SESSIONS 5 & 6

WORKBOOK

TOPICS FOR THE WEEK

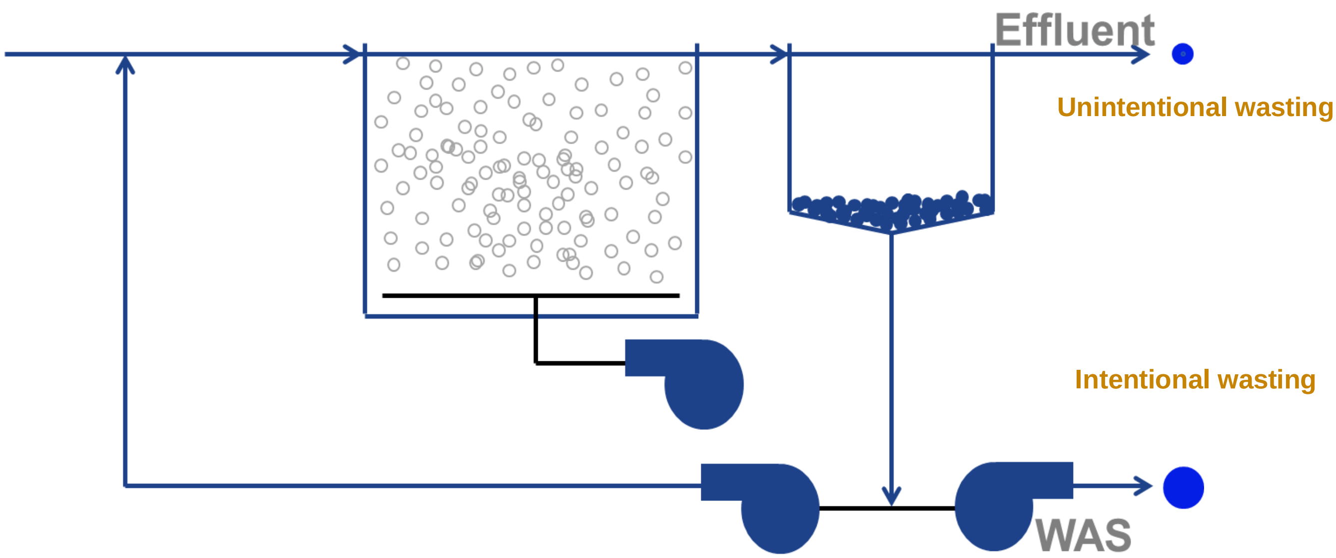
Welcome and Introductions
Tools of the Trade
Sludge Quality and SRT
WAS Flow Calculation
Fans and Odor Control
RAS Flow Optimization
State Point Analysis
Closing Remarks

TOOLS OF THE TRADE PART 1

Energy Projects

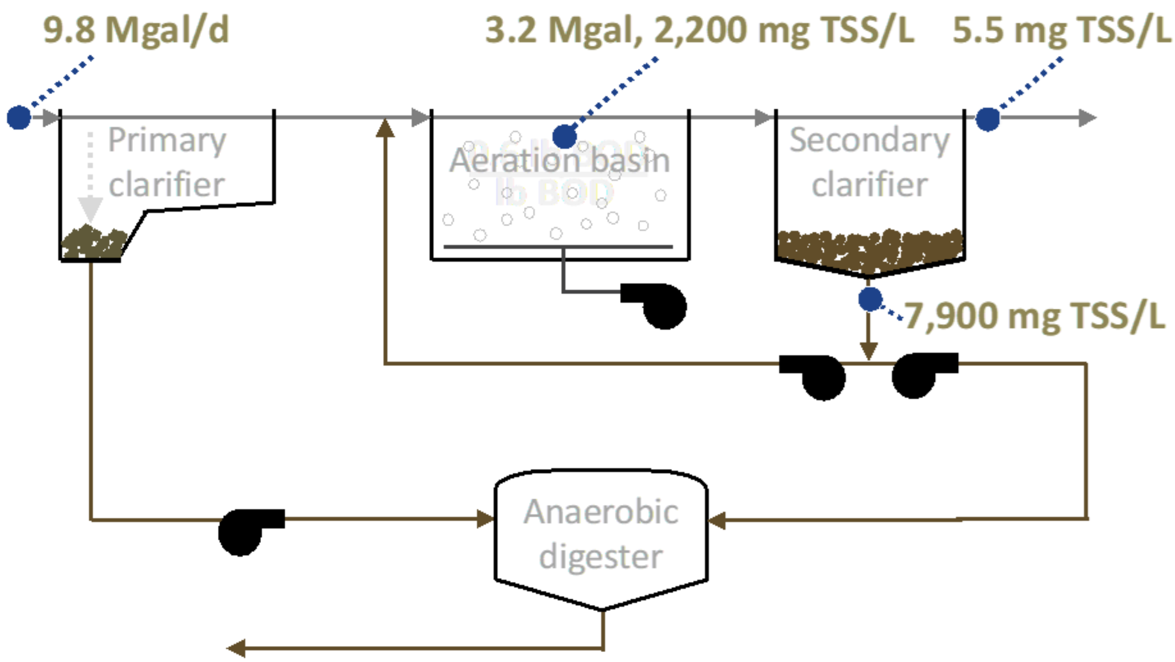
Energy Project		VALUE MATRIX		Step 1	Identify					
Opportunity #	Opportunity Name	Savings (1-10)	Cost/Effort (1-10)		Opportunity Description	Location	System*	Date Submitted	Capital or O&M	Submitted By
1	Lower W3 Pressure	3	2							
2										
3										
4										
5										
6										
7										

Sludge Quality Not *Effluent Quality*



Notes

EXERCISE – WAS FLOW



The operational strategy is to keep as little sludge blankets in the secondary clarifiers as possible. Over the last 24 hours, the online TSS meter measuring the mixed liquor suspended solids has averaged 2,200 mg/L. The secondary clarifier effluent TSS average a consistent 5.5 mg/L. The suction lines to the RAS and WAS pumps come off the same header. The return ratio is maintained at a constant 45% giving a TSS concentration in the RAS of 7,900 mg/L. The plant flow averages 9.8 Mgal/d and aeration basin volume currently online totals 3.2 Mgal. Calculate the WAS flow necessary to maintain an SRT_{TARGET} of 6.5 days (the plant is required to nitrify). The graphic summarizes the given information.

EXERCISE – WAS FLOW CALCULATION AREA

TREASURE HUNT

HVAC, FANS, AND ODOR CONTROL

TOOLS OF THE TRADE PART 2

EXERCISE – AERATION PRESSURE

Purpose: To develop knowledge, comfort and proficiency with the relationship between energy and aeration air discharge pressure.

Materials needed: Laptop

C) Impact of Blower Pressure on Energy

Impact of Discharge Pressure Reduction on Blower Energy

Discharge Pressure	Reduction in pressure of ___ psig.				
	-0.5	-1	-1.5	-2	-4
12	3.3%	6.7%	10.1%	13.4%	26.9%
11	3.7%	7.4%	11.1%	14.8%	29.6%
10	4.1%	8.3%	12.4%	16.5%	32.9%
9	4.6%	9.3%	13.9%	18.5%	37.0%
8	5.2%	10.6%	15.8%	21.0%	42.1%
7	6.1%	12.2%	18.3%	24.3%	48.6%

Example: 12 psig discharge lowered by 2 psig saves 13.4% at blower. (Assumes 70% blower eff. & 92% drive eff.)

psig	inches of H_2O
0.1	2.8
0.5	13.8
1	27.7
1.5	41.5
2	55.4
2.5	69.2
3	83.0
3.5	96.9
4	110.7

1 psi = 2.31 feet of water; 1 foot of water = 0.43 psi

What is the savings potential from lowering blower discharge pressure?

250	hp, blower
10	psig, discharge pressure
-0.5	pressure reduction
4.1%	%, potential energy savings
50,974	kWh annual energy savings
$3,058	annual cost savings @ $0.06/kWh

Instructions: Using the calculator (shown above) on your laptop, input information as necessary into the yellow cells to answer the following activity questions.

ACTIVITY QUESTIONS

a. How much energy is saved if this 50 hp blower's discharge pressure is reduced from 7 psig to 5.5 psig?	kWh/year	
b. What if it's a 150 hp blower, and the pressure is lowered from 10 psig to 9.5 psig. What percentage of energy is saved?	%	
c. If a 75 hp blower is turned down from 11 psig to 9 psig, how much money is saved (if energy costs 6¢ per kWh)?	$ /year	
d. If a 40 hp blower is turned down from 8 psig to 7 psig, how much energy is saved, and what percentage does that represent?	kWh/year	%

EXERCISE – DO RESIDUAL

Purpose: To develop knowledge, comfort and proficiency with the relationship between energy and residual dissolved oxygen (DO).
Materials needed: Laptop

Oxygen is required by the organisms that carry out secondary treatment in the aeration basin. Installed DO meters read how much “residual” or leftover oxygen is present. While many plants control blower operation automatically to maintain 1 mg/L DO or lower, we also see that many aeration basins carry excess DO “just in case” a large load comes in unexpectedly. This extra DO has an energy cost. The cheat sheet table shows how much energy savings (as a percentage) is available if residual DO is reduced to 1 mg/L, at various mixed liquor temperatures.

The calculator allows you to explore different scenarios and determine the approximate actual savings associated with these scenarios.

B) Impact of DO Levels on Energy

Saturated DO minus DO in basin = driving force for oxygen transfer; Driving force UP means Energy goes DOWN

Impact of Average DO Level on Blower Energy

Mixed Liquor Temp		DO Sat	Energy Savings Potential if DO Reduced from ___ to 1.0 mg/l			
ºC	ºF	mg/l	2	3	4	5
0	32	14.6	7.4%	14.7%	22.1%	29.4%
2	36	13.8	7.8%	15.6%	23.4%	31.3%
5	41	12.8	8.5%	16.9%	25.4%	33.9%
10	50	11.3	9.7%	19.4%	29.1%	38.8%
15	59	10.1	11.0%	22.0%	33.0%	44.0%
20	68	9.1	12.3%	24.7%	37.0%	49.4%
25	77	8.2	13.9%	27.8%	41.7%	55.6%

Note: *Higher impact as elevation increases.*

How much could my plant benefit from reducing DO to 1.0 mg/l?

100	hp, blower
68	°F, mixed liquor temp
9.1	mg/l, DO Sat
4	current DO level
37.0%	%, potential energy savings
212,779	kWh annual energy savings
$12,767	annual cost savings @ $0.06/kWh

Instructions: Use the table and calculator above to answer the questions below. Adjust information in the yellow fields as needed to answer the questions.

EXERCISE – DO RESIDUAL CONTINUED

Questions

a. What percentage of energy could be saved if an aeration basin holding 25^{o}C mixed liquor lowered its DO residual from 2 mg/L to 1 mg/L? __________%

b. If a plant is running 200 hp of blowers, and it has 59 ^{o}F mixed liquor, how many kWh/y of energy might it save by lowering its DO from 3 mg/L to 1 mg/L? __________kWh/year

c. In b) how much cost is saved (at $0.06/kWh)? $_________/year

d. How much total money can be saved if a plant running 100 hp of blowers in 20 ^{o}C mixed liquor reduces their DO residual from 5 mg/L to 1 mg/L? __________kWh/year

e. Your plant runs (on average) what total horsepower of blower? What is the approximate temperature of your plant's mixed liquor? What is the DO residual setpoint at your plant?

__________hp

__________^{o}F

___________mg/L

f. How much total money is saved if your plant reduces DO residual to 1 mg/L? $_________/year

OPTIMIZING RETURN RATE EXERCISE

This equation,

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

Can be rearranged to:

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

This factor,

$$\frac{Q_{RASmin}}{Q}$$

So calculated (times 100 to get %) is the minimum RAS flow percentage.

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.

SSV_{30}, mL/L	RAS flow, % (Q_{RASmin}/Q)
125	
150	
175	
200	
250	
300	
400	
500	
600	

ACTIVITY - STATE POINT ANALYSIS EXERCISE

Purpose: To develop knowledge, comfort and proficiency with a mass balance tool setting a return activated sludge (RAS) rate.

Materials needed: Laptop

The RAS rate can be minimized when mass balance information is available to predict clarifier performance. The Excel-based State Point analysis tool provides that prediction.

The calculator allows you to explore different scenarios to see how far the RAS can be turned down without clarifier failure (loss of solids over the weirs).

Instructions: Use the State Point spreadsheet to enter the given information in the yellow fields and answer the questions below.

This spreadsheet will generate a flux curve given the following inputs (insert value in the appropriate cell between thick lines -- mind your units):

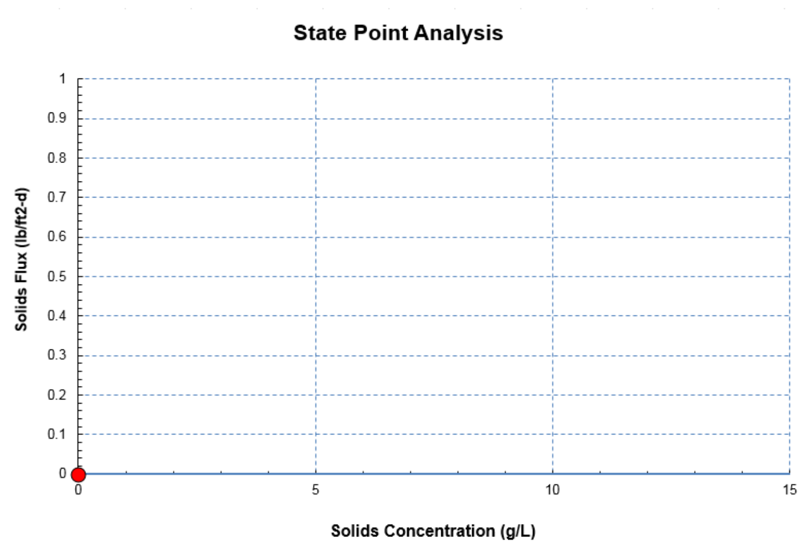
SVISN	0	mL/g
Number of clarifiers	0	
Area of each clarifier	0	ft^2
MLSS	0	g/L
Influent flow	0	mgd
RAS flow	0	mgd

Alternate influent flow	0	mgd
Alternate RAS flow	0	mgd

Choose desired flux units by placing a "1" in place of the "0" next to desired units:	
kg/m^2h	0
kg/m^2d	0
lb/ft^2d	0

Influent flow	0	gpm
	0	mgd
Combined RAS flow	0	gpm
	0	mgd

2-L Settleometer without stirring - Typically use this graph



ACTIVITY SHEET – STATE POINT ANALYSIS EXERCISE CONTINUED

1. Input a "1" to choose desired flux units lb/ft^{2}d
2. Set SVISN to 225 mL/g
3. Set "number of clarifiers" to 1
4. Set "area of each clarifier" to 1,950 ft^2
5. Set MLSS to 2.5 g/l (this is 2,500 mg/L)
6. Enter influent flow in the lower calculator to 1000 gpm, then enter the resulting calculated MGD above in the "influent flow" input box.
7. Set RAS flow at 0.25 Q (25% of influent flow) a. Is this RAS flow acceptable for holding solids in the clarifier? b. If yes, how much lower can it be adjusted and still hold solids in the clarifier? c. If no, what RAS change needs to be made?
8. Decrease SVI to 175 mL/g. Describe what this means, and what happens regarding the clarifier's capacity.
9. We don't really have direct, immediate control of SVI. Increase SVI back to 225 mL/g and put a second clarifier into service. Describe what is happening. Can RAS rate now be lowered while allowing the clarifiers to hold the solids?
10. Note how improving SVI impacts this scenario.

SRT EXERCISE

From experience the process control engineer knows that an SRT target (aerobic) of 7 days will meet the

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

effluent NH3 requirements during the winter. Because the supernatant in the modified settleometer test has been turbid, she wants to increase the SRT target to 7.5 days.

From the following recent data, calculate today's WAS flow rate (gal/hr):

Q = 2.6 Mgal/d

MLSS = 2,550 mg/L

Va = 0.65 Mgal (aerobic)

TSSEFF = 16 mg/L

TSSWAS = 7,700 mg/L

ANSWER SHEET – EXERCISE – AERATION PRESSURE

a. How much energy is saved if this 50 hp blower's discharge pressure is reduced from 7 psig to 5.5 psig? _____________ kWh/year A = 52,431 kWh/year

b. What if it's a 150 hp blower, and the pressure is lowered from 10 psig to 9.5 psig. What percentage of energy is saved? ___________% A = 4.1%

c. If a 75 hp blower is turned down from 11 psig to 9 psig, how much money is saved (if energy costs 6¢ per kWh)? $__________/year A = $3,827/year

d. If a 40 hp blower is turned down from 8 psig to 7 psig, how much energy is saved, and what percentage does that represent? __________kWh/year, _____% A = 24,263 kWh/year, 10.6%

ANSWER SHEET: EXERCISE – DO RESIDUAL

a.	What percentage of energy could be saved if an aeration basin holding 25°C mixed liquor lowered its DO residual from 2 mg/L to 1 mg/L? _____% A = 13.9%
b.	If a plant is running 200 hp of blowers, and it has 59 °F mixed liquor, how many kWh/y of energy might it save by lowering its DO from 3 mg/L to 1 mg/L? __________kWh/year A = 252,528 kWh/year
c.	In b) how much cost is saved (at $0.06/kWh)? $__________/year A = $15,152/year
d.	How much total money can be saved if a plant running 100 hp of blowers in 20 °C mixed liquor reduces their DO residual from 5 mg/L to 1 mg/L? __________kWh/year A = $17,022/year
e.	Your plant runs (on average) what total horsepower of blower? _____hp A = *plant-specific* What is the approximate temperature of your plant's mixed liquor? _______ °F A = *plant-specific* What is the DO residual setpoint at your plant? ________mg/L A = *plant-specific*
f.	How much total money is saved if your plant reduces DO residual to 1 mg/L? $__________/year A = *plant-specific*

ANSWER SHEET – OPTIMIZING RETURN RATE EXERCISE

This equation,

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

Can be rearranged to:

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

This factor,

$$\frac{Q_{RASmin}}{Q}$$

So calculated (times 100 to get %) is the minimum RAS flow percentage.

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.

SSV_{30}, mL/L	RAS flow, % (Q_{RASmin}/Q)
125	14%
150	18%
175	21%
200	25%
250	33%
300	43%
400	67%
500	100%
600	150%

ANSWER SHEET – STATE POINT ANALYSIS EXERCISE

1. Input a "1" to choose desired flux units lb/ft^2d.
2. Set SVISN to 225 mL/g.
3. Set "number of clarifiers" to 1.
4. Set "area of each clarifier" to 1,950 ft^2
5. Set MLSS to 2.5 g/l (this is 2,500 mg/L)
6. Enter influent flow in the lower calculator to 1000 gpm, then enter the resulting calculated MGD above in the "influent flow" input box.
7. Set RAS flow at 0.25 Q (25% of influent flow).
    a. Is this RAS flow acceptable for holding solids in the clarifier? A = No.
    b. If yes, how much lower can it be adjusted and still hold solids in the clarifier? N/A
    c. If no, what RAS change needs to be made? A = increase to something like 0.9 mgd
8. Decrease SVI to 175 mL/g. Describe what this means, and what happens regarding clarifier's capacity.
   It is easier to hold solids in the clarifier when SVI is lower, solids take up less volume.
   ____
   ____
9. We don't really have direct, immediate control of SVI. Increase SVI back to 225 mL/g and put a second clarifier into service. Describe what is happening.
   ____
   ____

   Can RAS rate now be lowered while allowing the clarifiers to hold the solids? A = Yes. RAS at or above about 0.6 MGD.
10. Input a typical operating condition for your system.
    a. How many clarifiers are in service? __________________ (input)
    b. What is a typical SVI? ________________________ (input)
    c. What is the area of each clarifier? ___________________ (input) [remember, A = 3.14 X Diameter^2 (in feet)÷4]
    d. What is the typical MLSS in g/L? _____________________ (input)
    e. What is typical influent flow, in mgd? ____________________ (input)
    f. What is the typical RAS flow, in mgd? _______________________ (input)
    g. Use cell D13 to explore: Is there a lower RAS flow rate that still holds the solids, under these conditions? ____________________ mgd
11. Note how improving SVI impacts this scenario.
   ____
   ____

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. Because the supernatant in the modified settleometer test has been turbid, she wants to increase the SRT target to 7.5 days.

From the following recent data, calculate today's WAS flow rate (gal/hr):

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MLSS = 2,550 mg/L

Va = 0.65 Mgal (aerobic)

TSSEFF = 16 mg/L

TSSWAS = 7,700 mg/L

A = 971 gal/h