



Department of  
**Environment &  
Conservation**

# **Introduction to Energy Optimization and Assessments**

**Bob Freeman – TDEC Energy Management Team**

# TN Plant Optimization Project

TDEC working with plants to help identify optimization opportunities.

Plant Optimization --- What is it???

- What does your plant DO?
  - Meet Permit Requirements
  - Good Neighbor (No Odors, Noise)
  - Meet Service Needs (Capacity)



# Optimization for Water & Wastewater

- **Water Plants**
- **80%+ Energy Use is pumps/motors controlled by system head**
- **Energy Optimization is primarily pump – motor efficiency, backwash control, tank storage management**
- **Wastewater Plants**
- **Most energy use controlled by process – aeration tanks, aerobic digesters, disinfection, biosolids handling**
- **Operators have more control**

**Focus in This Introduction Will Be  
Wastewater Plants**

# Wastewater Optimization

- Are we using what we have effectively? Probably yes – meet permit; good neighbor; meet customers' needs
- Are we using what we have efficiently? Maybe – how do we know?
- Can we get more out of our plant by using our knowledge & skill?



# Optimization – How Does It Happen?

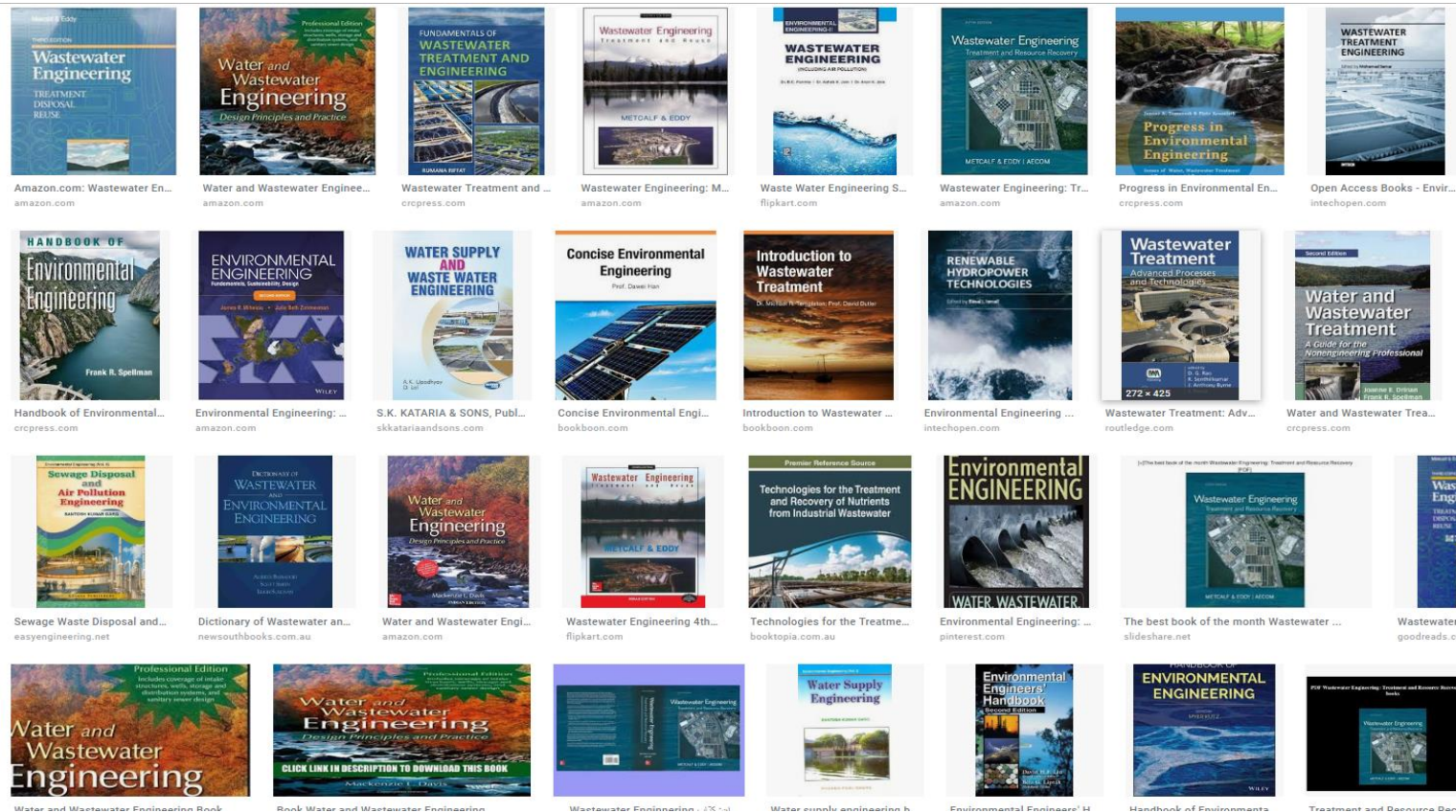
- Understanding what you can make your plant DO – not just knowing and monitoring what your plant DOES
- Operators manage their processes – D.O. set points, Aeration run times, WAS rate (RAS rate, MLSS conc.), Biosolids processing (digestion, dewatering)
- **MOST IMPORTANT** – willingness to try something different than the way it has always been done.





# Going Beyond Basics

We have dozens of books about how wastewater treatment is supposed to work



Too bad the bugs can't read!!

# So - What is Optimization?

## Optimization –

- Operators applying their skills to identify opportunities to use their existing plant structures to achieve:
  - **Greater energy efficiency**
  - **Reduced chemical usage**
  - **Biological nutrient removal**
  - **Better operational control**
- Many plants have all these opportunities



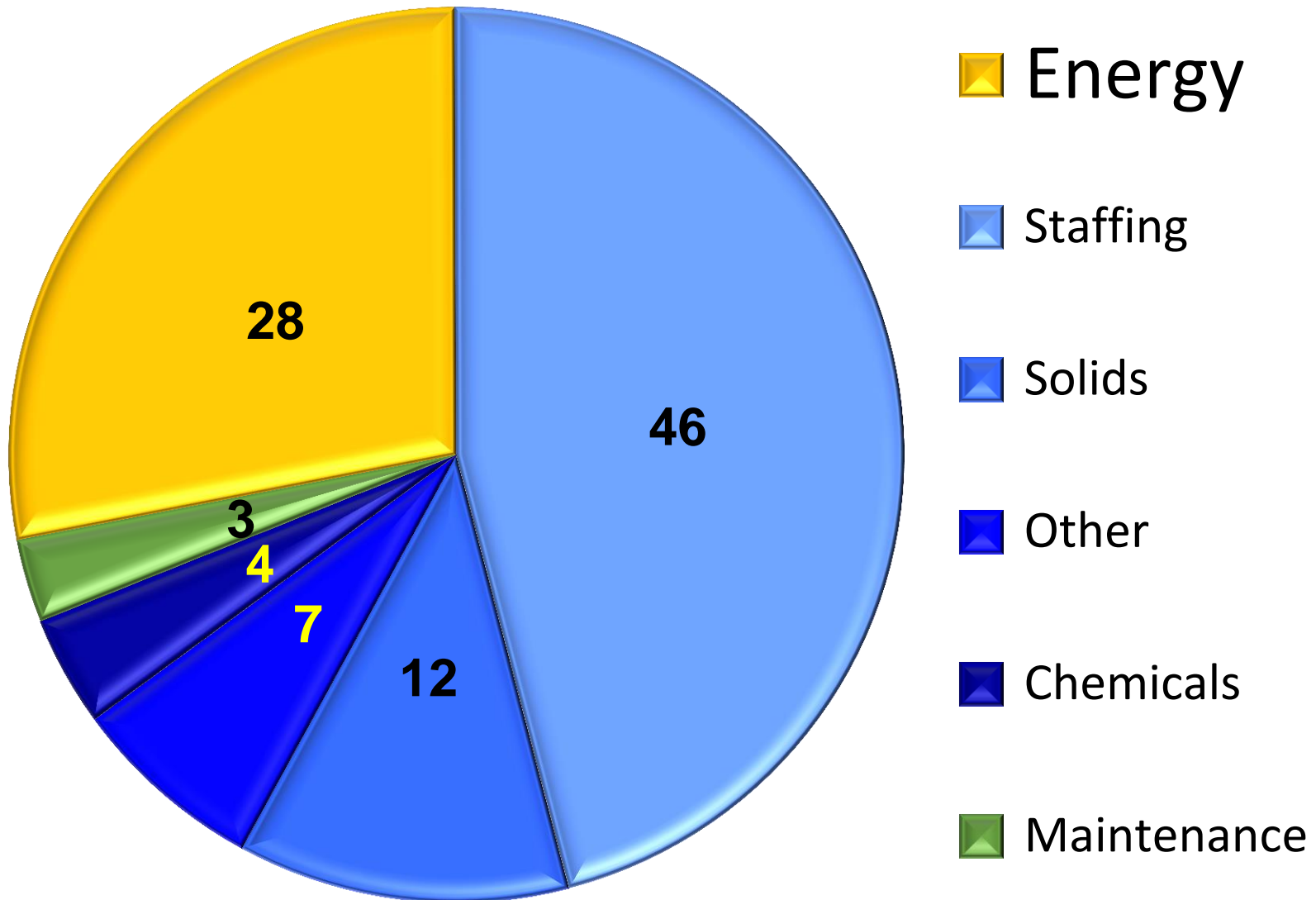
# Where is Energy Usage on My Permit?

- **Plant Staff Rarely See Energy Bills**
- **Energy bills are typically paid “downtown” – by a finance office with no idea where the plant is!**
- **How would you manage your plant if you never saw BOD or TSS data?**
- **How can you manage your energy use without measuring it??**





# Costs for Typical Wastewater Facilities - %



# Energy Cost as % of Total O&M Costs

CITY	DESIGN FLOW mgd	ACTUAL FLOW mgd	ENERGY % OF TOTAL O&M COST
Fayetteville, TN	3.3	1.6	28
Columbia, TN	10	5	29
Franklin, TN	14	10	18

**Cost % calculated from 2011-2012 City Budgets**



# Why Should I Be Interested?

- **Water/Wastewater treatment - largest energy demand in government budgets**
- **Energy -- largest controllable cost of wastewater services-- typically 18-35% of a utilities total O&M costs**
- **Optimization measures can reduce chemical usage and improve biosolids management.**
- **Nutrient Removal With Cost Savings!**



# Most Important Reason for Optimization

**We work for the public – they pay for your plant and our salaries.**

**Rate payers want to know that their utilities are doing all that they can to control costs and we owe them that.**

**Optimization can help improve plant performance and reduce costs.**



# Do Wastewater Plants Have Money to Burn?



**Is this happening at your plant?**  
**Energy Wasted = \$ Wasted**

# Fire Extinguisher – Plant Assessment

- What is an Assessment???
- Two Basic Steps – Background & Plant Visit
- Background:
  - Review plant processes – SBR, Oxidation Ditch, Conventional Activated Sludge, Digestion, etc.
  - Review plant loading – hydraulic & organic, and effluent data
  - Request energy data from plant staff – monthly kWh usage/cost, kW demand info





# Plant Site Visit – Most Important

- **Plant Visit – Typically 4-6 hours on site**

## **Talk to operators**

**Discuss normal operational procedure**

**Aeration practice – sizes and types of aerators**

**Aeration basin DOs – typical MLSS**

**WAS/RAS concentration & volume if known**

**Tankage sizes – clarifier blanket depths –  
biosolids processing/dewatering – disinfection –  
any chemical addition**

**Any problem areas – wet weather issues**



# Plant Site Visit - Continued

- **Walk through plant front to back – use BioTiger Activated Sludge model to evaluate operational alternatives**
- **Discuss possible optimization measures and discuss implementation with plant staff.**

*BioTiger is Dr. Larry Moore's activated sludge process model that has been successfully used in dozens of WWTPs and will be discussed in a later session.*



# Will Assessments Help All WWTPs?

- **Short Answer – YES** – but not necessarily to save energy – may already be efficient
- What kind of Plants could benefit most?
  - **Activated Sludge – all types – lots of aeration**
  - Aerated lagoons
- Who does that leave out?
  - Trickling Filters
  - Facultative Lagoons



# Plant Assessment - Results

- Assessment Report – summary of observations, operator information, recommendations, projected benefits/savings.
- Model plant processes to identify possible operational modifications. BioTiger Model.
- Energy Assessment Tool (EAT) - Track Energy Data – Usage and Cost – see changes over time
- EAT can produce charts to show before and after impacts of implementing recommendations contained in Assessment Report
- Track Nutrient Data – loading and effluent



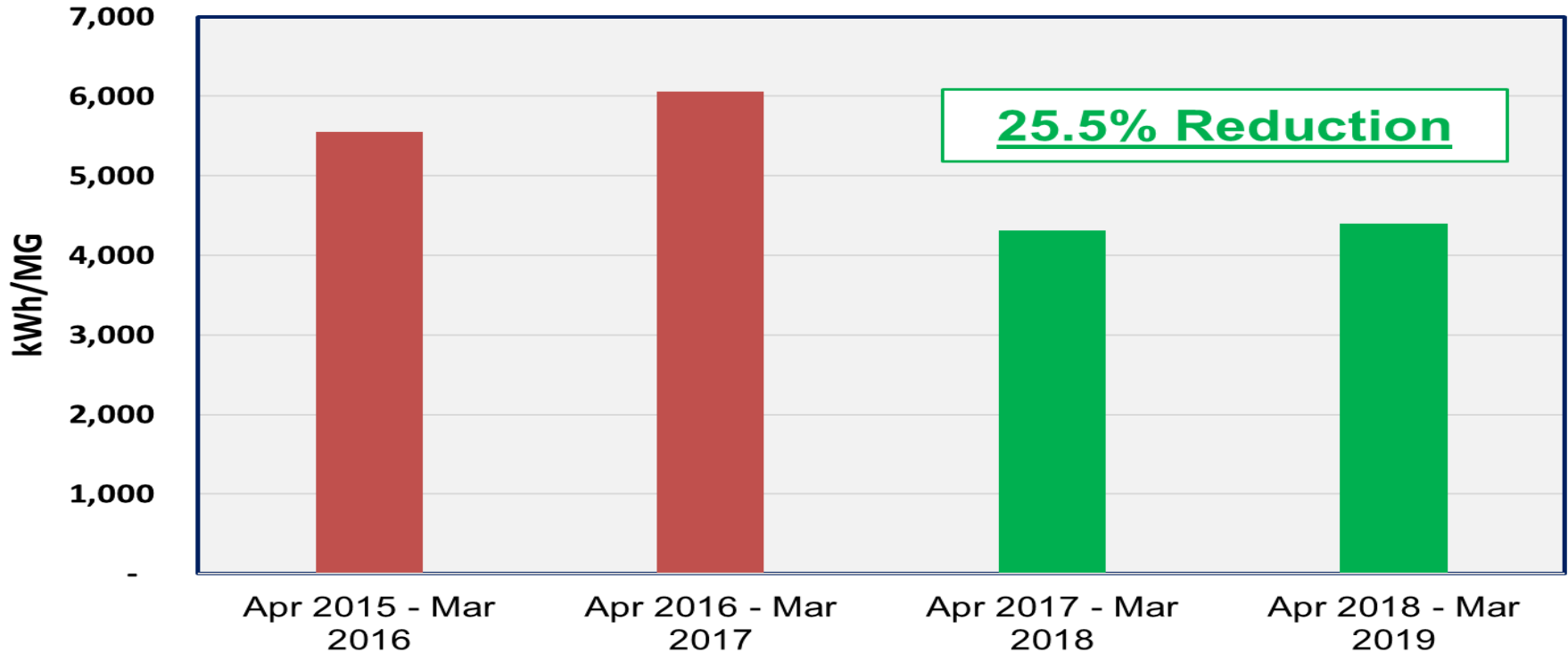
# Turning Report Results into Reality

- **Key Factor – Willingness to change the “Way We Have Always Done That”**
- Take plant off “Cruise Control” and see what you can make your plant do.
- Change things gradually and if it doesn't work change back and relook at what is going on.
- You are not in this alone – we are in this to help.



# Results – Lawrenceburg, TN – 4.5 mgd

**Lawrenceburg TN WWTP**  
**Energy Usage per MG Treated - kWh/MG**



**RED bars BEFORE optimization - GREEN bars AFTER**

**Energy Savings – 360,000 kWh/YEAR**

**Cost Savings - \$21,000/YEAR**





# What Changed?

## Energy Assessment Report for Lawrenceburg WWTP



ENERGY CONSERVATION STUDY

at

Lawrenceburg Wastewater Treatment Plant  
Lawrenceburg, TN

The University of Memphis  
Civil Engineering Department  
and

The University of Tennessee  
Municipal Technical Advisory Service  
in conjunction with TDEC, USDOE, and USEPA

by

Larry W. Moore, Ph.D., P.E.,  
Brett Ward, UTMTAS Utility Operations Consultant

May, 2017



# Lawrenceburg Assessment Report

- Site visit March 7, 2017 – Met with plant staff to discuss operations – average daily flow is 1.4 mgd.
- Three SBRs, all in operation, each 25 ft. deep,
- 2 X 350 hp blowers – one runs approx. 13 hrs/day at 60% output using inlet/outlet control and vents approx. 50% of that output .
- Each SBR has 2 X 25 hp mixers that run continuously during the “mixed fill,” “react fill,” and “aerobic react” periods .
- Two aerobic digesters have 2 X 40 hp blower that run 18 hrs/day – SRT approx. 70 days.



# Lawrenceburg Report Findings

- BioTiger model showed excess aeration in SBRs. The oxygen required at actual flow could be supplied by one 100 hp blower. Due to inlet – outlet control and venting only 30% of one 350 hp blower capacity is used.
- SBR mixers not needed during aerated portion of “react fill” and “aerobic react” – aeration provides ample mixing.
- Aeration needed for aerobic digesters can be supplied with one 40 hp blower for 8 hrs/day SRT of 70 days – already digested biosolids



# Lawrenceburg Report Results

- Excess Aeration - 100 hp blowers (one used, one standby) would cost approx. \$150,000 but reduce energy use over 60,000 kWh/month – saving over \$70,000/year.
- Reducing SBR mixer run times requires changing the Programmable Logic Controllers and saves approx. 15,000 kWh/month – being implemented
- Aerobic digester blower run time reduced to one 40 hp blower 8 hrs/day – saves 21,000 kWh/month



# Lawrenceburg Bottom Line

- **Energy savings – over 360,000 kwh/year**
- **Cost savings – over \$21,000/year**
- The plant flow increased 13% over this period which would have increased energy usage/costs.
- **Cost to Implement these savings - \$0.00**
- Plant staff pursuing purchase of smaller hp blowers for greater savings.



# Lawrenceburg Shout Out



## Case Study: Lawrenceburg, TN

September 2018



Staff from the Lawrenceburg Utility Systems (LUS) Wastewater Treatment Plant (WWTP) were invited to participate in the Energy Management Initiative of the Tennessee Water and Wastewater Energy Efficiency Partnership, a joint technical assistance program through the U.S. EPA Southeast Regional Office, U.S. Department of Energy, TVA, and the Tennessee Department of Environment and Conservation. A team of representatives from those agencies, the University of Memphis and the University of Tennessee Municipal Technical Advisory Service conducted a site assessment in March 2017. Plant superintendent Lisa Porter met with the team to discuss ways to optimize treatment.

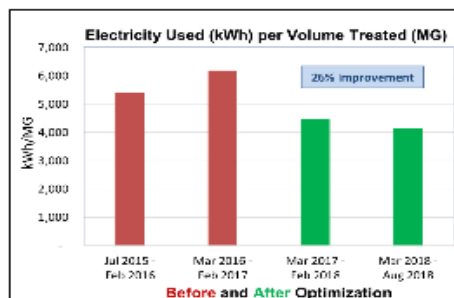
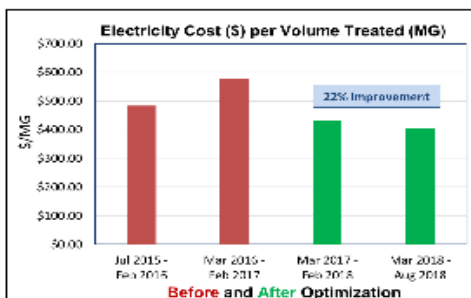
Lawrenceburg, a city of approximately 10,000, is set on Shoal Creek, just 15 miles north of the Alabama state line. The plant is designed to treat 4.5 million gallons per day (mgd), and currently treats about 1.5 mgd of municipal wastewater. It uses three sequencing batch reactors (SBR) aerated with up to two 350-HP centrifugal blowers. Biosolids generated during treatment are processed in aerobic digesters fed by two 40-HP blowers.



Lawrenceburg Wastewater Treatment Plant

The team analyzed the loading to the plant and observed the SBR blowers provided excess aeration but that design constraints of the blowers prohibited full optimization. Additionally, solids loading to the digester indicated that the aerator runtime could be reduced by up to 75%. Following the team's recommendation, the WWTP staff reduced the aeration to the SBRs and digesters. This no-cost change reduced total electric use by 13% and saved 30,000 kilowatt-hours (kWh) per month. During the "after optimization" phase highlighted in the graphs below, the plant's wastewater loading increased 13%, which would have resulted in higher electrical usage without the optimized operation. The results achieved at the time of writing are summarized below.

While no capital was required, diligent operator oversight was necessary to implement this recommendation, and the team appreciates Lisa and her team's continued efforts to optimize their processes.



• Annual Energy Savings:  
• Annual Cost Savings:  
• Cost to Implement:

>360,000 kWh/year  
>\$21,000/year  
\$0

• Energy Usage and Cost Reduction: 13% and 8%  
• Influent Loading: 13% Increase  
• Peak Electrical Demand: 3.5% Reduction

For more information, please contact Ben Bolton at TDEC Office of Energy Programs ([ben.bolton@tn.gov](mailto:ben.bolton@tn.gov))



This material is based upon work supported by the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy (EERE), under Award Number DE-EE0007226.



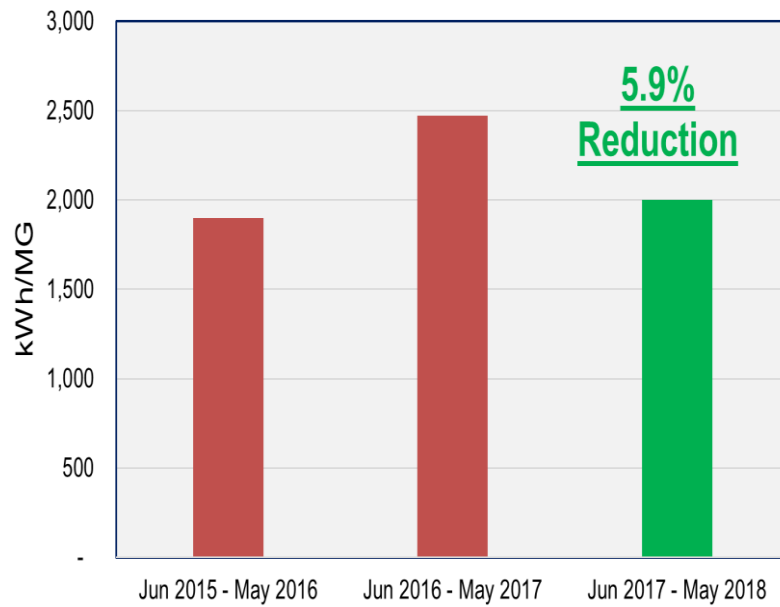


# Pell City, AL – Dye Creek WWTP

## Energy Results

### Pell City, AL - Dye Creek Plant

Energy use per million gallons treated, before and after optimization



RED bars BEFORE optimization - GREEN bar AFTER



Imagery



# Pell City AL – Assessment Report

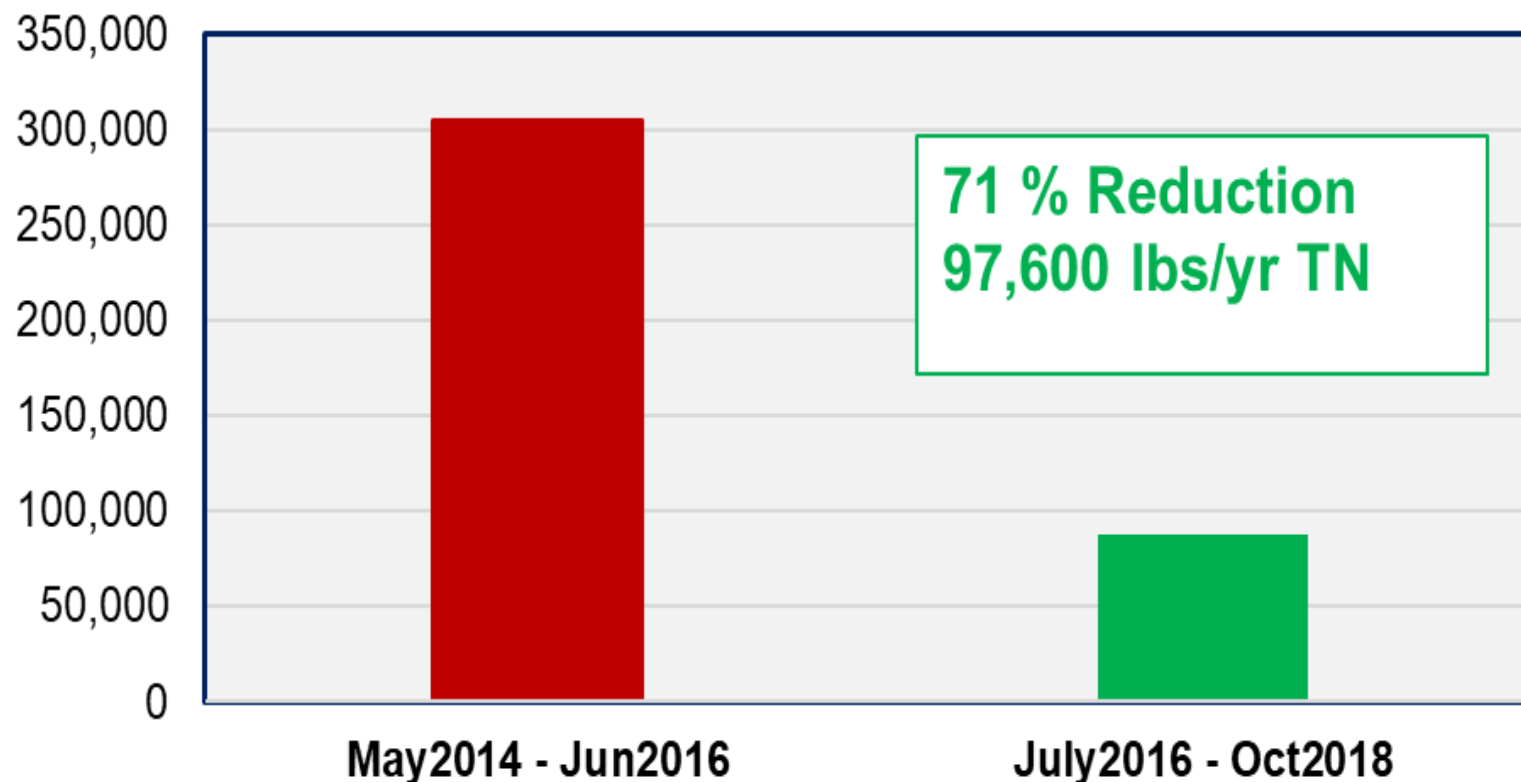
- Site visit with plant staff May 2016 to discuss operations, gather data, and observe all processes.
- Oxidation ditch – 4.75 mgd design, 2.2 mgd actual flow chlorination-dechlor, biosolids holding and centrifuges.
- Alum feed to ditch influent for phosphorus control to 1.0 mg/l summer limit. Discharge is to Logan Martin Lake.
- Effluent NO<sub>3</sub> of over 15 mg/l - process model showed opportunity for anoxic conditions in ditch to denitrify & use the oxygen in the NO<sub>3</sub>.
- Report recommended all rotors shut down 4 hrs overnight to create anoxic denitrification conditions



# Total Nitrogen Discharge Results

## Pell City, AL - Dye Creek WWTP

**Pell City WWTP - Total TN Discharged - LBS**  
27 Months **Before** Optimization - 27 months **After**



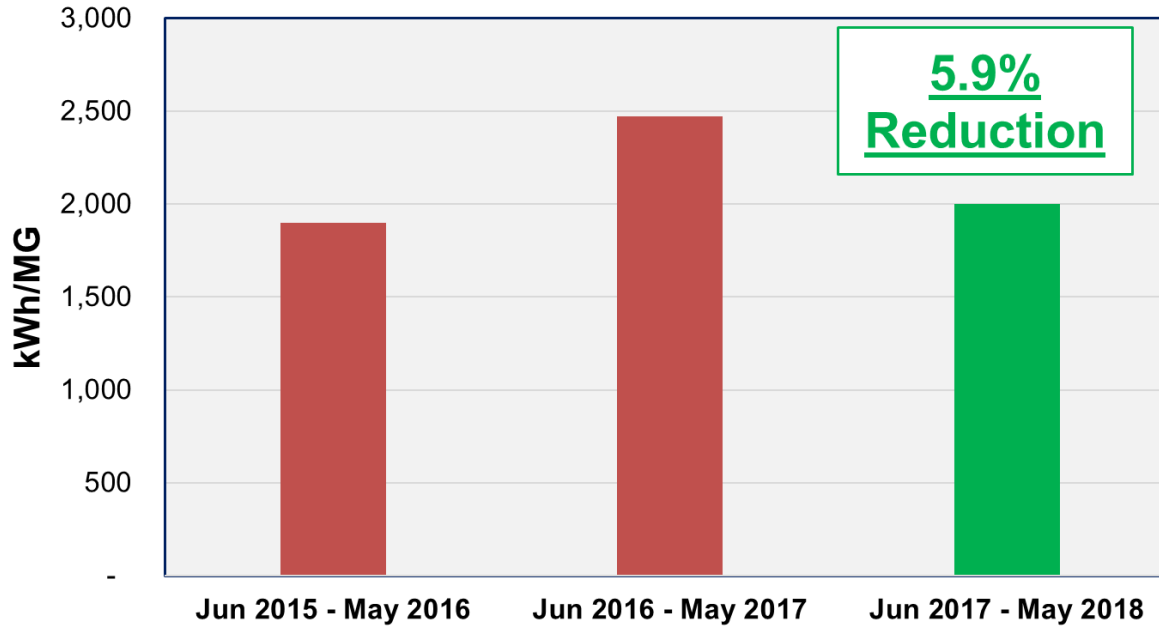
**RED bar - BEFORE Optimization - GREEN bar - AFTER**



# Pell City WWTP – Bottom Line

## Pell City, AL - Dye Creek Plant

Energy use per million gallons treated, before and after optimization



RED bars BEFORE optimization - GREEN bar AFTER

**TN Discharged  
to Logan Martin  
Lake**

**Before – over  
140,000 lbs/year**

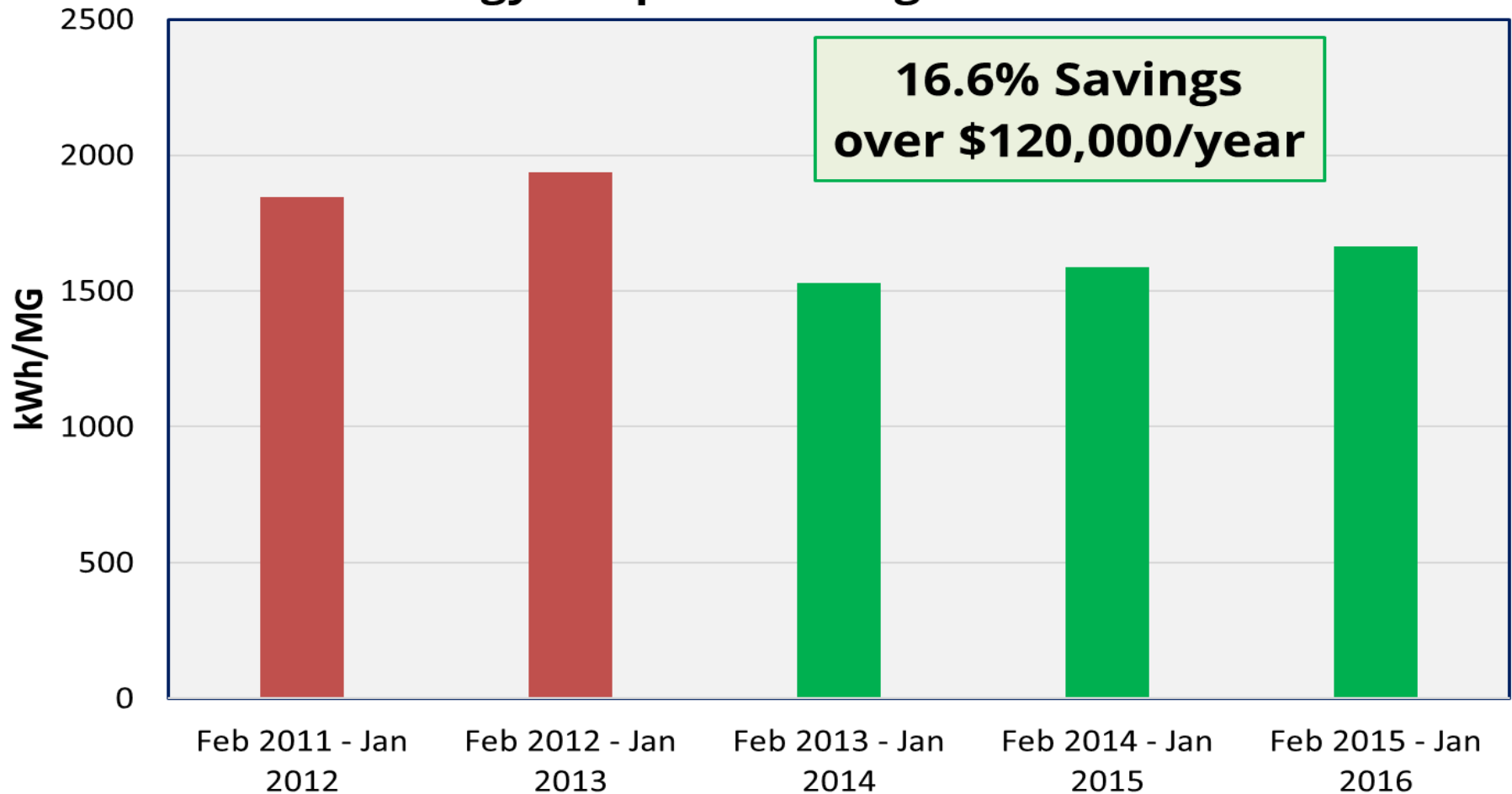
**After – less than  
40,000 lbs/year**

**Cost to Implement -- \$0.00**



# Does Efficiency Continue to Pay?

## Franklin, TN WWTP - 12 mgd Energy use per million gallons treated

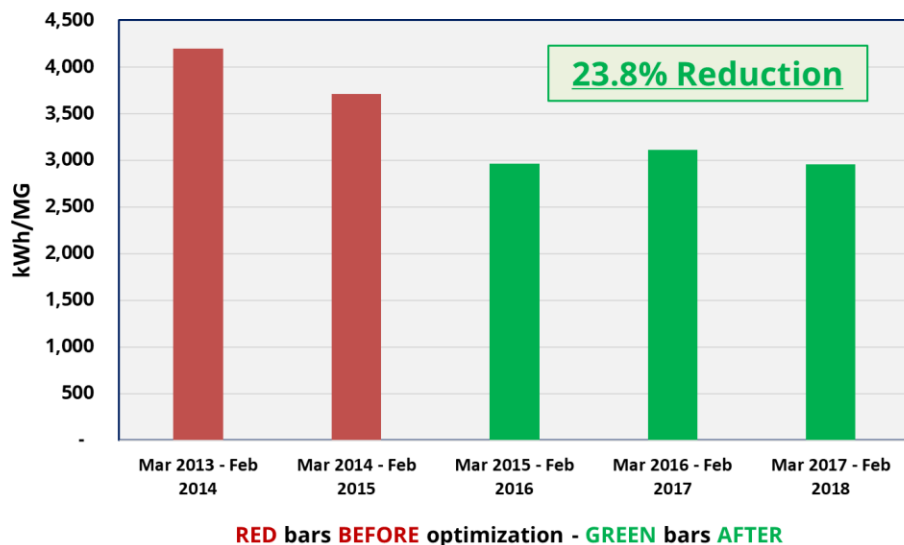


**16.6% Savings  
over \$120,000/year**

**RED bars BEFORE optimization GREEN bars AFTER**

# Wetumpka, AL WWTP – 2.2 mgd

Wetumpka, AL Wilako WWTP  
Energy use per million gallons treated

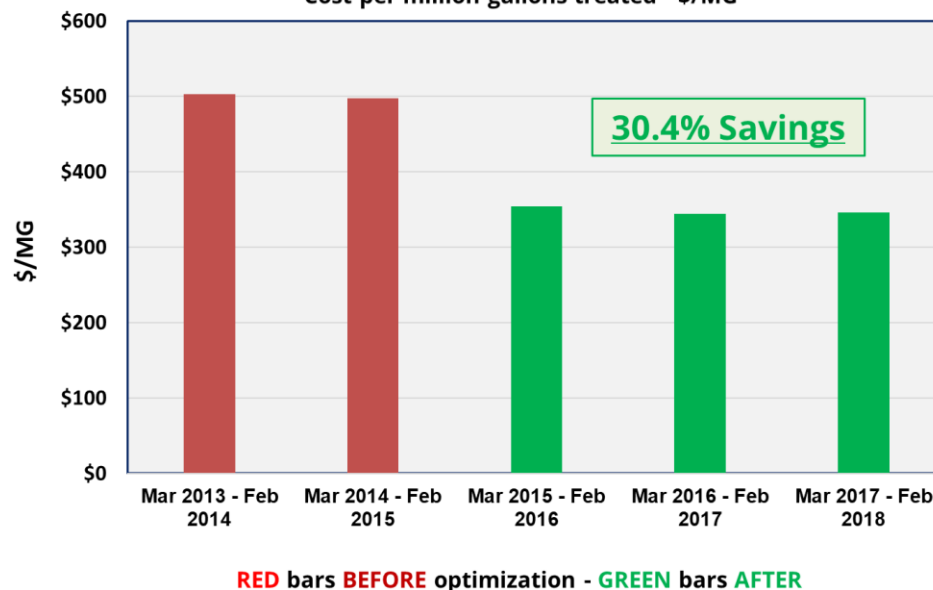


**Energy Savings  
Over 600,000 kWh/year  
2015 - 2017**

**Implementation Cost  
\$0.00**

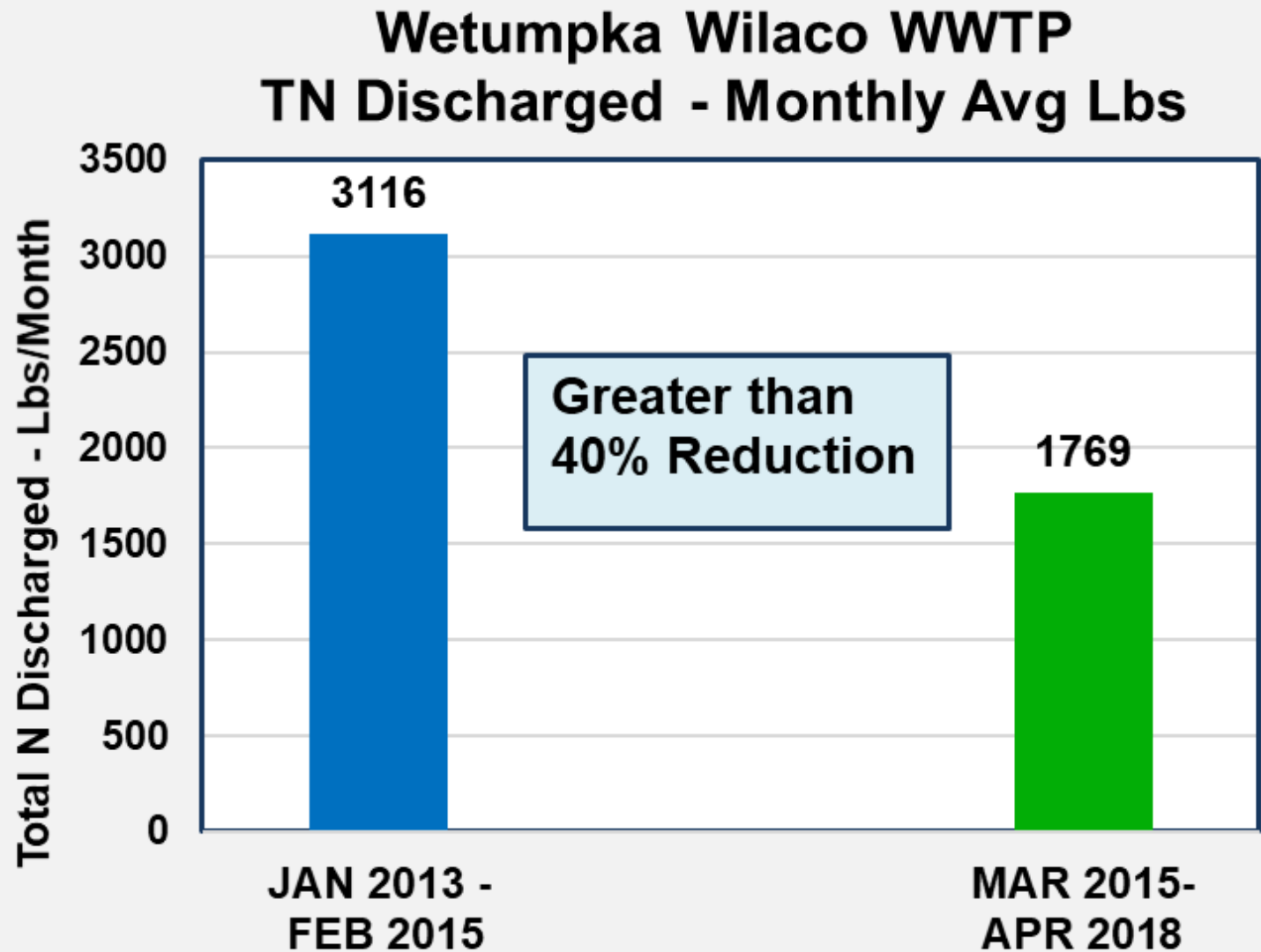
**Cost Savings  
Over \$100,000/year  
2015 - 2017**

Wetumpka, AL Wilako WWTP  
Cost per million gallons treated - \$/MG





# Wetumpka, AL - No Cost Nitrogen Removal



# Is Your Plant a Good Candidate?

- Have organic mass loading (BOD lb/day) under design capacity?
- Have elevated DO levels in aeration basin – above 1.5 mg/l?
- Have elevated nitrate in effluent?
- Often achieve low effluent CBOD/NH<sub>3</sub>-N values?
- Willingness to consider change.



# Common Opportunities

- **Match the oxygen supplied to the system demand**
  - **Turn down or turn off aerators**
  - **Reduce the number of basins in service**
  - **Adjust the number of bacteria in the system – high MLSS uses more oxygen**
  - **Avoid high dissolved oxygen concentrations – oxygen transfer is worse at higher DO concentrations**



# More Common Opportunities

- **Use anoxic zones or on/off aeration to denitrify nitrates – reuses the oxygen in  $\text{NO}_3$** 
  - Saves energy by reducing aeration need
  - Reduces nutrient discharge
  - Can improve sludge settleability in clarifiers
  - Recovers alkalinity used by nitrification
- **Don't over-aerate in sludge digesters**
  - Plants with old sludge – high SRT - will need less volatile solids reduction
  - Nitrates may be present here also



# Wastewater Plants Typical Energy Use

- **Ranges of Energy Used per MG Treated**
  - **Conventional AS – 1200 – 2300 kWh/MG**
  - **AS + Nitrification – 1800 – 2600 kWh/MG**
  - **Extended Air AS – 1800 – 3500 kWh/MG**
  - **Oxidation Ditch AS – 1800 – 3500 kWh/MG**
- **If your energy use is at the higher end of these ranges you may have opportunity.**

**Important to know your energy usage and to track it – the EAT can help do that.**



# THE QUESTION IS:

Do you want a **more efficient WWTP** that can **save you money** and possibly reduce nutrient discharge for very low or **NO COST?????**



# Follow Up Is Invited

**For More Information Contact:**

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