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OWEA Technical Conference & Expo

Nutrients Technical Session

June 26, 2019

1:30 – 2:15 PM

The City of London
A Look into Nutrient Removal Design

Presented by:

Jamie Mills, E.I.

Strand Associates, Inc.®

Presentation Outline

- About City of London WWTP
- City of London - Nutrients
- Process Exploration
  - Total Nitrogen Removal
  - Biological Phosphorus Removal
  - Chemical Phosphorus Removal
  - Bench Testing
  - Design
- Paths Forward

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City of London WWTP

Map Data: Google

London WWTP Service Area:

- London Population 10,100
- Two State Correction Institutions
  - 4750 Inmates
- Average Flow 2.68 MGD

Source: Ohio Department of Transportation

City of London WWTP

- Upgrade in 2007
- Design Flow 5.8 MGD
- Peak Flow 17.1 MGD
- Cost $24M+

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SEAL OF THE CITY OF LONDON, OHIO 1811

Existing WWTP Liquid Train

Screening and Grit Removal

Primary Clarifiers

Influent Pumping

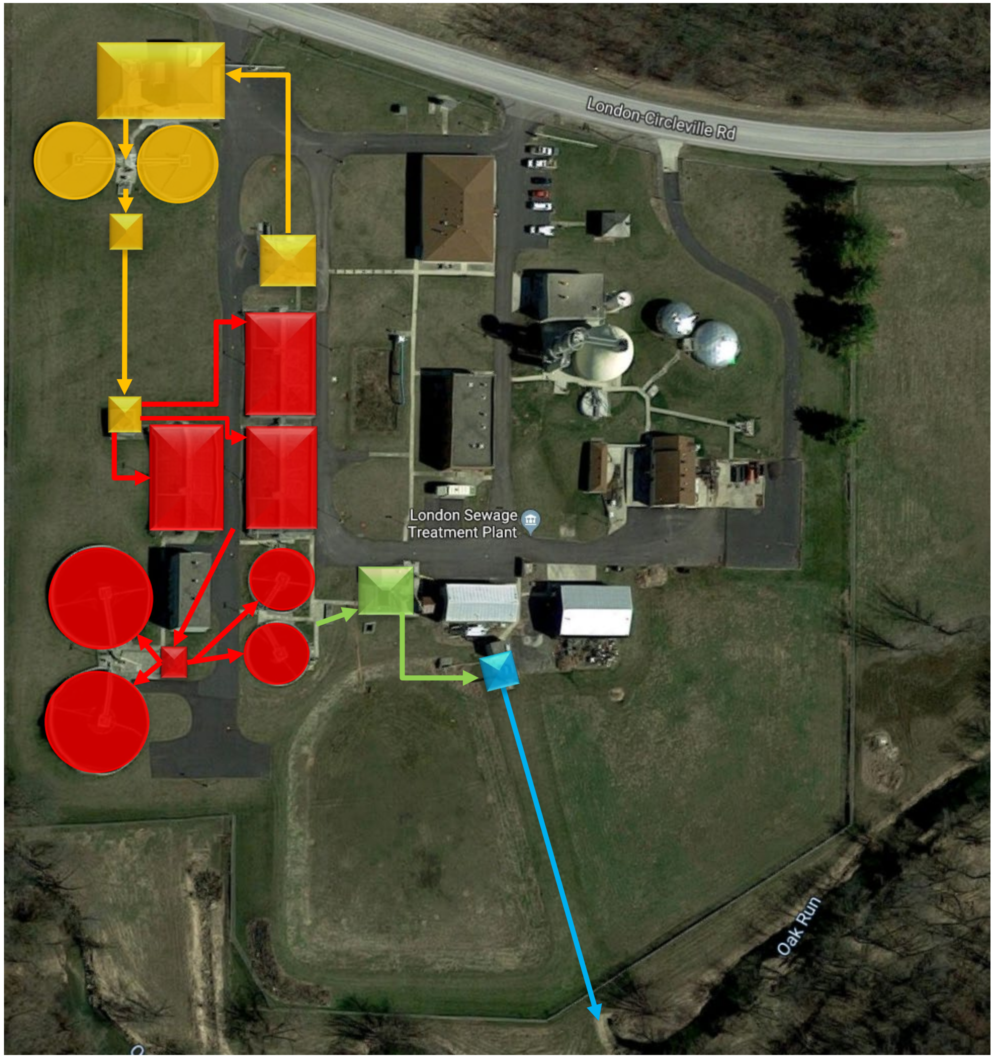
Flow Splitting

Activated Sludge

Final Clarifiers

Post Aeration and UV Disinfection

Effluent Pumping



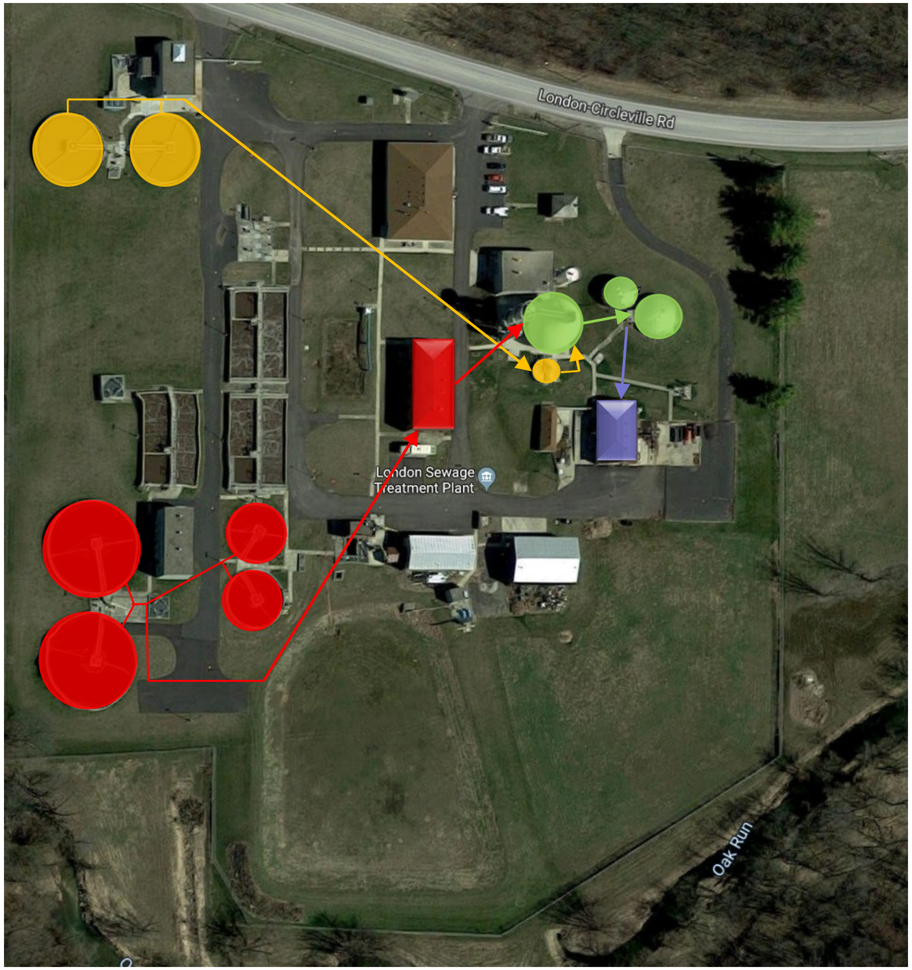
Map Data: Google

Existing WWTP Solids Train

Primary Sludge

Sludge Concentration Building

Waste Activated Sludge (WAS)



Map Data: Google

Anaerobic Digestion and Sludge Storage

Gravity Thickener

Sludge Dewatering

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City of London – Nutrients

Total Phosphorus Loading

Plant Data- 3 Months

Total Phosphorus

	Influent	Primary	Effluent
Average	3.86	4.01	1.76
Daily Maximum	8.94	10.2	3.66

City of London – Nutrients

Total Phosphorus Loading

2016 Septic Hauling

- WWTP received 2,753,615 gallons
- Septic TP: Approximately 15 lbs TP/day

2018 Septic Hauling

- WWTP received 3,617,541 gallons
- Septic TP: Approximately 20 lbs TP/day

2019 Septic Hauling (Up to May)

- WWTP received 1,879,270 gallons
- Septic TP: Approximately 26 lbs TP/day

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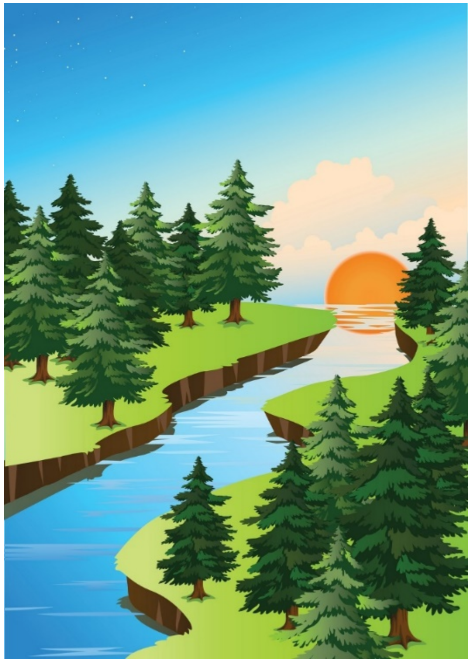
City of London – Nutrients

- City of London WWTP discharges to Oak Creek
  - Oak Creek is a tributary of Deer Creek lake

- Oak Creek flows in Comparison to WWTP flows
  - Low flow Stream 1.5 MGD
  - Design flow 5.8 MGD
  - Average Flow 2.8 MGD



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Nutrient Removal Options

	Phosphorus Control	Nitrogen Control
Physical/Chemical Processes	• Chemical precipitation • Clarification/filtration • Media adsorption/ion exchange • Chemicals + UF membranes • Reverse osmosis • Struvite precipitation	• Air or steam stripping • Ion exchange • Break-point chlorination • Activated carbon • Struvite precipitation
Biological Processes	(Enhanced) Biological Phosphorus Removal	• Ammonification (hydrolysis) • Nitrification • Denitrification • Deammonification (anammox)

Total Nitrogen Removal

Aerobic Zone
- Food Source = NH_4^+
- Energy Source = DO

Anoxic Zone
- Food Source = BOD
- Energy Source = Nitrate

Nitrification

$NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-$

Active microbes:

Nitrosomonas, Nitrobacter

Denitrification

$NO_3^- \rightarrow NO_2^- \rightarrow N_2O \rightarrow N_2$

Active microbes:

Pseudomonas, Achromobacter, Micrococcus

Source: Maryland Biochemical Company

Total Nitrogen Removal Benefits

$NH_3\text{-}N \rightarrow NO_2 \rightarrow NO_3 \rightarrow N_2$

- Increased Settleability
- Nitrogen Removal (Good for the receiving streams)
- Alkalinity Restoration
- Oxygen Credit/Energy Savings
- Increased Oxygen Transfer
- Beneficial for BPR

MODIFIED LUDZACK-ETTINGER (MLE) PROCESS
2-STAGE NITROGEN REMOVAL

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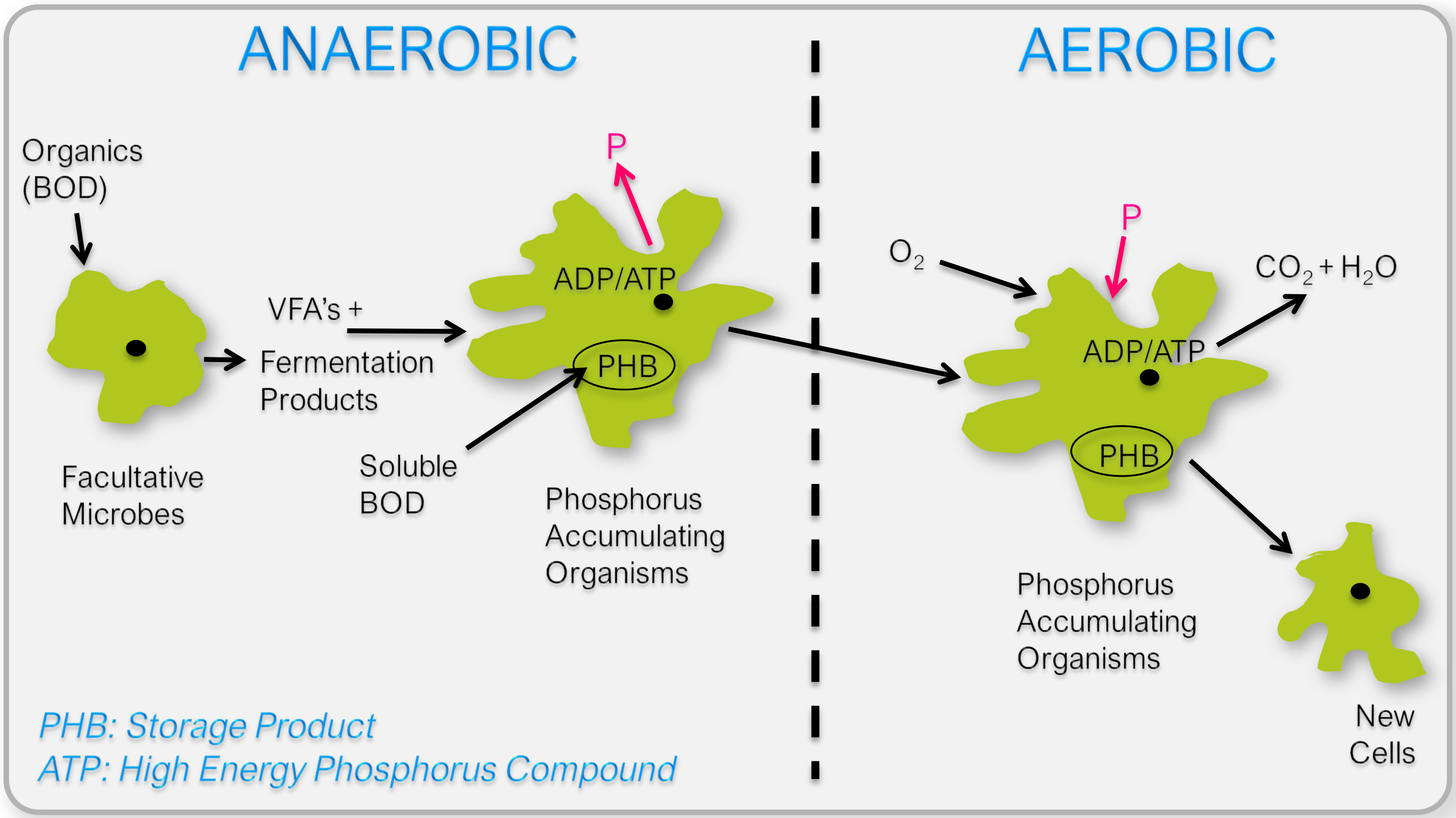
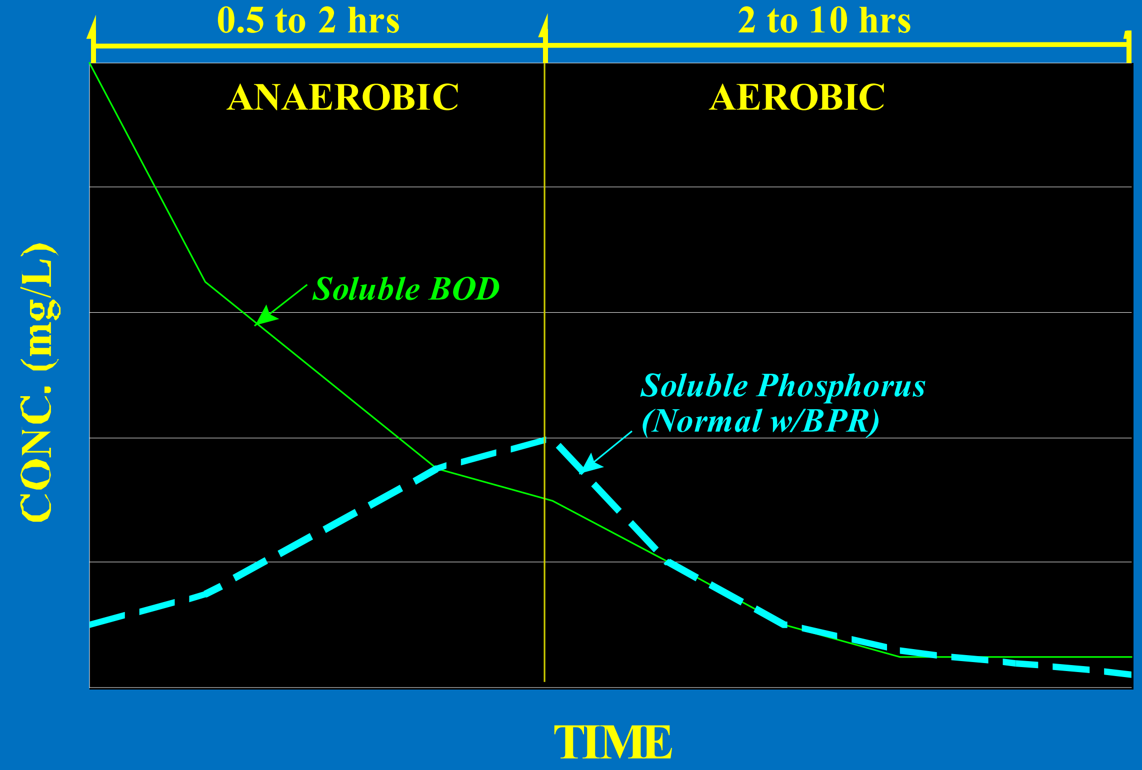
Biological Phosphorus Removal (BPR)

- Facilitate Growth of Phosphorus Accumulating Organisms (PAOs)



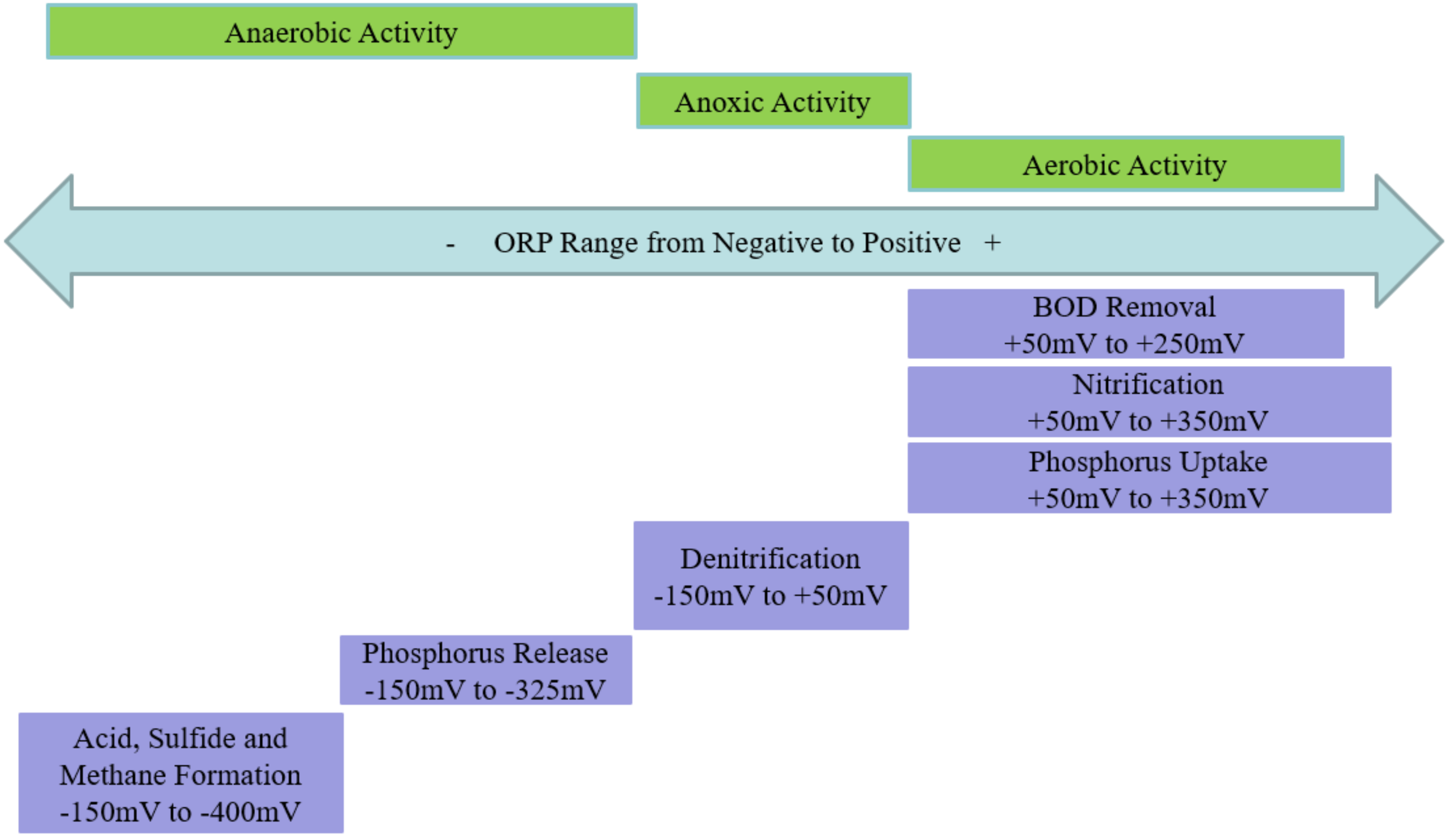
Biological P Removal - Principles

Phosphorus cycle involves release in anaerobic zone, "luxury" uptake in aerobic zone



Biological Phosphorus Removal (BPR)

Controls and Monitoring of PAOs

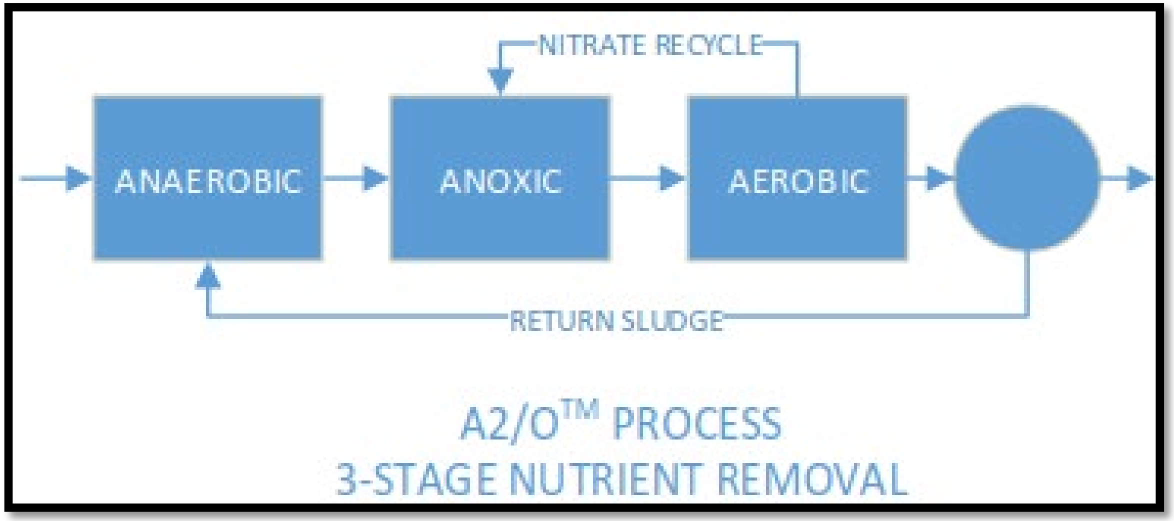


Oxidation Reduction Potential Values and Corresponding Biochemical Reactions

Biological Phosphorus Removal (BPR)

Several Difference Tank Configurations Exist

- A2O Process
- Cape Town Process
- Bardenpho
- RAS Fermentation



Biological Phosphorus Removal (BPR)

Where is BPR a Good Candidate?

- Where BPR tends **TO** work
  - Plants with long sewers/force mains
  - High strength wastewater
  - Large industrial flows with high soluble BOD

- Where BPR tends **NOT** to work
  - Plants with low strength wastewater
    - Fermentation step or soluble BOD may need to be added
  - Attached growth plants
    - Trickling filters/Rotating Biological Contactors (RBCs)
  - Plants that use co-thickening

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Chemical Phsophorus Removal - Principles

- Chemical Phosphorus Removal
  - Add lime, iron, or aluminum salt
  - Precipitation of soluble phosphorus
  - Precipitated P removed during clarification, filtration
  - Relatively simple process
  - Higher sludge production

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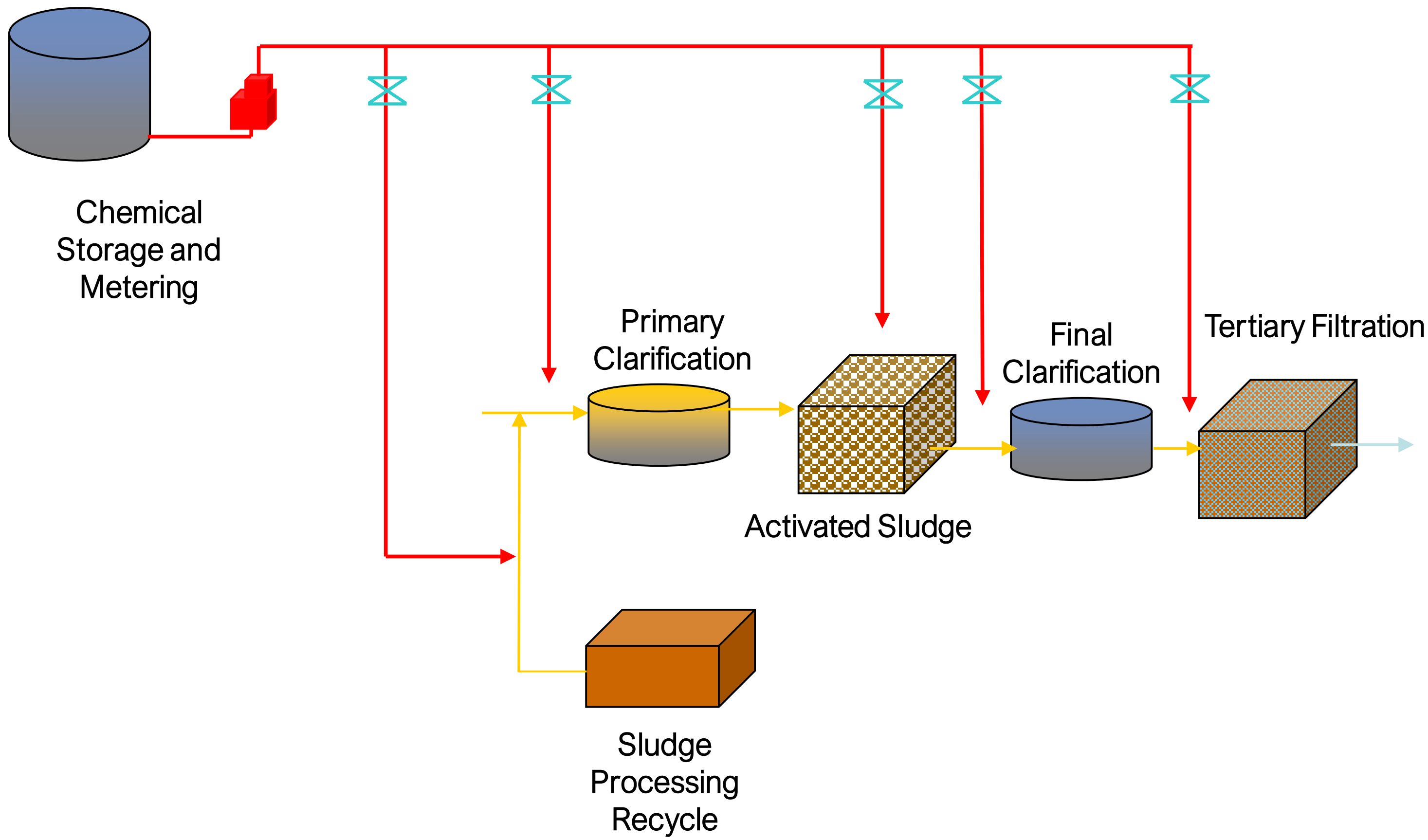
Chemical P Removal - Principles

CPR - Typical Schematic



Chemical Phosphorus Removal (CPR)

Pros

- Simplicity
- Effectiveness

Cons

- Lowers pH
- Consumes alkalinity
- Increases sludge production 15-25%

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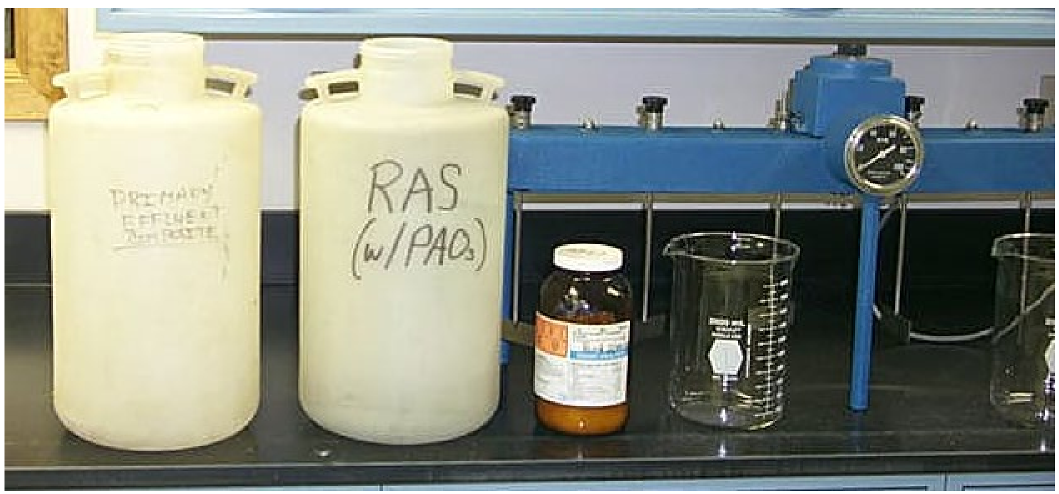
Bench-Scale BPR Testing - Purpose

- “Potential Testing” - Determine if wastewater has enough VFAs and soluble BOD to facilitate BPR
- Measure phosphorus release with target WWTP raw wastewater and biomass from BPR WWTP



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Bench-Scale BPR Testing

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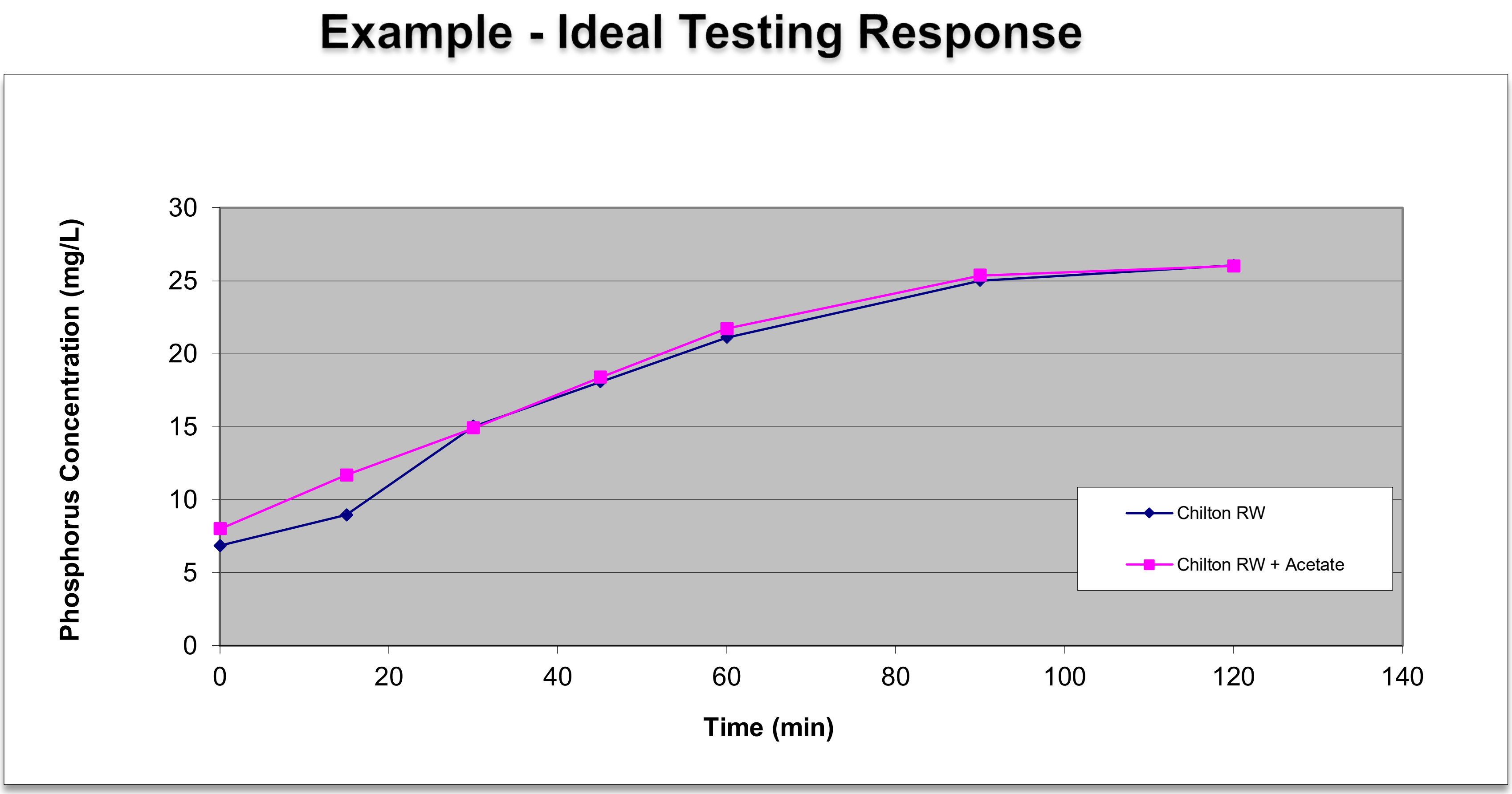
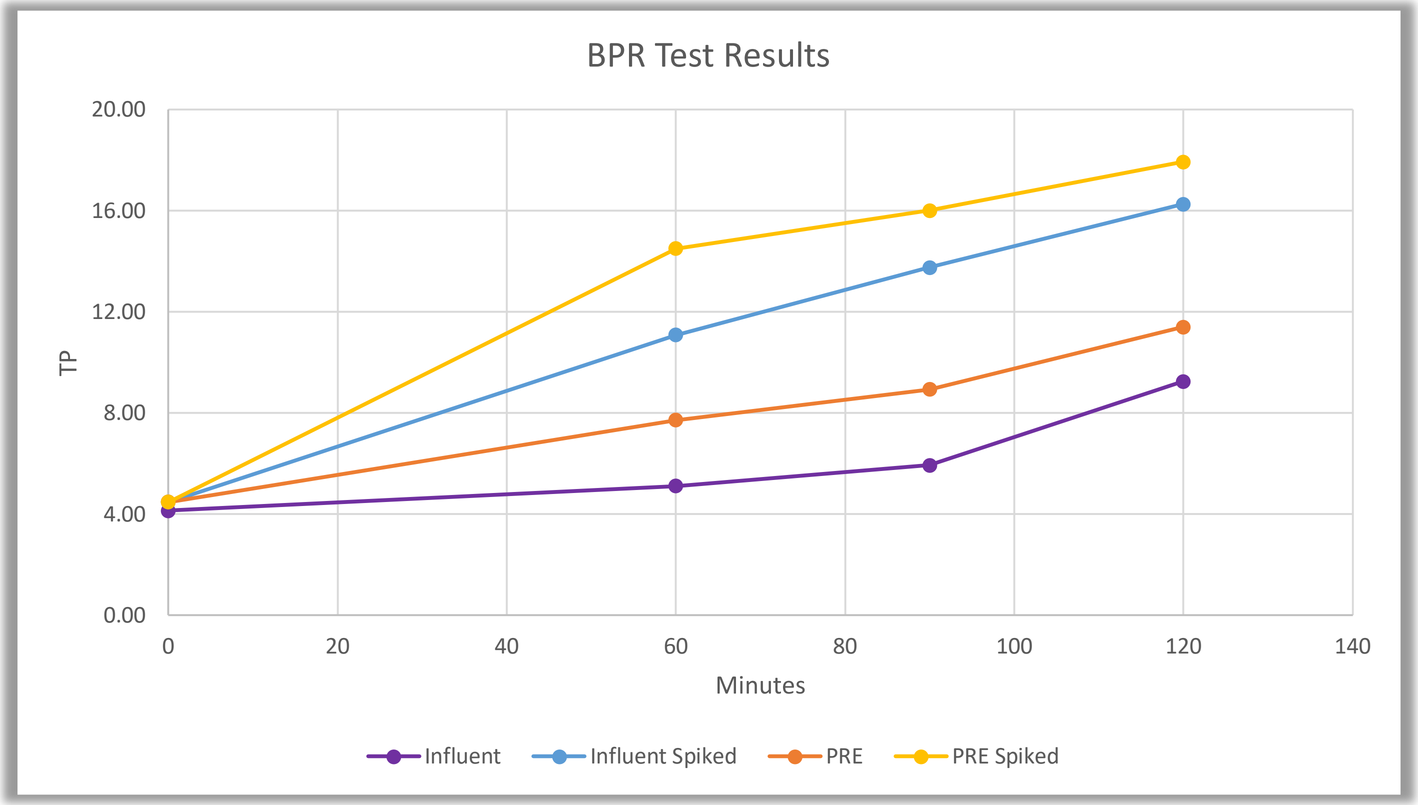
Bench-Scale BPR Testing



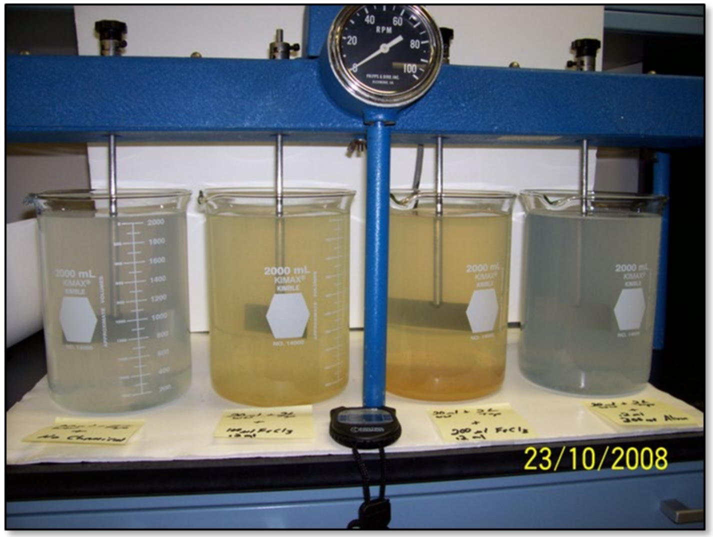
Bench-Scale BPR Test Results – City of London

- Anaerobic phosphorous release larger in spiked sample
- Moderate potential for BPR, limited by lack of “food” in influent



CPR Jar Test - Purpose

- Dose Rates – Identify the most economical chemical
- Dose Location
- Determine Side Effects
  - pH Depression
  - Alkalinity Loss



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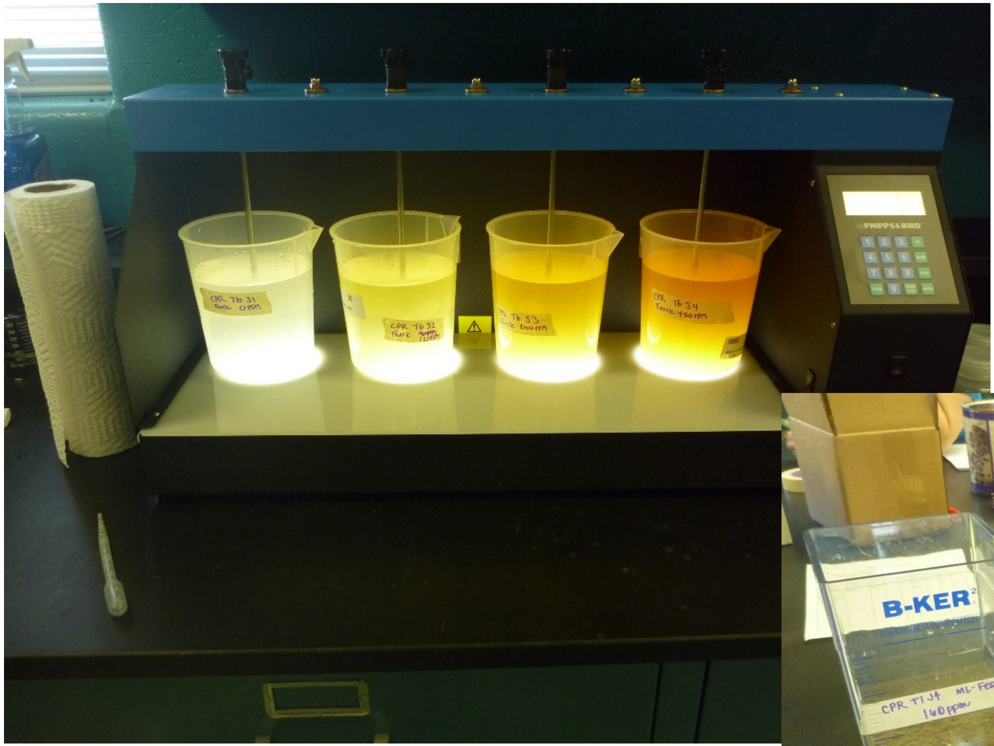
CPR Jar Test



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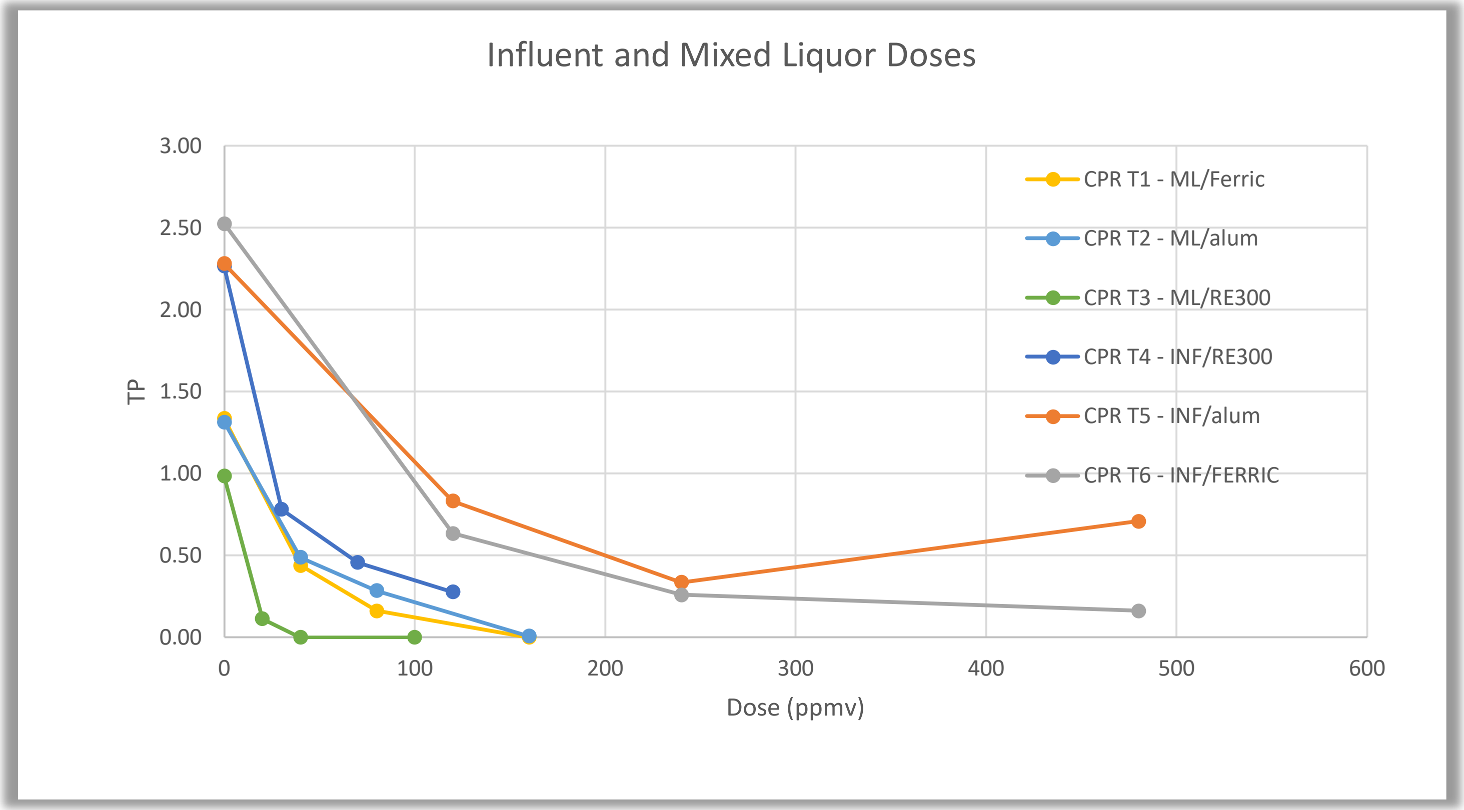
CPR Jar Test Results – City of London

- Higher doses needed for influent vs mixed liquor
- Effectiveness at high doses decreases



Phosphorus Removal Summary

- CPR or BPR can meet 1 mg/L when implemented properly
- Important to understand pros and cons of each process before making decision

Factor	CPR	BPR
Capital Costs	Lower	Higher
Operation	Easier?	More Difficult?
Maintenance	Higher Cost	Lower Cost
Reliability	Higher	Lower
Sludge Costs	Higher	Lower
Lower Limits	May Meet/Filtration	Add CPR/Filtration

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WWTP Liquid Train - Incorporating Nutrient Removal Design

Screening and Grit Removal

Primary Clarifiers

Influent Pumping

Flow Splitting

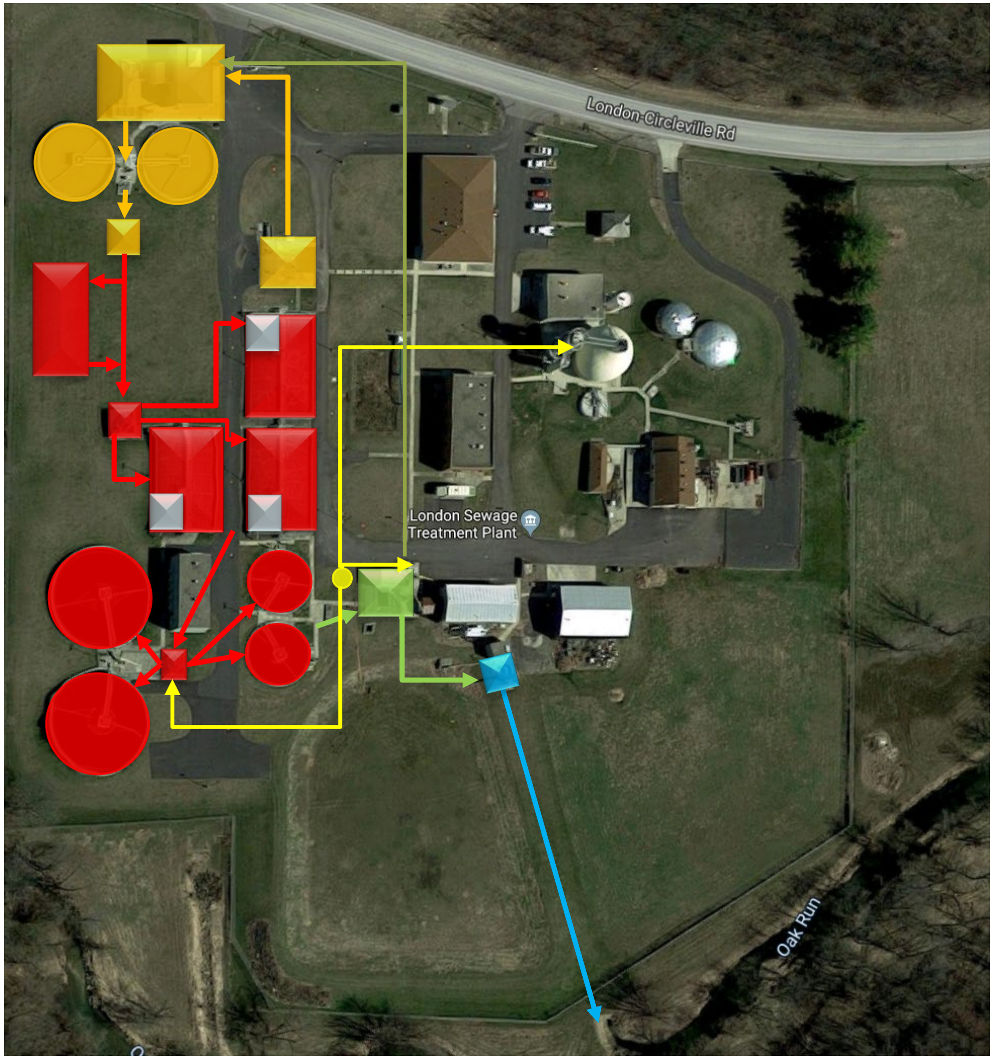
Flow Splitting

Activated Sludge

Final Clarifiers

Post Aeration and UV Disinfection

Effluent Pumping



Anaerobic Selector Tank

Improved Anoxic Zones

Chemical Dosing

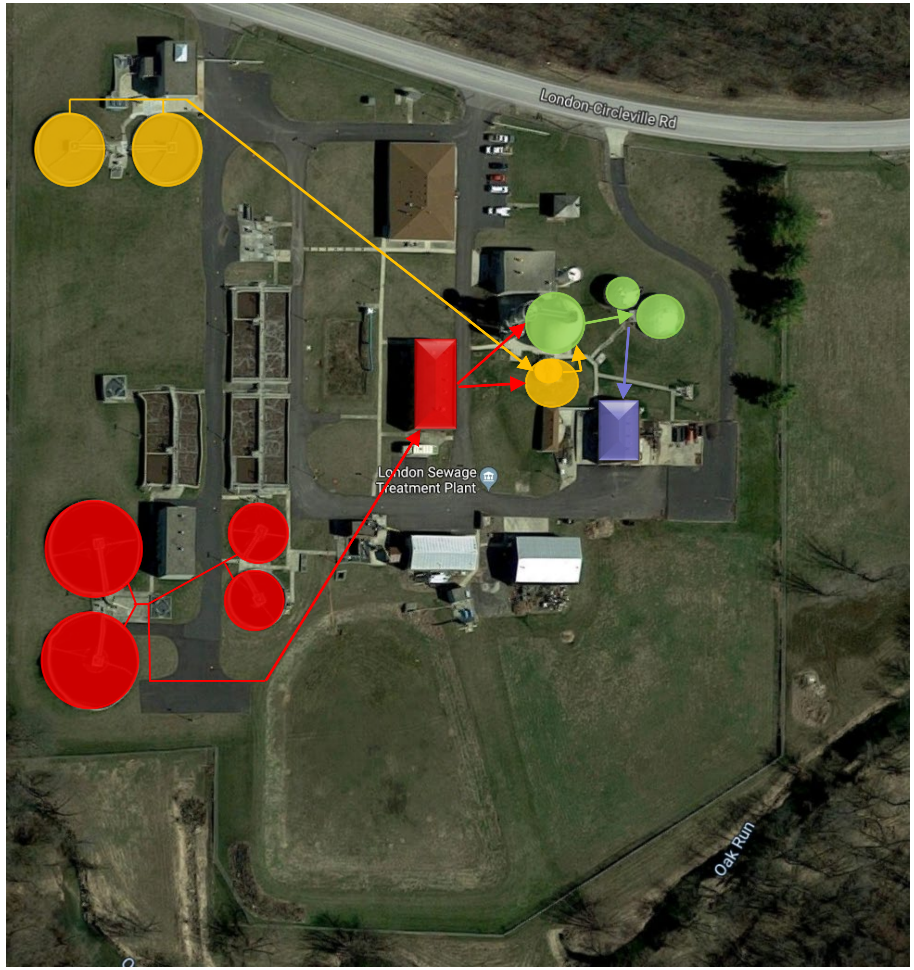
Map Data: Google

WWTP Solids Train – Incorporating P-Removal Design

Primary Sludge

Sludge Concentration Building

Waste Activated Sludge (WAS)



Source: Google

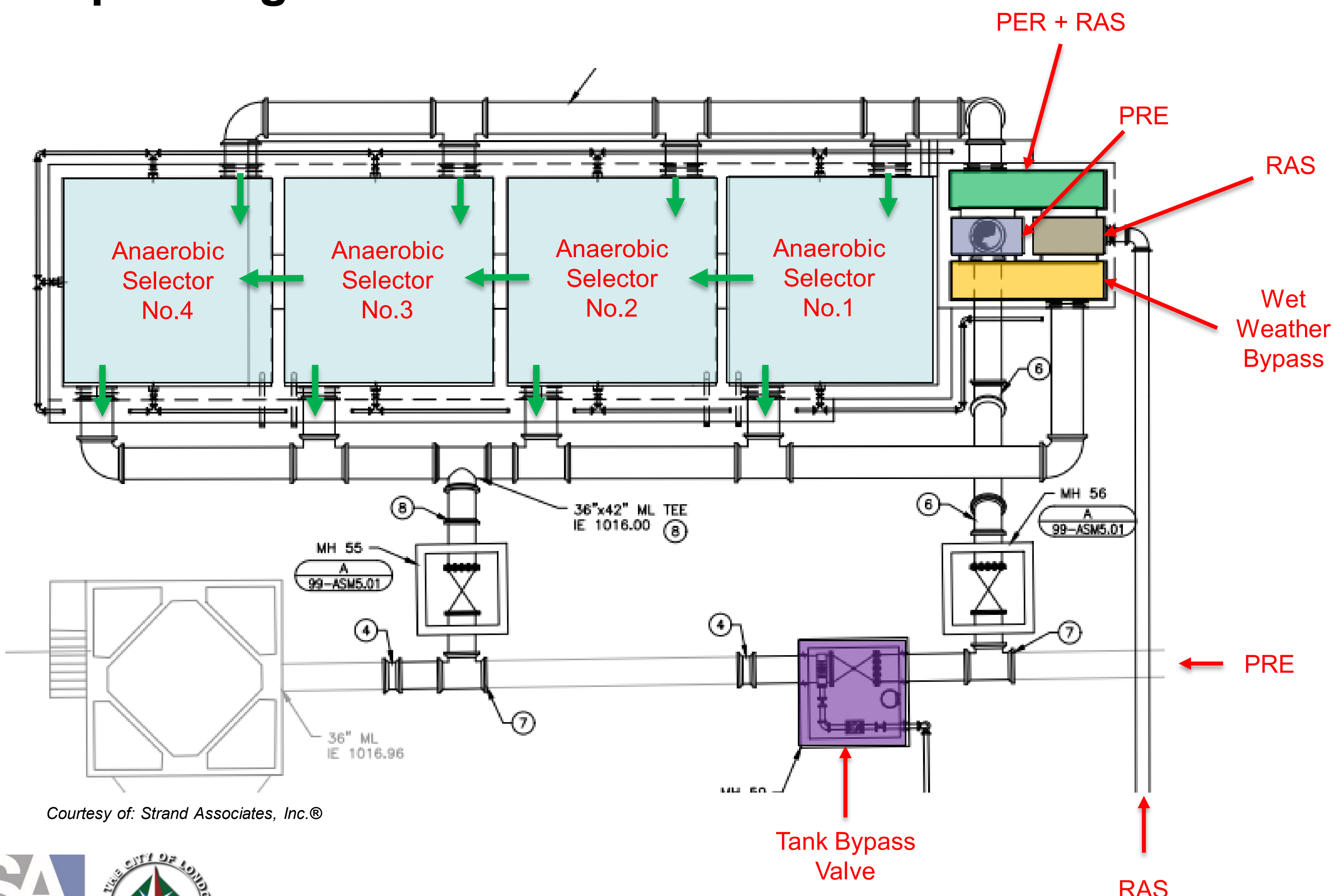
Anaerobic Digestion and Sludge Storage

Sludge Equalization Tank

Gravity Thickener

Sludge Dewatering

Incorporating BPR at London's WWTP



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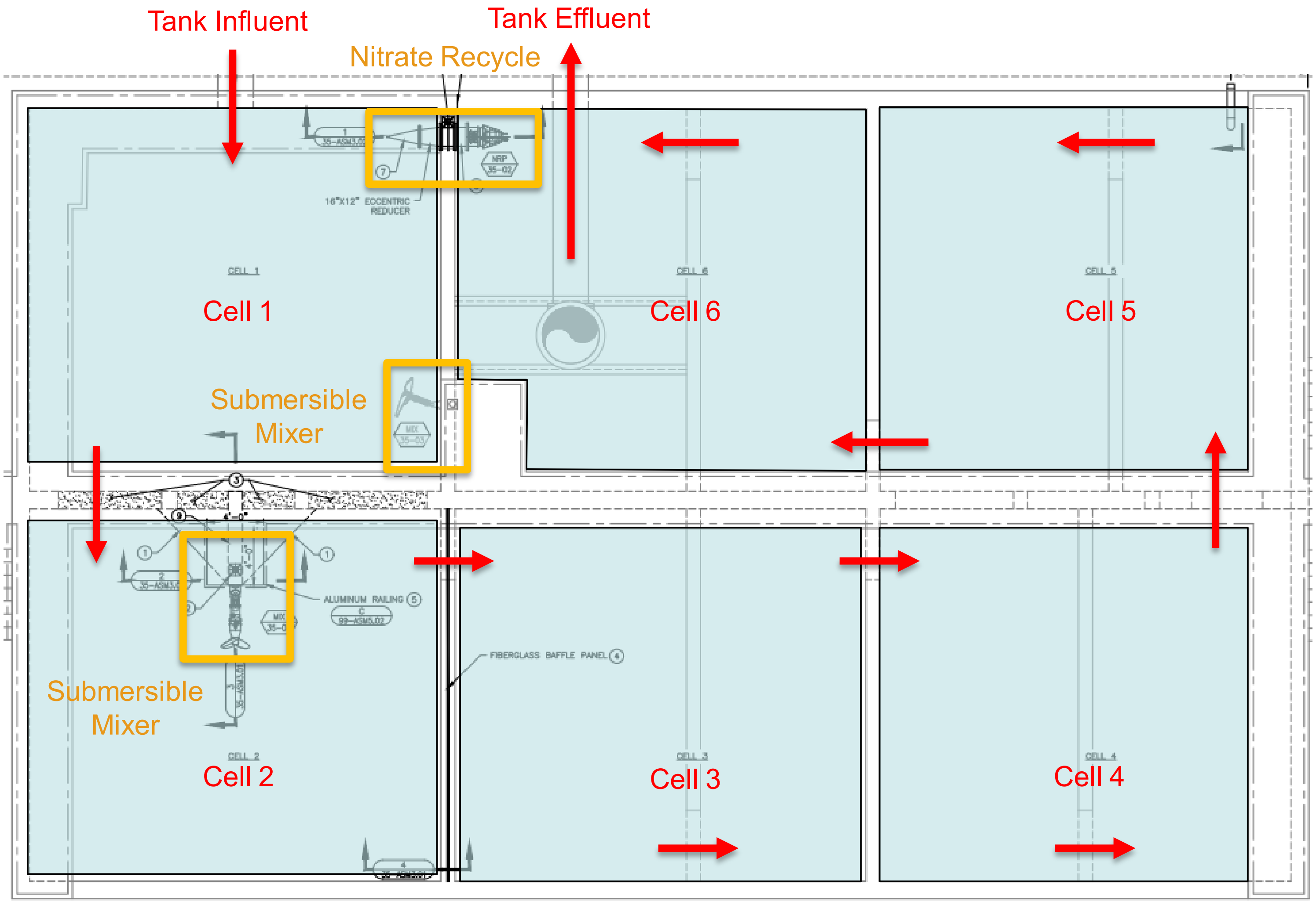
Incorporating N-Removal at Londons WWTP



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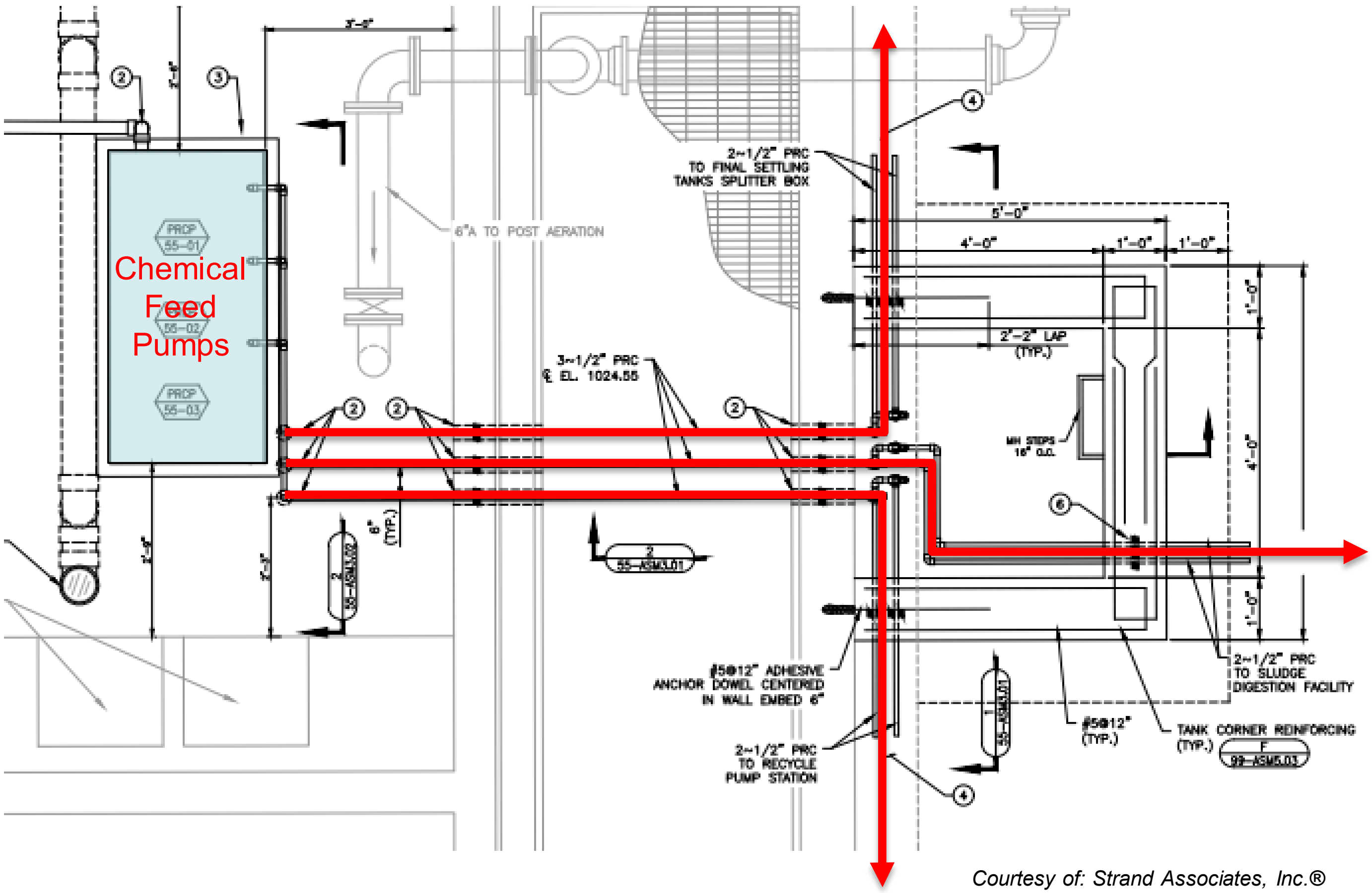
Incorporating CPR at Londons WWTP



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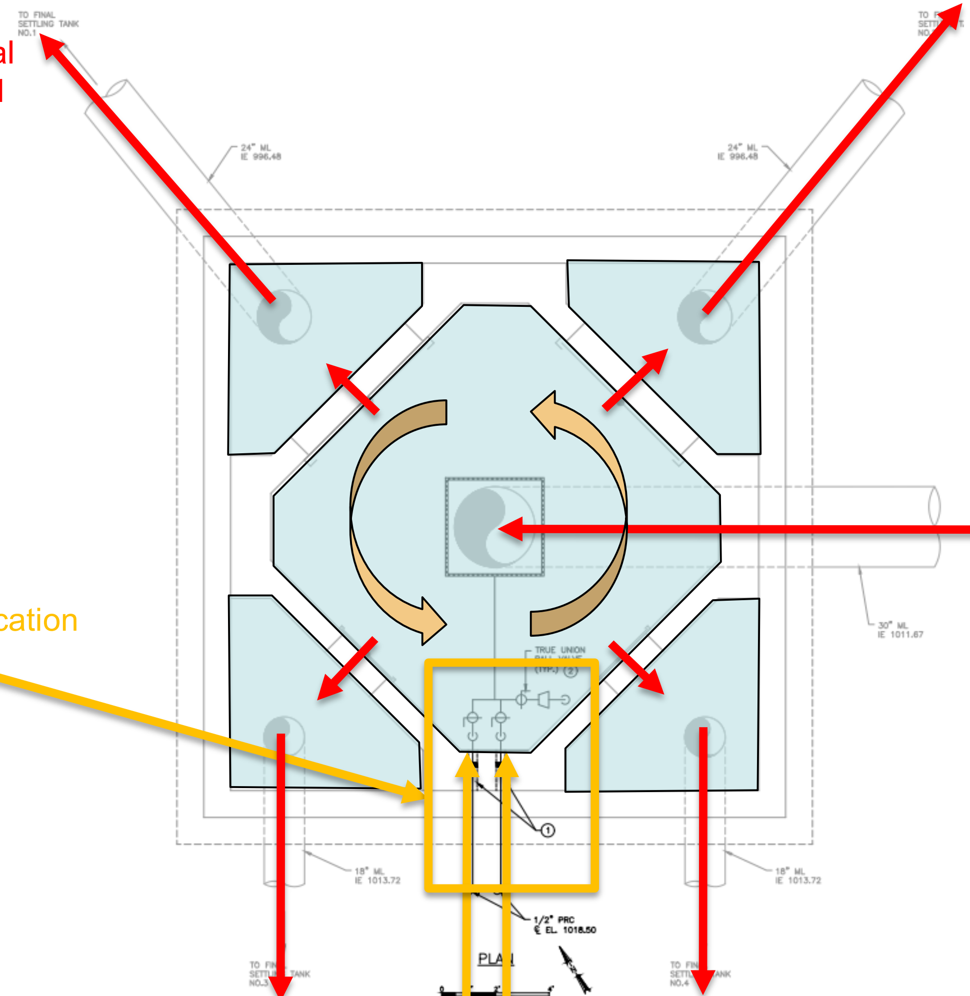
Incorporating CPR at Londons WWTP



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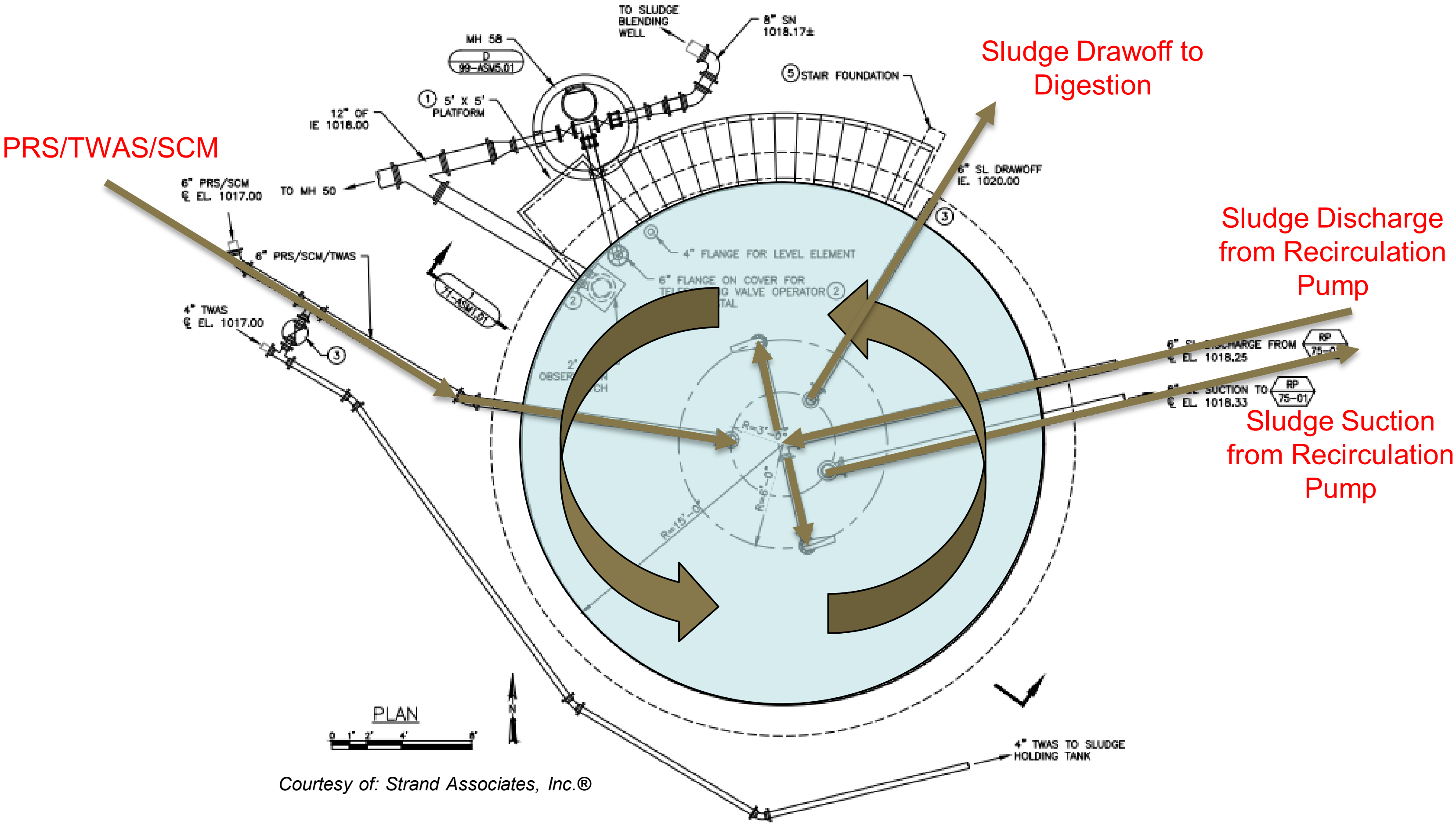
Incorporating Solids Handling at London's WWTP



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- **Paths Forward**

Paths Forward

- Design is complete and now awaiting funding from WPCLF
- Design:
  - To year 2040 and projected population of approximately 18,000
- Nutrient Project includes
  - Add Denitrification for Total Nitrogen Removal
  - Implement A_2/O Process for Bio-P Removal
  - Implement Chemical Phosphorus Removal
  - Add Sludge Equalization Tank for Sludge Storage

Questions?

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Thank you!

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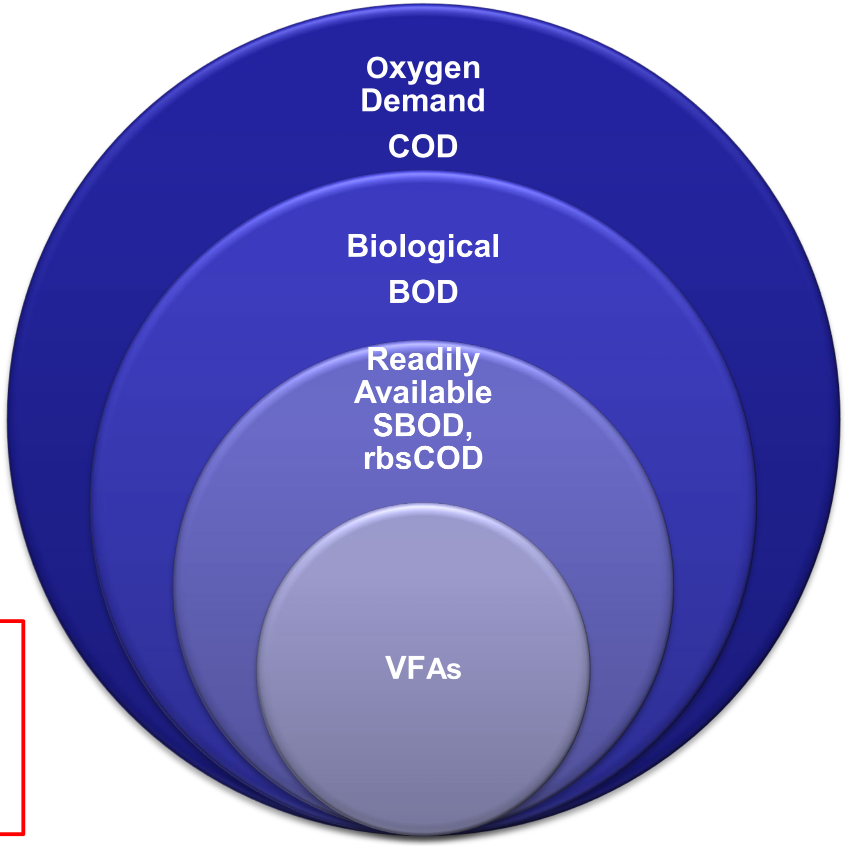
BPR Process Understanding Still Evolving Today

- Conventional mainstream anaerobic zone promotes Accumulibacter PAO that needs supply of VFA (acetic and propionic)
- Mainstream conditions not ideal for symbiotic PAO species like Tetrasphaera, which can ferment glucose and amino acids and other higher carbon forms and also store phosphorus
- Sidestream anaerobic fermenter allows Tetrasphaera produce VFA that allows Accumulibacter to also function alongside
- Tetrasphaera denitrify under anoxic conditions
- Keys to the puzzle:
  - Need ORP < -300 mV; most anaerobic zones struggle to get -150 mV
  - Impossible to achieve with NO3 or DO present
  - Turbulence, air entrainment, air mixing prevent low ORP

Key Influent Data

- Minimum recommended influent concentrations and ratios
  - Readily biodegradable soluble COD: 60 mg/L
  - BOD_5/TP: 20
  - Soluble BOD_5/soluble phosphorus: 15
  - Total COD/TP: 50

London:
$CBOD_5$/TP = 44 mg/L (Influent)
$CBOD_5$/TP = 36 mg/L (Primary Effluent)



City of London – Nutrients

Total Phosphorus Recycle

Belt Press Filtrate

- Class A anaerobic digester system
- 2016 Sludge Press - 5.67 MG
- 22 lbs TP per day in the Filtrate

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