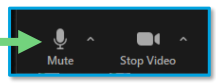
What are you looking forward to in fall?

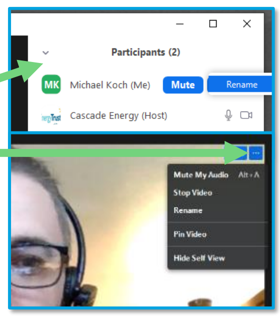
1

Using Zoom!

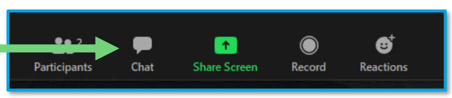
Mute yourself!
Have a question?
Use the chat feature.
Controls accessed at the bottom



Rename yourself
"Name (Company)"
Right click on your picture or 3 dots
OR
Controls accessed at the right after clicking 'Participants' at bottom.



Access Chat at the bottom



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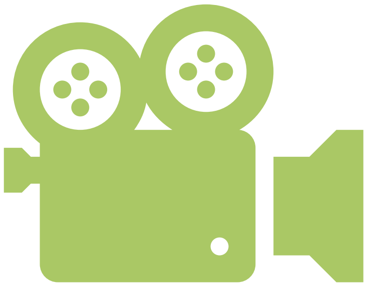
Recording

This meeting is being recorded (both audio and video)

If you do not consent to being recorded, please let the meeting moderator know ASAP and we will facilitate your participation in another way or adjust our procedure.



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WW VINPLNT SESSION 5

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Thank You!

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Today's Agenda

Homework Report Out & Review	**Fans & Odor Control**
A Challenge.....	**HVAC**
Sludge Quality and SRT	**Closing Remarks**

Polling…

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Homework

- Find 3 opportunities to input into your Opportunity Register (MEASUR Treasure Chest)
- Complete the entries
- Be prepared to discuss them during the session

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An Example….

- Plant Flow Rate: 4 MGD
- RAS Rate: 85%(0.85)
- Static Head 20 Feet
- Friction Head 40 Feet
- Pump Efficiency 71%
- Motor Efficiency 92%
- Hours/Year 8760 hours

RAS Flow gpm = 0.85 * (4,000,000 gal / ~~day~~ * 1 ~~day~~ / 1,440 min) = 2,361 gpm

$$BHP = \frac{(GPM) \times (TDH) * sg}{3960 \times (pump\ eff.)}$$

BHP = (2361 gallons / minute * 60 feet * 1) / (3960*0.71) = 50.4 bhp

kW = 50.4 ~~hp~~ / 0.92 * 0.746 kW / ~~hp~~ = 40.8 kW * 8760 hours / year = 357,408 ~~kWh~~ / year * $0.1039 / ~~kWh~~ = $37,135 / year

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Let's just say that you find out you can actually reduce your RAS rate to 30% w/o impacting effluent quality….

- Plant Flow Rate: 4 MGD
- RAS Rate: **30%(0.30)**
- Static Head 20 Feet <<<<<<<< Won't change
- Friction Head 40 Feet <<<<<<<< Will actually go down
- Pump Efficiency 71% <<<<<<<< Could change
- Motor Efficiency 92% <<<<<<<< Could drop way off
- Hours/Year 8760 hours <<<<<<<< Better not change

- RAS Flow GPM = 0.30 * (4,000,000 gal/d/1,440 min/day) = 833 gal/min
  - kW = (833 gal/min*60 ft)/(3960*.71*.92) * 0.746 = 14.4 kW

    kWh = 14.4 kW * 8760 hr/year = 126,269 kWh/year

    $/year = 126,269 kWh/year * $0.1039/kWh = $13,120/year

Final Annual Savings = $37,185 - $13,120 = $24,065/year

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Let's just say that you find out you can actually reduce your RAS rate to 30% w/o impacting effluent quality….

- Plant Flow Rate: 4 MGD
- RAS Rate: **30%(0.30)**

RAS to Riches

$$$

11

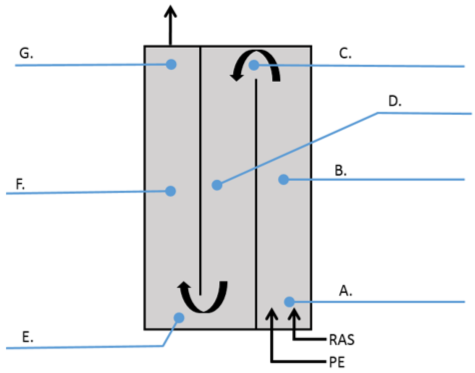
HOMEWORK REPORT OUTS

12

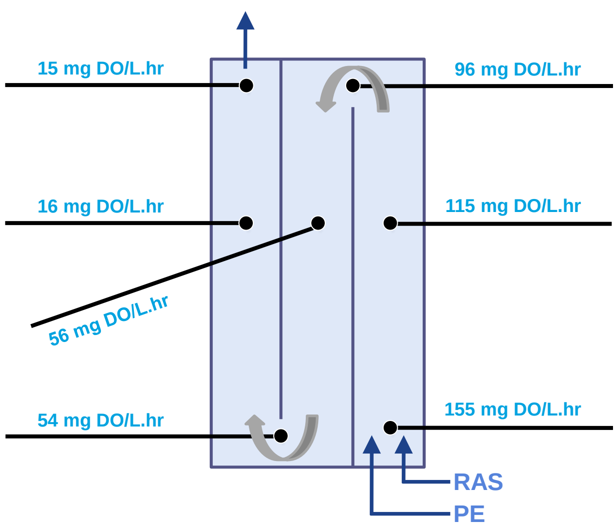
HOMEWORK: OUR – FINDING ENDOGENOUS RESPIRATION

Part 1: What is your OUR? Go out to your aeration basin and take at least one OUR test. Capture about 7 reads (0 – 60) 10 seconds apart. Be prepared to report your findings to the cohort!

Part 2: An example problem. A 3-pass aeration basin is shown below. On the following page are the results of 7 OUR tests performed on the basin.



OUR Profile



Polling…

Most of you have activated sludge plants (SBRs and MBRs are activated sludge variants). How is activated sludge at your plant controlled?

a. F:M ratio
b. MLSS or MLVSS concentration
c. MLSS or MLVSS mass
d. Sludge quality based on microscopic exams
e. SRT/MCRT/sludge age

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Session 5
Sludge Quality and SRT

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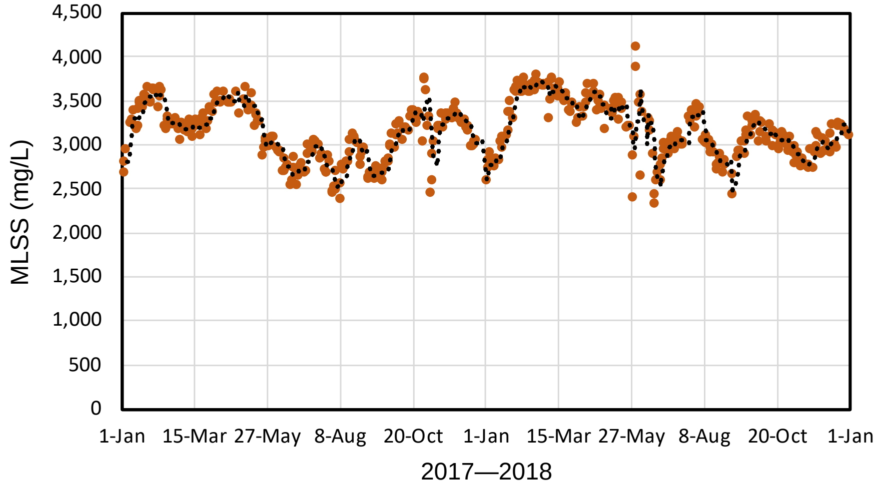
Let's Cut to the Chase
There's a Saying in the Wine Business

"You can make good wine with good grapes, you can make bad wine with good grapes, but you can never make good wine with bad grapes."

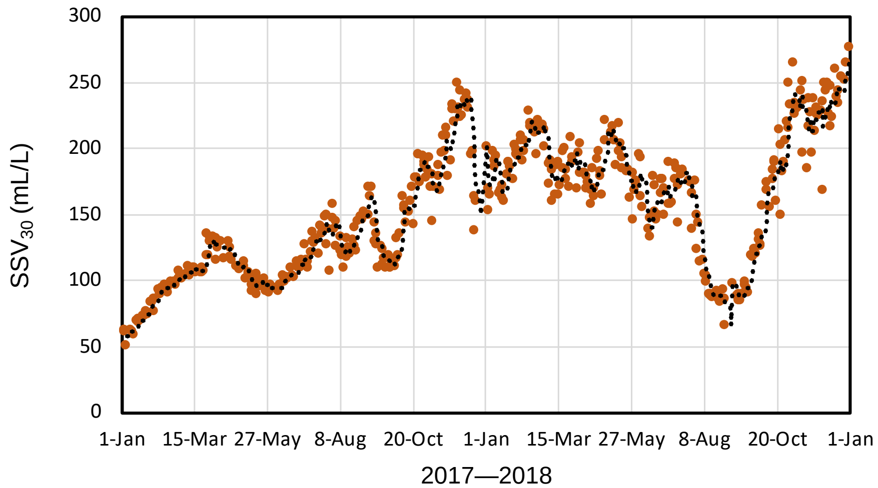
In the Business of Treating Wastewater with the Activated Sludge Process

"You cannot have good effluent quality without good sludge quality."

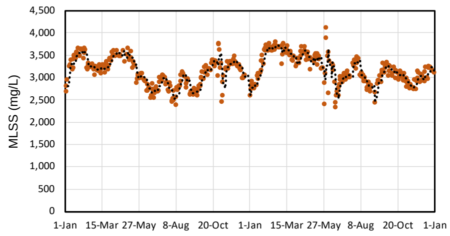
In an SEM Cohort in the Northwest, the MLSS Concentration is Relatively in Control…



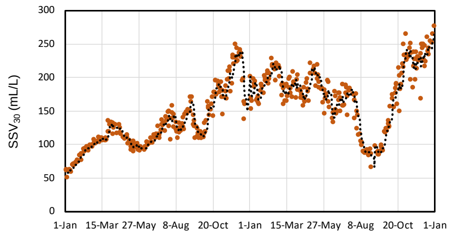
But Sludge Quality is Definitely **NOT** in Control (nor is Effluent Quality)



Which is More Important, Sludge Quantity or Sludge Quality



Quantity?



Quality?

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21

Reminder

"You cannot have good effluent quality without good sludge quality."

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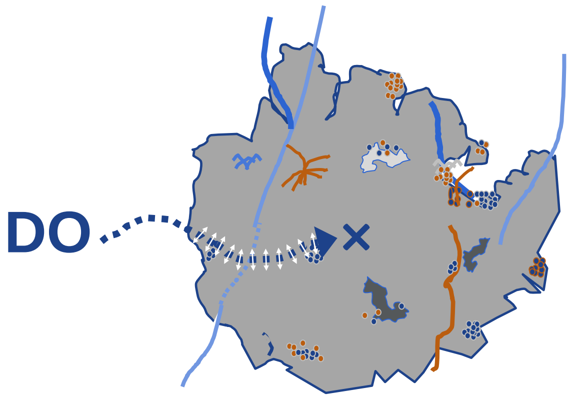
22

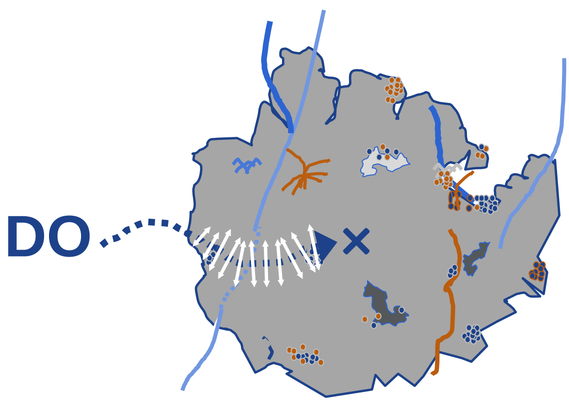
2. While Oxygen is Being Continuously Consumed for Aerobic Respiration

Oxygen Uptake Rate = OUR

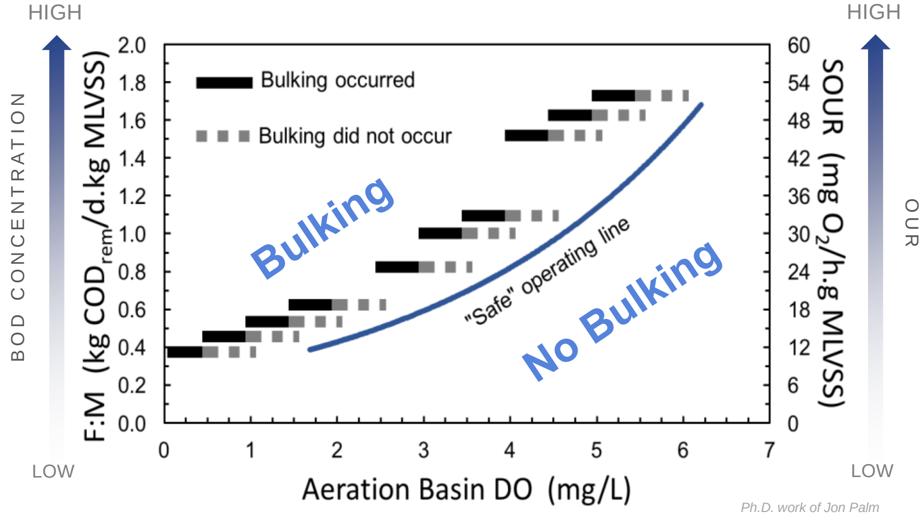


More BOD Results in Greater OUR, Requiring Higher DO Concentration in Mixed Liquor

Oxygen Uptake Rate = OUR

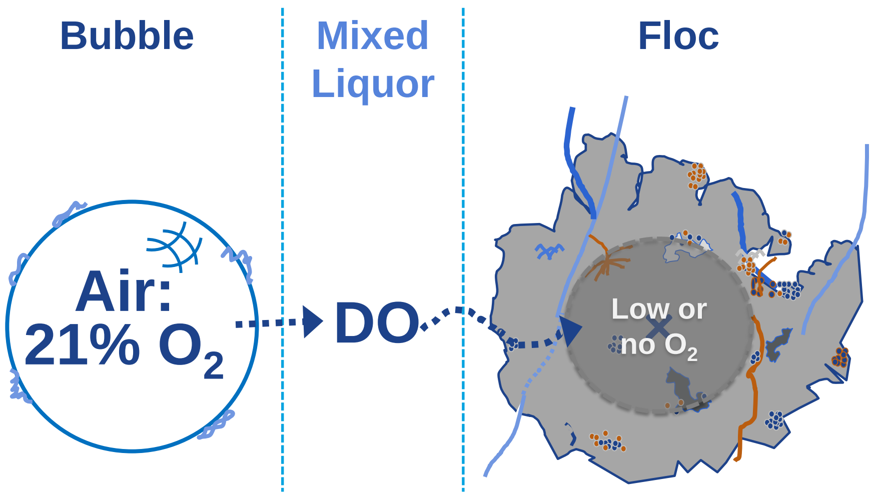


This is What Jon Palm's Ph.D. Work Showed: Greater OUR Requires Higher DO Set Points

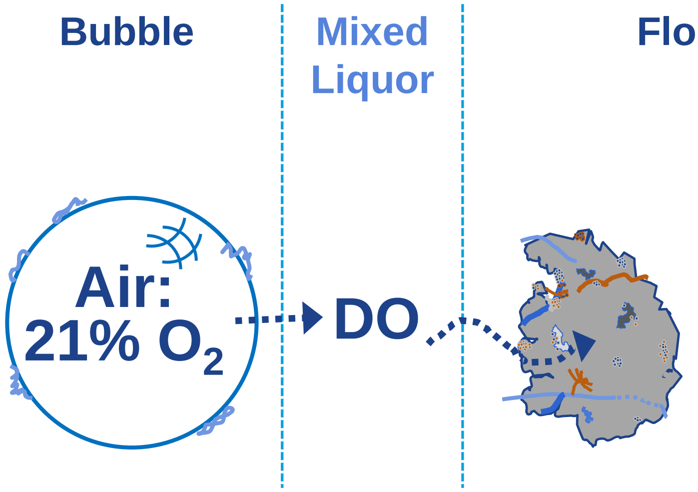


Ph.D. work of Jon Palm

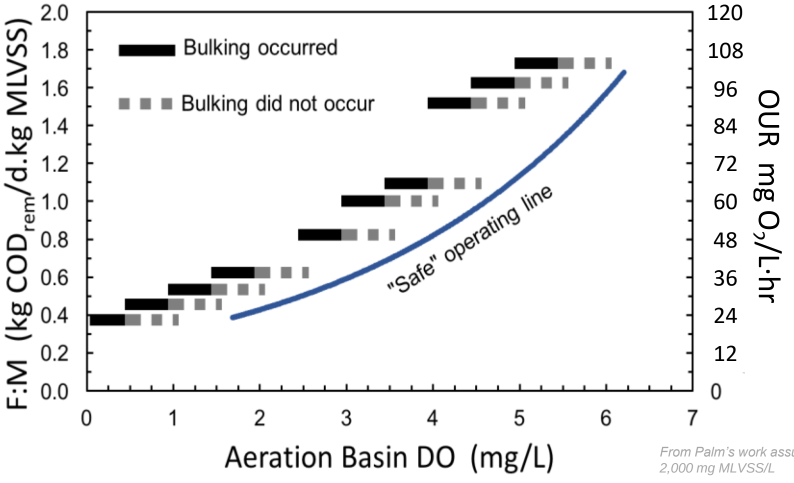
Insufficient DO to Drive Diffusion Results in Low/No DO in Center of Floc



Small Floc Settle Slowly, If at All

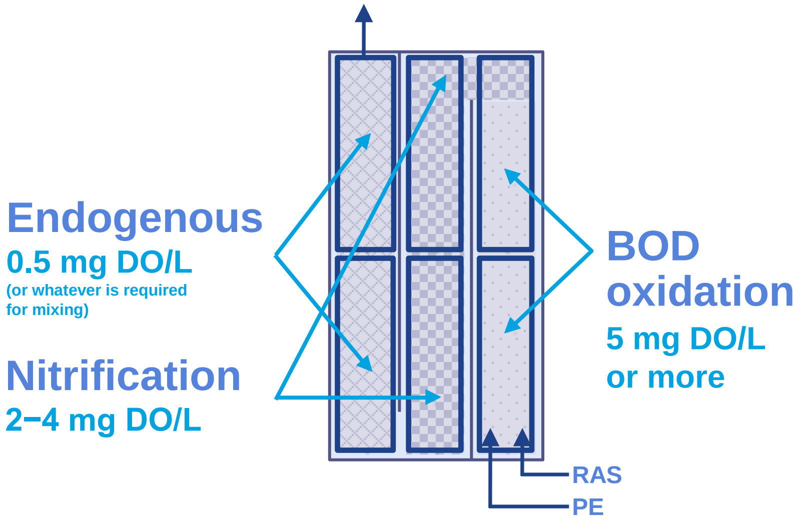


Aeration Basin DO Affects Sludge Quality! Sludge Quality Fixes Effluent Quality



From Palm's work assuming 2,000 mg MLVSS/L

Different Subzones Have Different DO Set-Point Requirements



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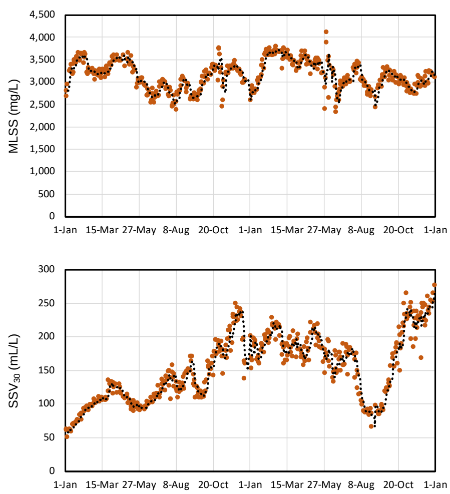
The MLSS Concentration Noes **NOT** Control Sludge Quality



Quantity?

Quality?

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30

Different Approaches to Controlling the Activated Sludge Process

1. Constant MLSS concentration
2. Constant MLSS mass (“inventory”)
3. Constant MLVSS concentration
4. Constant MLVSS mass
5. Constant F:M ratio
6. Constant sludge quality
7. Constant SRT (similar to MCRT)

Design Equation (Modified for Operations) Using BOD

$$\text{MLSS} = \frac{\text{SRT} \times Q}{V_{AB}} \left(\text{ISS}_{INF} + Y_g \times \frac{\text{BOD}_{INF} - \text{sBOD}_{EFF}}{1 + b \times \text{SRT}} \right)$$

A Response Variable Cannot be Used as a Control Variable

$$MLSS = \frac{SRT \times Q}{V_{AB}} (ISS_{INF} + Y_g \times \frac{BOD_{INF} - sBOD_{EFF}}{1 + b \times SRT})$$

The MLSS concentration cannot be used for control.

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A Response Variable Cannot be Used as a Control Variable

$$MLSS \times V_{AB} = SRT \times Q \times (ISS_{INF} + Y_g \times \frac{BOD_{INF} - sBOD_{EFF}}{1 + b \times SRT})$$

The MLSS mass (inventory) cannot be used for control.

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A Response Variable Cannot be Used as a Control Variable

$$MLVSS = \frac{SRT \times Q \times Y_g \times (BOD_{INF} - sBOD_{EFF})}{V_{AB} \times (1 + b \times SRT)}$$

The MLVSS concentration cannot be used for control.

A Response Variable Cannot be Used as a Control Variable

$$MLVSS \times V_{AB} = \frac{SRT \times Q \times Y_g \times (BOD_{INF} - sBOD_{EFF})}{(1 + b \times SRT)}$$

The MLVSS mass cannot be used for control.

F:M Ratio

$$\underbrace{MLVSS \times V_{AB}}_{M} = \frac{SRT \times \overbrace{Q \times Y_g}^{F} \times (BOD_{INF} - sBOD_{EFF})}{(1 + b \times SRT)}$$

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Why Has No One Ever Told Us? The M in F:M is Controlled by F*

$$M = \frac{SRT \times Y_g \times [F - (Q \times sBOD_{EFF})]}{V_{AB} \times (1 + b \times SRT)}$$

*By the microorganisms, not engineers & operators

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Operators and Engineers Don't Control M, The Microbes Do

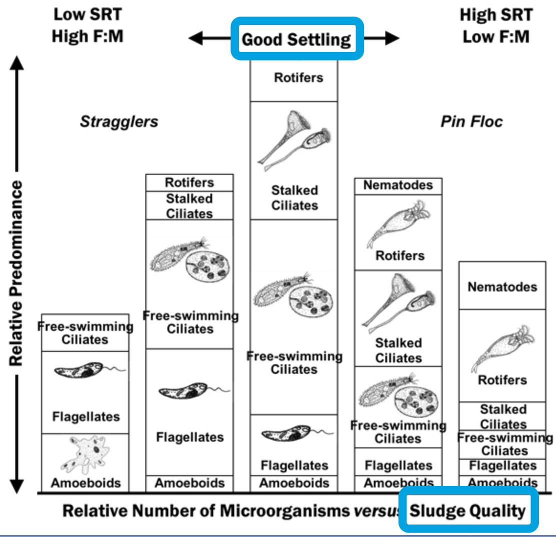
$$MLSS = \frac{SRT \times Q}{V_{AB}} \left(ISS_{INF} + Y_g \times \frac{BOD_{INF} - sBOD_{EFF}}{1 + b \times SRT} \right)$$

↓ Temperature, ↑ MLSS Concentration

↑ Temperature, ↓ MLSS Concentration

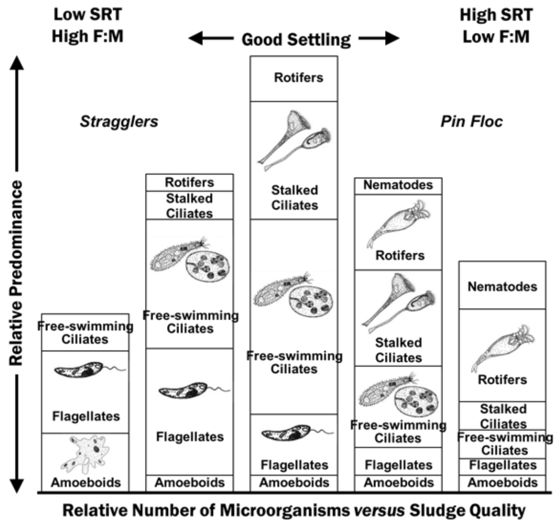
39

Graphic Used for Sludge-Quality Control Approach (Presumably: Good Settling = Good Sludge Quality)



40

What's Wrong With this Picture?



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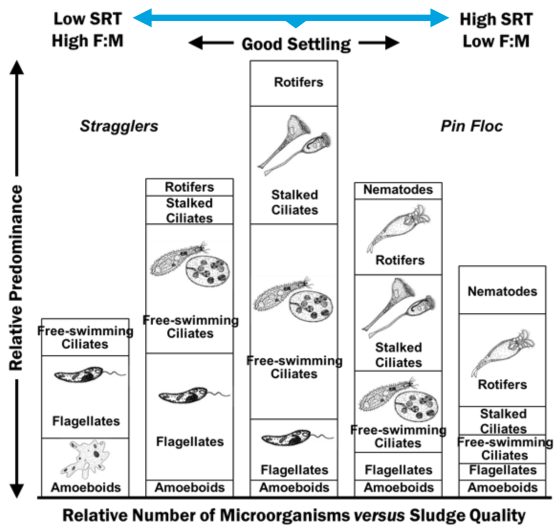
Sludge Quality is Controlled by SRT by Operators Not Rotifers



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Reminder

"You cannot have good effluent quality without good sludge quality."

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43

Only One Way to Control the Activated Sludge Process

- ✗ Constant MLSS concentration
- ✗ Constant MLSS mass ("inventory")
- ✗ Constant MLVSS concentration
- ✗ Constant MLVSS mass
- ✗ Constant F:M ratio
- ✗ Constant sludge quality
- ✓ Constant SRT (similar to MCRT)

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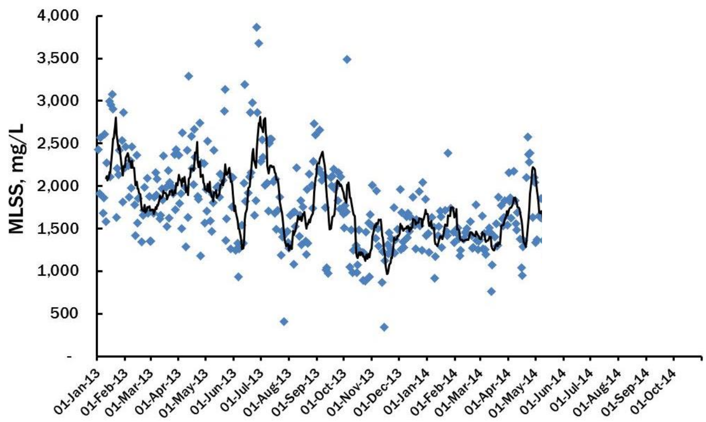
44

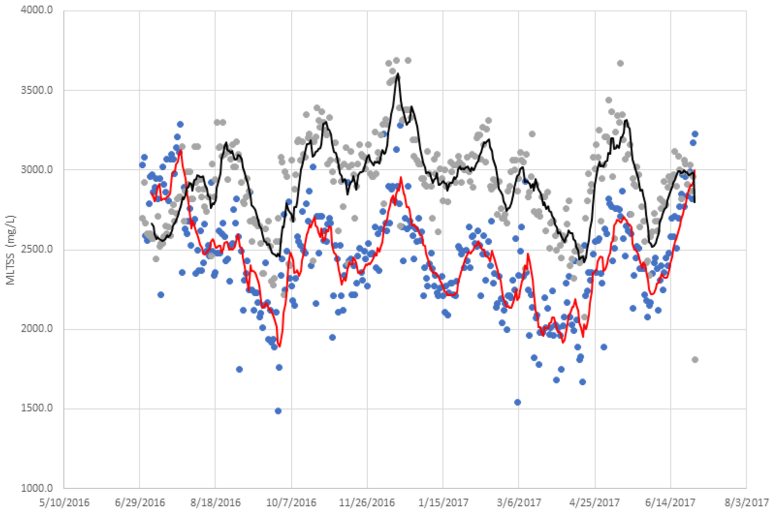
Question We Got Last Time We Did This

"Why are we even talking about this?"

Does This Look in Control



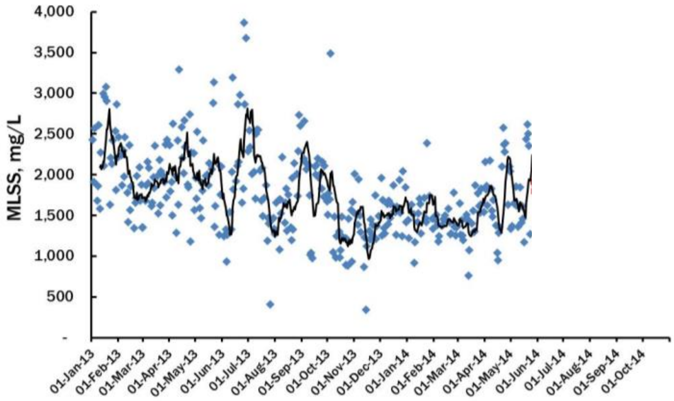
How Can Something Being Controlled Be so Out of Control



Three Wastewater Treatment Plants Over 220 MGD

- Three-year SEM project
- Was on 6-month hold while staff "reprioritized" their commitment
- Senior VP/COO, "I have to ask for a rate increase next November. By the time I go in front of the City Council, I want to know what every one of us is doing to contain, hopefully lower, treatment costs."

MLSS Control (and others) Doesn't Work
But SRT Control Does



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BREAK

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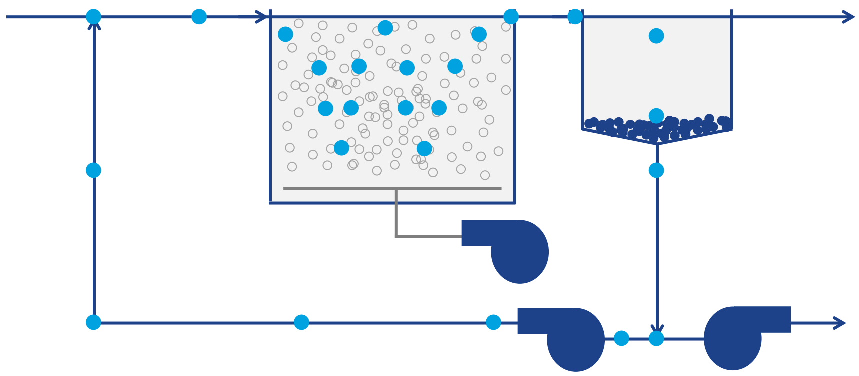
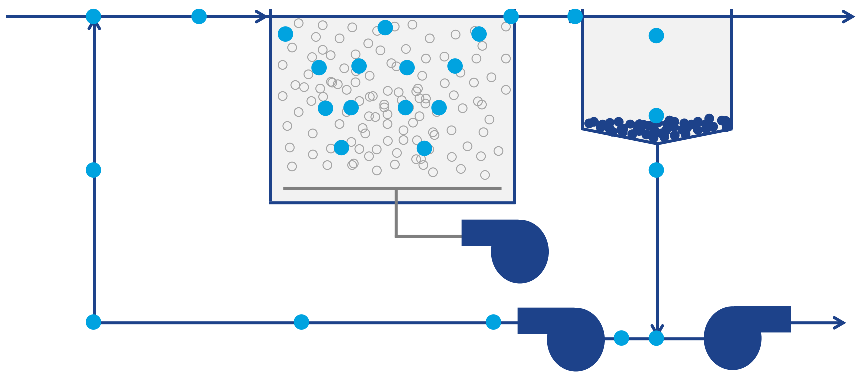
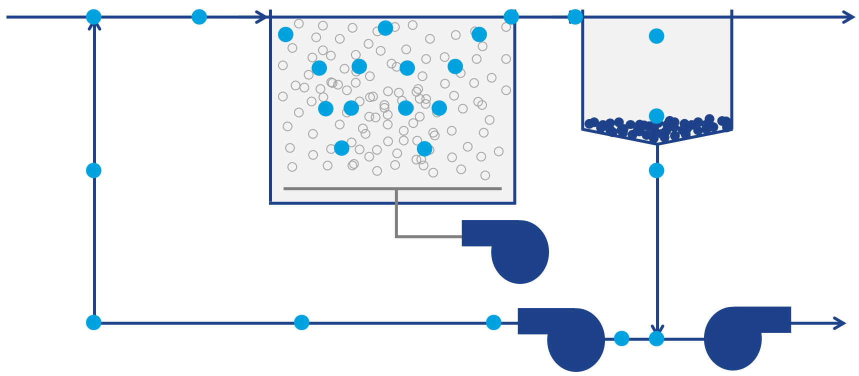
A Bacterium Moves Through the System



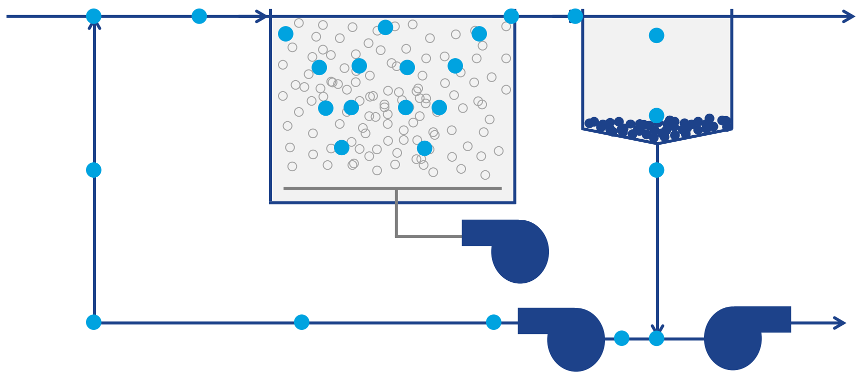
And so it Continues…



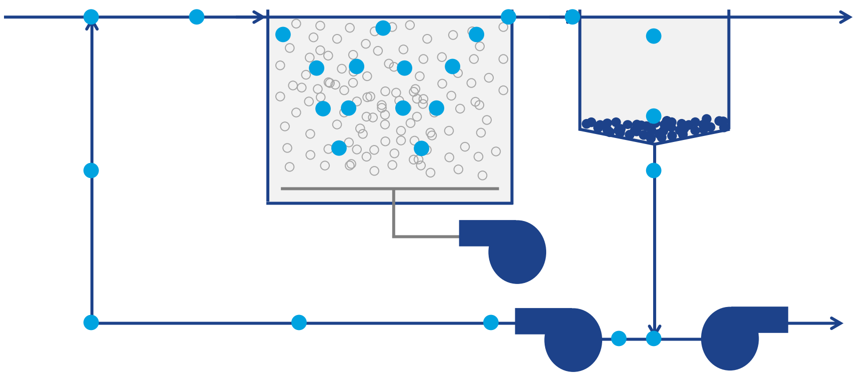
…Over and Over Again…



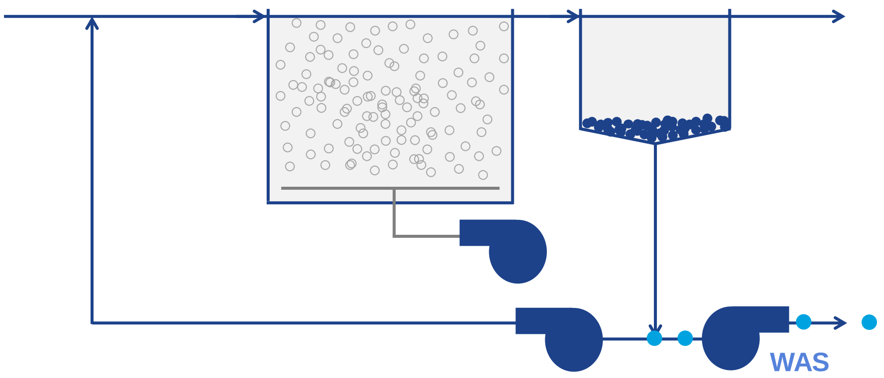
…and Again…



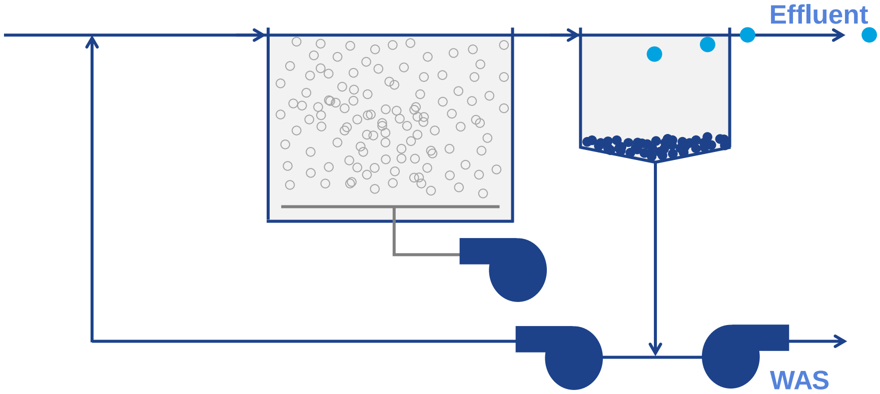
…Until One of Two Things Occurs



1. The Bacterium is **Intentionally** Wasted from the System in the WAS



2. The Bacterium is **Unintentionally** Wasted from the System in the Effluent



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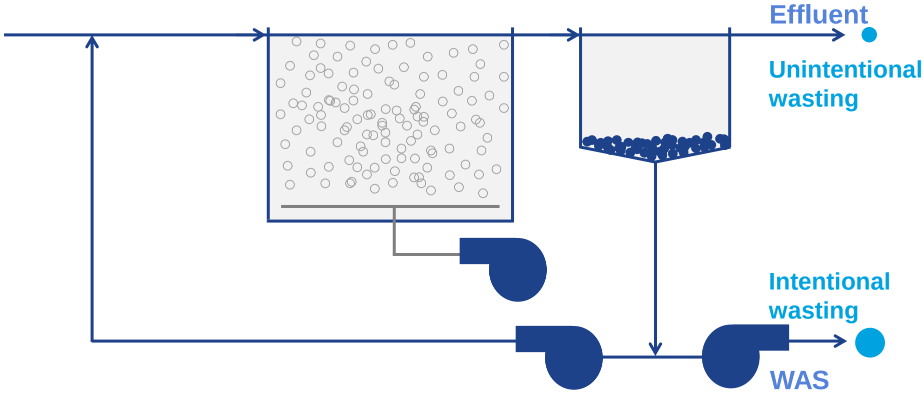
As Professionals We Minimize Unintentional Wasting by Optimizing **Sludge Quality**



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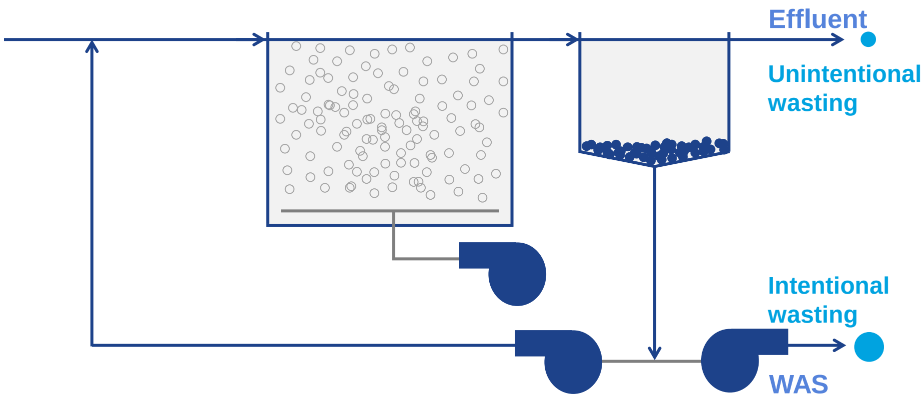
Sludge Quality **Not** *Effluent Quality*



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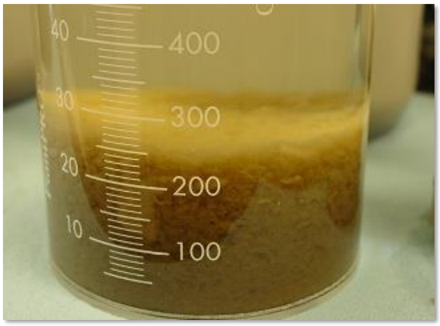
Sludge Quality Defined Treatment Success Depends on Three Sludge Characteristics

1. Flocculates
2. Settles
3. Compacts



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Sludge Quality Largely Controlled by the G_R of Microorganisms in the System

G_R = Growth Rate

The Amount of Growth is Balanced by

1. Intentional wasting
2. Unintentional wasting
3. Death
4. Decay

Expressed Mathematically

$$G_R = \frac{1}{SRT} + \gamma + b$$

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And Because γ and b Are Relatively Small, G_R is Controlled by the SRT

$$G_R \approx \frac{1}{SRT}$$

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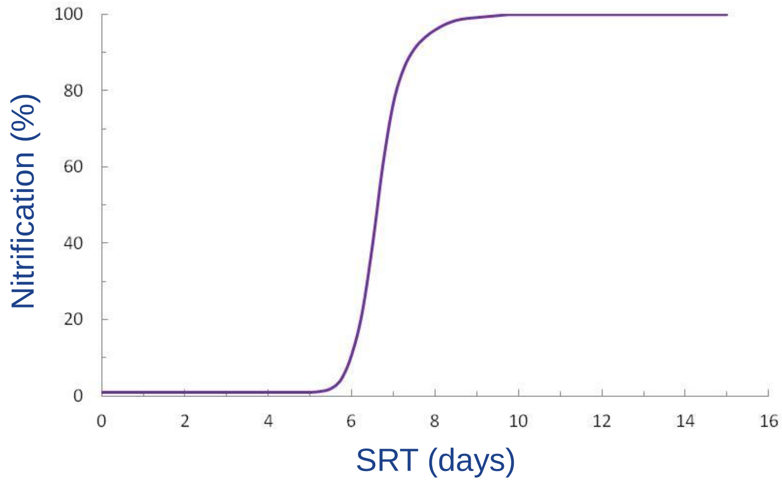
Operators Control Growth Rate by Controlling SRT

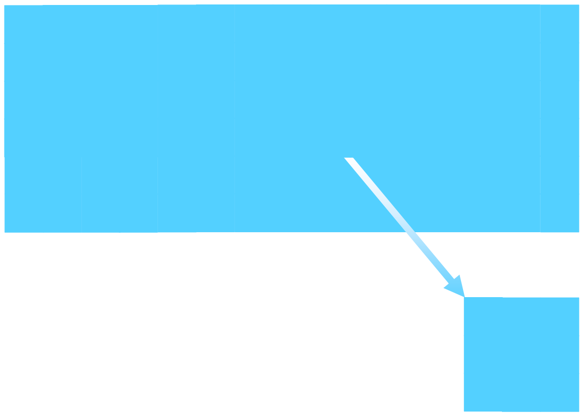
$$G_R \approx \frac{1}{SRT}$$

This Proves It



SRT = 10 days, G_R = 0.1/day

Aeration basin biomass 90,000 lb

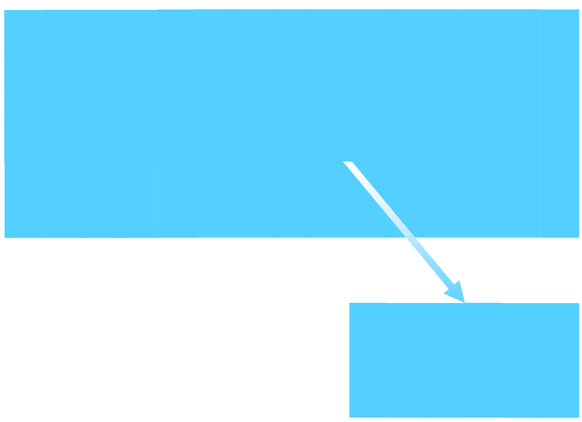


WAS
9,000 lb/d

67

SRT = 5 days; G_R = 0.2/day

Aeration basin biomass 90,000 lb

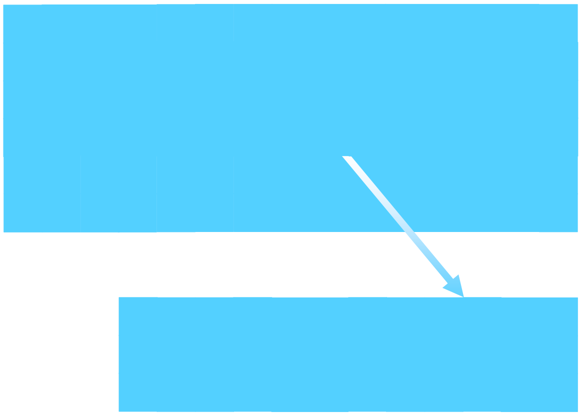


WAS
18,000 lb/d

68

SRT = 2.5 days; G_R = 0.4/day

Aeration basin biomass 90,000 lb



WAS
36,000 lb/d

More WAS, Higher the Growth Rate

A Higher Growth Rate Results in a More Responsive Biomass

Why Would You Want a "More Responsive Biomass"

> "A Higher Growth Rate Results in a More Responsive Biomass"

Three Considerations Setting SRT_{TARGET}

1. Effluent ammonia requirement
2. Best sludge quality
3. Minimum SRT_{TARGET} that will satisfy 1 and 2

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Sometimes Nitrification is a Goal Not a Requirement

1. **Effluent ammonia requirement**
2. Best sludge quality
3. Minimum SRT_{TARGET} that will satisfy 1 and 2

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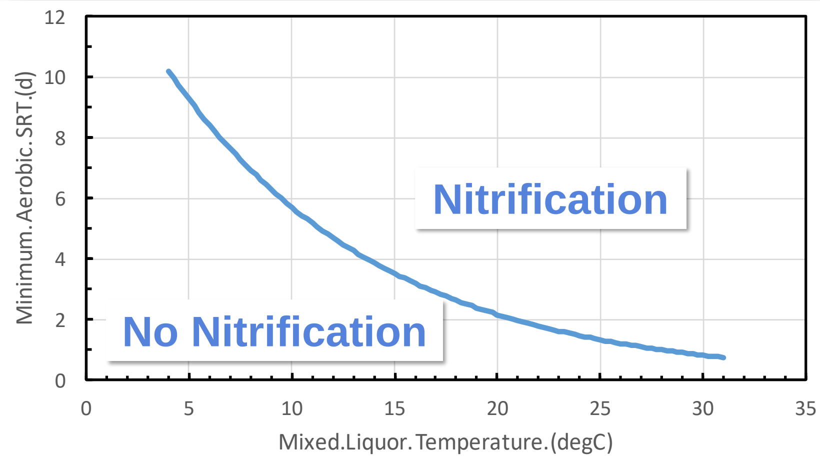
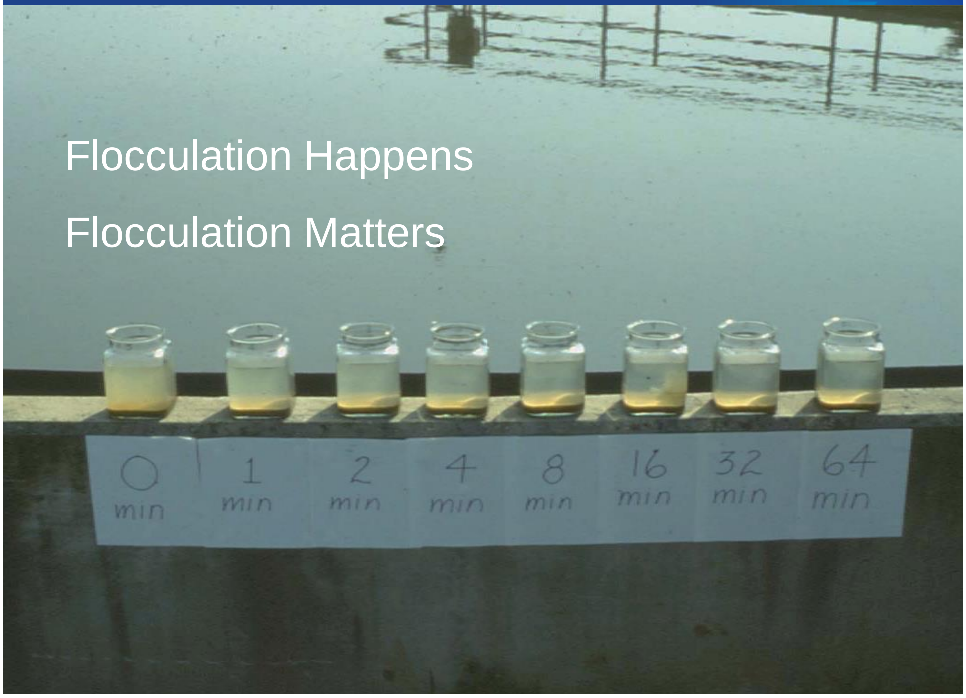
If You Don't Have to Nitrify, Know it's Real Expensive if You Are



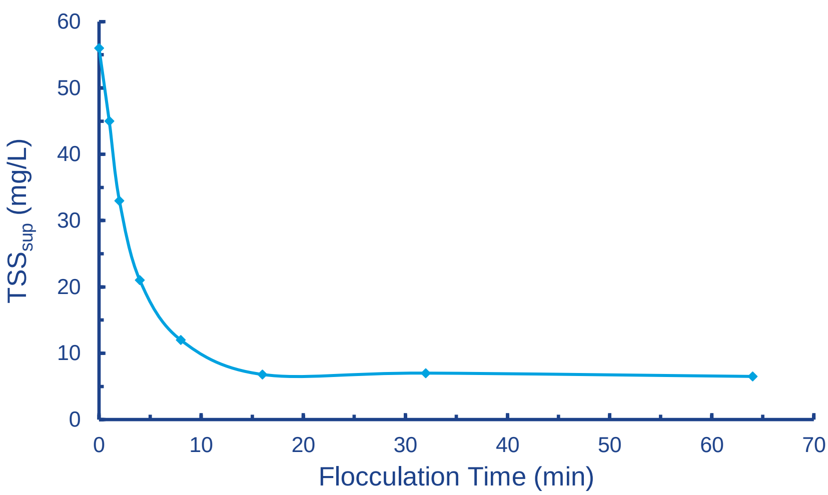
Three Considerations Setting SRT_{TARGET}

1. Effluent ammonia requirement
2. **Best sludge quality**
3. Minimum SRT_{TARGET} that will satisfy 1 and 2



77

Flocculation Results Plotted



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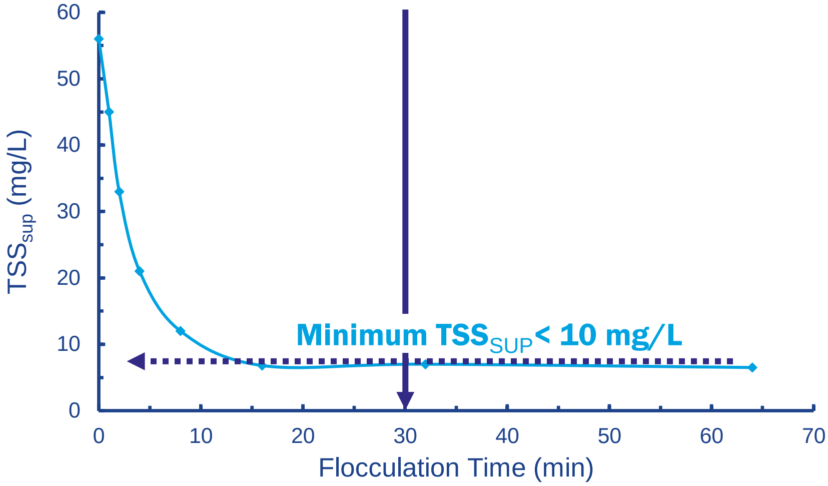
78

Supernatant TSS (TSS_{SUP}) at Minimum, Less than 10 mg TSS/L, Within 30 Minutes



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79

Modified Settleometer Measures Sludge Quality

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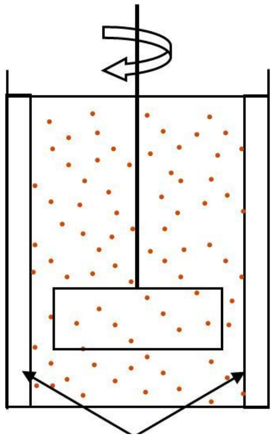
80

Test Begins with 30 Minutes Flocculation



1. **Flocculate for 30 min (with baffles).**

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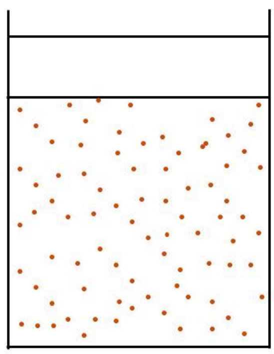
81

SSV_5 Measures Settling



1. Flocculate for 30 min (with baffles).
2. **Measure 5-min settled sludge volume (SSV_5).**

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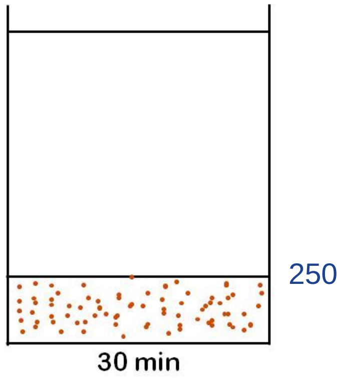
82

SSV_{30} Measures Compaction



1. Flocculate for 30 min (with baffles).
2. Measure 5-min settled sludge volume (SSV_5).
3. **Measure 30-min settled sludge volume (SSV_{30}).**

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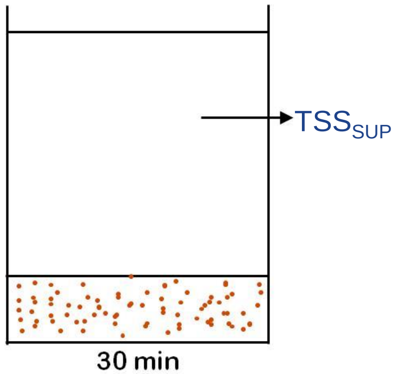
83

TSS_{SUP} Measures Flocculation



1. Flocculate for 30 min (with baffles).
2. Measure 5-min settled sludge volume (SSV_5).
3. Measure 30-min settled sludge volume (SSV_{30}).
4. **Measure supernatant TSS or turbidity after 30 min settling (TSS_{SUP}).**

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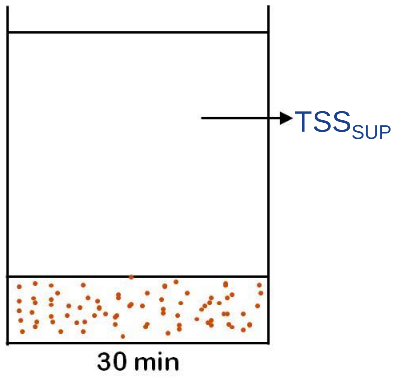
84

Good Effluent Quality is Not Possible Without Good Sludge Quality



1. SSV_5 = how it settles (kind of)
2. SSV_{30} = how it compacts
3. TSS_{SUP} = how it flocculates

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Initial Sludge Quality Targets

1. **SSV_5 500 – 600 mL/L**
   (> 1.4 inches/min settling velocity)
2. **SSV_{30} Settled sludge concentration, $MLSS_{30}$ > 8,000 mg/L**
3. **TSS_{SUP} < 10 mg/L**

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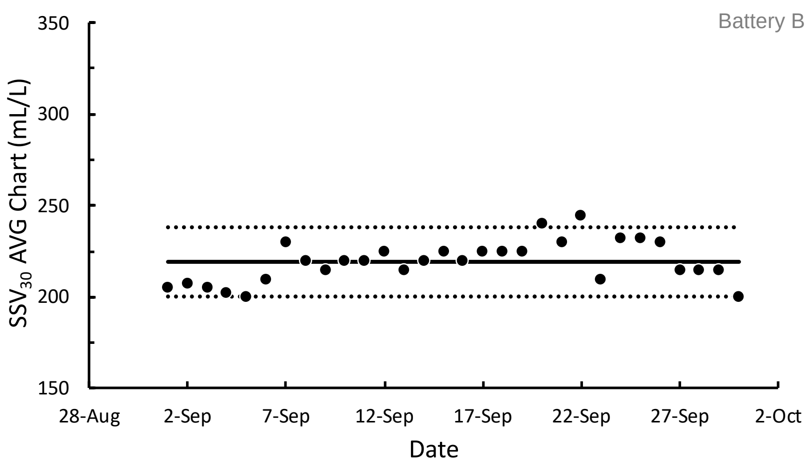
Know the Statistical Accuracy of Sludge Quality Data



Three Considerations Setting SRT_{TARGET}

1. Effluent ammonia requirement

2. Best sludge quality

3. **Minimum SRT_{TARGET} that will satisfy 1 and 2**

High Growth Rate Means Low SRT

"A Higher Growth Rate Results in a More Responsive Biomass"

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89

Setting Q_{WAS} to Maintain SRT_{TARGET} a Simple Calculation

$$Q_{WAS} = \left(\frac{V_{AB}}{SRT_{TARGET}} \times \frac{MLSS}{TSS_{WAS}} \right) - \left(Q \times \frac{TSS_{SCE}}{TSS_{WAS}} \right)$$

[Assumes negligible solids in the secondary clarifier(s)]

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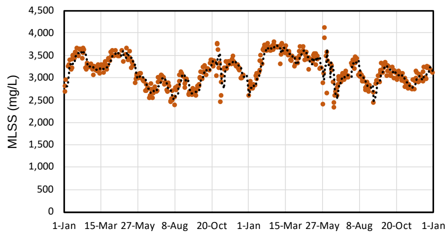
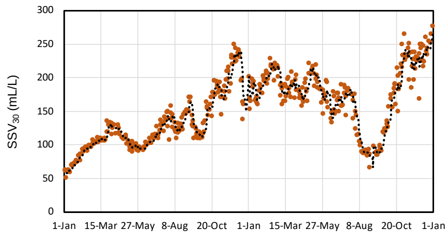
The MLSS Concentration Noes **NOT** Control Sludge Quality

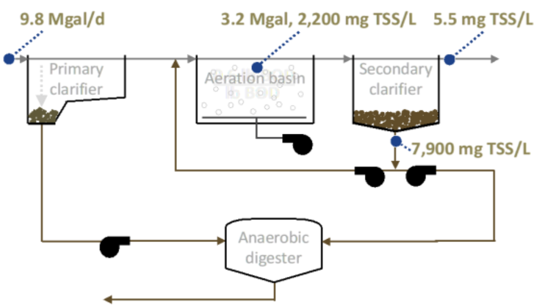


Quantity?



Quality?

HOMEWORK



1. Calculate the WAS flow necessary to maintain the following $SRT_{TARGETS}$

A. 3 days (Plant is not nitrifying)
B. 6.5 days
C. 9 days (Full Nitrification)

2 For those of you with Activated Sludge, use your most recent applicable plant data and:

A. Perform the same calculations.
B. Measure SSV_{30}

Treasure Hunt
How many opportunities can you find?

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93

FANS AND ODOR CONTROL

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94

Fans and Odor Control

95

Odor Control

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96

Hydronic Application Basics

$$\text{BHP} = \frac{(\text{GPM})\ \text{x}\ (\text{TDH}) * \text{sg}}{(\text{eff.})\ \text{x}\ 3960}$$

Where

GPM = Flow Rate gallons per minute
TDH = Total Dynamic Head of System
eff. = Pump efficiency, unitless
s.g. = specific gravity of liquid (= 1.0 for water)
3960 = conversion factor

Airside Application Basics

$$\text{BHP} = \frac{(\text{CFM})\ \text{x}\ (\text{FTP})}{(\text{eff.})\ \text{x}\ 6356}$$

Where

CFM = Cubic Feet per minute
FTP = Fan Total Pressure, in inches of water
eff. = Fan efficiency, unitless (0 – 1.0)
6356 = conversion factor including density of air

HVAC

99

HVAC Quick Hits

1. Assign appropriate unoccupied schedules (including temperature setbacks and fan cycling)
2. Assign appropriate occupied temperature setpoints
3. Don't over-ventilate
4. Stay on top of routine maintenance
5. Maintain economizer dampers and controls
6. Do not allow space heaters in offices

102

Opportunity Register Thoughts?

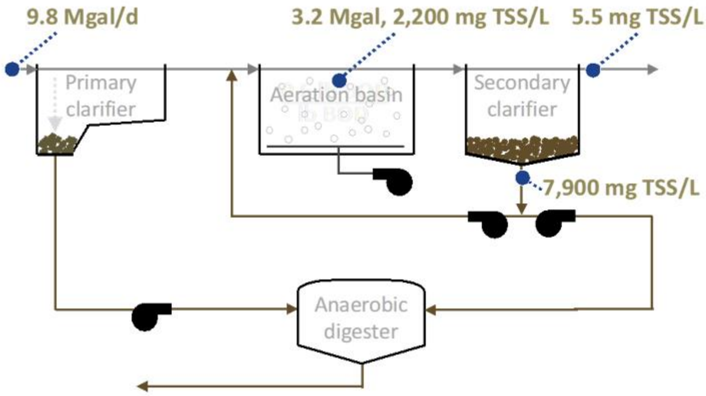
Opportunity #	Opportunity Name	Description	Location	System*	Submitted By

Homework

- **Find 3 opportunities to input into your Opportunity Register (MEASUR Treasure Chest)**
- **Complete the entries**
- **Be prepared to discuss them during the session**

Homework

HOMEWORK – WAS FLOW



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106

Closing

See You Next Week

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107