Michigan Water
Environment Association
Process Seminar
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Choices to Address Filamentous Growth

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DONOHUE

Outline

- Battle Creek
  - Introduction
  - Experiences
- Background
  - Filament Facts
  - Indicators
- Control Strategies
  - Temporary
  - Long Term

Battle Creek Wastewater Treatment Facility

- Design capacity 27 mgd
- Currently operating at 9 mgd
- Flows have decreased over the years
- Significant loadings from food processors and paper
  - Influent BOD
    - 580 mg/L (2013-2014)
    - 650 mg/L (2015)

Battle Creek
Wastewater Treatment Facility

Battle Creek Wastewater Treatment Facility

- Nutrient deficiency
  - Insufficient nitrogen and phosphorus for activated sludge based on high BOD loadings
  - Initial control for filament blooms was chlorination of RAS
  - Operators watched for indicators
    - Microscopy, settling, and effluent characteristics
  - Chlorination was started immediately if bloom was detected

Battle Creek Wastewater Treatment Facility

- Nutrient deficiency
  - First attempt for nitrogen and phosphorus addition included monitoring the primary effluent
    - Ortho-P analyzer
    - UV-BOD probe
    - Ammonia probe
  - Nitrogen and phosphorus was dosed based on meeting a 100:5:1, BOD:N:P ratio
  - Started talking with industrial customers

Battle Creek Wastewater Treatment Facility

- Nutrient deficiency
  - Primary effluent monitoring equipment didn't work
  - Recent strategy is manual feed of nitrogen and phosphorus based on lab data (COD, TKN, P)
  - Nitrogen feed, UAN-28: 25 tons annually
  - Phosphorus feed, phosphoric acid: 823 tons annually

Battle Creek Wastewater Treatment Facility

- Phosphorus removal
  - Ferric chloride is regularly dosed for a settling aid in the mixed liquor
  - Adds to the complexity of daily control balancing phosphorus addition and phosphorus removal
  - Winter effluent limit 1 mg/L
  - Summer voluntary TMDL limit of 0.5 mg/L

Battle Creek Wastewater Treatment Facility

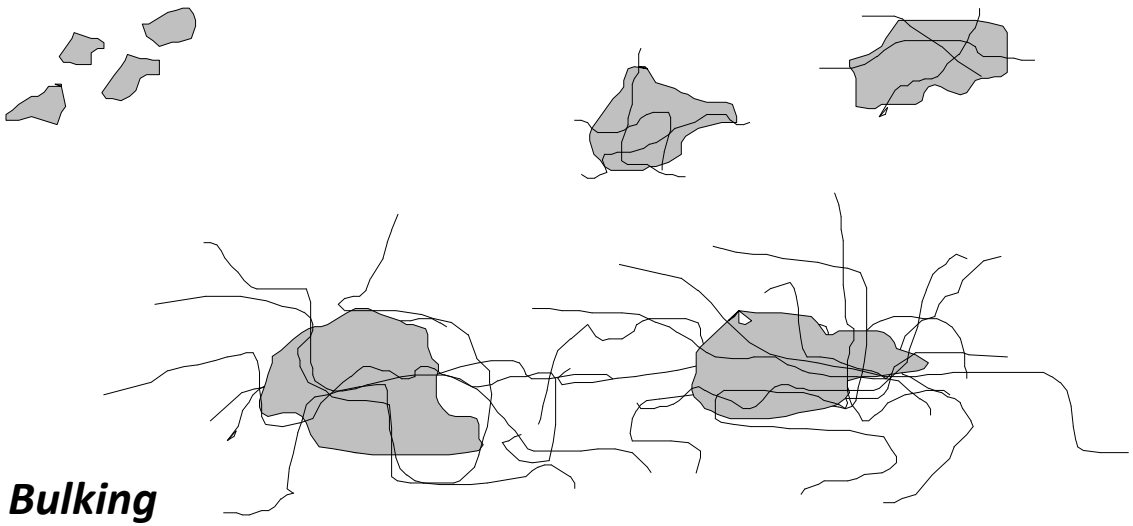
- Filamentous bulking episodes
  - Prior to dosing N and P, “blooms” were occurring every 2 weeks
  - Current control has reduced frequency of blooms
  - Control using RAS chlorination has always been an effective tool

Background on Filament Growth

Filaments Are Important Components of Mixed Liquor

Too Few Filaments

Moderate Filament Growth



Filamentous Bulking Condition

Sludge Volume Index (SVI) – An Indicator of ML Settleability

- SVI < 60 mL/g
  - Too Low, Not Enough Filaments, Fine Solids in Effluent
- SVI = 60-120 mL/g
  - Good Settling ML, Clear Effluent, Compact Blankets
- SVI = 120-180 mL/g
  - Fair Settleability, Clear Effluent
- SVI = 180-250 mL/g
  - Marginal/Poor Settleability, Clear Effluent
- SVI > 250 mL/g
  - Poor Settleability/Bulking

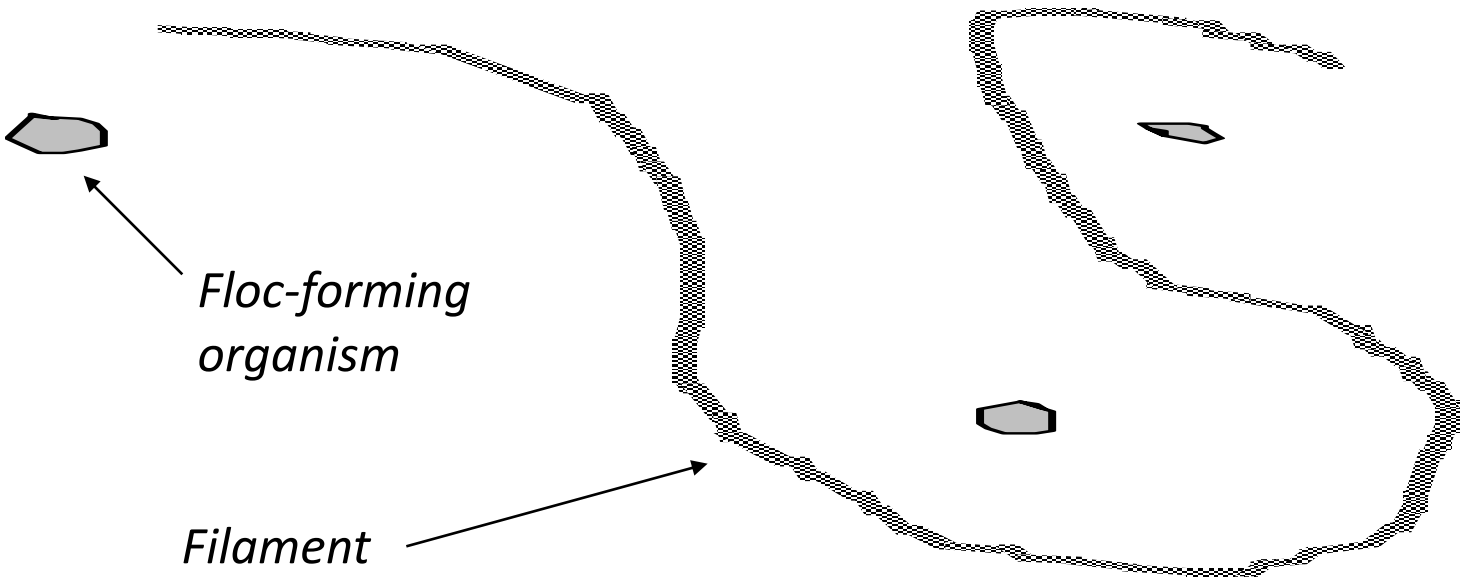
So you think you have filaments?

- Don’t jump to conclusions
- Stepwise Approach:
  A. Identify the Filament (send sample to lab)
     - RAS Chlorinate in the meantime
  B. Research the Filament (what does it like)
  C. Critique your Environment (what’s causing it)
  D. Identify and Implement a Solution

Primary Causes of Bulking

- Needed Compound Lacking or in Short Supply
  - Nutrient Deficiency
  - Low Dissolved Oxygen Concentrations
  - Low Substrate (Food/BOD) Concentrations
- High SRT
- Different causes result in the propagation of different filamentous organisms.

Why do filaments “bloom”



Filaments higher surface area provides a selective advantage when essential food / nutrients / DO are limiting.

Control Strategies

Bulking Control Strategies

- Kill the Filaments – RAS Chlorination
  - Baseline Provision
- Modify Environmental Conditions to Eliminate What's Causing the Filaments
  - Nutrient Addition
  - Basin Configuration/Feed Pattern
  - Aeration Upgrades
  - System SRT

RAS Chlorination Basics

- Preferred Feed Point Location
  - RAS Line
  - Good Mixing
  - Contacts All Mixed Liquor Several Times Per Day
- Feed Rate Basis
  - Pounds of Chlorine Applied Per Day Per 1,000 Pounds of Mixed Liquor Suspended Solids in the System

RAS Chlorination Feed Rates

- Maintenance Dosage
  - 1-2 lbs Cl_2/1,000 lbs MLSS/day
  - Can Apply 24/7
- Toxic Dosage
  - Hit ‘em Hard for Limited Periods
  - Aggressive – 4-8 lbs Cl_2/1,000 lbs MLSS/day
  - Very Aggressive – 8-12 lbs Cl_2/1,000 lbs MLSS/day
  - **Only Apply for 4-8 hours Every 3-4 days**, Using Maintenance Dose Rest of Time
  - **Be Very Careful**, Particularly at Very Aggressive Rates

Modify Environmental Conditions

- Nutrient Deficiency
  - BOD:N:P Ratio of 100:5:1 is Good Target
  - Nutrient Addition

Battle Creek Primary Effluent			
Date	BOD	TKN	Tot-P
07/12/15	100	8.1	0.6
07/14/15	100	5.8	0.6
07/16/15	100	5.8	0.5
07/19/15	100	5.4	0.6
07/21/15	100	3.9	0.4
07/23/15	100	3.7	0.3

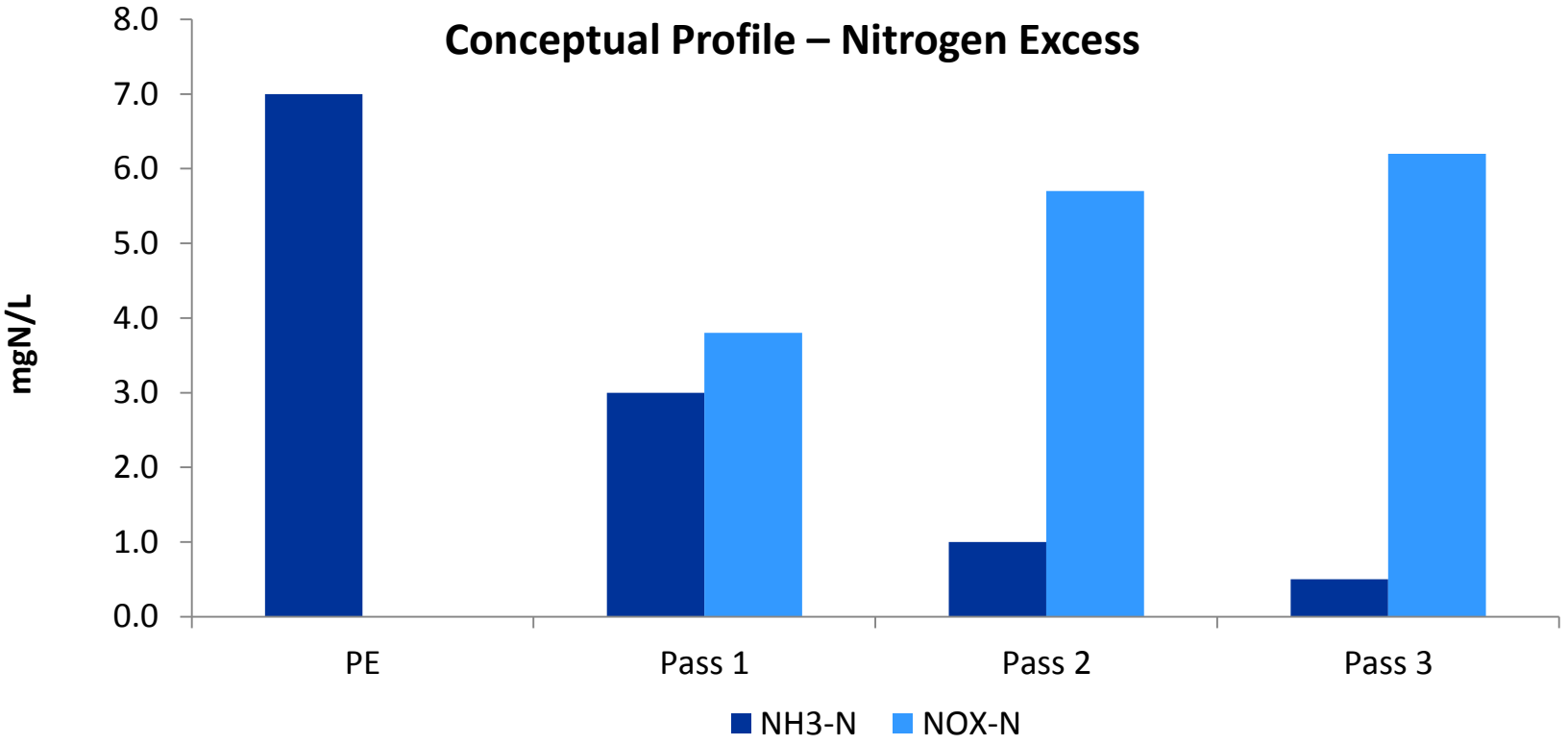
Modify Environmental Conditions

- Nutrient Deficiency
  - BOD:N:P Ratio of 100:5:1 is Good Target
  - Nutrient Addition – UAN-28 and Phosphoric Acid

Battle Creek PE including N + P Dosing			
Date	BOD	TKN	Tot-P
07/12/15	100	8.1	1.1
07/14/15	100	5.8	1.1
07/16/15	100	5.8	0.9
07/19/15	100	5.4	1.1
07/21/15	100	4.5	0.8
07/23/15	100	4.6	0.8

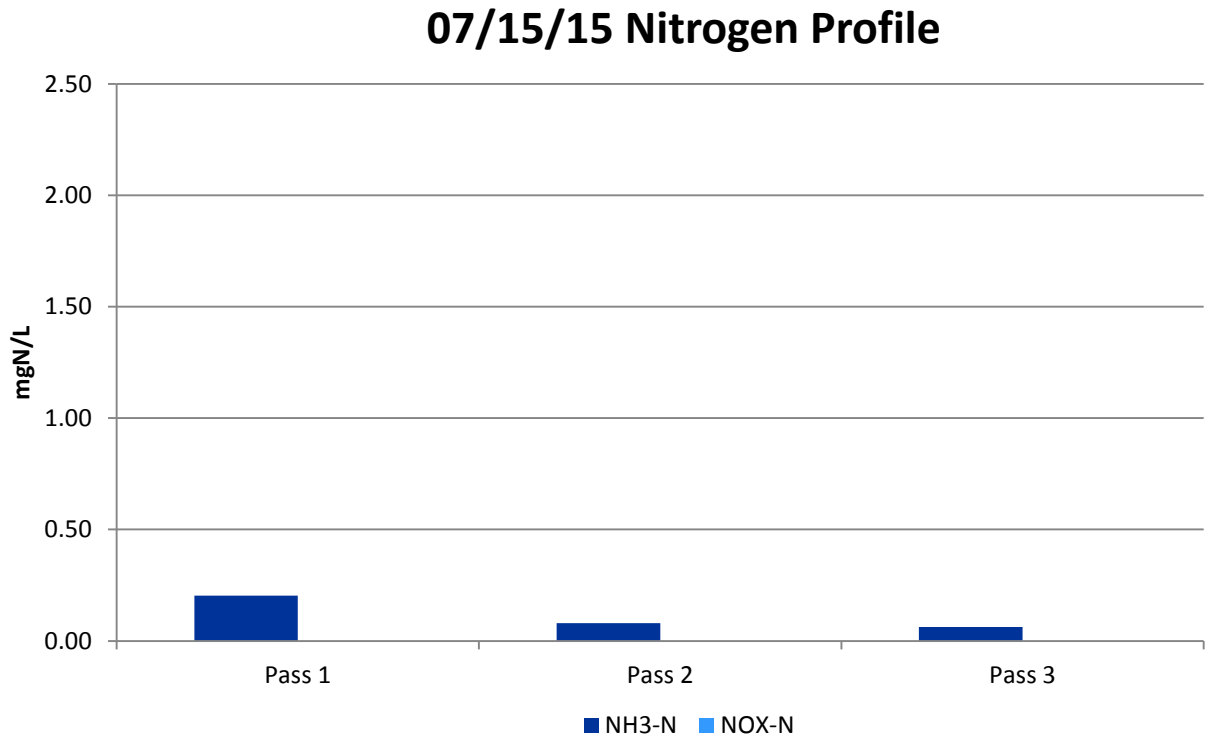
Modify Environmental Conditions

- Nutrient Deficiency



Modify Environmental Conditions

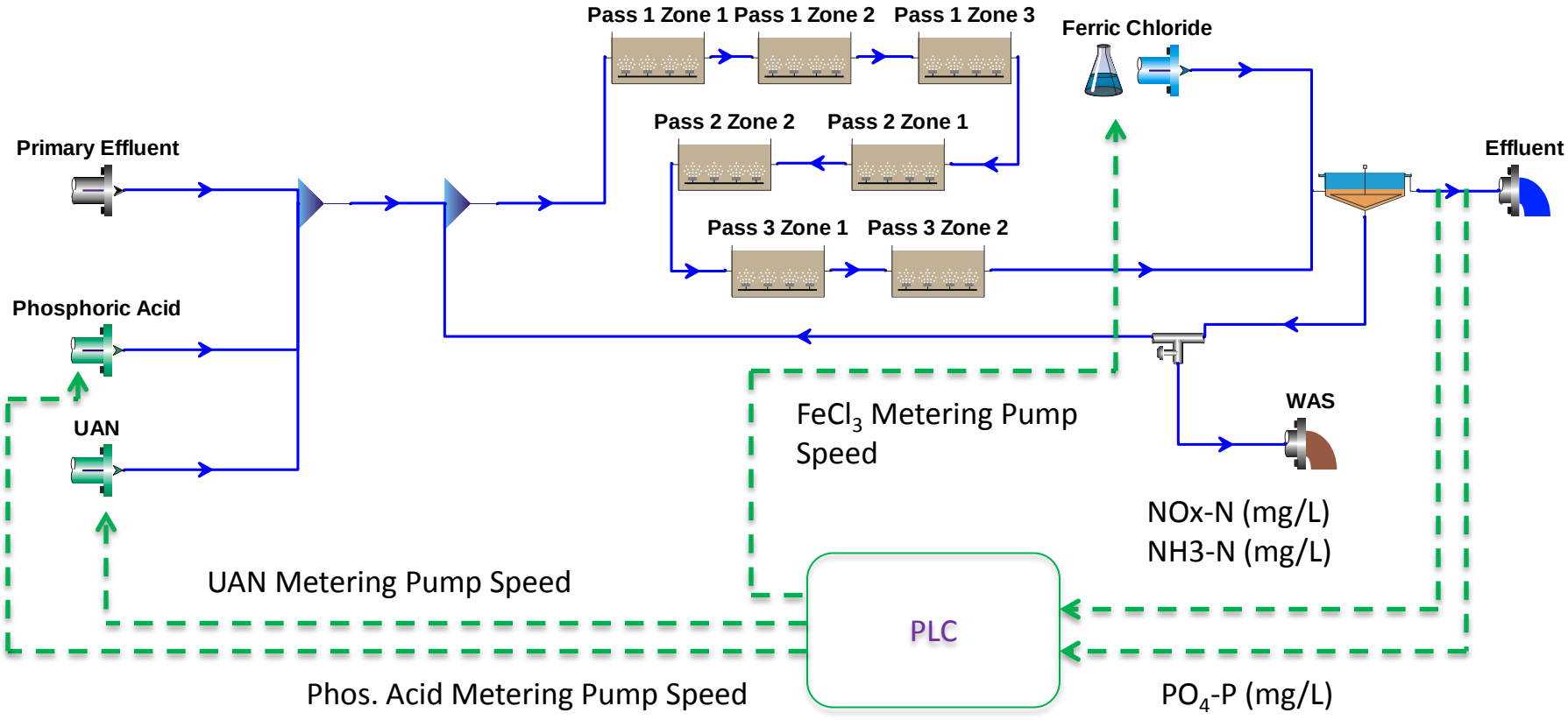
- Nutrient Deficiency
  - Battle Creek: 3 of 6 days showed similar numbers



Modify Environmental Conditions

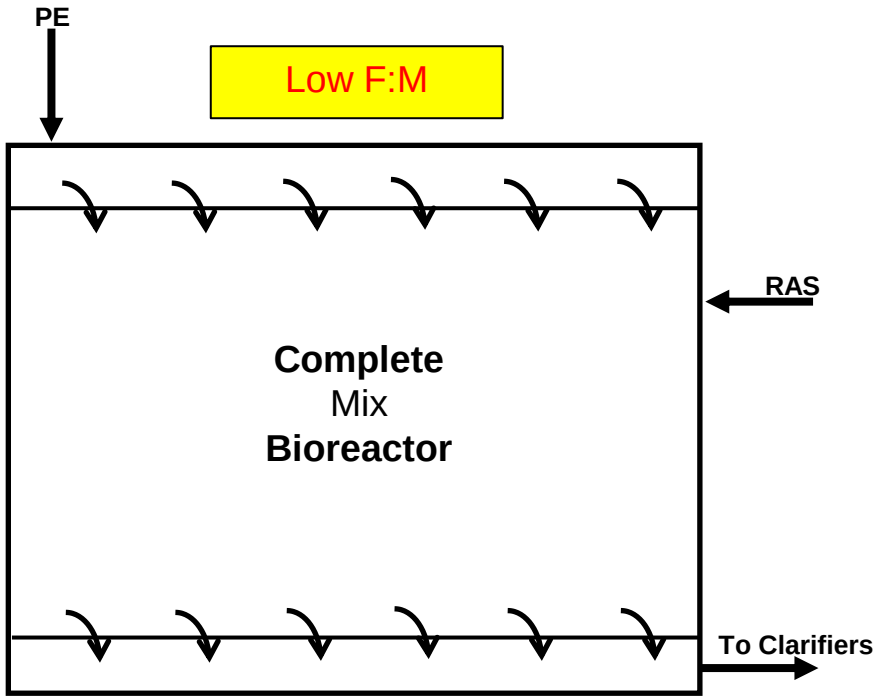
- Nutrient Deficiency
  - Battle Creek initial recommendations
    - Increase UAN-28 dosing
    - Start monitoring effluent nitrate concentration

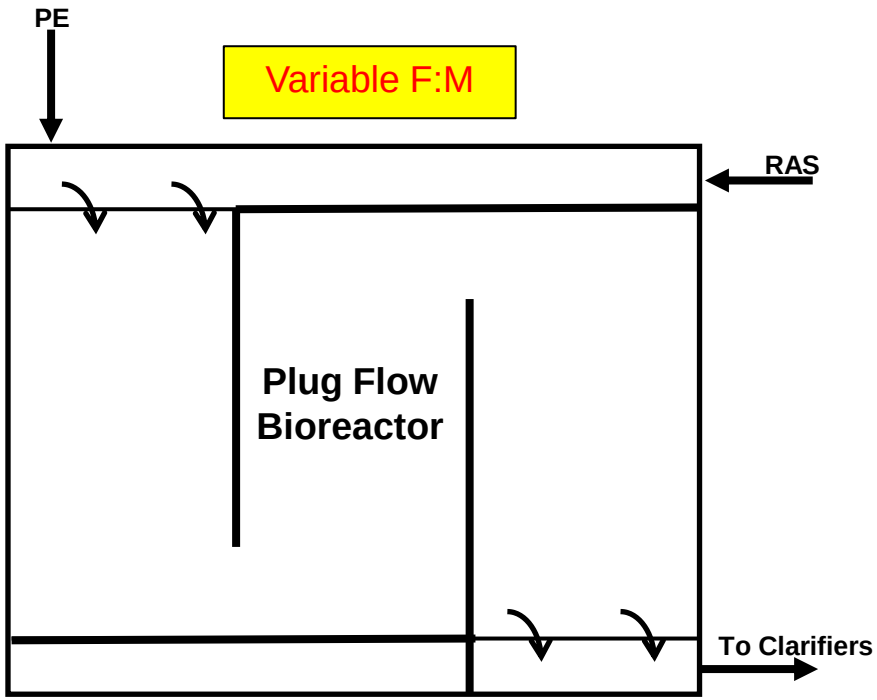
Recommended Chemical Dosing Strategy



Modify Environmental Conditions

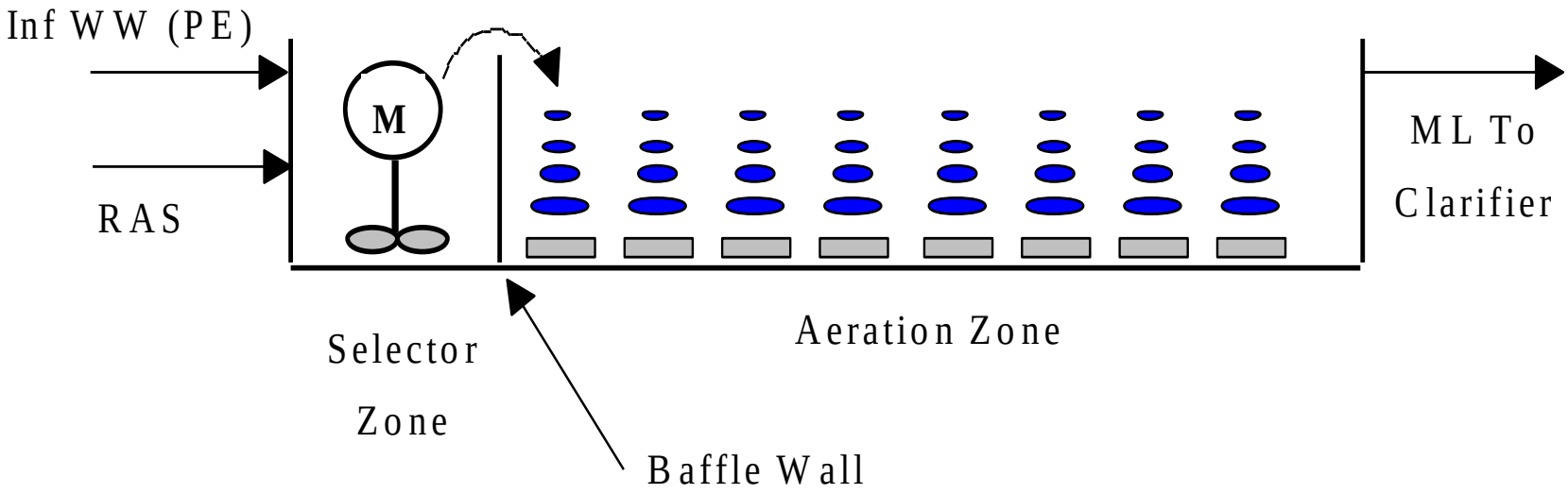
- "Select" Against Filaments
- Example – Convert From Complete Mix to Plug Flow





Modify Environmental Conditions

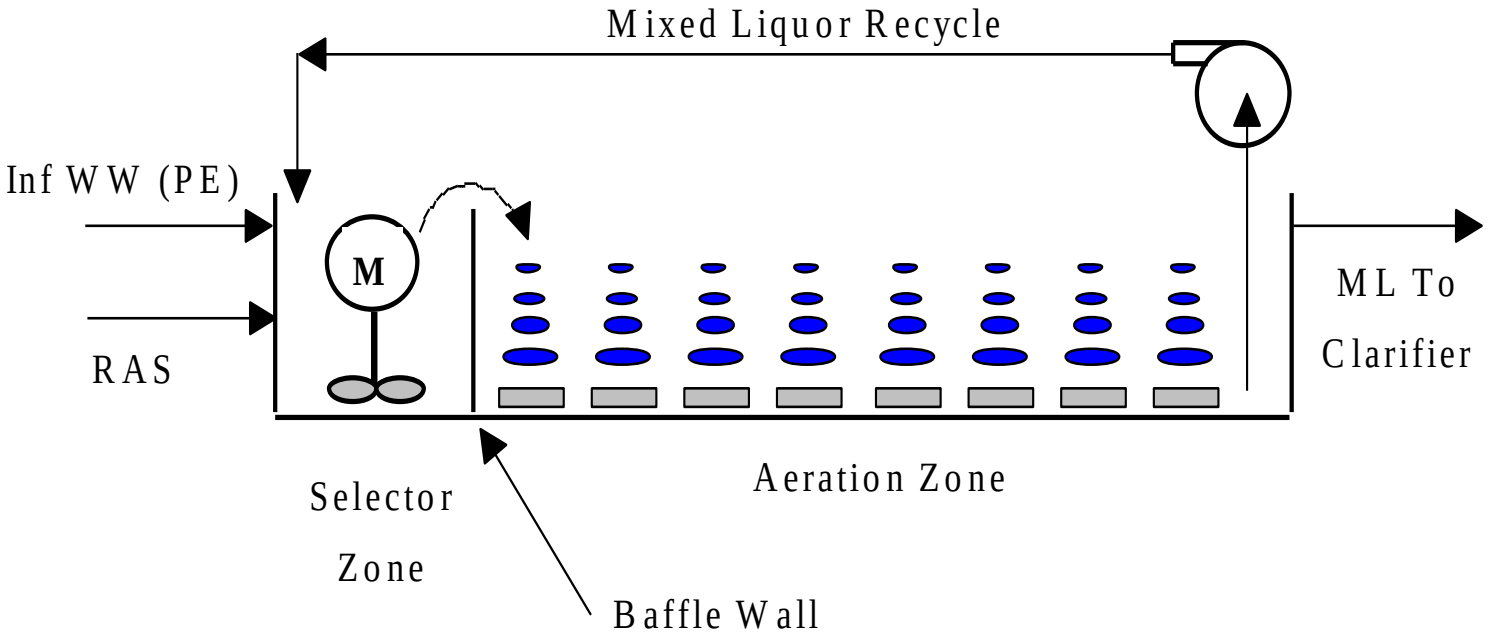
- Add “Selector” Zones Upstream of Aeration Basins.



Selectors Provide Environmental Conditions Which Promote Growth of Floc Formers

- High Substrate Concentration
  - Eliminates Filament Size Advantage
- Short Detention Time
  - Takes Advantage of Substrate Storage Capabilities of Floc Formers
- Anoxic or Anaerobic Conditions
  - Takes Advantage of Floc Formers Anoxic or Anaerobic Respiration Capabilities

Typical Anoxic Selector Configuration



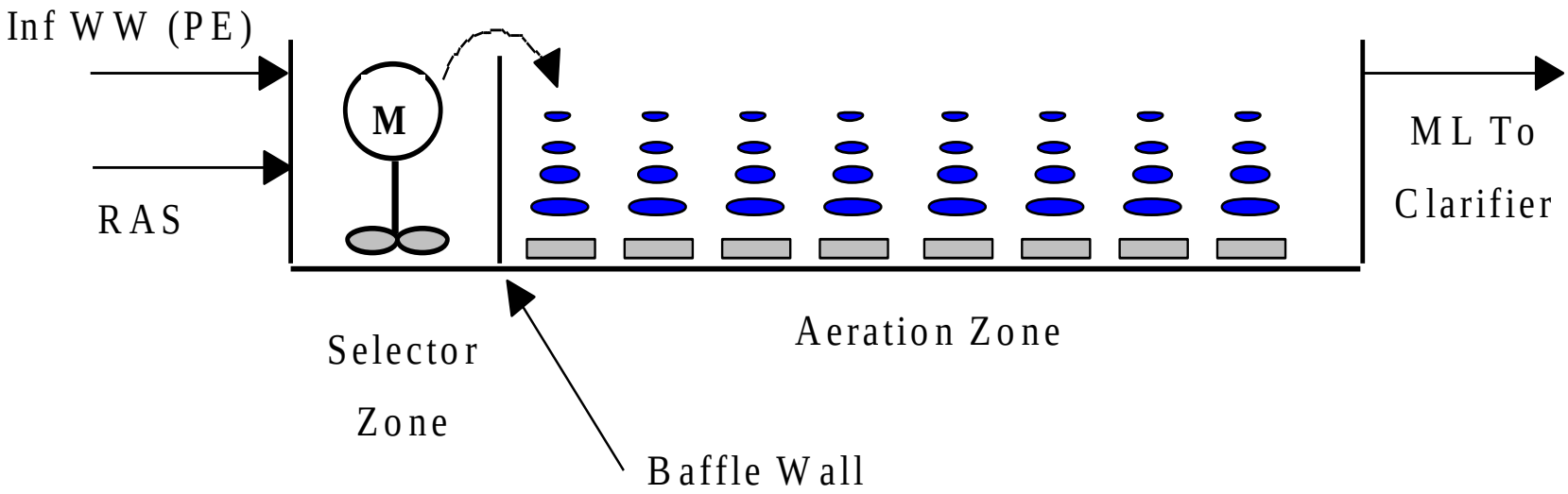
Nitrate is supplied to the selector zone via mixed liquor recycle and RAS.

Anoxic Selector Upstream of Plug Flow Aeration Basin

Anoxic Selectors Can Provide Additional Benefits

- Reduced Aeration Requirements
  - 2.86 mg of oxygen equivalent is supplied for every 1 mg of nitrate denitrified to nitrogen gas
- Reduced Consumption of Alkalinity
  - Nitrification consumes 7.1 mg alkalinity for each mg of ammonia nitrified to nitrate
  - Denitrification produces 3.6 mg alkalinity for each mg of nitrate denitrified to nitrogen gas

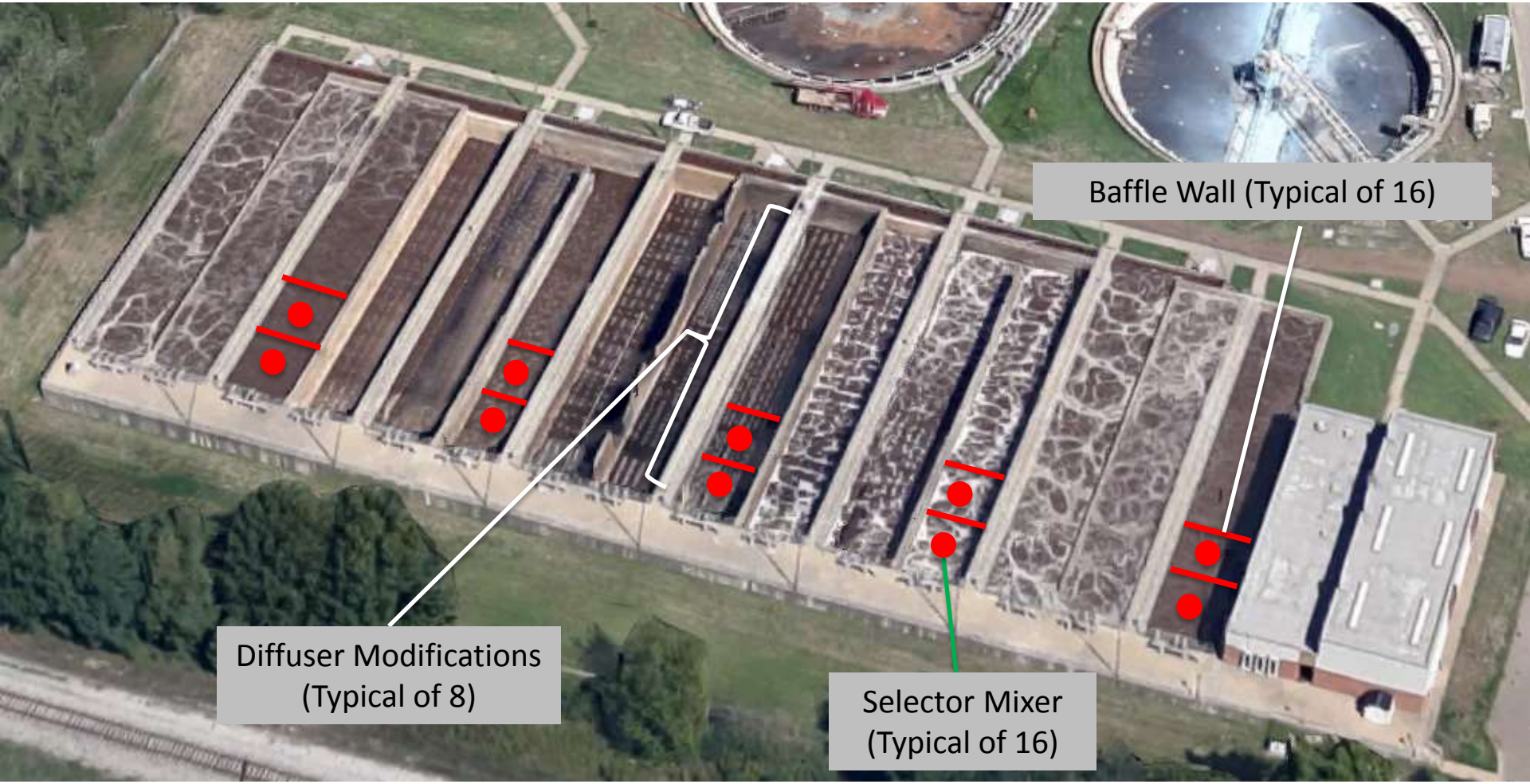
Simple Anaerobic Selector



Anaerobic/aerobic cycling provides environment selecting for PAOs.

Bio-P Bugs Settle Fast

Battle Creek West Aeration Tanks Recommended selector layout



Selectors Are Not Always Effective

- You Must Prevent Bleed Through of Soluble Substrate to Bulk Aeration Basin
  - Target < 60 mg/L Soluble COD (20-30 mg/L SBOD5)
  - Function of Selector Loading and Configuration
- They Won't Cure Other Problems
  - "Nutrient" Deficiency
- Some Filaments Are Immune to Selector Effect
  - Long SRT Filaments

Concluding Thoughts

- Not All Filaments Can Be Controlled By Selectors
- Not All Bulking Caused By Filaments
- Microscopic Examination/Identification Provides Very Valuable Information
  - Potential Causes
  - Corrective Actions
- Key Fundamentals Can't Be Taken For Granted
  - *SRT Control*
  - *Control P Removal Chemical Dosages to Avoid Nutrient Deficient Conditions*
  - Maintain Provisions for RAS Chlorination

Finally – Use the Proven Stepwise Approach to Address the Problem

A. Identify the Filament (or that it's not a filament)
   - If It's Filamentous Bulking Start RAS Chlorination
B. Research What Factors Favor That Filament (or Condition)
C. Evaluate Your Situation For What Might Be Contributing
D. Identify and Implement a Solution if Possible