Chat Question for the Week

Favorite BBQ?

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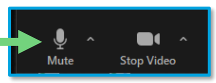
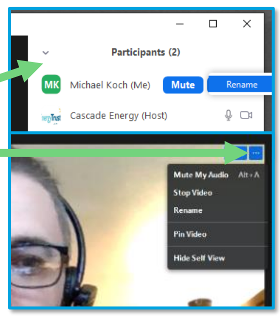
Using Zoom!

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.



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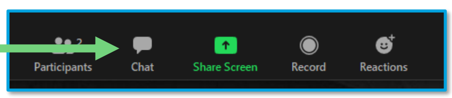

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Recording

This meeting is being recorded (both audio and video)

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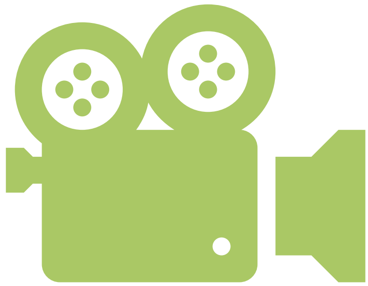

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WASTEWATER VINPLT SESSION 6
OPTIMIZING RAS RATE, STATE POINT ANALYSIS AND MORE ENERGY MATH

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Thank You!

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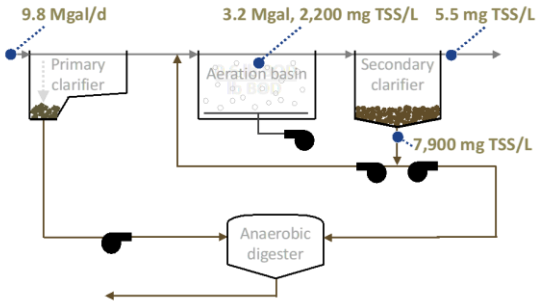
Today's Agenda

Welcome	**State Point Analysis**
Compressed Air	**Quiz**
Optimizing RAS Rate	**Closing Remarks**

HOMEWORK

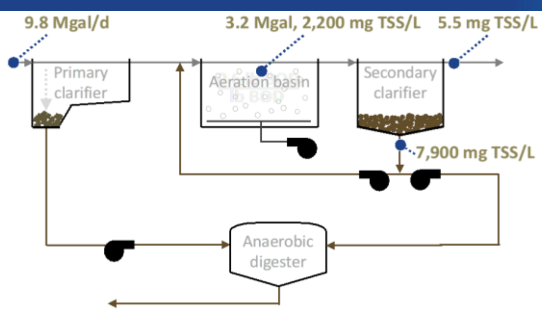


1. Calculate the WAS flow necessary to maintain the following $SRT_{TARGETS}$
   A. 3 days (Plant is not nitrifying)
   B. 6.5 days
   C. 9 days (Full Nitrification)

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

1. Calculate the WAS flow necessary to maintain the following $SRT_{TARGETS}$
   C. 9 days (Full Nitrification)

HOMEWORK



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

$$Q_{WAS}=\left(\frac{3,200,000\ gal}{9\ d}\times\frac{2,200\ \cancel{mg\ TSS/L}}{7,900\ \cancel{mg\ TSS/L}}\right)-\left(9,800,000\ gal/d\times\frac{5.5\ \cancel{mg\ TSS/L}}{7,900\ \cancel{mg\ TSS/L}}\right)$$

$$Q_{WAS}=(99,000\ gal/d)-(7,000\ gal/d)=92,000\ gal/d$$

Polls

- Do you know your **plant and RAS flow rates**?
- Do you know your **RAS recycle percentage**?
- Do you know your **MLSS concentration**?
- Do you know your ***RAS TSS concentration****?*
- Do you know your ***SSV30***?

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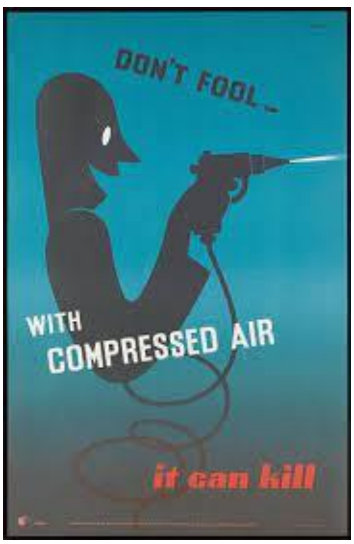
Air Compressors



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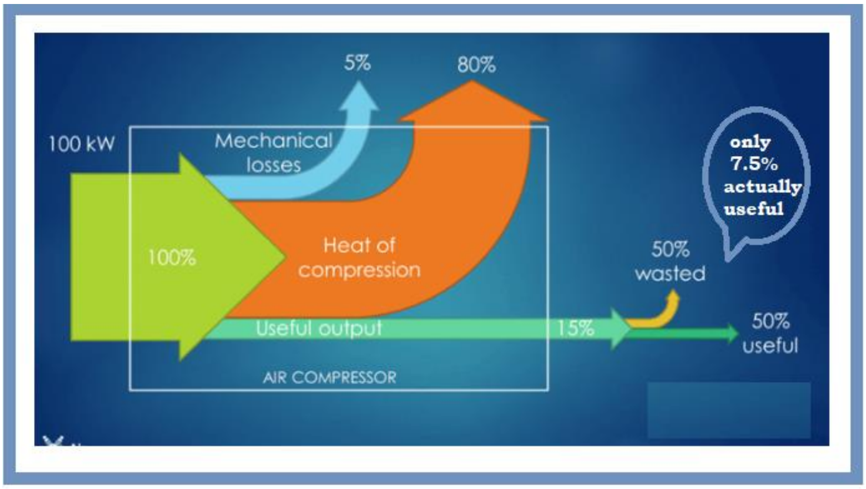
Air Compressors……all Shapes & Sizes

Compressor Energy Sankey Diagram



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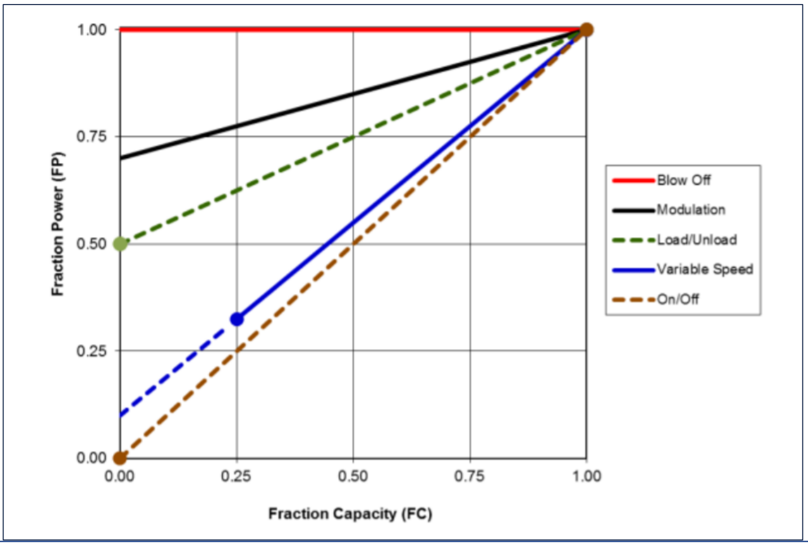
Control Options & Performance



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Compressed Air Opportunities

Pressure Limiting User	Is one end-use driving up your pressure requirements? What is the maximum pressure you actually require ?
Compressor Checks	Do you have more than one compressor? Are they all operating, and do they have to be?
Compressor Pressure Setpoints	**2 psi = 1%** **Minimize pressure reductions**
Filter & Dryers	Desiccant or refrigerated? Filters checked regularly

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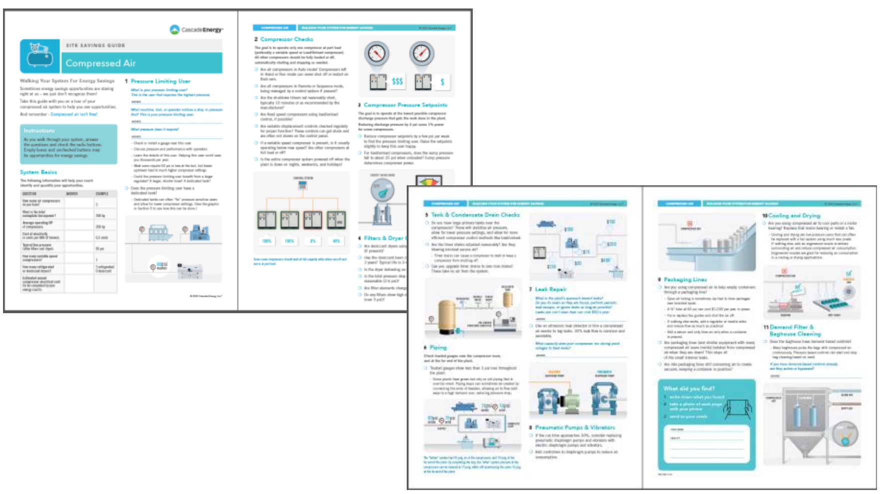

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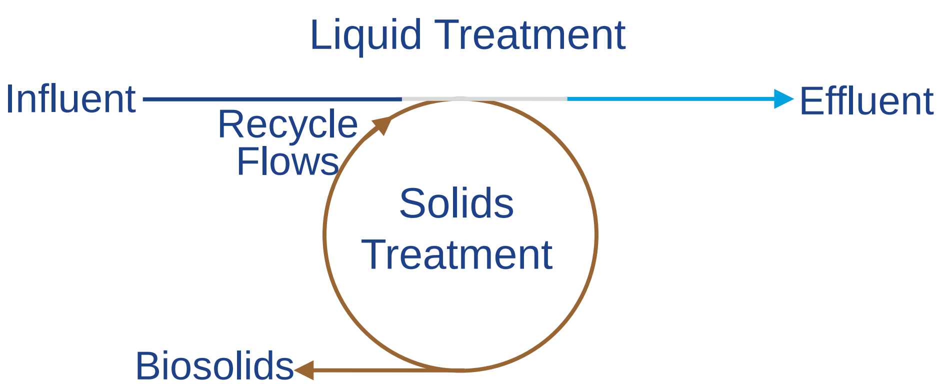
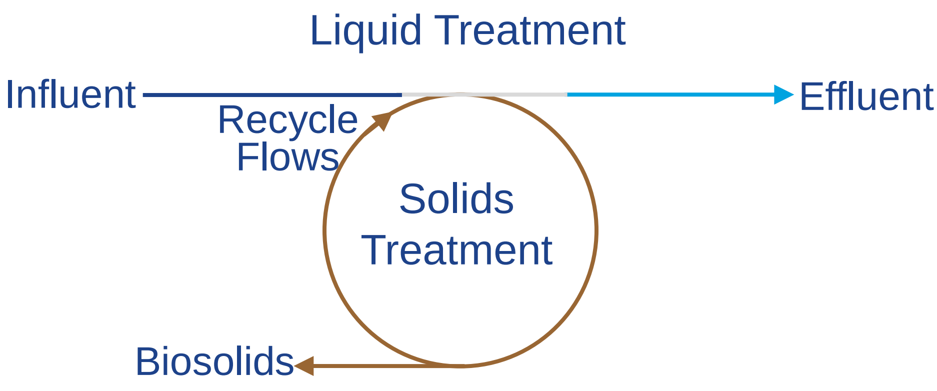
Time to Get Serious for a Moment…

A WWTP is Like a Manufacturing Plant



But What is It We Produce?



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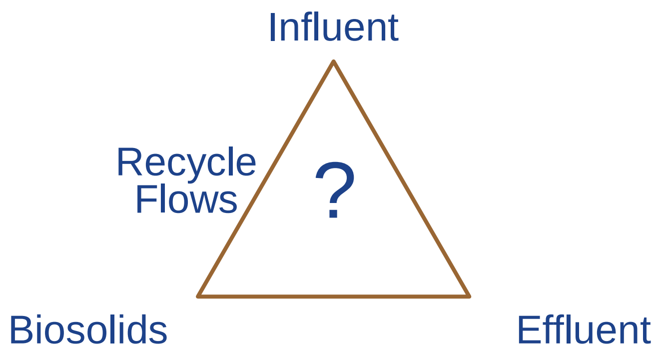
More Importantly, What is It We Do?



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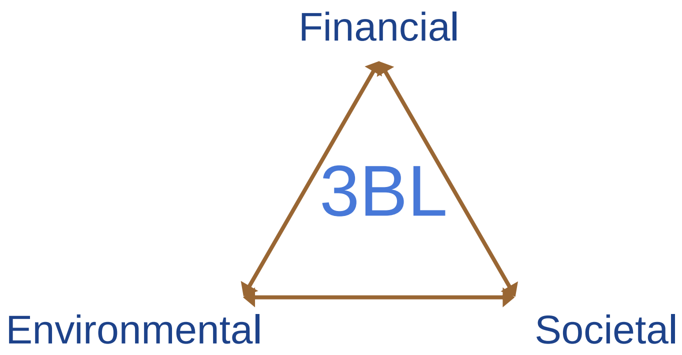
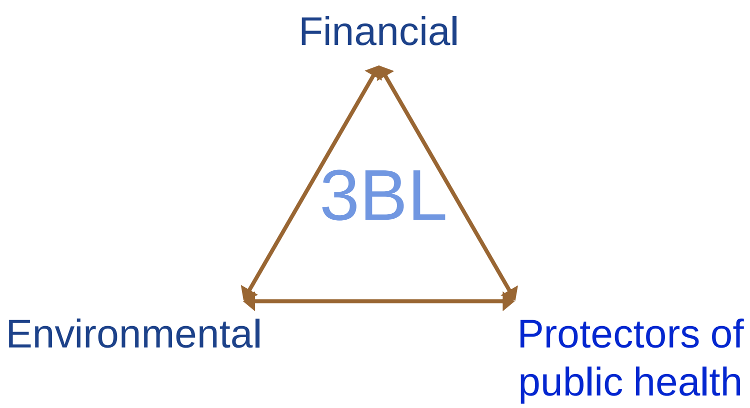
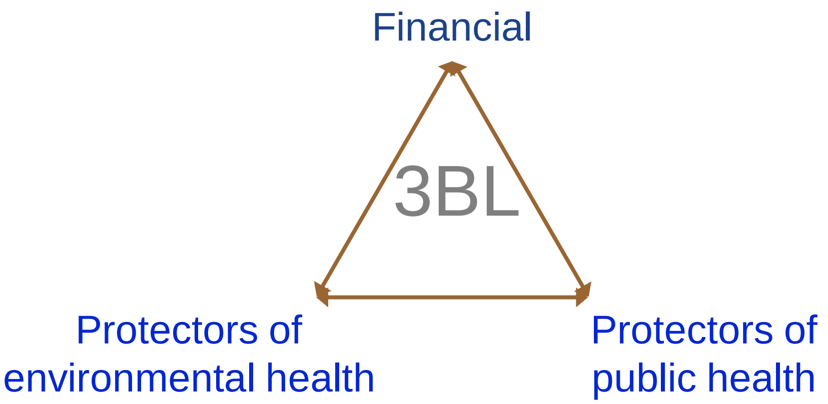
As Operations Professionals We Live the Triple Bottom Line (3BL) Every Day



For Society



For the Environment



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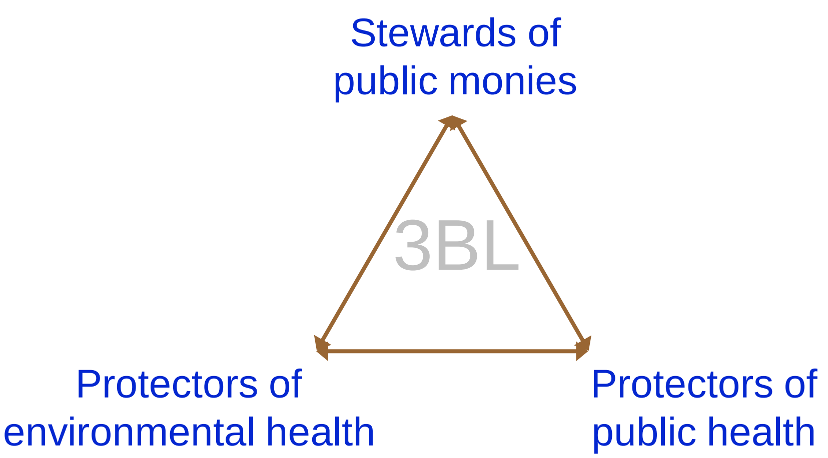
For Our Ratepayers



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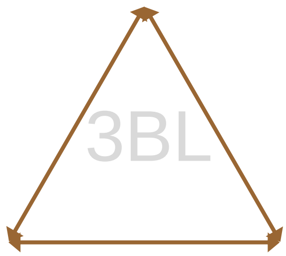
Much, Much More Than "Making Permit"

Stewards of
public monies



Protectors of
environmental health

Protectors of
public health

Professional Operator Credo:

To remove pollutants from the incoming water while complying with all permits—water, air, and land—and convert them to recyclable biosolids as sustainably and cost effectively as possible.

As a Profession, We've Put a Lot of Emphasis Here…

To remove pollutants from the incoming water while complying with all permits—water, air, and land—and convert them to recyclable biosolids as sustainably and cost effectively as possible.

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…and Here…

To remove pollutants from the incoming water while complying with all permits—water, air, and land—**and convert them to recyclable biosolids** as sustainably and cost effectively as possible.

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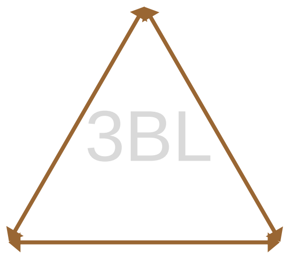
But Remember…



This is Why We're All Here!

To remove pollutants from the incoming water while complying with all permits—water, air, and land—and convert them to recyclable biosolids **as sustainably and cost effectively as possible.**

Bottom Line: We Build and Operate Multi-Million/ Billion $$$ Facilities with Someone Else's Money

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Clean Water is More Important Than Wine, Even Good Wine

> "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."

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In the Activated Sludge Process, Good Sludge Quality is Key to the 3BL

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

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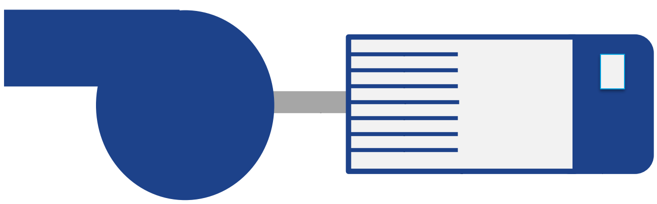
RAS Pumps Use Big Motors and Run All the Time



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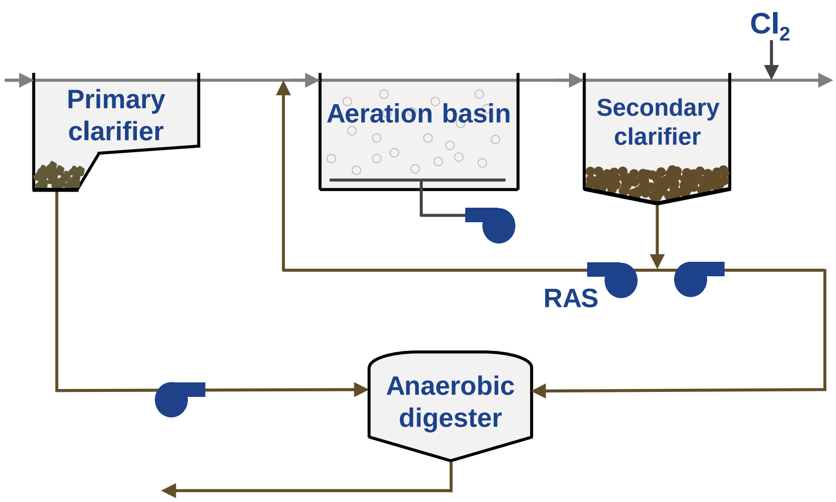
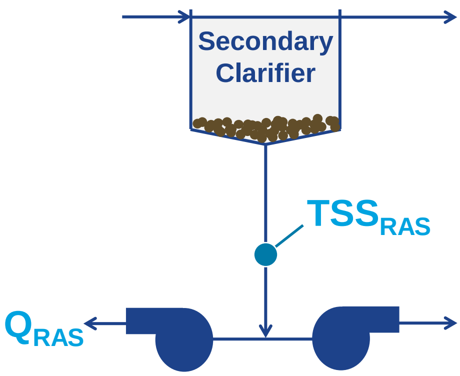
To Talk About RAS, We Need to Talk About the Secondary Clarifier



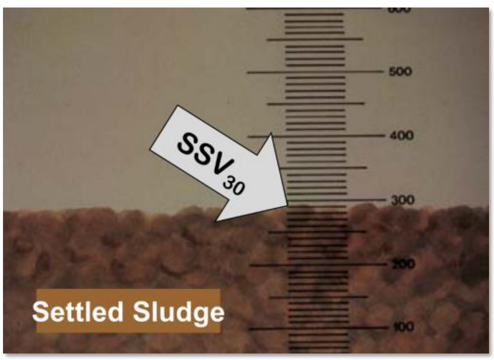
Two Reasons for Confusion Around RAS Flow (Q_{RAS}) and RAS TSS Concentration (TSS_{RAS})



1. Thickening is ***NOT*** a Process Objective of the Secondary Clarifier

To remove settleable solids (biomass).

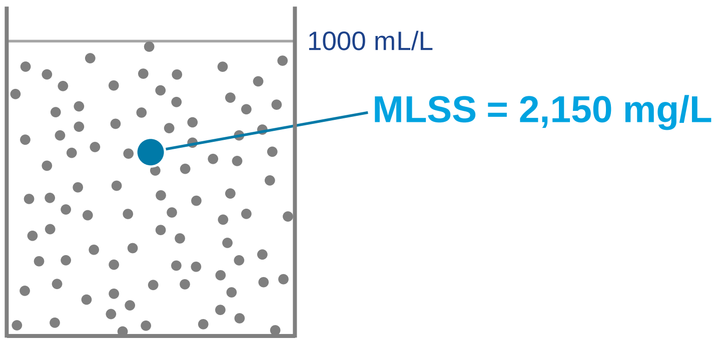
Activated Sludge Does Not **Appreciatively** Settle/Thicken/Compact More After 30 min



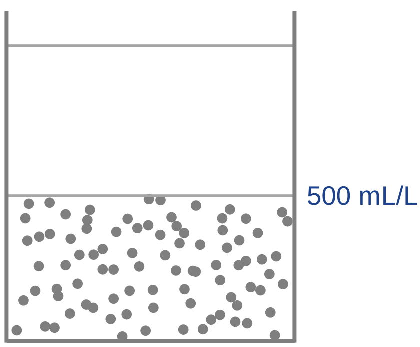
SSV_{30} = 290 mL/L

SSV_{60}, SSV_{120}
not much different

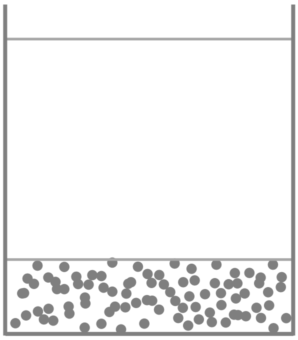
Measure MLSS on Sample
Used In Settleometer Test



SSV$_5$



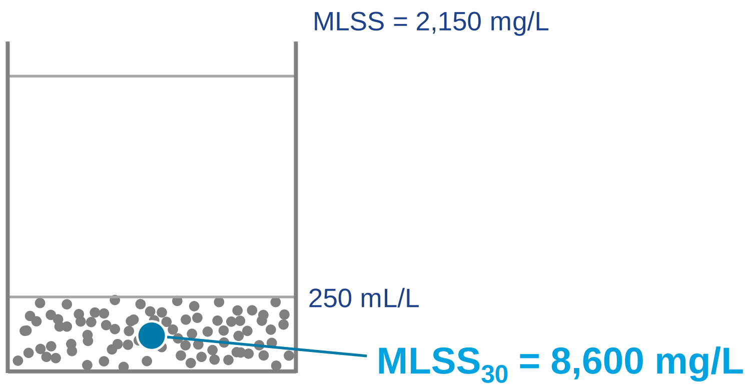
SSV_{30}



$MLSS_{30}$ = Sludge Blanket TSS mg/L After 30 min Settling In Settleometer

$$MLSS_{30} = \frac{MLSS \times 1{,}000}{SSV_{30}}$$

Calculate $MLSS_{30}$



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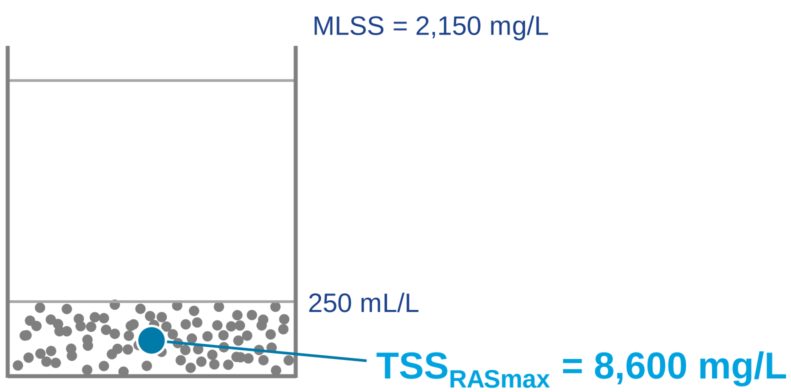
For All Intents and Purposes, $MLSS_{30}$ is Max Possible RAS Concentration (TSS_{RASmax})



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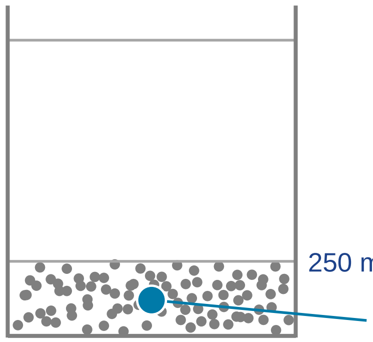
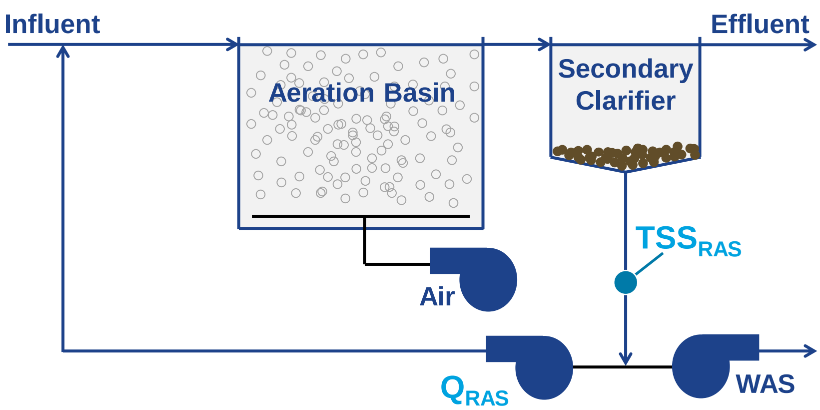
Thickening is ***NOT*** a Process Objective of the Secondary Clarifier



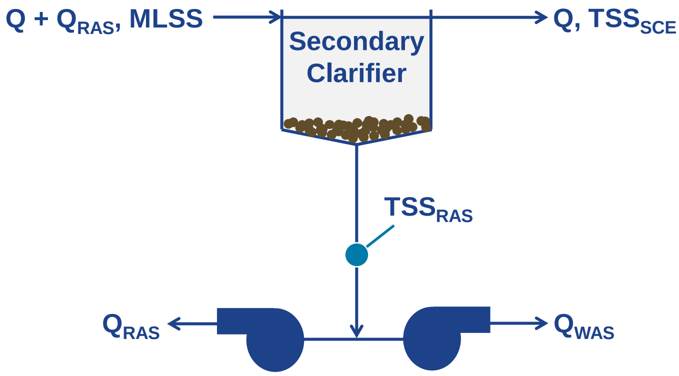
Compaction (thickening) is a sludge quality characteristic, not a function of the secondary clarifier

TSS_{RASmax} = 8,600 mg/L

2. Q_{RAS} Controls TSS_{RAS} ***NOT*** the Other Way Around



Perform a Solids Mass Balance Around Secondary Clarifier



Four Simplifying Assumptions

1. **Mass of solids entering neither increases by growth nor decreases by decay and death**
2. **The sludge blanket is neither increasing nor decreasing ("steady state")**
3. **Q_{WAS}, compared to Q and Q_{RAS}, is small enough to ignore**
4. **TSS_{SCE} is small enough to ignore**

First Two Assumptions Give Very Logical Result

Mass of solids in = Mass of solids out

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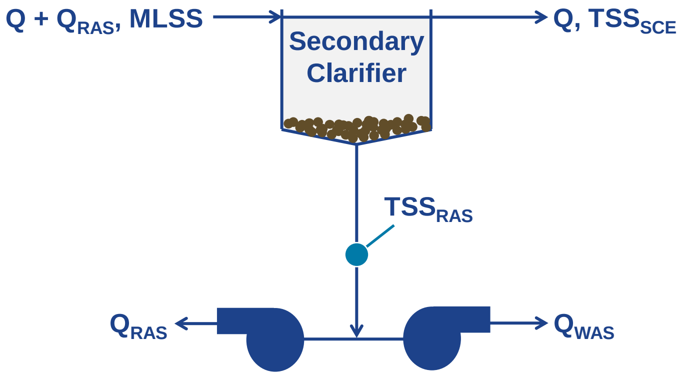
Solids Mass Equals Concentration × Flow



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Mass In Equals Mass Out

mass in

equals

$$(Q + Q_{RAS}) \times MLSS =$$

$$Q_{RAS} \times TSS_{RAS} + Q \times TSS_{SCE} + Q_{WAS} \times TSS_{RAS}$$

mass out

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Third Assumption Eliminates This Term

$$(Q + Q_{RAS}) \times MLSS =$$

$$Q_{RAS} \times TSS_{RAS} + Q \times TSS_{SCE} + \cancel{Q_{WAS} \times TSS_{RAS}}$$

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Fourth Assumption Eliminates This Term

$$(Q + Q_{RAS})\times MLSS \approx$$

$$Q_{RAS}\times TSS_{RAS} + \cancel{Q\times TSS_{SCE}}$$

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Mass of Solids in Mixed Liquor Flow Nearly Equals Mass of Solids Out in RAS Flow

mass in

nearly equals

$$\underbrace{(Q + Q_{RAS}) \times MLSS}_{\text{mass in}} \approx \underbrace{Q_{RAS} \times TSS_{RAS}}_{\text{mass out}}$$

mass out

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Does Q_{RAS} Control TSS_{RAS} or Does TSS_{RAS} Control Q_{RAS} ???

$$(Q + Q_{RAS}) \times MLSS \approx Q_{RAS} \times TSS_{RAS}$$

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Q_{RAS} Controls TSS_{RAS} Solve for TSS_{RAS}

$$(Q + Q_{RAS}) \times MLSS \approx Q_{RAS} \times TSS_{RAS}$$

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TSS_{RAS} is Always a Fixed Multiple of MLSS But Varies with Q and Q_{RAS}

$$TSS_{RAS} \approx \left(1 + \frac{Q}{Q_{RAS}}\right) \times MLSS$$

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A Mass Balance is Fundamental It's Non-negotiable

Example:

$Q = 1.2$ Mgal/d

$Q_{RAS} = 375$ gal/min = 0.54 Mgal/d

MLSS = 2,000 mg/L

$$TSS_{RAS} \approx \left(1 + \frac{1.2\ \text{Mgal/d}}{0.54\ \text{Mgal/d}}\right) \times (2{,}000\ \text{mg/L})$$

$$TSS_{RAS} \approx 6{,}444\ \text{mg/L}$$

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Some Plants Have Proportional RAS Flow Control (r is Constant)

$$r = \frac{Q_{RAS}}{Q}$$

$$TSS_{RAS} \approx (1 + \frac{Q}{Q_{RAS}}) \times MLSS$$

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TSS_{RAS} is a Fixed Multiple of MLSS, and Does NOT Change with Q and Q_{RAS}

$$TSS_{RAS} \approx (1 + \frac{1}{r}) \times MLSS$$

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A Mass Balance is Fundamental
It's Non-negotiable

Example:

r = 85% = 0.85

MLSS = 3,500 mg/L

$$TSS_{RAS} \approx \left(1 + \frac{1}{0.85}\right) \times (3{,}500\ mg/L)$$

$$\underline{TSS_{RAS} \approx 7{,}618\ mg/L}$$

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Remember the Chat Question…

Who wants to volunteer their plant numbers?

- Plant flow (Q)
- RAS flow rate or percentage (Q_{RAS} or r)
- MLSS
- TSS_{RAS} (**but don't tell us what it is**)

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The Purpose of the RAS is Twofold

1. **To keep the microorganisms in the system longer than the water**
2. **To control the *distribution* of solids between the aeration basin and secondary clarifier (NOTE: it is critical to have as many of the solids in the aeration basin as possible at all times)**

So, What Should My RAS Flow Be

?

Two Reasons to Run Q_{RAS} as *Low as Possible* (without building sludge blankets)

1. **Higher RAS flows than necessary waste electricity (and ratepayer money)**

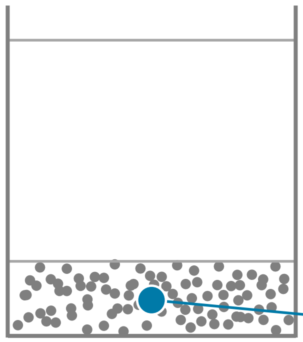
2. **Due to turbulence in the secondary clarifier, high RAS flows can deteriorate performance by increasing TSS_{SCE}**

Mass-balance Equation Shows TSS_{RAS} Increases With Decreasing Q_{RAS}

$$TSS_{RAS} \approx \left(1 + \frac{Q}{Q_{RAS}}\right) \times MLSS$$

Infinitely?

Said Here $TSS_{RASmax} = MLSS_{30}$, Calculated Using SSV_{30} from Settleometer



Compaction (thickening) is a sludge quality characteristic, not a function of the secondary clarifier

TSS_{RASmax} = 8,600 mg/L

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TSS_{RASmax} Achieved At Q_{RASmin}

$$TSS_{RASmax} \approx \left(1 + \frac{Q}{Q_{RASmin}}\right) \times MLSS$$

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Set Eqns. 1 and 2 Equal, Solve for Q_{RASmin}

$$TSS_{RASmax} \approx \left(1 + \frac{Q}{Q_{RASmin}}\right) \times MLSS \quad \textit{(Eqn. 1)}$$

$$TSS_{RASmax} = \frac{MLSS \times 1{,}000}{SSV_{30}} \quad \textit{(Eqn. 2)}$$

Optimum RAS Flow (Q_{RASmin}) or Percentage (r_{min}) Fixed by Extent of Compaction

$$Q_{RASmin} = \frac{SSV_{30}}{1{,}000 - SSV_{30}} \times Q$$

$$r_{min} = \frac{SSV_{30}}{1{,}000 - SSV_{30}}$$

Good Sludge Quality Saves Ratepayer Money

SSV_{30} (mL/L)	r_{min} (%)
150	18
250	33
350	54
450	82
550	122
650	186
750	300

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Example: If You're SSV_{30} is 250 mL/L and r is 75%, You're Wasting Ratepayer $$$

SSV_{30} (mL/L)	r_{min} (%)
150	18
250	33
350	54
450	82
550	122
650	186
750	300

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Another: If You're SSV_{30} is 450 mL/L and r is 25%, You Have Sludge Blankets

SSV_{30} (mL/L)	r_{min} (%)
150	18
250	33
350	54
450	82
550	122
650	186
750	300

BREAK

Until 7 after the hour

INTRODUCTION TO STATE POINT ANALYSIS

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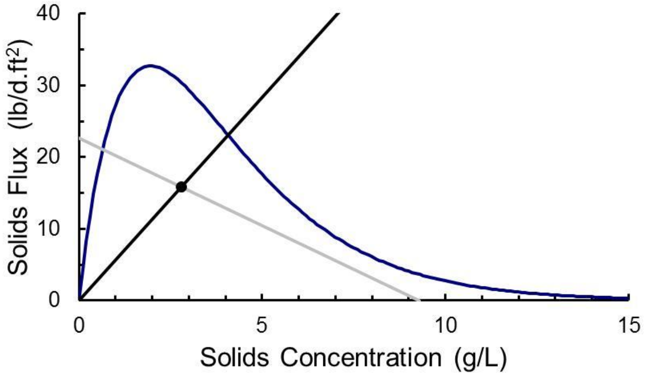
Introduction to State Point Analysis



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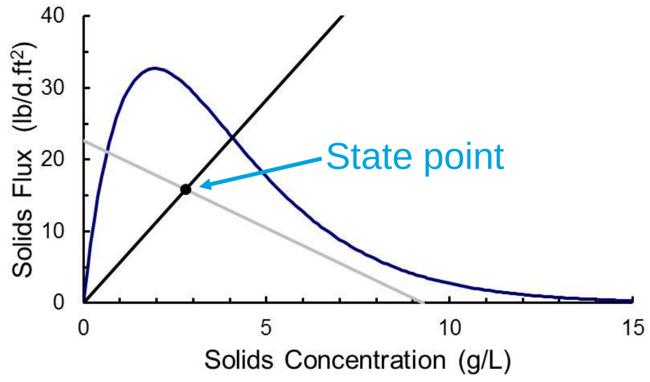
The State Point Is At the Intersection of the Two Operating Lines



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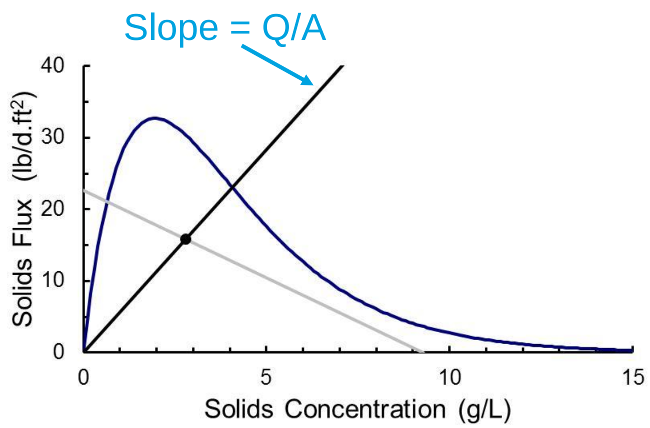
The Line Going Up From Left to Right is the Overflow Rate Operating Line



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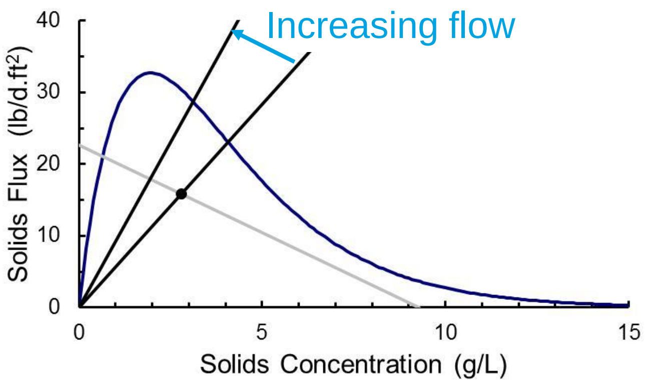
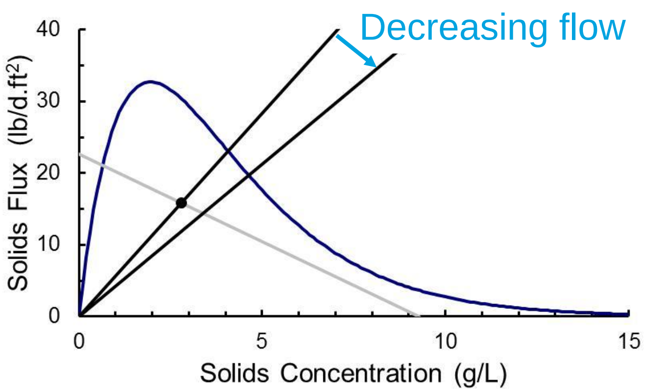
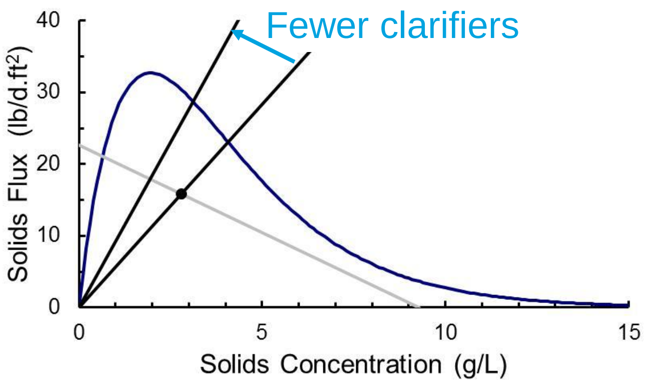
The Slope Changes With Changes in Flow (Q) and Online Clarifiers (A)



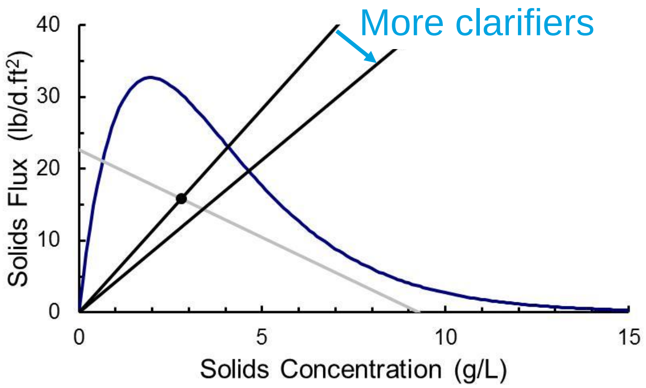
The Slope Changes With Changes in Flow (Q) and Online Clarifiers (A)



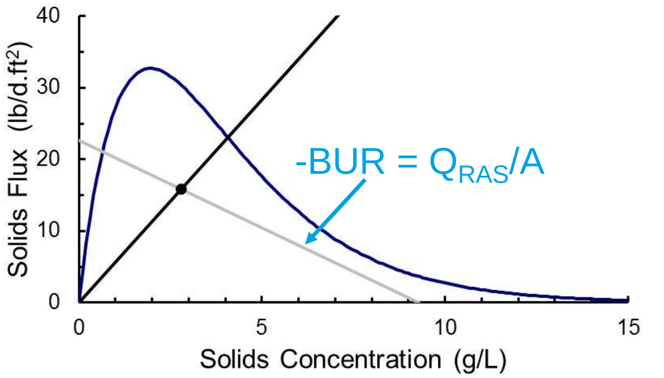
The Slope Changes With Changes in Flow (Q) and Online Clarifiers (A)



The Slope Changes With Changes in Flow (Q) and Online Clarifiers (A)



Line Going Down Left to Right is Bottom Underflow Rate Operating Line (BUR)



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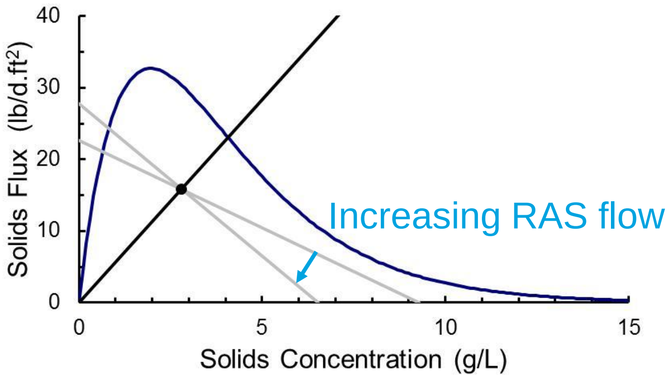
The Slope Changes With Changes in Q_{RAS}



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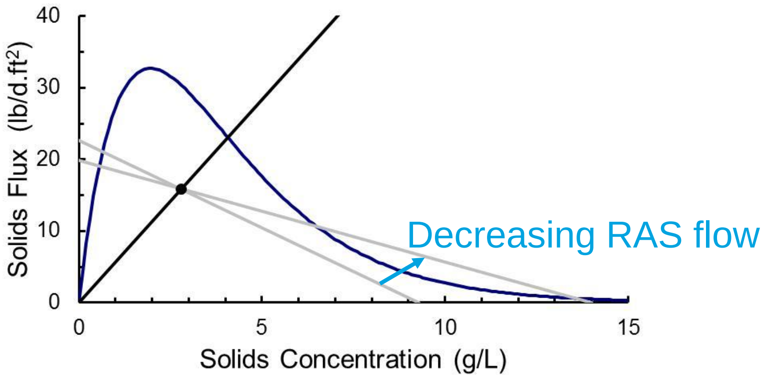
The Slope Changes With Changes in Q_{RAS}



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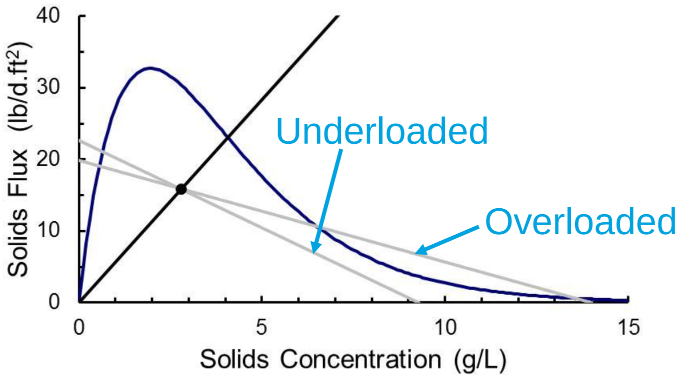
This is Important



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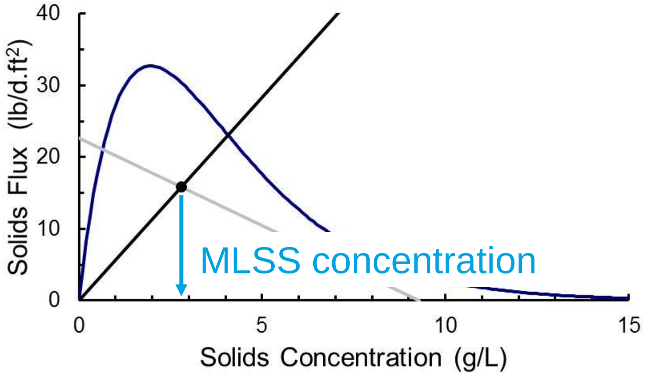
The Two Lines Intersect at the MLSS Concentration



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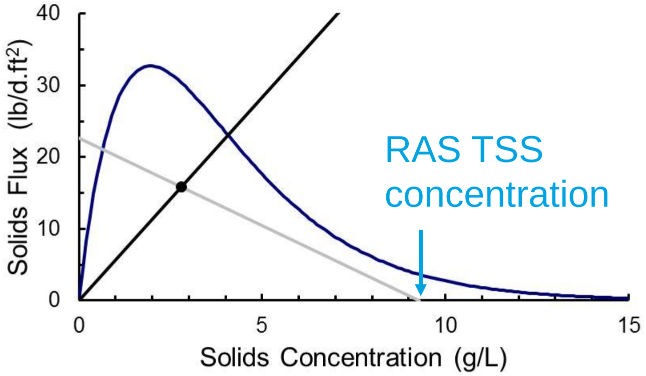
Underflow Rate Operating Line Intersects x-axis at TSS_{RAS} (when passing below curve)



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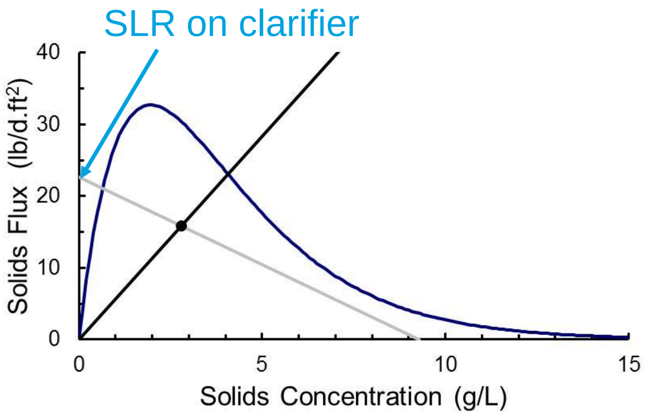
And the y-axis at Solids Loading Rate (regardless where it is relative to curve)



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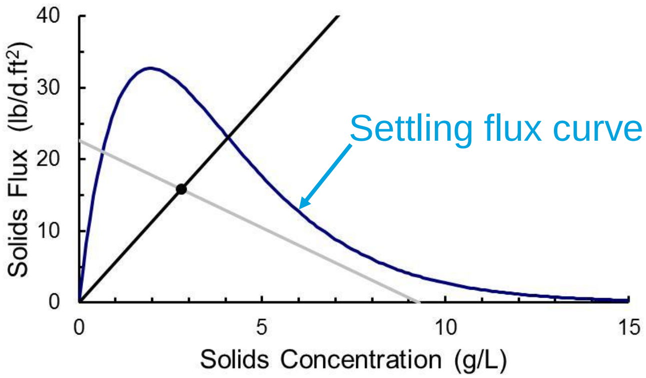
The Settling Flux Curve is Defined by Sludge Settleability



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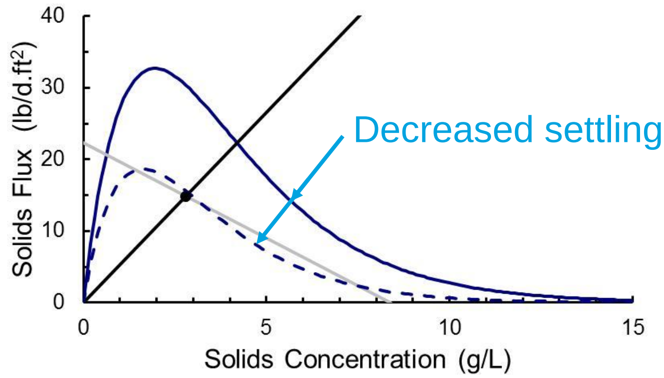
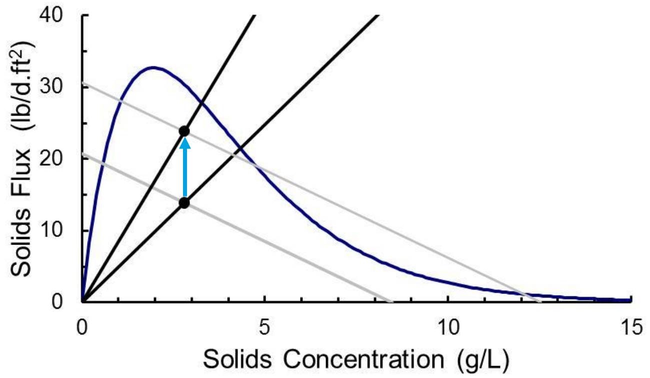
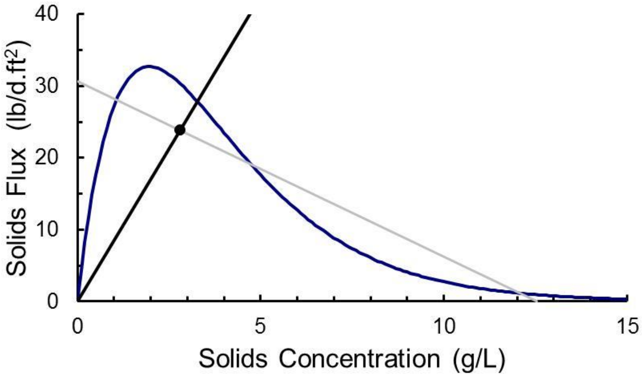
The Settling Flux Curve is Defined by Sludge Settleability



Increased Flow Causes Overloaded Condition



What Happens When a Secondary Clarifier is Overloaded?



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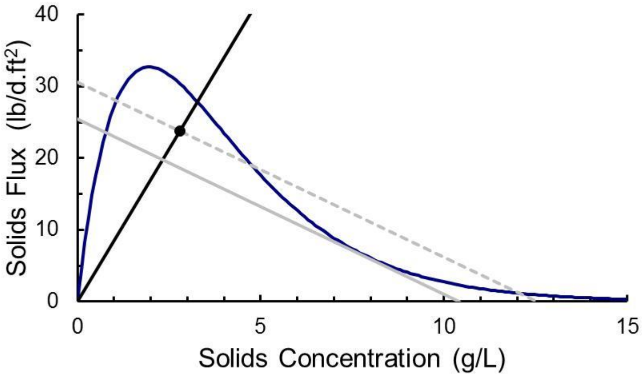
System Responds All By Itself—But at a Cost…a Sludge Blanket



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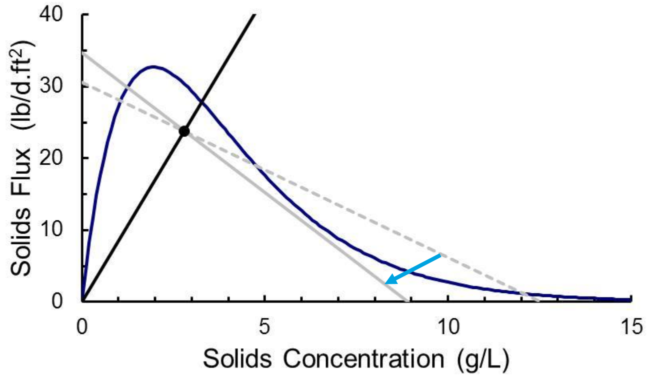
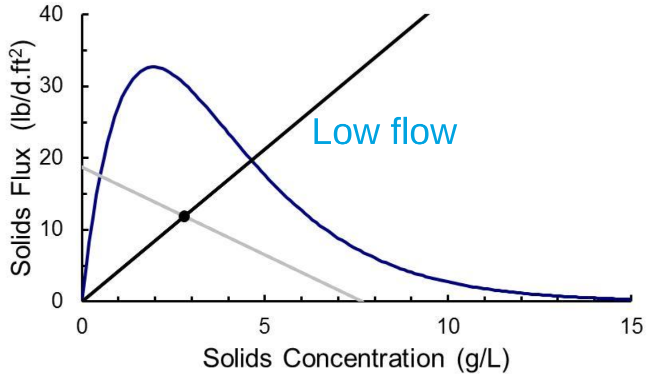
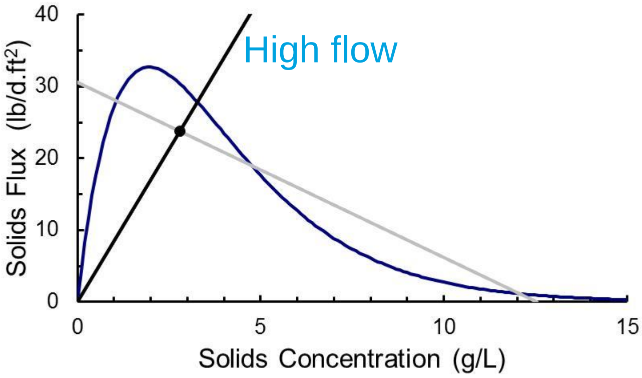
Proper Response Sould Have Been to Increase RAS Flow When Overloaded



Consider a Plant with Two Flows, Low & High Flows but Constant RAS Flow



Consider a Plant with Two Flows, Low & High Flows but Constant RAS Flow



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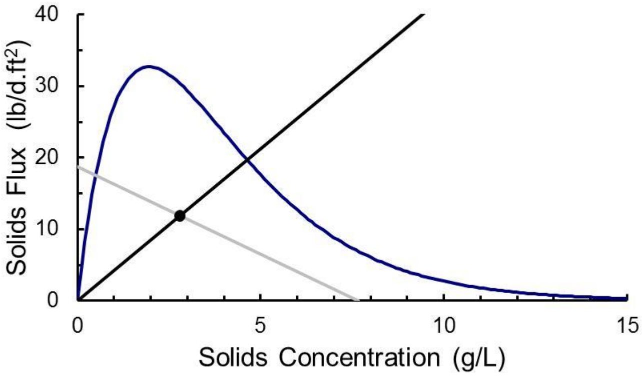
Start at Low Flow



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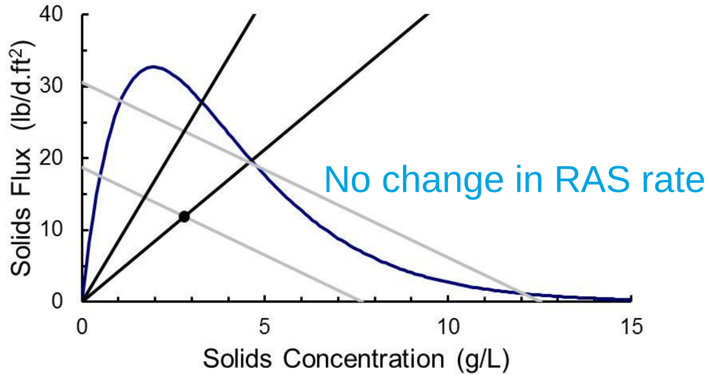
Flow Changes From Low to High, No Change in RAS Flow



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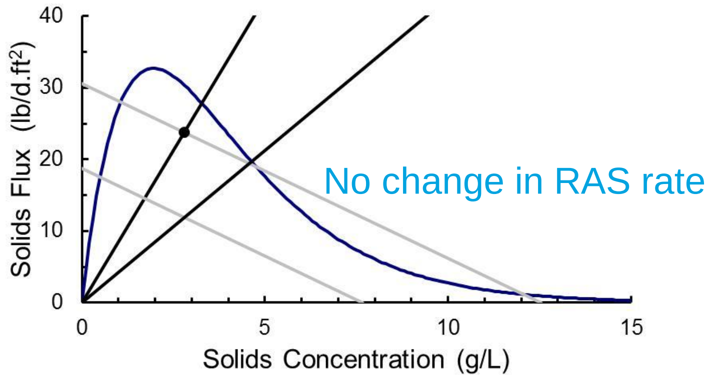
State Point Moves Up



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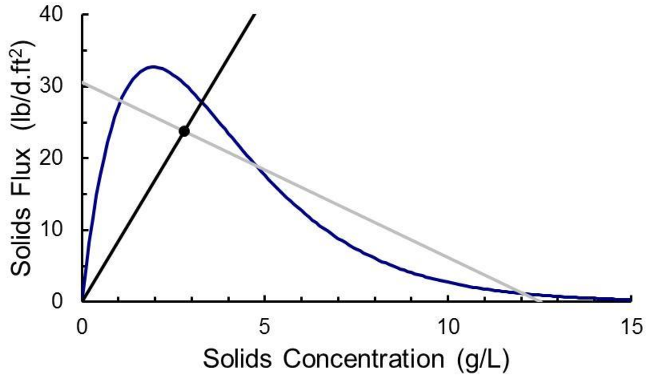
Overloaded



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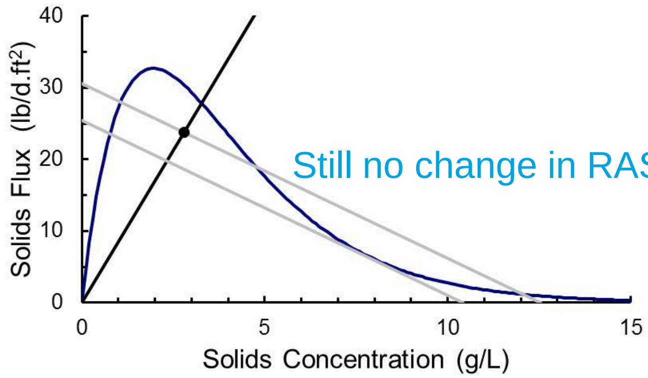
Overloaded Condition Causes State Point to Move Again as Blanket Forms



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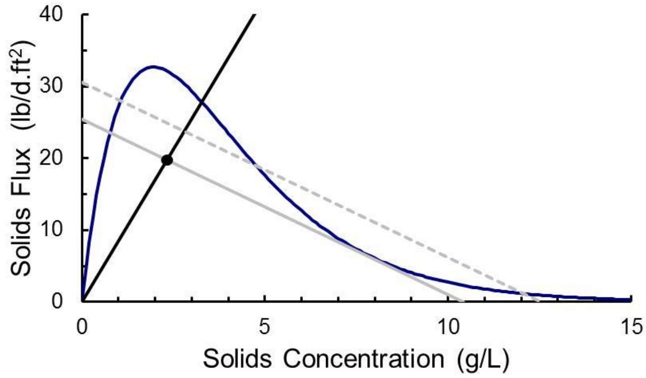
State Point Stops Here to “Critically Loaded Condition”



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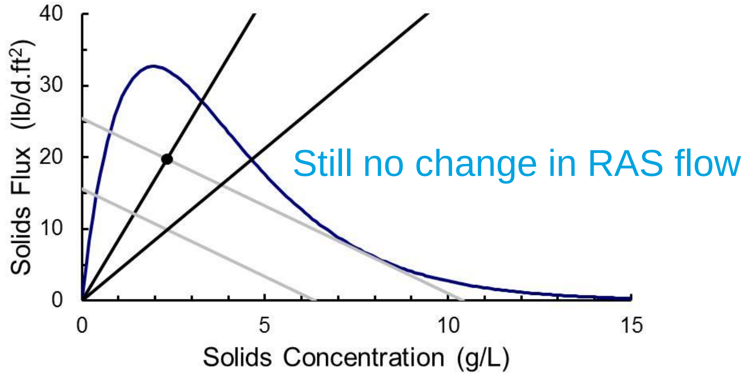
Flow Goes from High to Low, Now Underloaded



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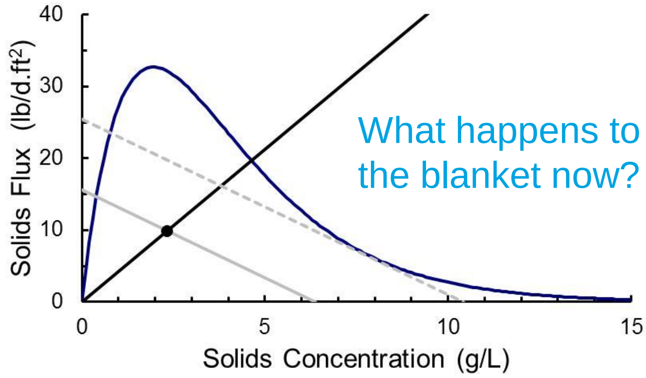
State Point Drops Down



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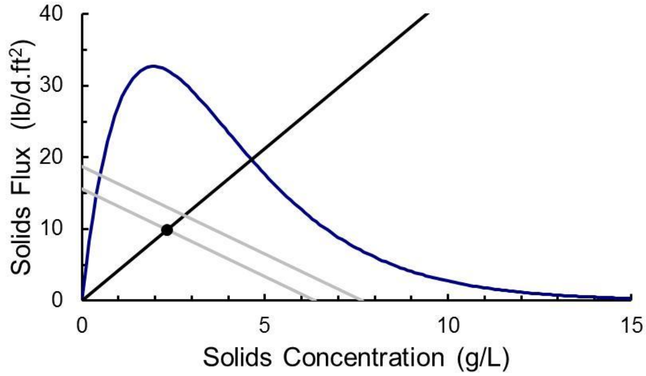
Blanket Solids are Transferred Back to the Aeration Basin, MLSS Increases



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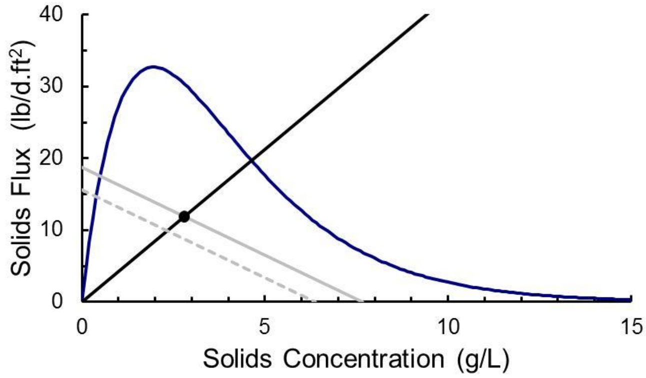
State Point Moves Up



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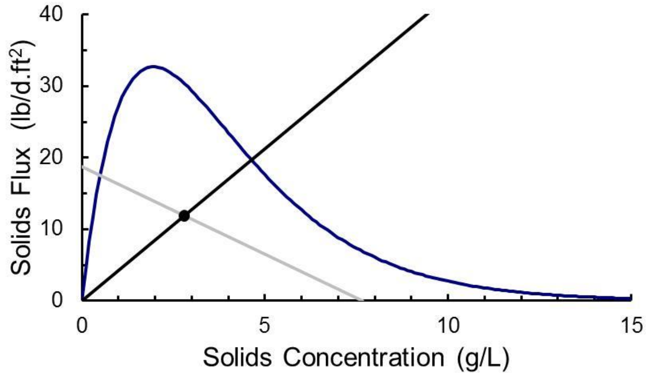
We're Back to Where We Started!



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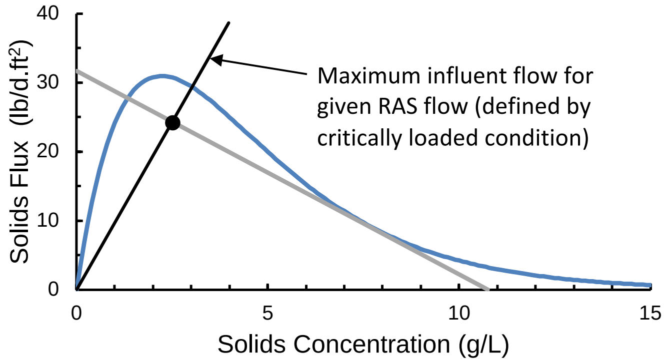
Can Be Used to Determine Maximum Flow System Can Handle



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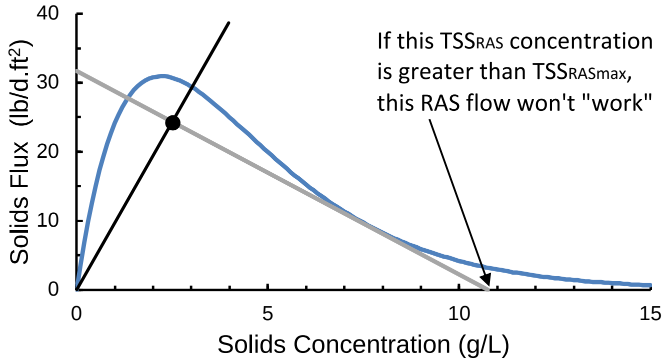
By the Way…Capacity Defined by How the Sludge *Settles* and *Compacts*



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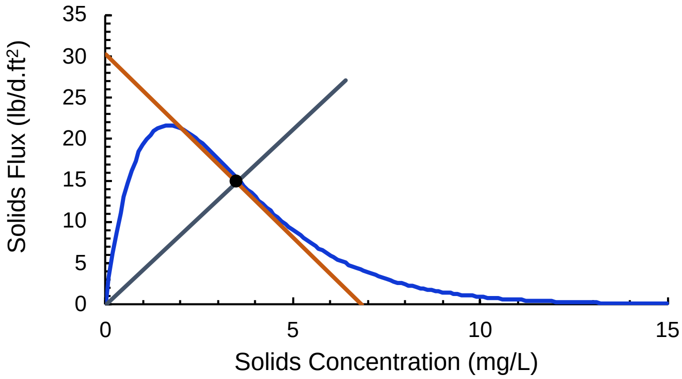
An Extremely Powerful Tool



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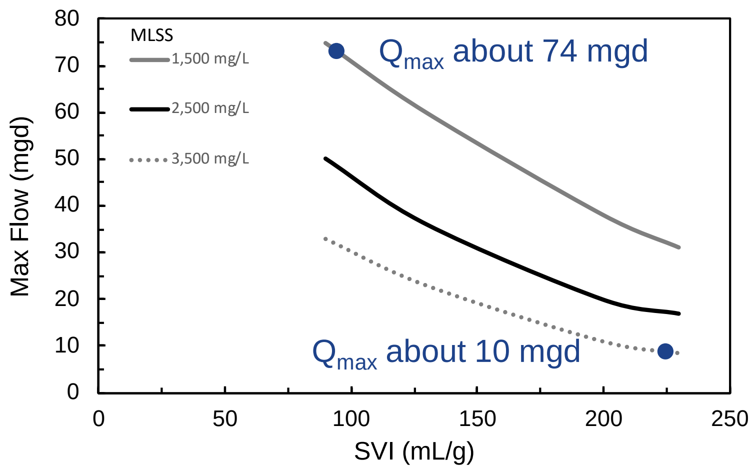
Sludge Quantity (MLSS) and Quality (SVI) Have *HUGE* Impact on Capacity



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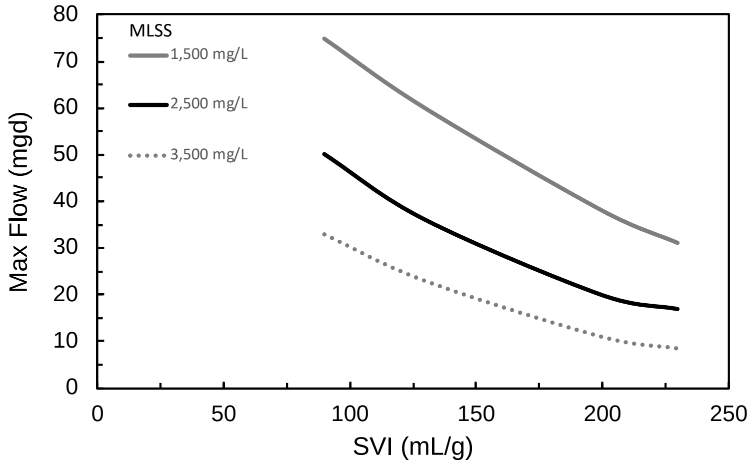
For Your Ratepayers: **Minimize Sludge Quantity, Maximize Sludge Quality**



That's What We Said Last Week: Three Considerations Setting SRT_{TARGET}

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

Summarizing Process Energy Conservation: 8 Guiding Principles

1. The performance of primary clarifiers and anaerobic digesters is largely controlled by influent characteristics.

2. Remove as much as possible in the primaries.

3. Give the mixed liquor just the air it needs when it needs it, where it needs it.

4. Identify and maintain the minimum SRT that meets the effluent ammonia target and gives best sludge quality.

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Summarizing Process Energy Conservation: 8 Guiding Principles

5. Determine and maintain the lowest RAS flow possible that does not result in increasing sludge blankets at any flow rate.

6. Maintain the organic loading to and the temperature in anaerobic digesters as stable, consistent, and uniform as possible.

7. Know the statistical accuracy of all data used to for control.

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Summarizing Process Energy Conservation: 8 Guiding Principles

8. Live by the operations professional credo: To remove pollutants from the incoming water, while complying with all permits—water, air, and land—and convert them to recyclable biosolids as sustainably and cost effectively as possible.

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Homework

$$\frac{Q_{RASmin}}{Q} = \frac{SSV_{30}}{1{,}000 - SSV_{30}}$$

Calculate the minimum RAS flow percentage for SSV_{30}s of 125, 150, 175, 200, 250, 300, 400, 500, and 600 mL/L. Comment on the impact that sludge compaction has on the potential for lowering RAS pumping costs.

SRT EXERCISE

$$Q_{WAS} = \left(\frac{V_a}{SRT_{target}} \times \frac{MLSS}{TSS_{WAS}}\right) - \left(Q \times \frac{TSS_{EFF}}{TSS_{WAS}}\right)$$

From experience the process control engineer knows that an SRT target (aerobic) of 7 days will meet the effluent NH3 requirements during the winter. However, because the supernatant in the modified settleometer test has been turbid, she wants to increase the SRT target to 7.5 days.

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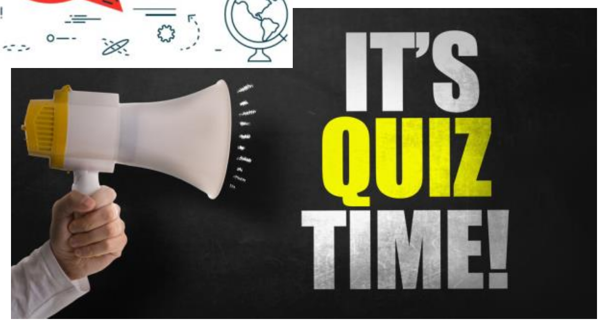

Closing

See You Next Week

CascadeEnergy

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