Better Plants
U.S. DEPARTMENT OF ENERGY

WEEK 4 – WORKBOOK

Use for Sessions 7 & 8 and for the Work Session

TOPICS FOR THE WEEK

Welcome and Introductions
Solid Stream Opportunities
DAFs
Compressed Air
Window Pane Review
Energy Hot Spots
Opportunity Register Work Session

TOOLS OF THE TRADE PART 1

Expand or collapse steps using the +/- signs above ↑ Expand or collapse steps using the +/- signs above ↑

Energy Projects

Energy Project		VALUE MATRIX (GO TO VALUE MATRIX)		Step 1	Step 2	Prioritize			
Opportunity #	Opportunity Name	Savings (1-10)	Cost/Effort (1-10)			Energy Savings	Type of Energy Saved*	Cost/Effort Required	Decision
1	Lower W3 Pressure	3	2						
2									
3									
4									
5									
6									
7									
8									
9									
10									

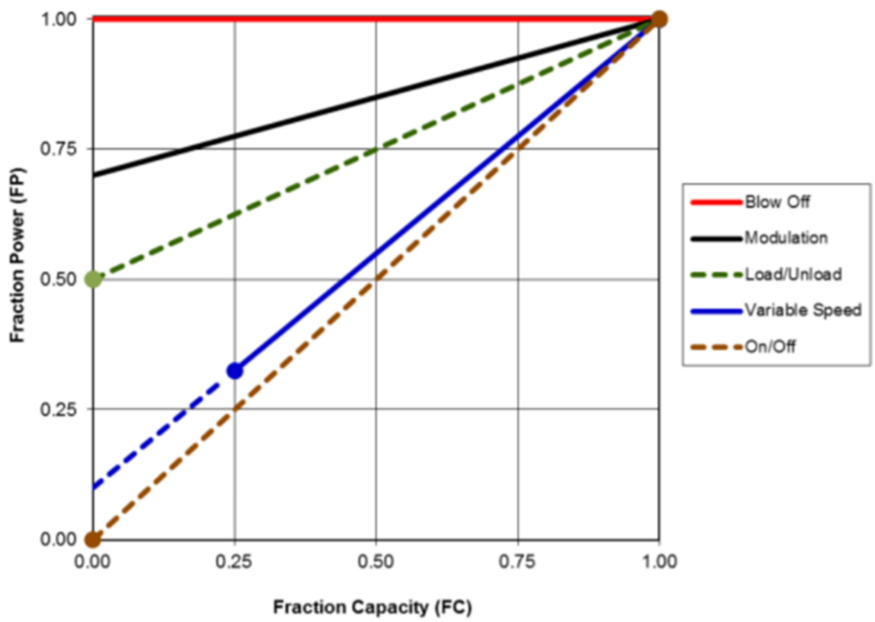
OPPORTUNITY VERIFICATION AND IMPLEMENTATION

Instructions: List your top three pending savings opportunities with the highest savings potential. For each project, list the roadblocks you will need to overcome. Lastly, list the steps you will need to take to overcome each roadblock.

Savings Opportunity	Anticipated Roadblocks	Steps to Completion
Example: *Dedicated compressor for fire suppression to reduce system pressure*	• *Capital* • *Buy-in from Safety* • *Maintenance resources*	• *Meeting with Safety and plant mgr* • *Schedule for next shutdown at direction of plant mgr*
1.		
2.		
3.		

DAFS

COMPRESSED AIR



WORKSESSION EXERCISES

ENERGY BASICS EXERCISE

In March 2010, the water plant in Wherzit, Oregon received the electric bill shown below. Wherzit produces wintertime flows averaging 8 MGD.

PAGE 2 OF 2

Questions about your bill: Call toll free

BILLING DATE: **Mar 26, 2010** ACCOUNT NUMBER: DATE DUE: **Apr 13, 2010** AMOUNT DUE: **$23,005.02**

ITEM 5 - ELECTRIC SERVICE

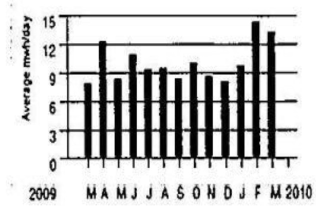
Sewer Treatment Schedule 30
Service ID: 113514817-003

METER NUMBER	SERVICE PERIOD From	To	ELAPSED DAYS	METER READINGS Previous	Current	METER MULTIPLIER	AMOUNT USED THIS MONTH
28819932	Feb 24, 2010	Mar 25, 2010	29	10344	10669	1,200.0	390,000 kwh
28819932	Demand	Mar 25, 2010			0.615	1,200.0	738 kw
28819932	Reactive	Mar 25, 2010			0.413	1,200.0	496 kvar

Next scheduled read date: 04-23. Date may vary due to scheduling or weather.

NEW CHARGES - 03/10	UNITS	COST PER UNIT	CHARGE
Basic Charge - 3P Pri Delivery	842 kw	0.6000000	782.20
Demand Charge Pri - Min 100 Kw	738 kw	3.8900000	2,870.82
Base Supply Demand Charge	738 kw	1.0000000	738.00
Delivery Charge Primary	390,000 kwh	0.0012200	475.80
Oregon Tax Charge	390,000 kwh	0.0014200	553.80
Reactive Power Charge Pri	201 kvar	0.6000000	120.60
Supply Enrgy Pri 1st 20000 Kwh	20,000 kwh	0.0455400	910.80
Supply Enrgy Pri > 20000 Kwh	370,000 kwh	0.0404500	14,966.50
Public Purpose		0.0300000	642.56
Energy Conservation Charge	390,000 kwh	0.0015700	612.30
Low Income Assistance	390,000 kwh	0.0005000	195.00
Jc Boyle Dam Removal Surcharge for 8 day(s)	107,586 kwh	0.0003200	34.43
Copco/iron Gate Dams Remv Schg for 8 day(s)	107,586 kwh	0.0009500	102.21
Total New Charges			23,005.02

Historical Data - *ITEM 5*



Your Average Daily kwh Usage by Month

PERIOD ENDING	MAR 2010	MAR 2009
Avg Daily Temp.	47	45
Total kwh	390000	231600
Avg kwh per Day	13448	7986
Cost per Day	$793.28	$517.00

Total rate: $0.04516/kWh

Demand Charge

Reactive Charge

ACTIVITY SHEET – ENERGY BASICS EXERCISE

a. How many kilowatt-hours of electricity did this facility use during this billing cycle? (Feb/Mar 2010)

b. During this billing cycle, what was Wherzit's highest 15-minute demand?

c. Wherzit's UV uses about 50% of the plant's total electricity on average. How many kWh does the UV use on average every day?

d. What kW demand is this, and what would be the equivalent motor horsepower that corresponds to this?

e. From the info above, what would be the average whole-plant benchmark in kilowatt-hours per million gallon produced?

Notes

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.

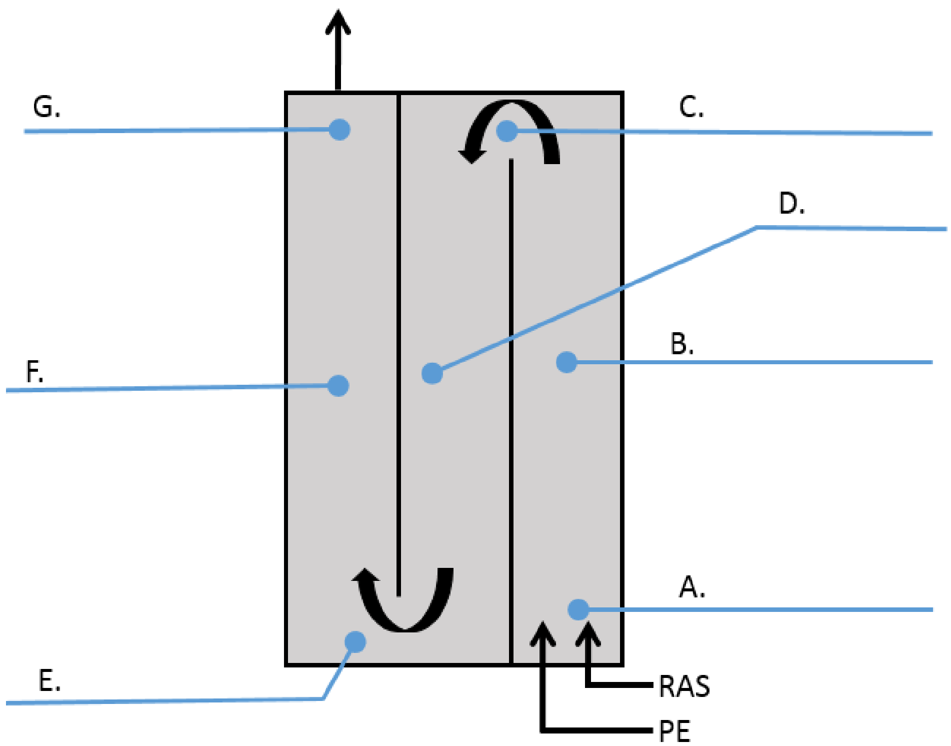
Calculate the minimum RAS flow percentage for SSV_{30}s of 125, 150, 175, 200, 250, 300, 400, 500, and 600 mL/L. Comment on the impact that sludge compaction has on the potential for lowering RAS pumping costs.

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

EXERCISE: OUR – FINDING ENDOGENOUS

Materials needed: Laptop

Use the laptop to input the A-G data from 7 locations on the 3-pass aeration basin shown.



1. Where does endogenous respiration begin?

2. Where does this basin need the most air? The least?

3. What are some possible approaches to optimizing the air in this basin?

Location: A. Beginning Pass 1 (after PE and RAS)	
Time (seconds)	DO (mg/L)
0	7.45
10	7.02
20	6.59
30	6.18
40	5.72
50	5.29
60	4.88

Location: B. Mid-tank Pass 1	
Time (seconds)	DO (mg/L)
0	7.44
10	7.12
20	6.81
30	6.48
40	6.16
50	5.84
60	5.52

Location: C. End Pass 1 beginning Pass 2	
Time (seconds)	DO (mg/L)
0	7.48
10	7.21
20	6.93
30	6.68
40	6.40
50	6.14
60	5.89

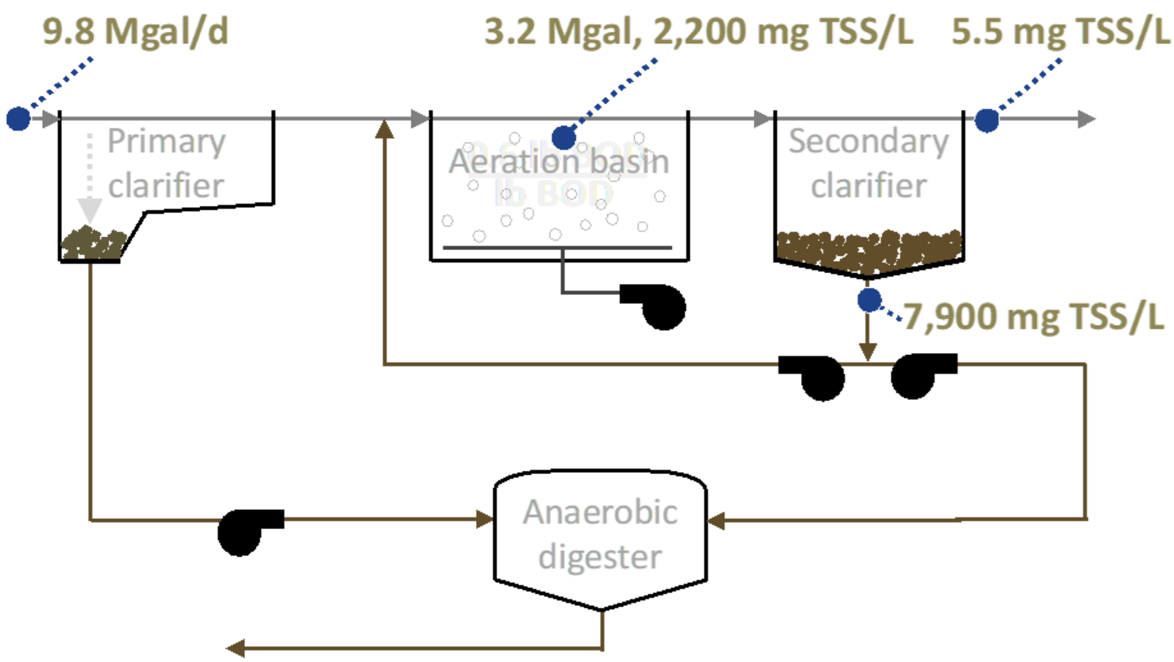
Location: D. Mid-tank Pass 2	
Time (seconds)	DO (mg/L)
0	7.47
10	7.31
20	7.15
30	7.00
40	6.85
50	6.69
60	6.52

Location: E. End Pass 2 beginning Pass 3	
Time (seconds)	DO (mg/L)
0	7.17
10	7.02
20	6.86
30	6.70
40	6.57
50	6.43
60	6.27

Location: F. Mid-tank Pass 3	
Time (seconds)	DO (mg/L)
0	7.37
10	7.32
20	7.28
30	7.24
40	7.20
50	7.15
60	7.10

Location: G. End Pass 3, aeration basin effluent	
Time (seconds)	DO (mg/L)
0	7.42
10	7.39
20	7.33
30	7.30
40	7.25
50	7.22
60	7.18

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

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

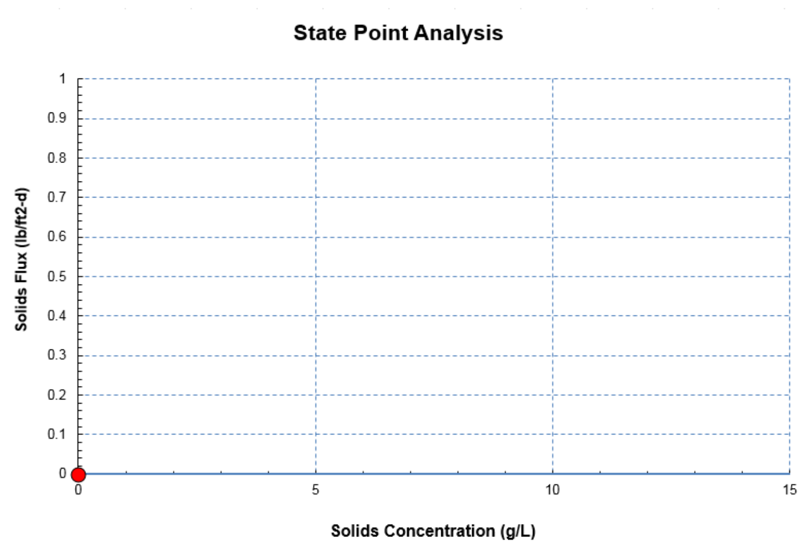
Alternate influent flow	0	mgd
Alternate RAS flow	0	mgd

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.

ANSWER SHEET – ENERGY BASICS EXERCISE

a. How many kilowatt-hours of electricity did this facility use during this billing cycle? (Feb/Mar 2010)

A = 390,000 kWh

b. During this billing cycle, what was Wherzit's highest 15-minute demand?

A: 738 kW

c. Wherzit's UV uses about 50% of the plant's total electricity on average. How many kWh does the UV use on average every day?

A = 390,000 kWh/29 days x 50% = 6,724 kWh/d

d. What kW demand is this, and what would be the equivalent motor horsepower that corresponds to this?

A: 6,724 kWh/d ÷ 24 h/d = 280 kW; 280 kW ÷ 0.75 kW/HP = 373 HP

e. From the info above, what would be the average whole-plant benchmark in kilowatt-hours per million gallon produced?

A: 390,000 kWh / 29 days = 13,448 kWh/d; 13,448 kWh/d ÷ 8 MGD = 1,681 kWh/MG

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^{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? 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):

Q = 2.6 Mgal/d

MLSS = 2,550 mg/L

Va = 0.65 Mgal (aerobic)

TSSEFF = 16 mg/L

TSSWAS = 7,700 mg/L

A = 971 gal/h