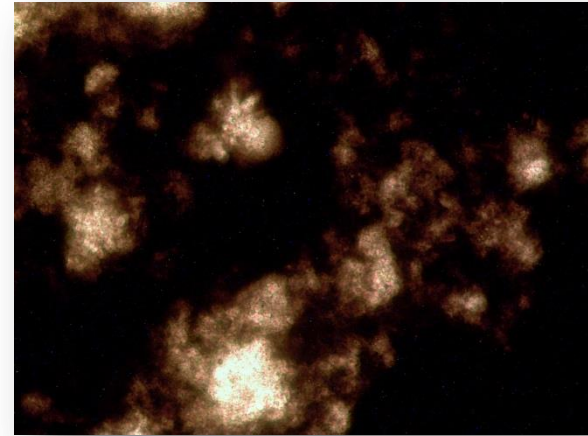
- Severe conditions including:
 - Low Nutrients
 - VFAs



Good ink penetration: Slime bulking not suspected



Poor ink penetration: Slime bulking



Inhibitory Slime Confirmed Consistent with

- VFAs
- Limited Nutrient Supplies
- Potentially Contributed to WWTP

Impact of Pectin Remains an Area of Interest

Products Employed to Limit Settling are Problematic to Wastewater Treatment Plants

- Triggers
 - Lost resources
 - Raw ingredients
 - Lost product
 - Wastes
 - Byproducts



Commercial salad dressings have added ingredients to prevent solids separation



Pectin Identification Assay Kit

The Pectin Identification assay kit is suitable for the identification of pectin in food ingredients. This kit now employs a new pectate lyase from *Aspergillus niger*.

Data Booklet

SDS



• Pectin Literature Review

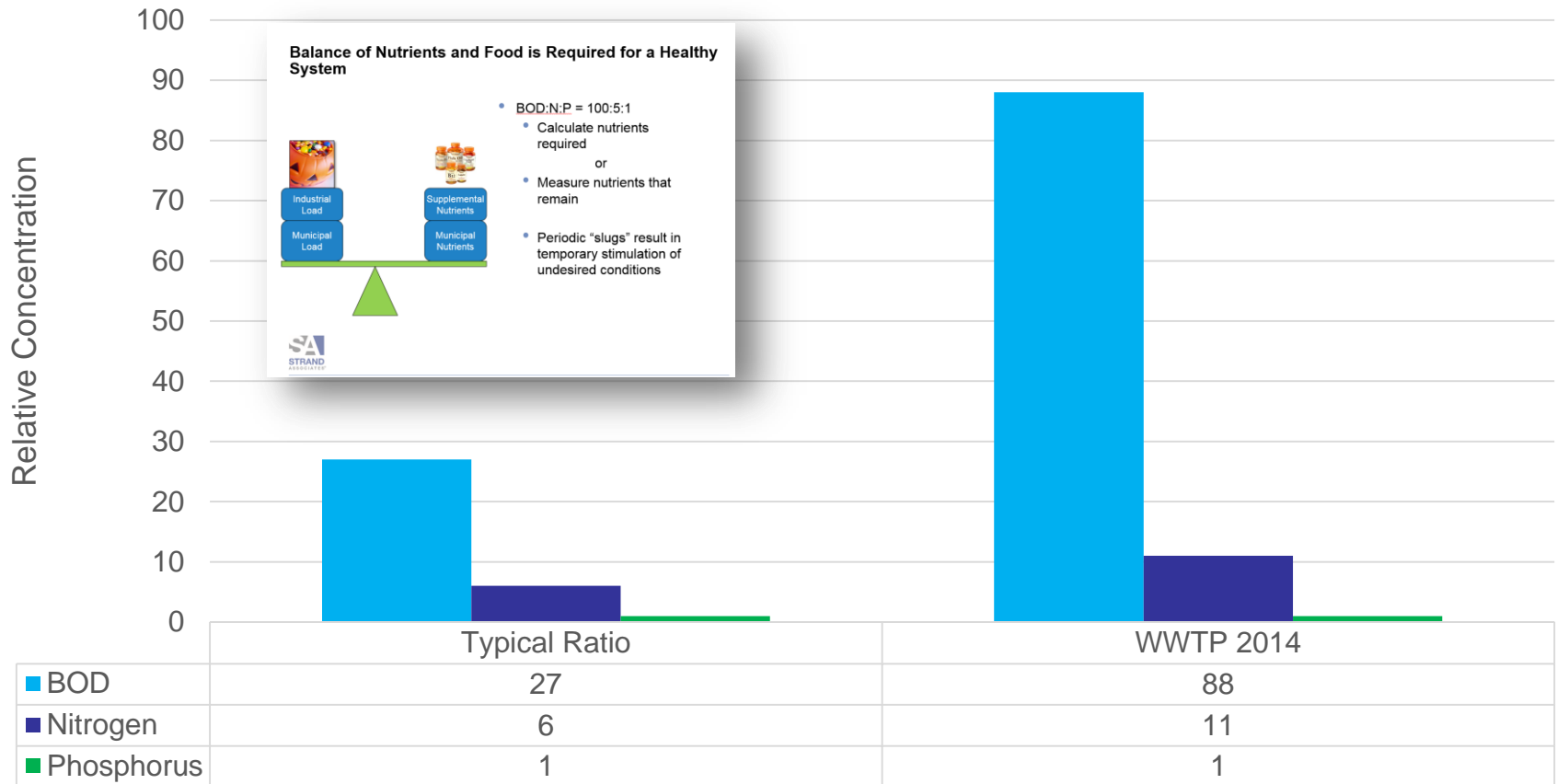
- Gel Formation dependent on
 - pH
 - Temperature
 - Pectin Concentration
 - Type of Pectin

Conversation Points

- Capture
- Use/Value
- Analyses
- Monitoring

Data Confirms That The WWTP Treats More BOD Than Typical In Relation to Their Phosphorus Supplies

BOD:N:P Balance Observations



In-situ Monitoring Proved Insightful

In-situ Monitoring Provides an Opportunity to Identify a Nutrient Deficiency Regardless of When it Occurs

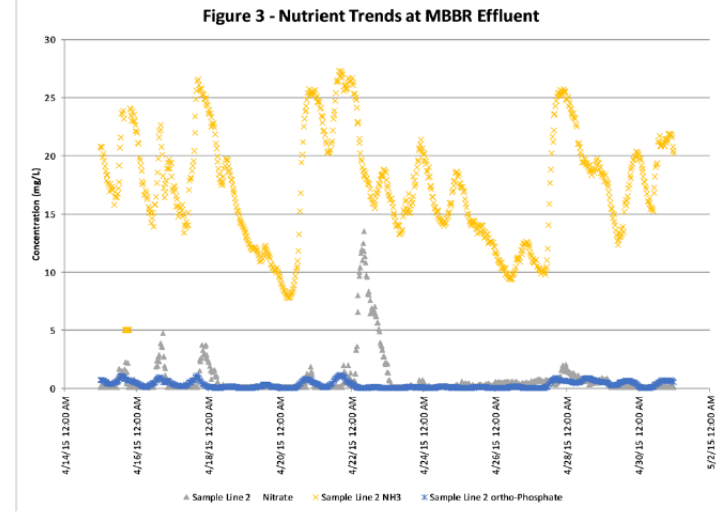
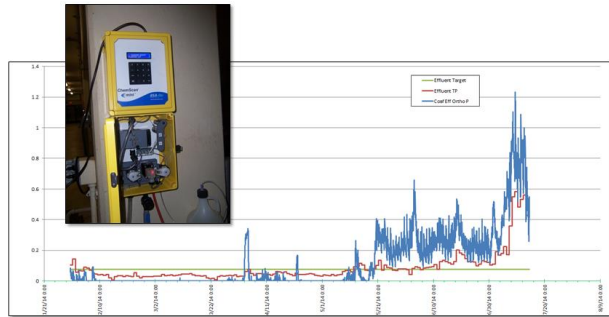


Figure 3 MBBR *In-Situ* Nutrient Data (Location 2 = at MBBR Effluent Channel)



MBBR Influent Sample



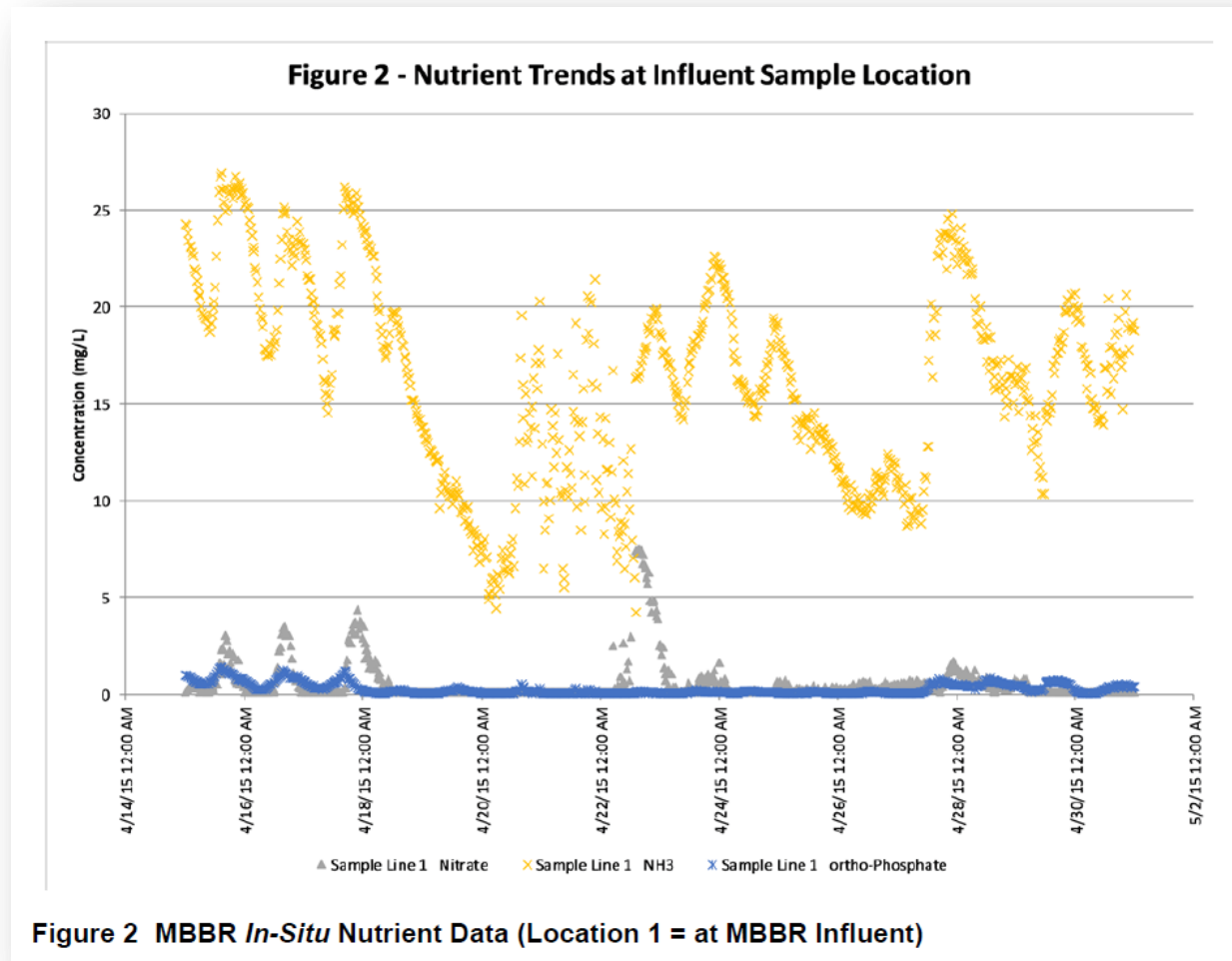
MBBR Effluent Sample



Sample Filter

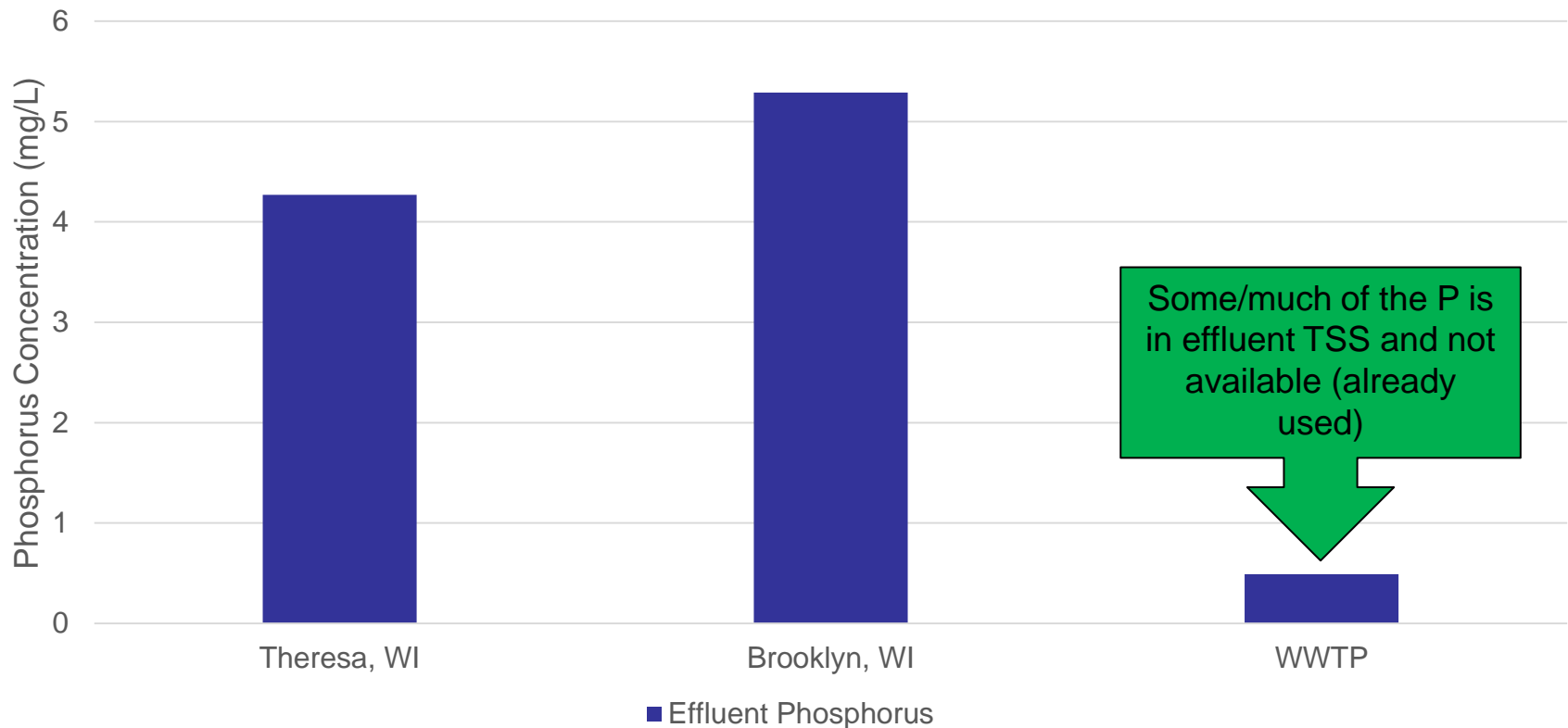


In-Situ Monitoring Confirmed Periodic-Extended Periods of Phosphorus Deficiencies

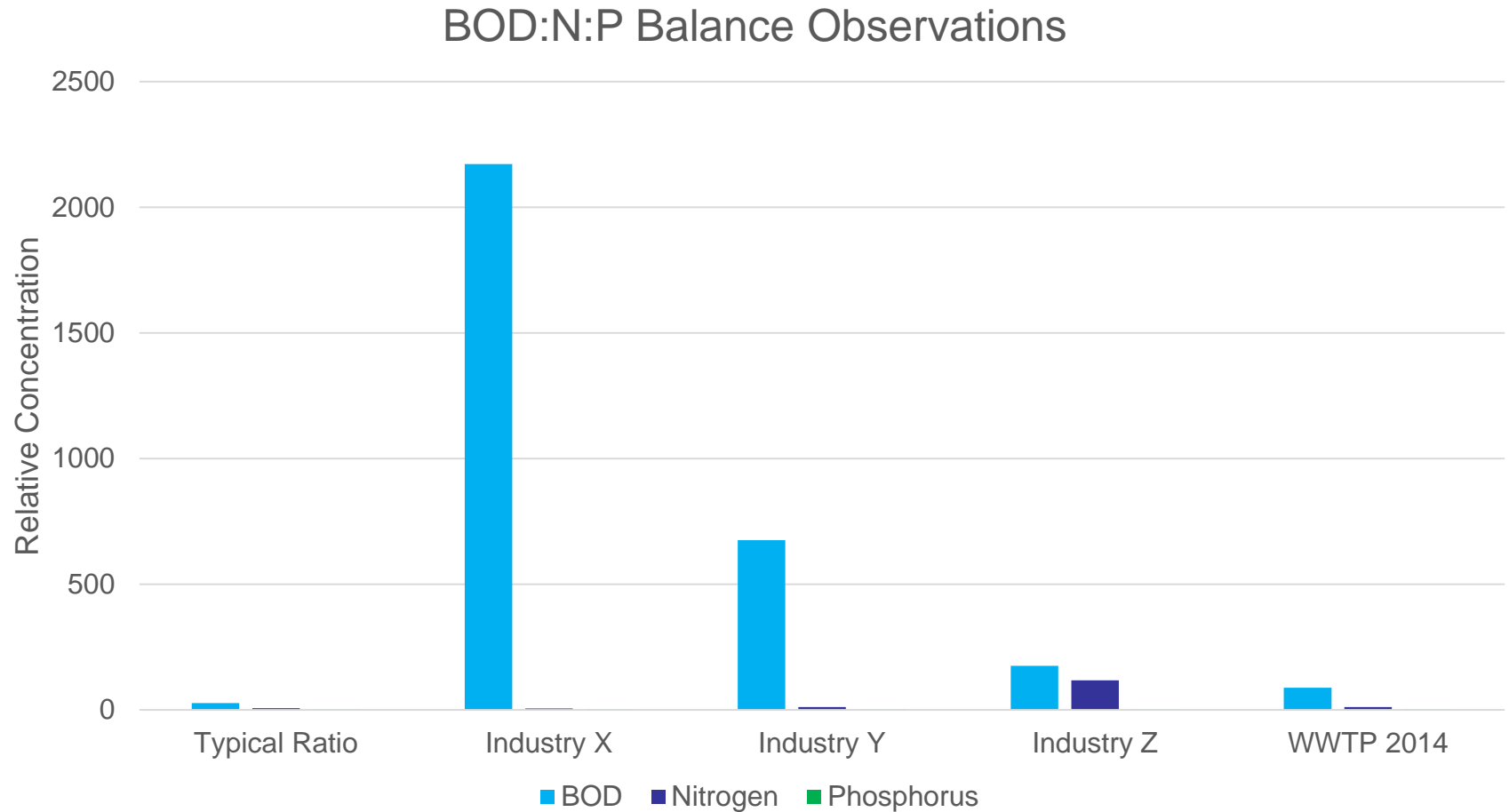


Impact of Phosphorus Deficiency is Obvious When Comparing Facilities without Phosphorus Removal

Comparison of Effluent Phosphorus Concentrations at Facilities Not Removing Phosphorus

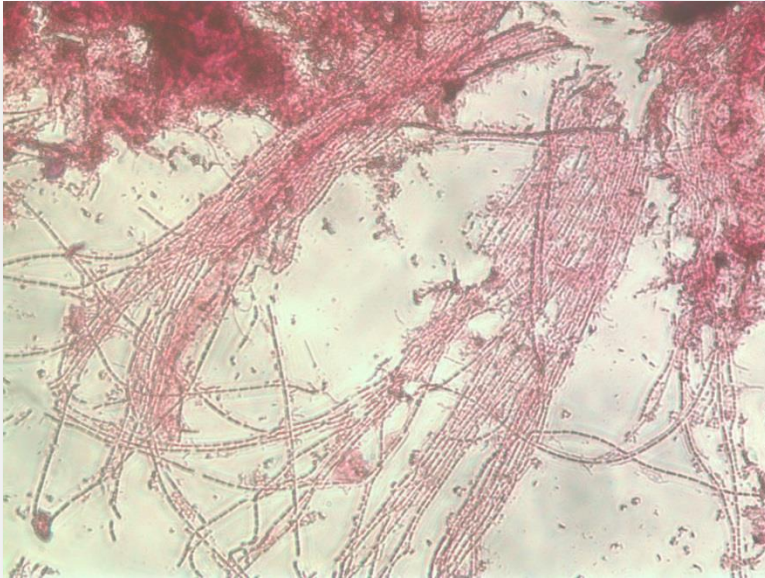


Data Confirms That All Participating Industries Supply Less Phosphorus Than Required to Treat Their BOD



Context – Phosphorus Is Required For Treatment Environment But Detrimental to Receiving Stream Environment

Too Little Phosphorus Creates Operational Issues



Too Much Phosphorus Creates Permit/Environmental Issues



Summarizing Triggers Allows Review of Potential Actions

- Triggers
 - High Soluble BOD Loading
 - Variable BOD Loading
 - Limited Nutrients – Phosphorus
 - Pectin
 - Not ruled out but not current focus
- Potential Actions
 - Remove BOD at Industry
 - Equalize BOD at Industry
 - Change POTW WW System to Be More Resilient
 - Add/Balance Nutrients
 - Haul Highest Strength WW to POTW

Industrial Operational Modifications

- Add Nutrients
 - Pro
 - Balance current discharge
 - Organization specific solution
 - Con
 - Individual systems required
 - Does not account for system wide assimilative capacity and therefore would result in excess nutrients at POTW
- Control Discharge
 - Pro
 - Match BOD with municipal nutrients
 - Con
 - Require management and EQ
- Continue Segregating High Strength Wastewaters
 - Pro
 - If digested produces gas, fewer nutrients are required
 - Avoids contact with troubled processes
 - Con
 - Hauling costs
- Monitoring Pectin
 - Pro
 - Continued resource capture
 - Con
 - Analytical effort
 - Enzyme Management

Industrial Onsite Treatment



Industrial Waste Digester

- ✓ High Soluble BOD Loading
- ✓ Variable BOD Loading
- Limited Nutrients - Phosphorus

- Pro
 - Destruction of BOD at the facility reducing the amount or VFA received at WWTP
 - Anaerobic (Industry X) treatment requires less nutrient
- Con
 - Cost
 - Build and Operate
 - Complexity
 - Run WWTP

Industrial On Site Equalization



- ❑ High Soluble BOD Loading
- ✓ Variable BOD Loading
- Limited Nutrients - Phosphorus

- Minimum 12 Hours
- Pro
 - Reduced wastewater variability
 - Allows discharge timing
- Con
 - Cost
 - Increased VFA formation

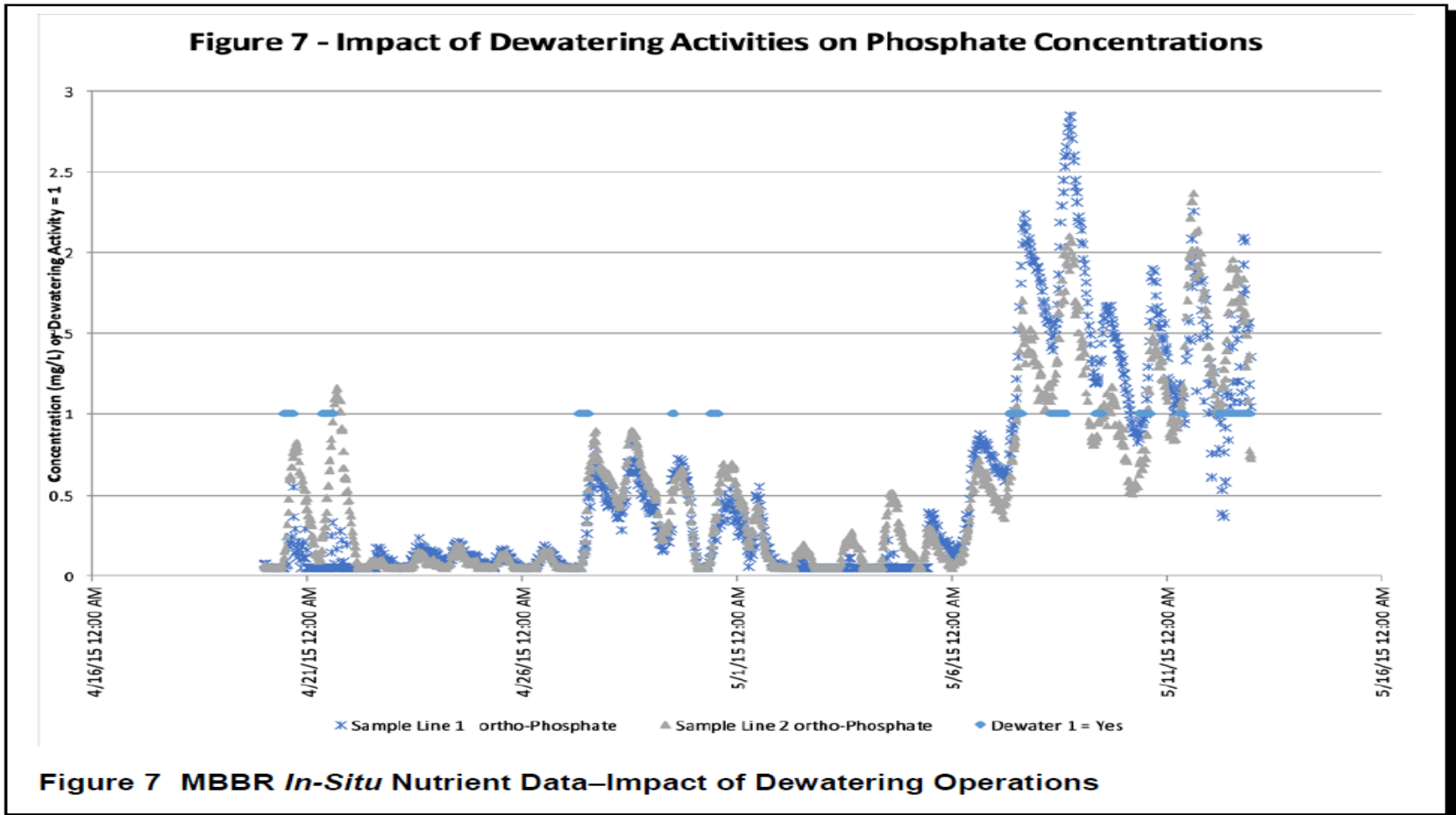
At the WWTP – Nutrient Addition: Chemical



- Pro
 - Operations staff accustomed to metering etc.
 - Full assimilative impacts realized before supplementation
- Con
 - Cost to build and own
 - Additional phosphorus to environment
 - Biosolids
 - Effluent

- High Soluble BOD Loading
- Variable BOD Loading
- Limited Nutrients - Phosphorus

Pilot Study Confirmed That Filtrate Management Impacts Available Phosphorus Concentrations



At the WWTP – Nutrient Addition: Filtrate Control



- High Soluble BOD Loading
- Variable BOD Loading
- Limited Nutrients - Phosphorus

- Pro
 - Full assimilative impacts realized before supplementation
 - No additional phosphorus to environment
 - Lower ownership costs
 - Other benefits associated with equalization
- Con
 - Cost to build

At the WWTP – Construct Selector



- High Soluble BOD Loading
- Variable BOD Loading
- Limited Nutrients - Phosphorus

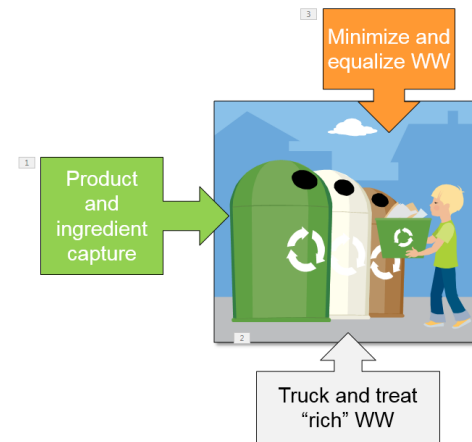
- Pro
 - Promote growth dynamic favoring floc forming bacteria
 - Promote growth of phosphorus accumulating bacteria
 - Phosphorus would be made available in selector during treatment
- Con
 - Cost to build

Product Capture Practices Have Eliminated “Low Hanging Fruit”

- Special Sampling
 - Industry X
 - Limited Opportunities*
 - ~ 3X BOD Concentration
 - < 2% Daily Flow
 - Industry Y
 - Limited Opportunities*
 - Test Area A Low BOD
 - Test Area B Low Volume
 - Industry Z
 - NA

*As warranted, hauling of higher strength wastewater to WWTP is encouraged.

Source Control will be Key to Relieving Pressure at the WWTP



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Summary of Potential Capital Improvements

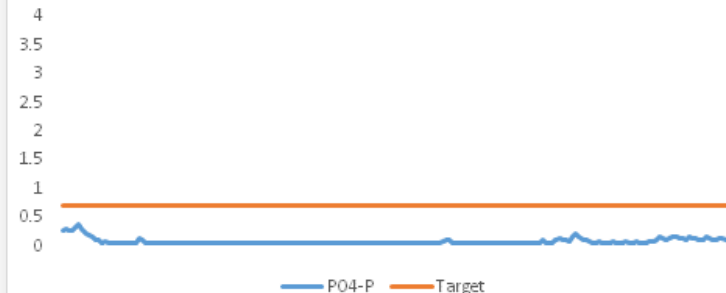
Project	Initial Cost Estimate per Draft Report	Address sBOD	Address Variable BOD	Address P Deficiency
On Site Treatment – Industry Y	\$2.5M to \$3.0M	Yes	Yes	Indirectly
On Site Treatment – Industry X	\$2.2M to \$2.5M	Yes	Yes	Indirectly
Greater On Site Equalization	\$1-\$4/gpd	No	Yes	Indirectly
Install Monitoring /Supplement	\$25K to \$100K	No	No	Yes
Filtrate Management	\$450K	No	Some	Yes
Selector	\$550K	Indirectly	Indirectly	Indirectly

Conclusions Following Collaboration Meeting – Pilot Supplementation Program

- **Collaboration** is working with others to do a task and to achieve shared goals.
- Lowest Cost Option – Phosphorus Supplementation (Phosphoric Acid) Phase
- Automated to maintain effluent quality.
- Initiated in May 2016



200 Consecutive 15 minute intervals below Target and near detection limit
4/23 - 4/25/16





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