# WASTEWATER IN-PLANT TRAINING

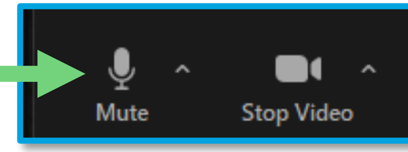
## SESSION 8 – REVIEW AND CLOSEOUT PRESENTATION

# Using Zoom!

**Mute yourself!**

Have a question?
Use the chat feature.

*Controls accessed at the bottom*



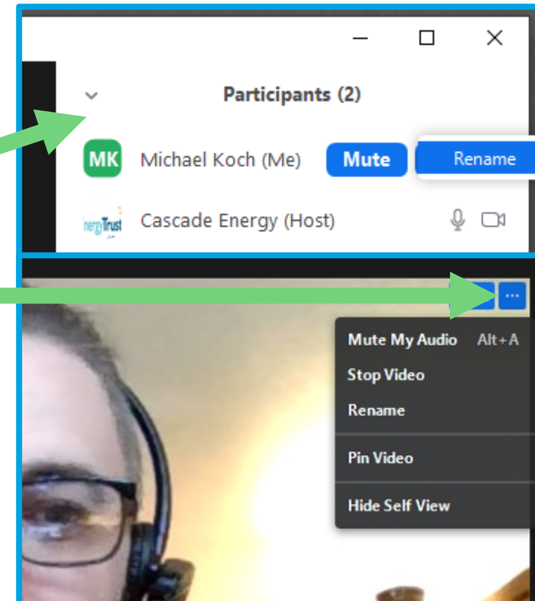

**Rename yourself**

"Name (Company)"

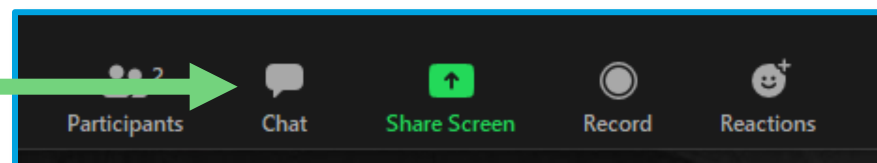
*Right click on your picture or 3 dots*

*OR*

*Controls accessed at the right after clicking 'Participants' at bottom.*




**Access Chat at the bottom**



# 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.*

# Thank You!

## Sponsor

Better Plants
U.S. DEPARTMENT OF ENERGY

# Today's Agenda

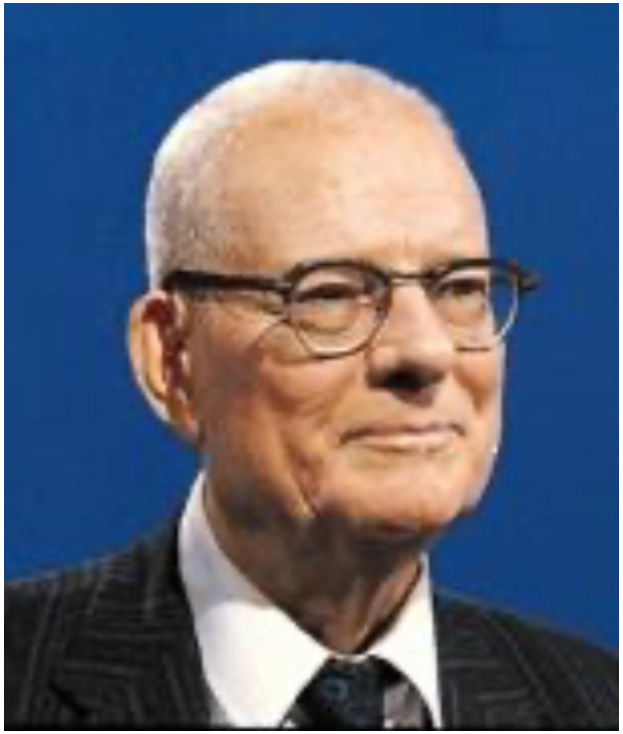
| | |
|---|---|
| Welcome and Introductions | Reports 3 & 4 |
| Plant Optimization 1 | Tying it All Together |
| Report Outs 1 & 2 | Report Outs 5 & 6 |
| Plant Optimization 2 | Final Quiz |

# Plant Optimization

# A Review of where we have been…….

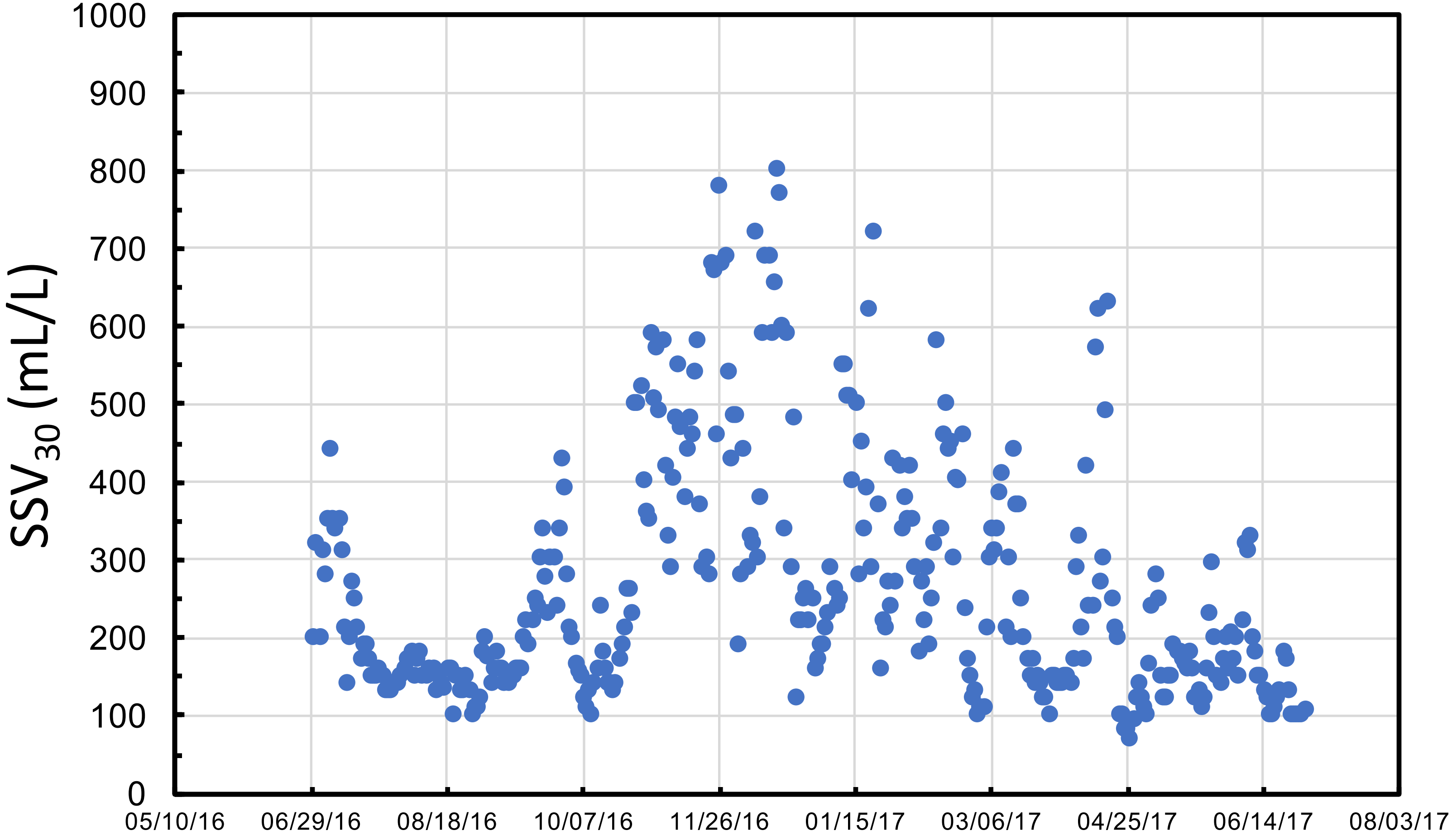
# ...and where we would like you to go

# W. Edwards Deming 1900—1993

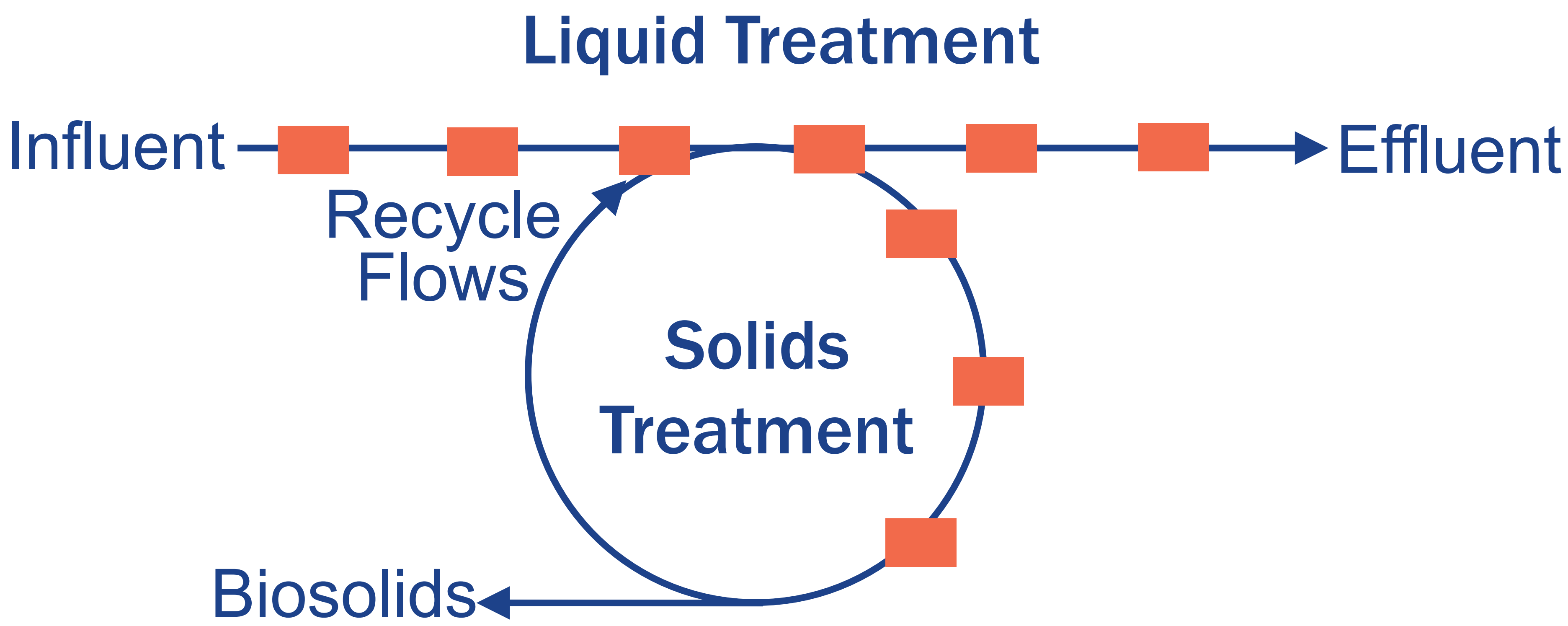


"It's not enough to do your best. You must know what to do, then do your best."

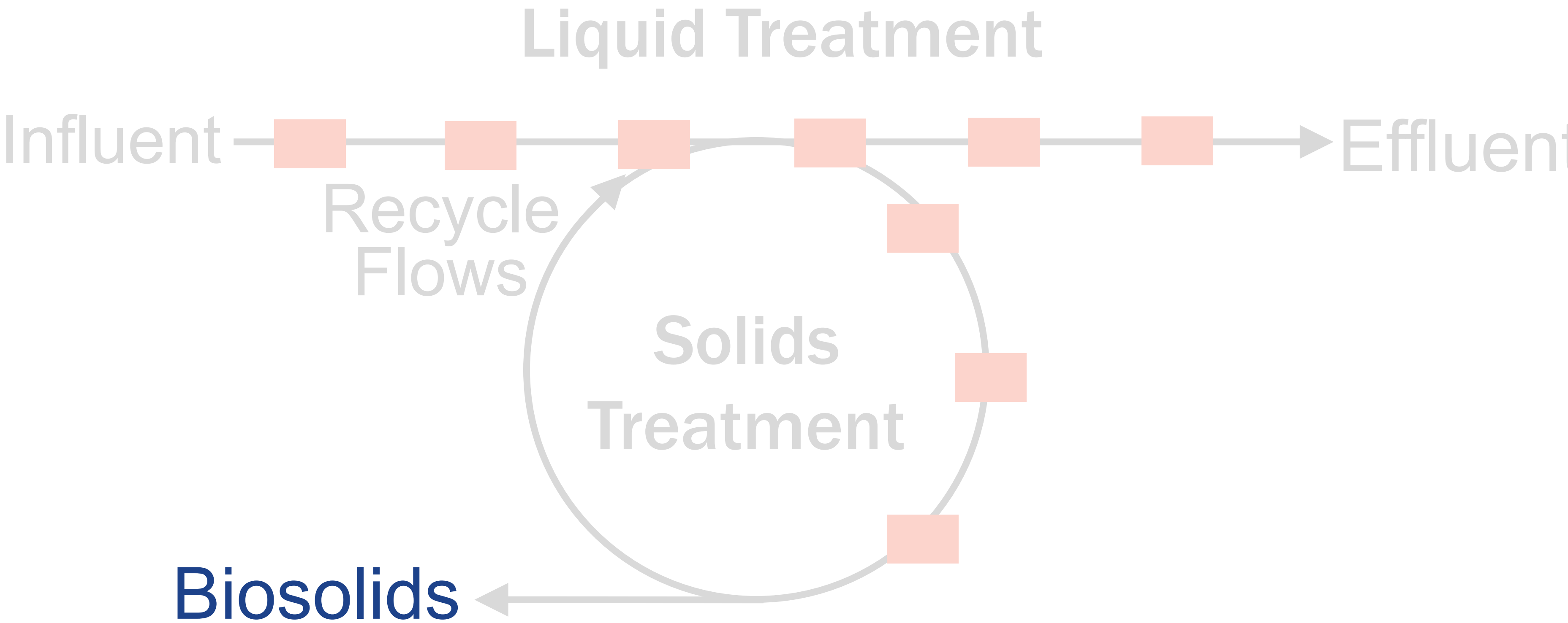
# First step in energy conservation: Decrease process variability



# Like manufacturing plants, WWTPs are made up of many unit processes…

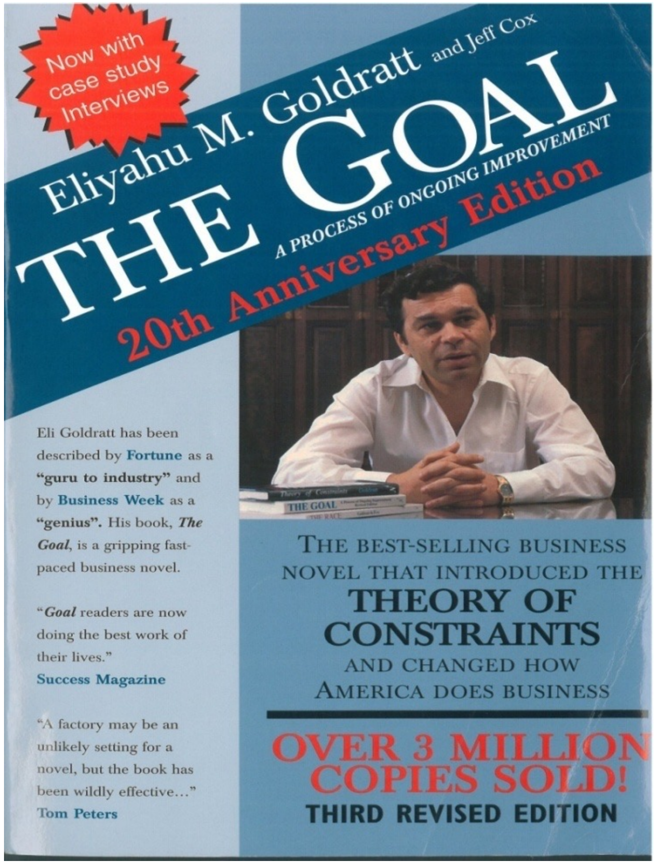


# …that produce biosolids



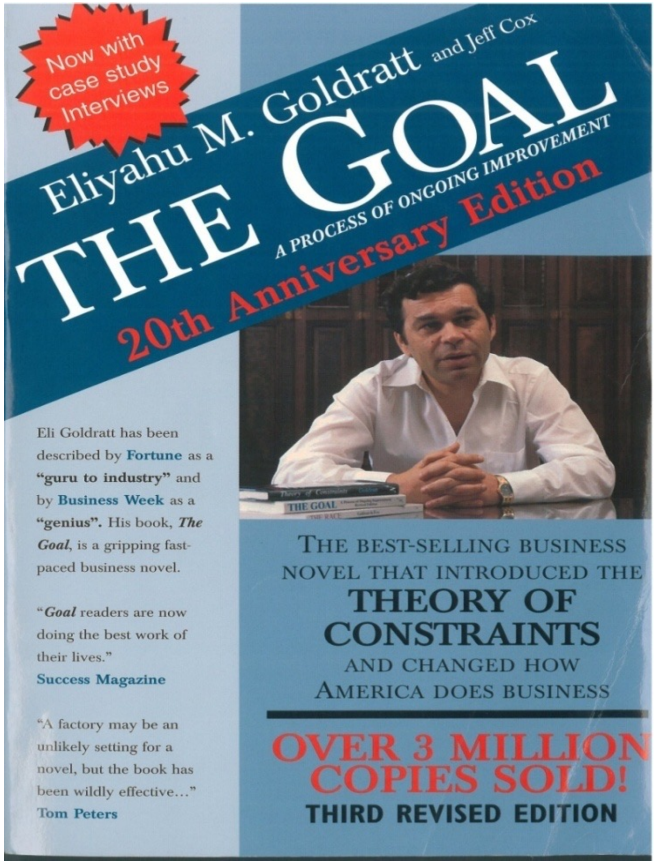
# The "goal" defined by The Goal

The goal of any manufacturing plant is to make as much money as possible.



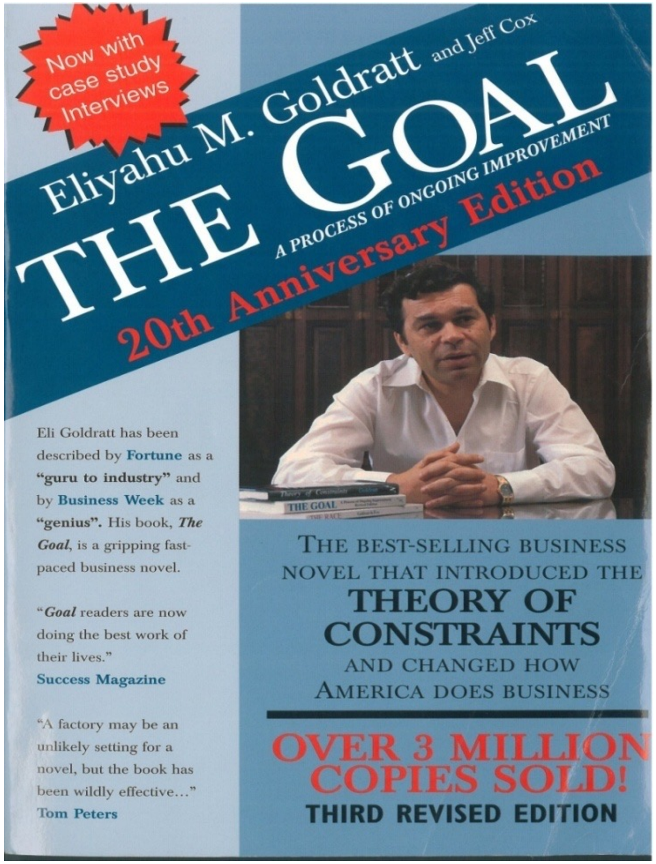
# Our goal

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



# By being cost effective, we put more money in the pockets of our ratepayers

Therefore, our goal is consistent with The Goal's goal.



# Three steps in achieving the goal

1. Maximize Throughput
2. Minimize Inventory
3. Minimize Operating Costs

# Throughput defined by the Goal

**Throughput is the rate at which the system generates money through sales, which *The Goal says you must maximize*.**

# Throughput defined a little differently in WWTPs – 4 considerations -

- We have to **treat every gallon** that comes down the pipe at us.
- **We don't generate money**, we do what we have to do as cost effectively as possible while meeting all permit requirements.
- **Plant capacity is fixed** by what we have in the ground, how we maintain it, and how we operate it.
- In maximizing throughput, operators at WWTPs must **ensure that as much excess capacity as possible is available** at any given time.

# Decisions we make impact the capacity our ratepayers paid for

**"Plant capacity is fixed by what we have in the ground, how we maintain it, and how we operate it."**

# Maximizing throughput means we have to think entirely differently

> **“In maximizing throughput, operators at WWTPs must ensure that as much excess capacity as possible is available at any given time.”**

# Inventory defined in The Goal

**Inventory is all the money that the system has invested in purchasing things which it intends to sell.**

# What's "inventory" in a WWTP? What allows us to treat wastewater?

We constantly refer to the following:

- Influent total suspended solids
- Primary clarifier solids removal efficiency
- Primary sludge total solids concentration
- Mixed liquor suspended solids
- RAS total suspended solids concentration
- Biological solids wasted; digested solids trucked
- Volatile solids destruction
- Solids capture efficiency

# What's "inventory" in a WWTP? What allows us to treat wastewater?

We constantly refer to the following:

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- Primary clarifier **solids** removal efficiency
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- RAS total suspended **solids** concentration
- Biological **solids** wasted; digested **solids** trucked
- Volatile **solids** destruction
- **Solids** capture efficiency

# Solids are “inventory” in a WWTP

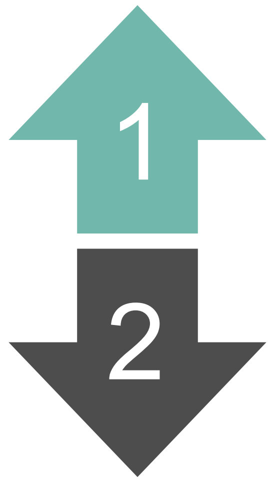
**To minimize inventory, the mass of solids residing in each and every process unit at any given time must be kept as low as possible (except anaerobic digesters)**

**Examples:**

- **Low sludge blankets in clarifiers**
- **Lowest SRT possible**
- **Minimal sludge “storage”**

# Cannot accomplish No. 3 without first accomplishing Nos. 1 and 2

Maximize Throughput

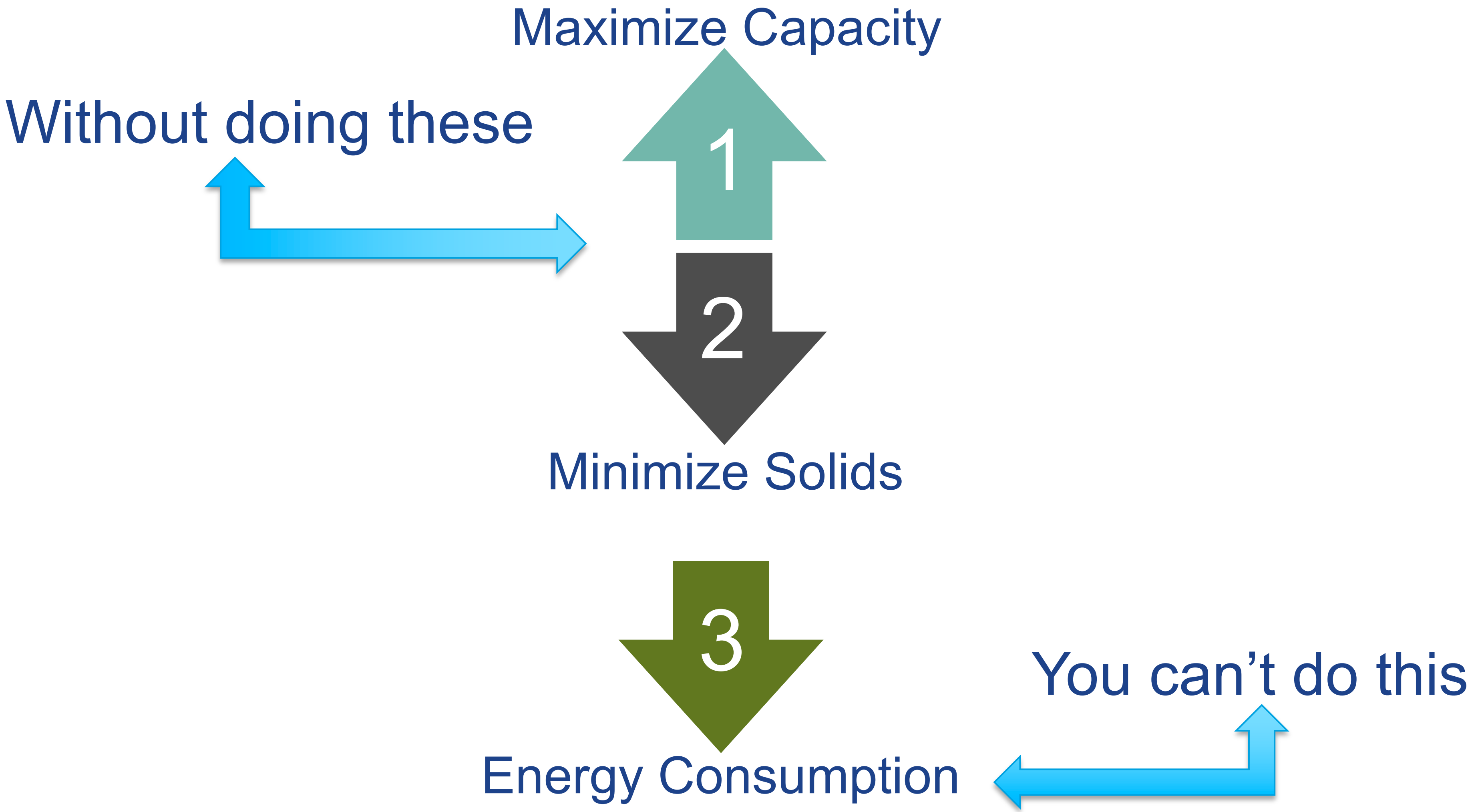



Minimize Inventory


Minimize Operating Costs

***OR, for WW Operators…..***

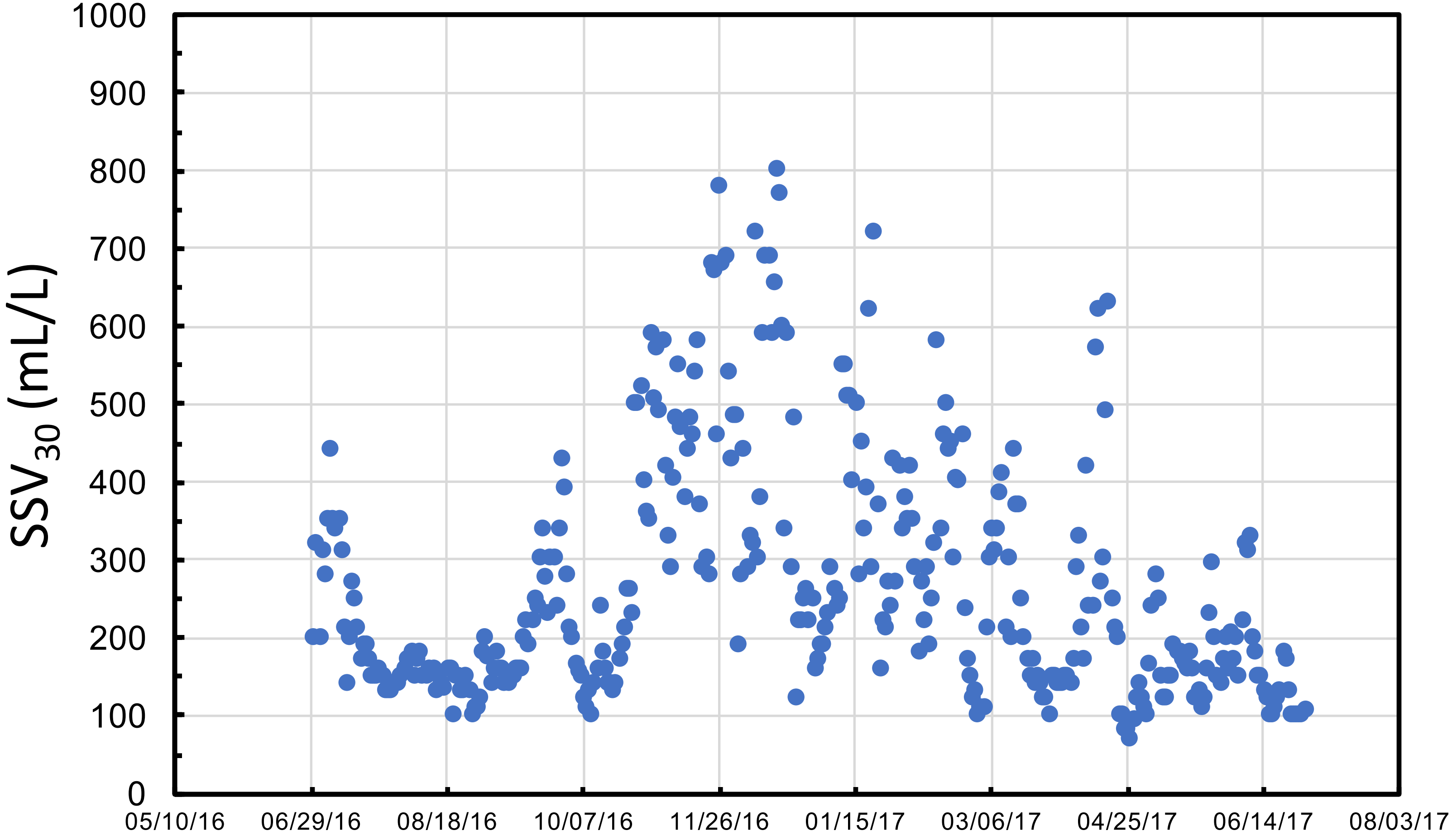
# Least operating cost solution No. 3 (think: energy usage) happens with Nos. 1 and 2



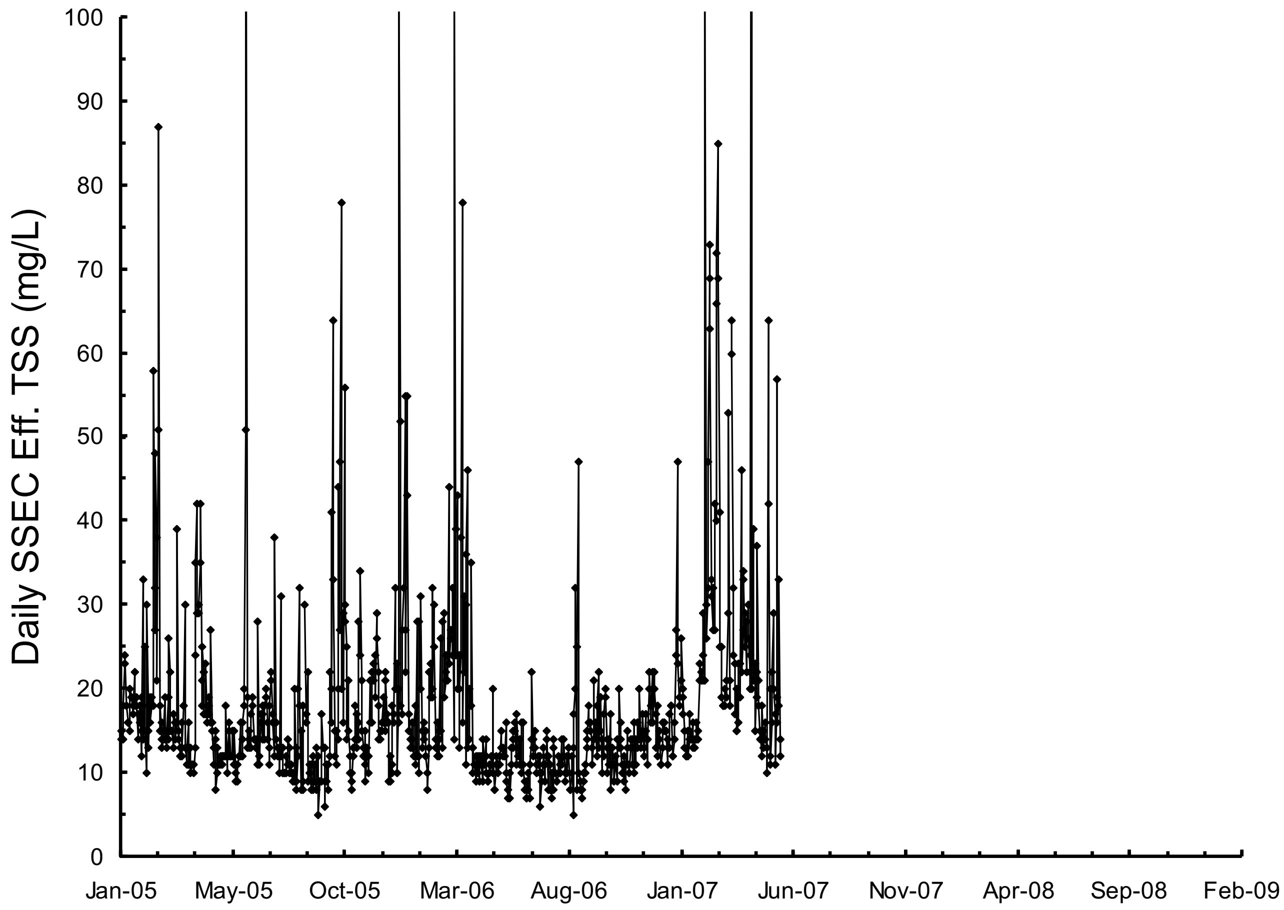
# One of my favorite excerpts from The Goal

"Alex, if you're like nearly everybody else in this world, you've accepted so many things without question that you're not really thinking at all,' says Jonah."

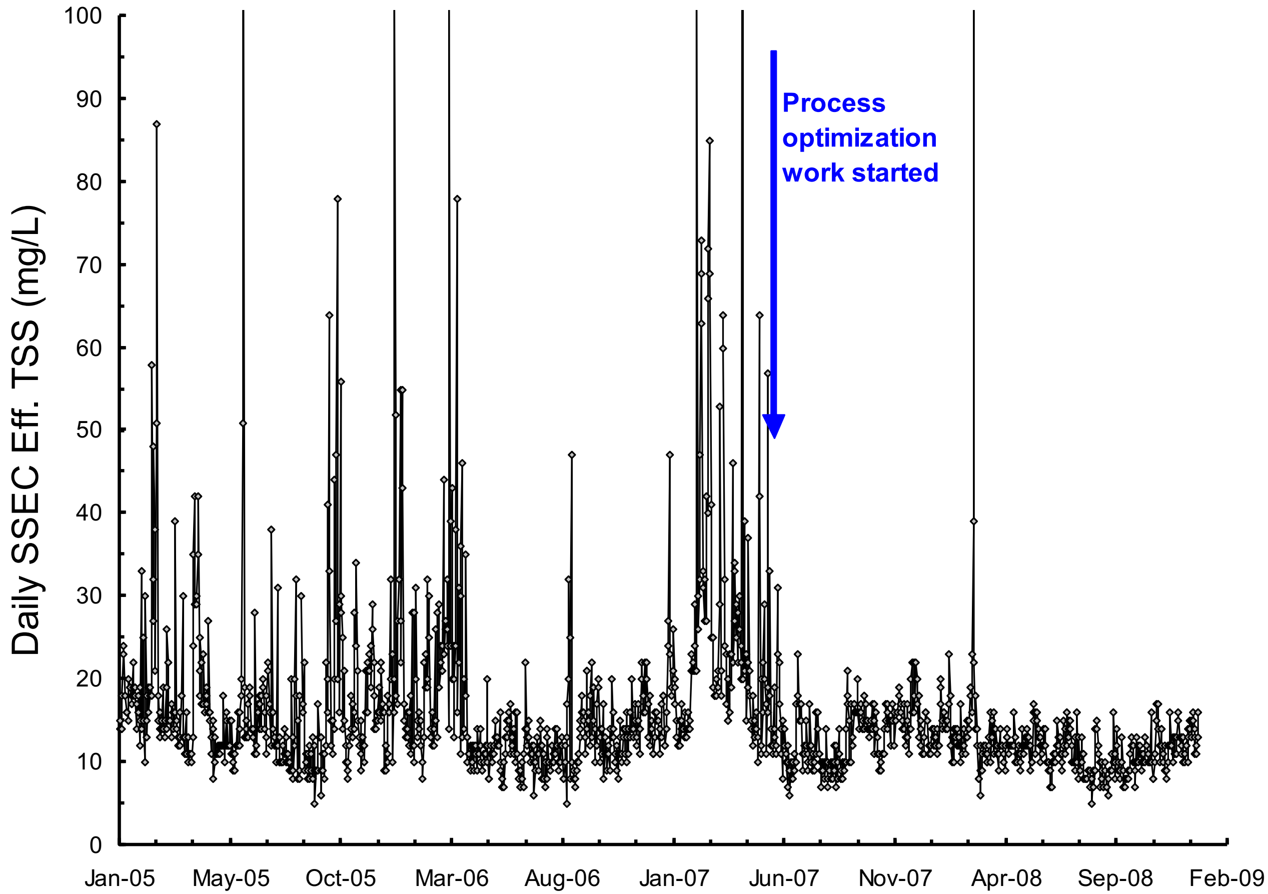
# First step in energy conservation: Decrease process variability



# Historic performance highly variable (hard to optimize with this much variability)



# Process optimization work initiated in May 2007

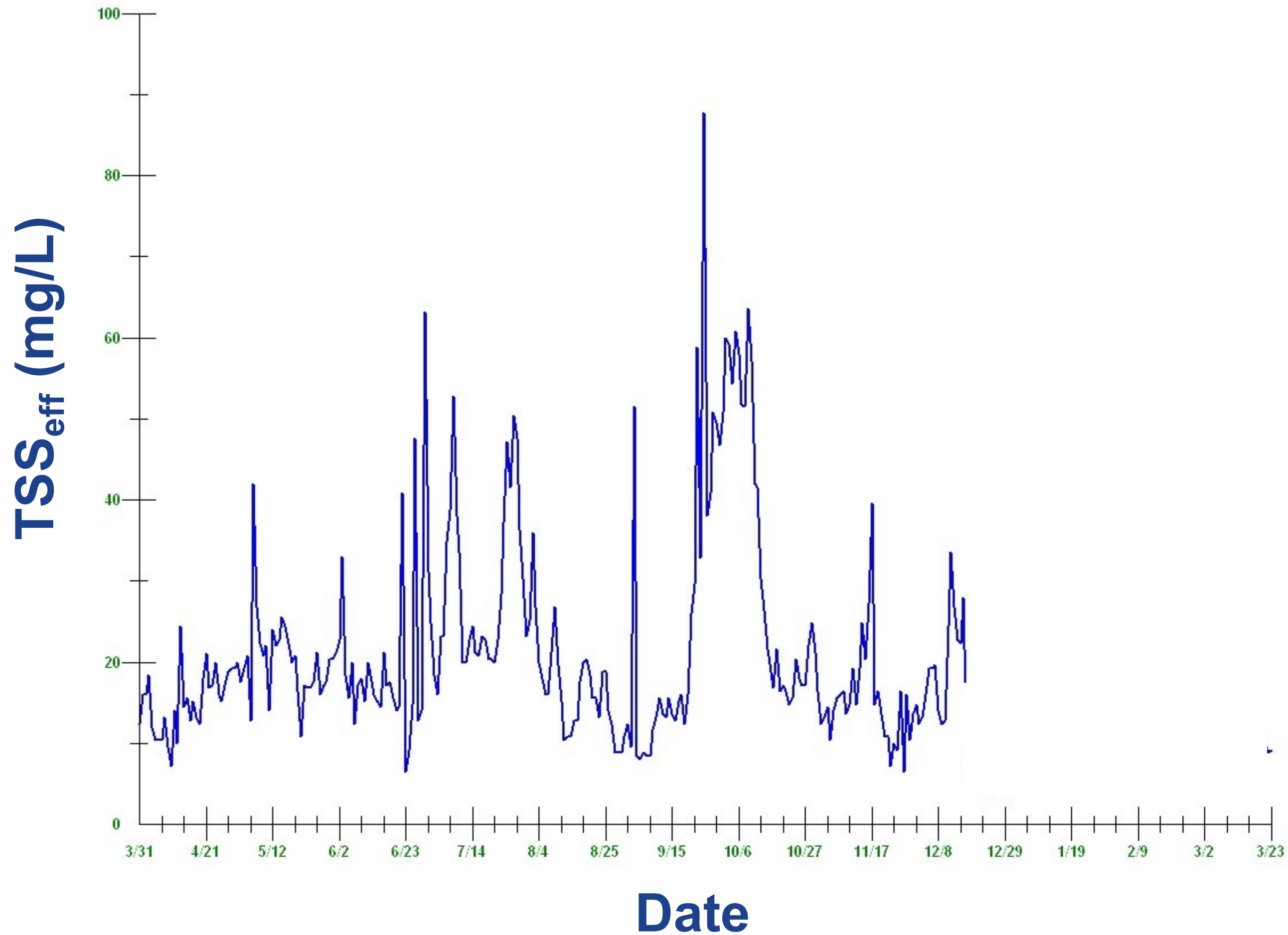


# Wasting mixed liquor ……….
# ………………..makes SRT control extremely easy

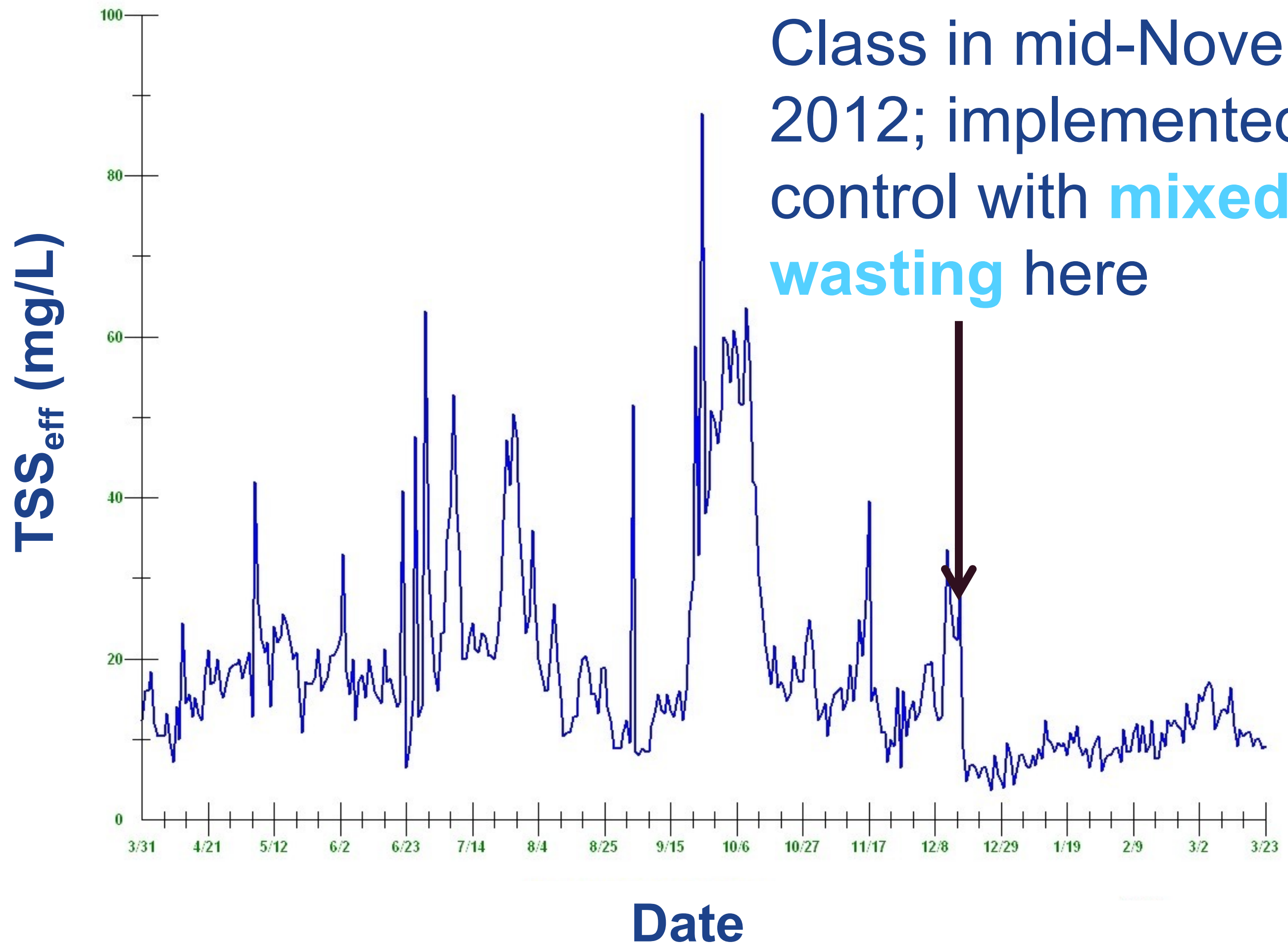
$$Q_{WAS} = \frac{V_{AB}}{SRT_{TARGET}}$$

**So why don't we do this more often?**

# Performance variability not necessary

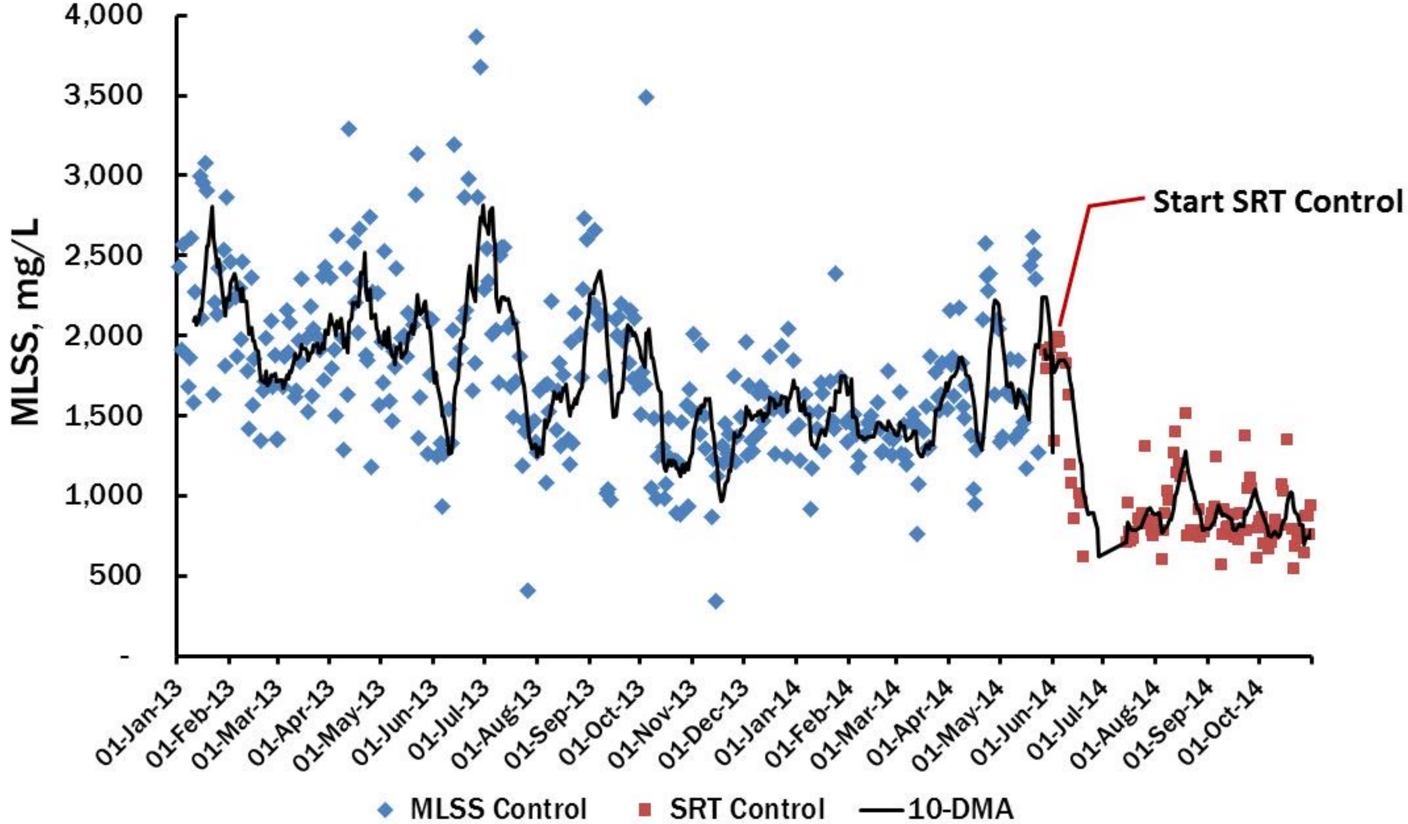


# For activated sludge, SRT control is key

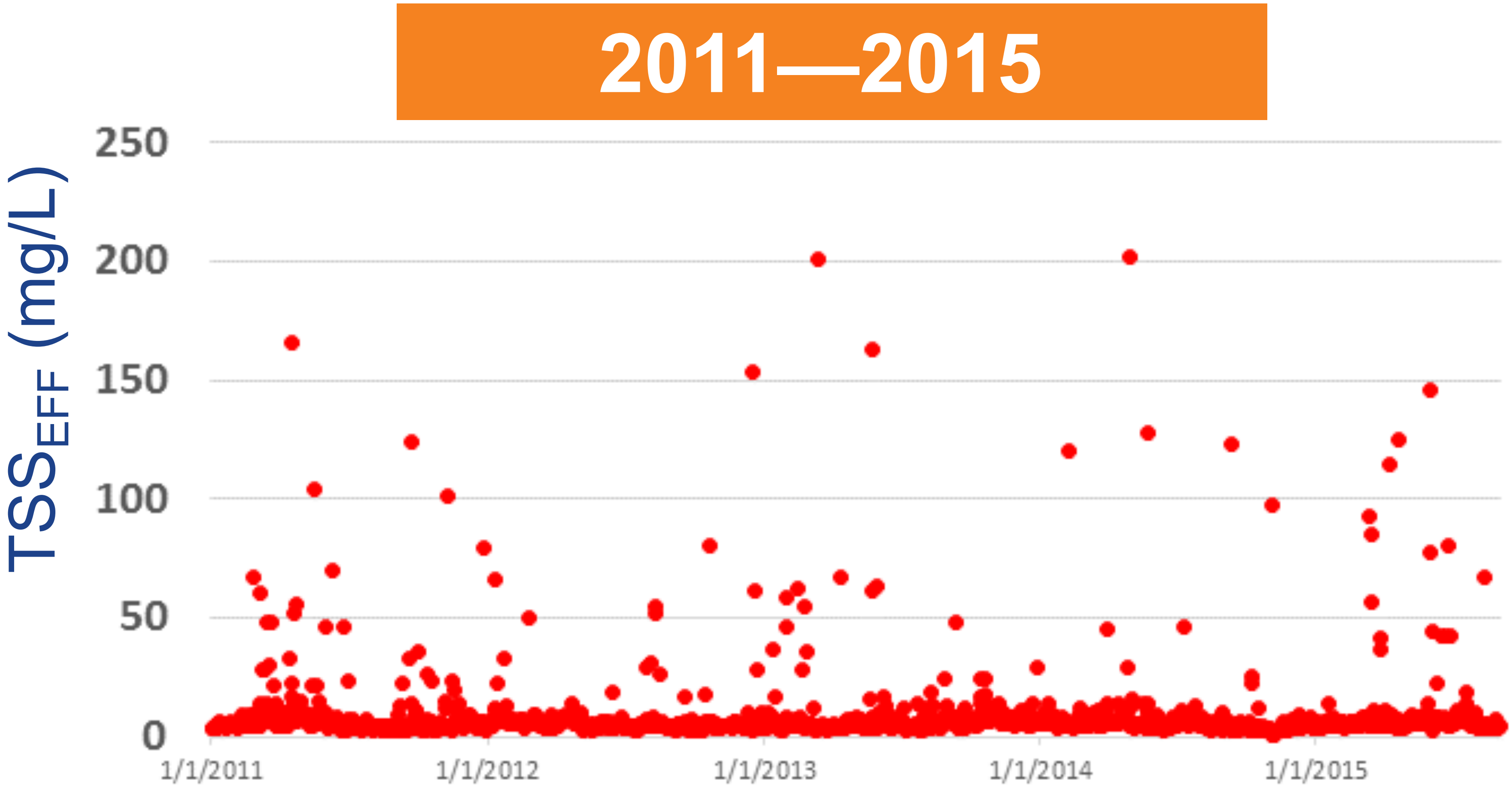



Class in mid-November 2012; implemented SRT control with **mixed liquor wasting** here

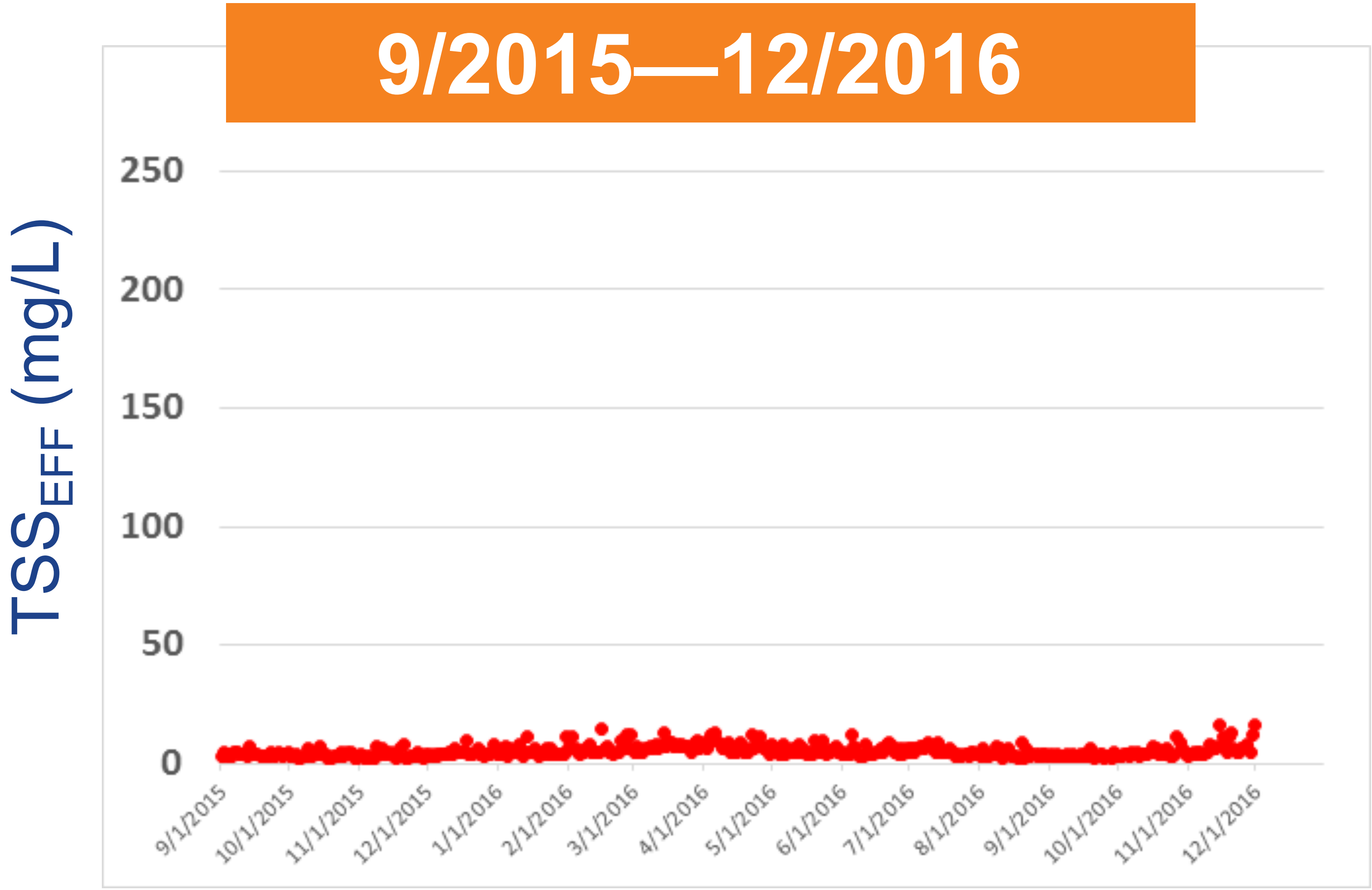
# Control by constant MLSS concentration or mass doesn't work



# Springfield, Mass. used to target a high MLSS concentration (4,500 mg/L)



# Effluent variability drastically reduced with SRT control



# Springfield's experience in an email

"Since September 2015 we have only bypassed 3 times. Once by mistake and twice when we only had 3 of 4 clarifiers online. And when we only had 3 clarifiers online we did take 180 MGD through the 3 clarifiers for a portion of time but bypassed before we puked solids. **On October 24 and 25, 2017 we took in 180 MGD for 6 straight hours without bypassing.** The blankets were about 6 feet in 11 foot clarifiers but they were not rising beyond that. We could have taken that 180 MGD flow for a lot longer. The TSS for the day was 18 mg/l and the BOD was 22 mg/L. **Before September 2015 under the fixed MLSS, high-solids-process-control plan we had a hard time taking in 134 MGD and taking in 180 was thought to be "impossible".**

Another benefit is that the Process Control Plan and High Flow Management Plan are now simple, concise, and easily understood. The plans can be consistently implemented under a variety of conditions with good success. **Now that the Operators have seen how SRT controls works, they would never go back.**"

# Save Energy with these Guiding Principles

1. Primary clarifiers can only remove $TSS_{set}$ and $pBOD_{set}$, but ensure they remove as much of the influent organics as possible
2. **Give the mixed liquor just the air it needs, when it needs it, where it needs it**
3. Find and maintain the minimum SRT that meets effluent ammonia requirements and gives the best sludge quality
4. **Know the statistical accuracy of all data used for process control**

# Save Energy with these Guiding Principles

5. **Determine and maintain the lowest RAS flow rate 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 stably, consistently, and uniformly as possible**

# Living by the credo of operations professionals is Guiding Principal No. 7

7. **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**

# In our case……

## *First…….*

**Process Improvement**

## *Second……*


***….Improve Process*** ***….Energy Savings will Happen***

# Plant KPI……. kWh/Mgal treated
# Know it and it's statistical variability!!!

Everyone should know his/her plants overall Key Performance Indicator

Everyone should start trending this indicator.

Here is how you calculate it:

- kWh/Mgal treated =

Annual Energy Use = 6,200,000 kWh
Average treated flow = 7 Mgal/day
Annual flow = 7 * 365 = 2,555 Mgal/year;
Therefore:

kWh/Mgal =
= (6,200,000 kWh/year)/(2555 Mgal/year)
= 2,426 kWh/Mgal

Is this good or bad?

# Wastewater O&M Savings Top 10

1 **TOP 10 CATEGORIES OF WASTEWATER**
O&M Energy Savings

| | |
|---|---|
| 1 Control & Optimize DO Levels | 6 Optimize Mixing |
| 2 Control & Minimize Blower Discharge Pressures | 7 Control Your Odor Control |
| 3 Optimize Pumps & Pumping | 8 Control Your UV System |
| 4 Non-potable Water: Flow & Pressure | 9 HVAC & Lights in Unoccupied Rooms |
| 5 Nitrification (needed?) w/o Denitrification | 10 Record/Standardize/Document |

## Aeration Optimization

# Aeration Optimization

## 2 IMPACT OF DO LEVELS ON ENERGY

### Saturated DO

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

### DO rule of thumb

0.5 mg/l reduction creates ~ 6% energy savings

### DO calibration & cleaning

A probe that reads 10% low (e.g. 2.0 when actual is 2.2) is costing you 2.4% at the blower.

### DO level increases

As mixed liquor temp increases, the impact of elevated DO levels increases.

**IMPACT OF AVERAGE DO LEVEL ON BLOWER ENERGY**

| Mixed liquor temp | | DO sat | Energy savings potential if DO reduced from __ to 2.0 mg/l | | | |
|---|---|---|---|---|---|---|
| ºC | ºF | mg/l | 2.5 | 3 | 4 | 5 |
| 0 | 32 | 14.6 | 4.0% | 7.9% | 15.9% | 23.8% |
| 2 | 36 | 13.8 | 4.2% | 8.5% | 16.9% | 25.4% |
| 5 | 41 | 12.8 | 4.6% | 9.3% | 18.5% | 27.8% |
| 10 | 50 | 11.3 | 5.4% | 10.8% | 21.5% | 32.3% |
| 15 | 59 | 10.1 | 6.2% | 12.3% | 24.7% | 37.0% |
| 20 | 68 | 9.1 | 7.0% | 14.1% | 28.2% | 42.3% |
| 25 | 77 | 8.2 | 8.1% | 16.1% | 32.3% | 48.4% |

**NOTE** Higher impact as elevation increases

# Aeration Optimization – Blower Pressure

## 3 IMPACT OF BLOWER PRESSURE ON ENERGY

| Disch. pressure | Reduction in pressure of ___ psig | | | | |
|---|---|---|---|---|---|
| | -0.2 | -0.4 | -0.6 | -0.8 | -1.0 |
| 12 | 1.3% | 2.7% | 4.0% | 5.4% | 6.7% |
| 11 | 1.5% | 2.9% | 4.4% | 5.9% | 7.4% |
| 10 | 1.6% | 3.3% | 4.9% | 6.6% | 8.3% |
| 9 | 1.8% | 3.7% | 5.5% | 7.4% | 9.3% |
| 8 | 2.1% | 4.2% | 6.3% | 8.4% | 10.6% |
| 7 | 2.4% | 4.8% | 7.3% | 9.7% | 12.2% |

*Assumes 70% blower eff & 92% motor/drive eff

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## Pumping Optimization

# Pumping Optimization

## 4 PUMPING ENERGY

### Basic equation

$$\frac{GPM \times Feet}{3960} \times \frac{1}{Pump\ Eff} \times \frac{1}{Motor\ Eff} \times 0.746 = kW\ from\ utility$$

Water HP | Brake HP (or Shaft HP) | Motor HP

Input HP $\times$ 0.746 = motor input kW*

# Wastewater O&M Savings Top 10

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## Mixing Optimization

# Mixing Optimization



So……

What can we do here and how would we do it?

## 5 CALCULATING kWh

**It takes 3.14 kWh to lift 1 million gallons 1 foot at 100% efficiency**

### Estimating energy from nameplate data

**BHP ≈ Motor Nameplate HP x 90% (for mixers) x "% of Full Load Power"**

**BHP ≈ Motor Nameplate HP x 80% (for pumps) x "% of Full Load Power"**

**BHP ≈ Motor Nameplate HP x Operating Amps / Full Load Amps (FLA)**

$$\frac{\text{Brake Horsepower (BHP)} \times 0.746}{\text{Motor Efficiency}} \times \text{hours} = \text{kWh}$$

### Amp to kWH calculation

For three phase power (be wary of using amps from a VFD panel readout)

$$\text{Amps} \times \text{Volts} \times 1.73 \times \text{Power Factor} \times \frac{1}{1{,}000} \times \text{hours} = \text{kWh}$$

## 7 USEFUL TIME AND ENERGY CALCS

| |
|---|
| **Constant (24/7) running** is 8,760 hrs annually |
| **8 hr/day for 7 days/week** = 2,920 hours |
| **8 hr/day for 5 days/week** = 2,085 hours |
| **Runtime reductions**<br>**1/24th** = 4.2% **1/7th** = 14.3% **1/12th** = 8.3% **1/52** = 1.9% |
| **Quick conversions**<br>**1 HP** = 0.75 kW **100 HP** = 75 kW **10 kW** = 13.4 HP |
| **Rough kWh** **10 HP 24/7** = 65,000 kWh |

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4. Non-potable Water: Flow & Pressure
5. Nitrification (needed?) w/o Denitrification
6. Optimize Mixing
7. Control Your Odor Control
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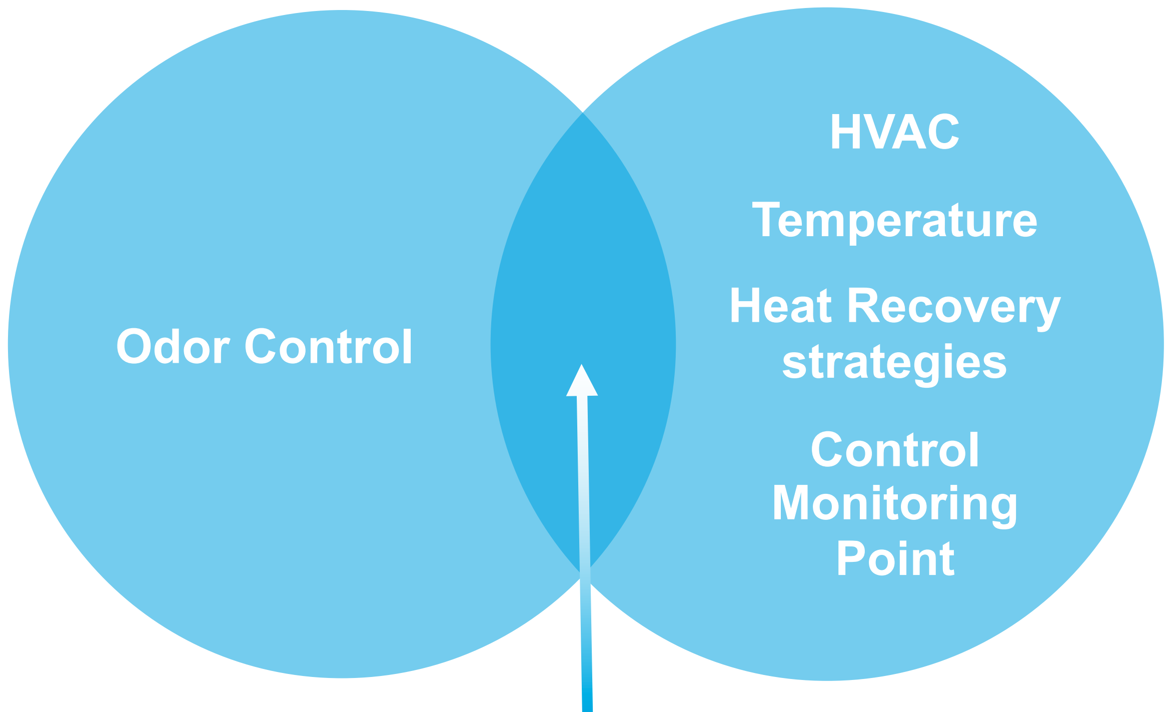
## Fans, Odors, Lights Optimization

# What You Can Control to Reduce Energy




- Seasonal auto settings
- Occupied vs. unoccupied auto settings
- Clean or replace air filters
- Fan speed (VFD or sheave change)

# 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 Fan Pressure, in inches of water

**eff.** = Fan efficiency, unitless (0 – 1.0)

**6356** = conversion factor including density of air

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# UV Optimization

| System Specifications | |
|---|---|
| System Characteristics | TrojanUV4000Plus™ |
| Typical Applications | 10 MGD and greater; primary, secondary, blended, and tertiary wastewater, CSO, SSO, and water reuse applications |
| Lamp Type | Medium-pressure, polychromatic UV output |
| Ballast Type | Electronic, variable-output (30 – 100%) |
| Input Power Per Lamp | 3,200 Watts |
| Lamp Configuration | Horizontal, parallel to flow |
| Lamps Per Module | 6 to 24 |
| Modules Per Bank | 2 to 7 |
| Level Control Device Options | Fixed weir or motorized weir gate |
| Enclosure Ratings | |
| Module Ballast Enclosure | TYPE 6P (IP67) |
| All Other Enclosures | TYPE 4, 4X or 3R (IP56, IP65 or IP14) |
| Ballast Cooling Method | Closed loop system; no air conditioning or forced air required |
| Structural Materials | Wetted parts: 316 SST; Non-wetted parts: 304 SST |
| Maximum Ambient Temperature | 122° F (50°C) |
| Sleeve Cleaning System | |