Continuous Commissioning: Maximizing Energy Savings

September 20, 2022

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SMART ENERGY DESIGN ASSISTANCE CENTER

Providing effective energy strategies for buildings and communities

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

ILLINOIS SUSTAINABLE TECHNOLOGY CENTER
PRAIRIE RESEARCH INSTITUTE

Who We Are

We assist buildings and communities in achieving energy efficiency, saving money, and becoming more sustainable.

We are an applied research program at University of Illinois.

Our goal: Reduce the energy footprint of Illinois and beyond.

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About the IEPA PWI Energy Efficiency Program

The Illinois EPA Public Water Infrastructure Energy Efficiency Program helps municipalities reduce the cost of water and wastewater treatment.

- FREE energy assessments and technical assistance
- Comprehensive report listing:
  - Cost of upgrades
  - Estimated payback period
  - Any applicable incentives or funding opportunities
- Operator continuing education events

Apply at: www.sedac.org/water

Funding provided in whole or in part by the Illinois EPA Office of Energy. This program is in partnership with the U.S. Dept. of Energy Sustainable Wastewater Infrastructure of the Future (SWIFT) Accelerator for energy efficiency in wastewater treatment.

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U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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Why Complete an Energy Assessment?

Older Existing System or No Previous Assessments?

Identify missed opportunities

Plan for capital improvements

Uncover what is possible

3rd party support for WWTP personnel's ideas

New or Recently Upgraded?

Always more to improve

Plan for future opportunities outside the scope of recent projects

New technologies and processes always in development

Identify opportunities for repairs or upgrades and associated funding!

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Apply for an Energy Assessment!

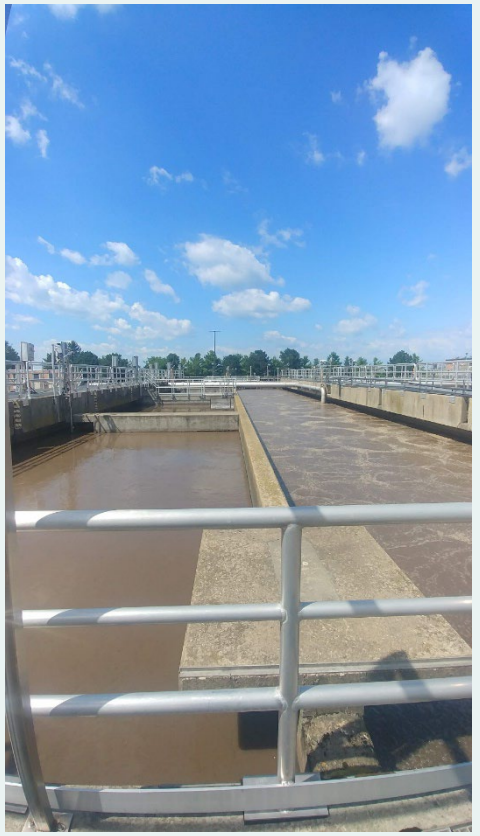
Step 1: Initial Application – Pre-Qualification

- Apply at www.sedac.org/water
- Be located in Illinois and be a publicly-owned plant
- Allow SEDAC/ISTC to visit site – remote visit is an option!
- Be willing to share facility information
- Share final assessment report with Illinois EPA

Step 2: Data Collection – We Can Help!

- Facility information –discharge reports, process flow, etc.
- 2 years of utility bills and DMRs

Step 3: Site Visit Scheduled



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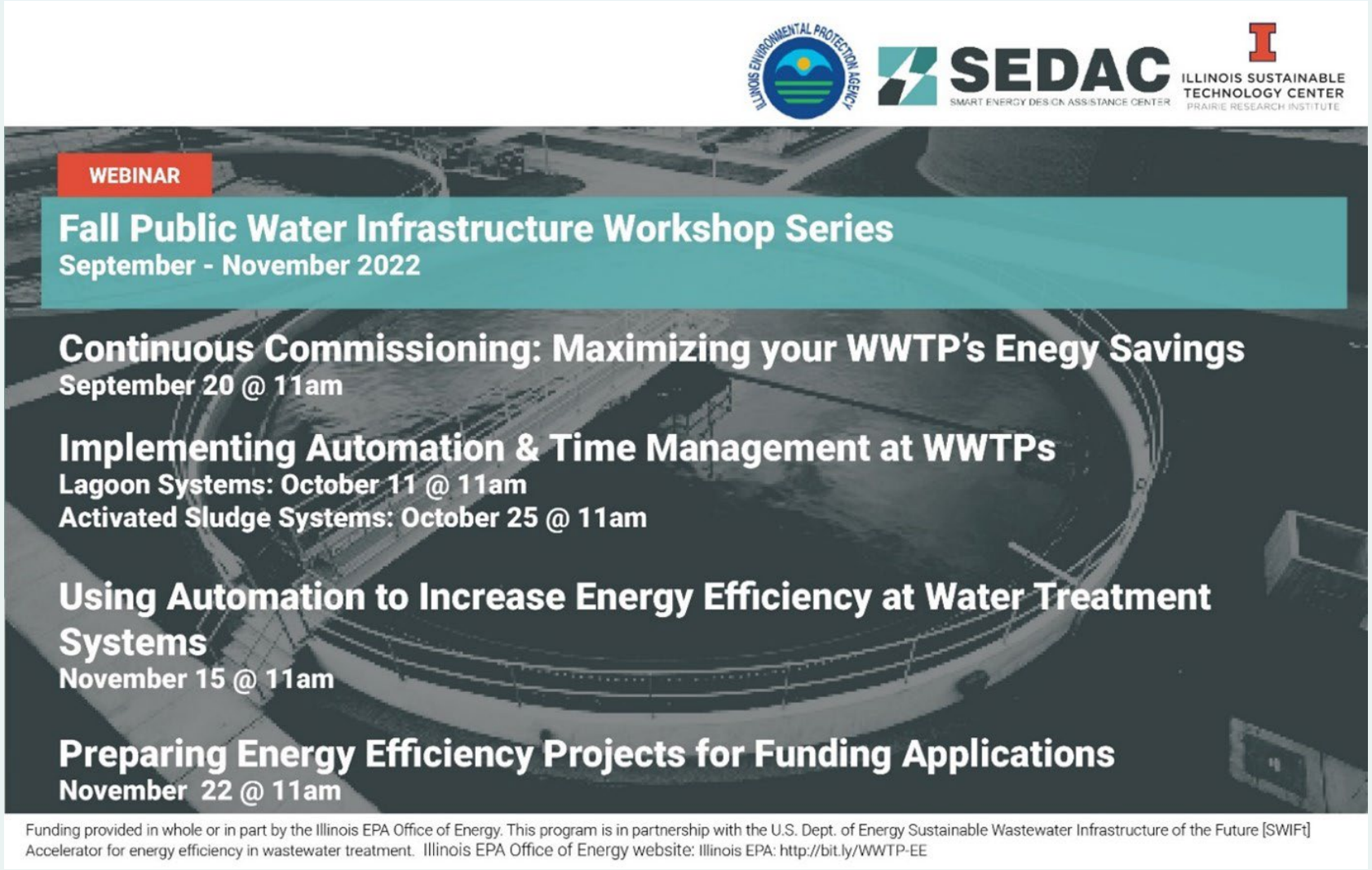
Upcoming Events



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Questions?

sedac-info@illinois.edu
800-214-7954

smartenergy.lllinois.edu/water

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CONTINUOUS COMMISSIONING AT WASTEWATER FACILITIES

DAVID SHAFER, P.E., P.L.S.

DIRECTOR OF PUBLIC WORKS AND VILLAGE ENGINEER VILLAGE OF HEYWORTH

COMMISSIONING

- **WHAT IS IT? MORE THAN START UP**
- **COMMISSIONING – WHEN INSTALLING NEW EQUIPMENT AND PROCESSES IT IS NOT ENOUGH TO JUST PLUG IT IN AND TURN IT ON.**
  - **VERIFY OVERLOAD SETTINGS**
  - **VERIFY CORRECT AMP DRAW OF MOTORS**
  - **VERIFY FLOW RATES OF PUMPS**
  - **CALIBRATE METERS/SENSORS**
  - **DOES IT FUNCTION AS DESIGNED / INTENDED?**
- **ESPECIALLY IN THE PAST COMMISSIONING NEW WATER AND WASTEWATER FACILITIES DID NOT GET DONE**
  - **NO NEED. NOT SEEN AS IMPORTANT**
  - **END OF THE JOB NO MONEY LEFT.**
  - **OWNER/OPERATOR IN A PUSH TO GET THE NEW FACILITY ON-LINE.**

CONTINUOUS COMMISSIONING?

» **CONTINUOUS COMMISSIONING IS AN ONGOING PROCESS TO RESOLVE OPERATING PROBLEMS, IMPROVE COMFORT, AND OPTIMIZE ENERGY USE.**

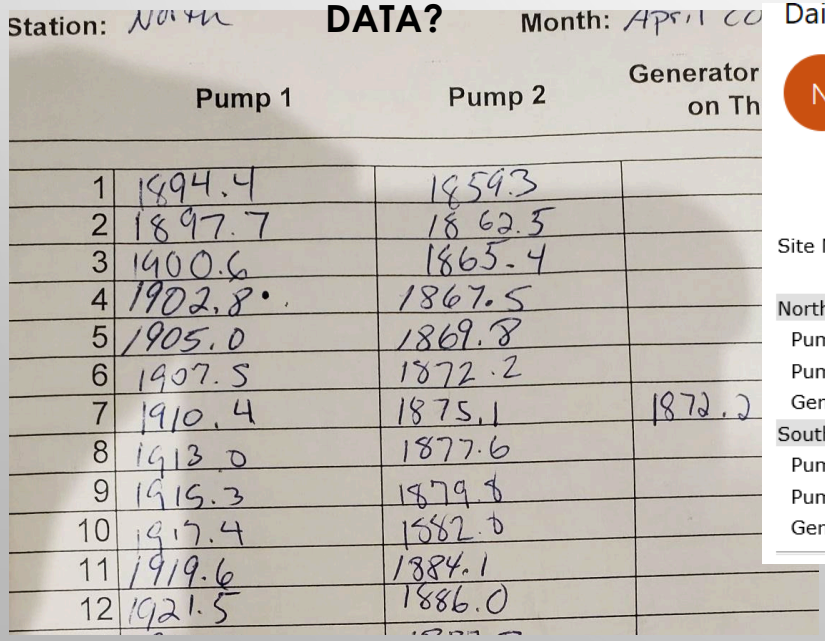
- **TYPICALLY INVOLVES GATHERING LOTS OF DATA AND MINING / REVIEWING DATA FOR TRENDS.**
- **IDEALLY YOUR DATA GATHERING IS IN A FORM YOU CAN READILY USE.**
- **OBSERVING AND ADDRESSING ISSUES**

» **WHAT ARE YOUR DATA POINTS?**

- **MOTOR RUN TIMES**
- **FLOW RATES**
- **AMP DRAW**
- **BEARING TEMPERATURE**

MOTOR RUN TIMES

- **MOST PUMPS/MOTORS HAVE HOUR METERS ON THEM**
  - **LOTS OF FACILITIES USE THAT ALONG WITH THE PUMP RATED CAPACITY TO DETERMINE GALLONS PUMPED PER DAY.**
  - **WHAT ARE YOU DOING WITH YOUR DATA**
    - **RECORD DAILY, PUT IN A FILE AT THE END OF THE MONTH SO YOU CAN TELL THE EPA YOU HAVE THE DATA?**
    - **ARE YOU COMPARING RUN TIMES (PUMP-PUMP)?**
    - **IS THERE ARE BETTER WAY TO DO THINGS THAT GIVES YOU MORE ACTIONABLE DATA?**


Station: North Month: April 20

	Pump 1	Pump 2	Generator on Th
1	1894.4	1859.3	
2	1897.7	1862.5	
3	1900.6	1865.4	
4	1902.8	1867.5	
5	1905.0	1869.8	
6	1907.5	1872.2	
7	1910.4	1875.1	1872.2
8	1913.0	1877.6	
9	1915.3	1879.8	
10	1917.4	1882.0	
11	1919.6	1884.1	
12	1921.5	1886.0	

Daily Runtime Report

Reply | Reply All

N notify@123mc.com
To David Shafer

Heyworth IL, Village of
21 April 2022

Site Name	-Runtime- Minutes	Gallons	Starts	Average (minutes/start)
North Lift Station				
Pump 1	112.0	134,400	134	0.8
Pump 2	111.0	133,200	134	0.8
Generator	0.0		0	-
Southwest LS				
Pump 1	61.0	48,800	85	0.7
Pump 2	59.0	47,200	85	0.7
Generator	0.0		0	-

MOTOR RUN TIMES

» **NOTICE THE DIFFERENCE WHEN NORTH LIFT STATION PUMP 2 IS REPLACED? A 13% REDUCTION IN RUN TIME**

Daily Runtime Report

N notify@123mc.com
To David Shafer

Reply | Reply All

Heyworth IL, Village of
5 May 2022

Site Name	-Runtime - Minutes	Gallons	Starts	Average (minutes/start)
North Lift Station				
Pump 1	238.0	285,600	220	1.1
Pump 2	207.0	248,400	220	0.9
Generator	0.0		0	-
Southwest LS				
Pump 1	122.0	97,600	168	0.7
Pump 2	129.0	103,200	168	0.8
Generator	0.0		0	-

FLOW RATES

- **IF YOU HAVE FLOW METERS ON YOUR PUMPS, VERIFYING THE FLOW RATE IS RELATIVELY EASY.**
  - **READ THE METER,**
  - **RECORD THE VALUE,**
  - **COMPARE TO PAST PERFORMANCE**
  - **TREND OF PERFORMANCE**

- **IF, LIKE A LOT OF SMALLER LIFT STATIONS YOU DON'T HAVE FLOW METERS WHAT CAN YOU DO?**
  - **WHY?**
  - **HOW TO OVERCOME**
    - **INSTALL A METER**
    - **CALCULATE THE FLOW RATE THROUGH A FILL AND DISCHARGE STUDY**

FILL AND DISCHARGE STUDIES

- NEED TO DO A LITTLE MATH, A LITTLE MEASURING, AND SPEND A LITTLE TIME.
- STEP 1 – MEASURE THE OPEN AREA OF THE WET WELL OR PIT YOU ARE PUMPING OUT OF.
  - CIRCULAR: $A = \pi r^2$
  - RECTANGULAR: $A = LW$
- STEP 2 – WITH THE PIT DRAWN DOWN MEASURE THE CURRENT WATER LEVEL AND START YOUR STOP WATCH.
  - RECORD THIS VALUE (DEPTH)
- STEP 3 – BEFORE THE PUMP KICKS ON MEASURE THE WATER LEVEL AND STOP YOUR STOP WATCH
  - RECORD BOTH VALUES (DEPTH & TIME)
  - YOU CAN CALCULATE THE VOLUME (AREA X CHANGE IN DEPTH) OF WATER THAT ENTERED THE PIT OR WET WELL. (MULTIPLY BY 7.48 TO CONVERT CU FT TO GALLONS)
  - YOU NOW CAN CALCULATE AN INCOMING FLOW RATE.

FILL AND DISCHARGE STUDIES CONTINUED

- **STEP 4 – MEASURE THE CURRENT WATER LEVEL AND START YOUR STOP WATCH AT THE SAME TIME YOUR TURN THE PUMP ON**
  - **RECORD THIS VALUE (DEPTH)**
- **STEP 5 – IMMEDIATELY AT PUMP OFF STOP YOUR STOPWATCH AND MEASURE THE WATER LEVEL.**
  - **RECORD BOTH VALUES (DEPTH & TIME)**
  - **YOU CAN NOW CALCULATE THE VOLUME OF LIQUID THAT WAS PUMPED OUT**
  - **YOU NOW CAN CALCULATE A PUMPING FLOW RATE.**
    - **(VOLUME PUMPED / TIME) + INCOMING FLOW RATE = PUMPING RATE**
- **WORKS BEST WHEN CONDITIONS ARE RELATIVELY CONSTANT**
  - **RECORD FLOW RATES, MONITOR FOR CHANGES**
  - **RUN FOR EACH PUMP SEPARATELY.**
  - **RUN FOR MULTIPLE PUMP SCENARIO.**

AMP DRAW:

- ANOTHER GOOD DATA POINT TO COLLECT ON YOUR MOTORS IS AMP DRAW – PROBABLY QUARTERLY IF YOU ARE DOING IN MANUALLY.
  - COMPARE AMP DRAW FROM EACH LEG ON 3 PHASE
    - ARE THE LEGS BALANCED
    - COMPARE TO PAST RESULTS
    - COMPARE TO OPERATING POINT IN STARTUP DOCUMENTS.

BEARING TEMP:

- FOR MOTORS AND EQUIPMENT WITH EXPOSED BEARINGS
  - USE A NO CONTACT IR THERMOMETER TO RECORD BEARING TEMPS NEAR THE END OF AN OPERATING CYCLE
  - INCREASE IN TEMP GENERALLY AN INDICATOR OF BEARING FAILURE.
  - MAKE SURE YOU GET ONE THAT COVERS THE TEMP RANGES YOU NEED.

DO SOMETHING WITH THE DATA YOU COLLECT

- YOU ARE ALREADY COLLECTING A LOT OF DATA POINTS
  - USE THEM TO MAINTAIN AND IMPROVE PLANT EFFICIENCY
  - AMP DRAWS ON PUMPS/MOTORS CAN BE USEFUL WHEN COMPLETING AN ENERGY EFFICIENCY GRANT APPLICATION
    - IF THE MOTOR SHOULD BE PULLING 20 AMPS, AND WHEN TESTED IS PULLING 30 AMPS YOU CAN DRAMATICALLY INCREASE YOUR GRANT FUNDING AMOUNT WHEN IT IS BASED ON KWH SAVED
  - FLOWS RATES LET YOU SEE WHERE ON THE PUMP CURVE YOU ARE OPERATING?
    - GOT AN OLD PUMP, MIGHT BE 40 – 50% EFFICIENT
    - MIGHT BE TIME TO REPLACE WITH SOMETHING IN THE 70 – 75% RANGE

Using SCADA Data to Optimize Aeration

Case Study at Kishwaukee WRD

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Kishwaukee Water Reclamation District

- Located in DeKalb, IL
- 8.6 MGD design; ~6 MGD average; ~4 MGD dry weather
- Activated sludge / anaerobic digestion
- Major plant upgrade in 2017; CHP; new equipment; VFDs; fine bubble aeration; LED lighting
- 4 Neuros Turbo Blowers, each with 960-2300 SCFM output flow range
- Energy assessment in 2021

Special thanks to Mike Holland, Assistant Manager / District Engineer!

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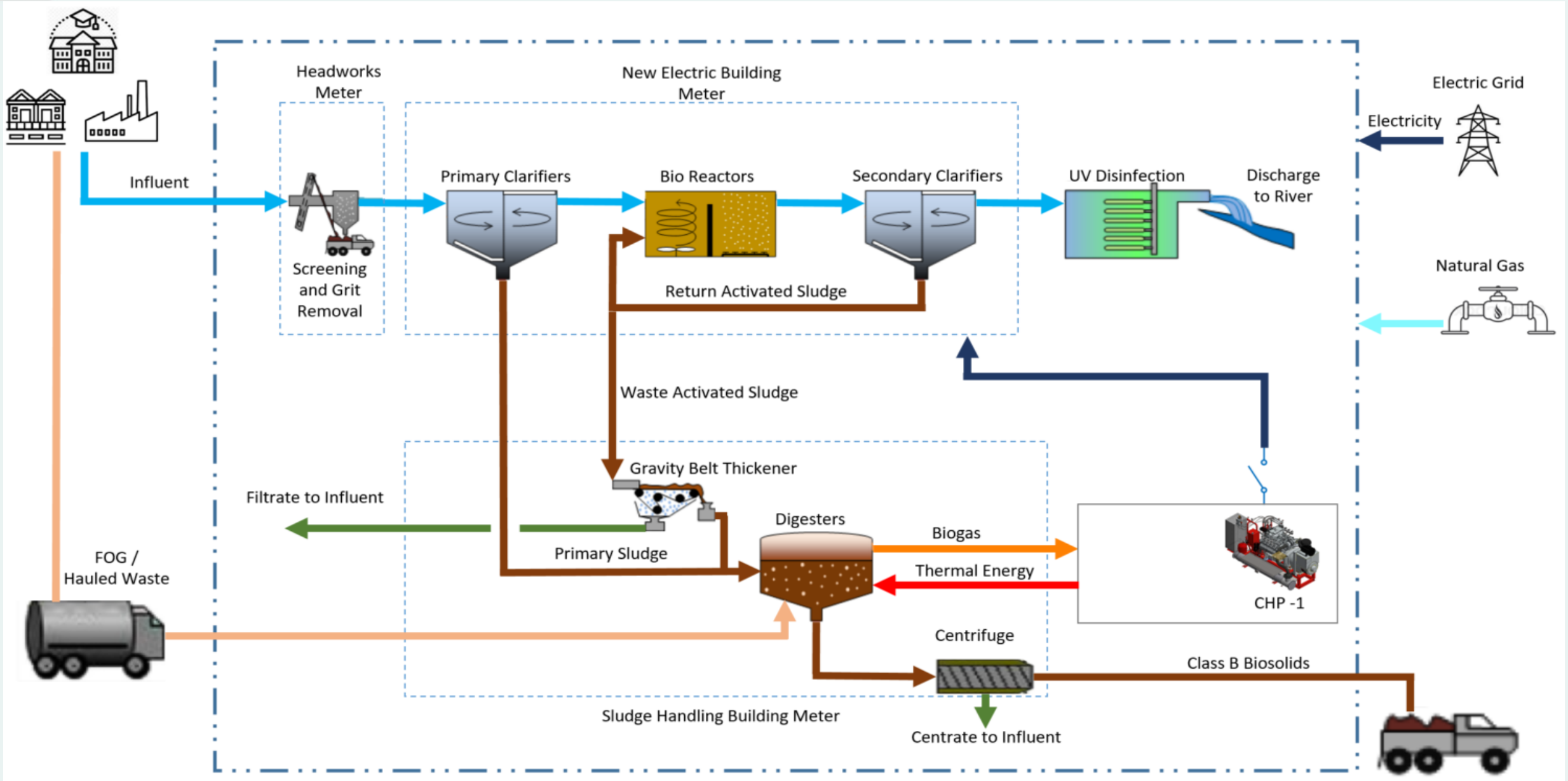
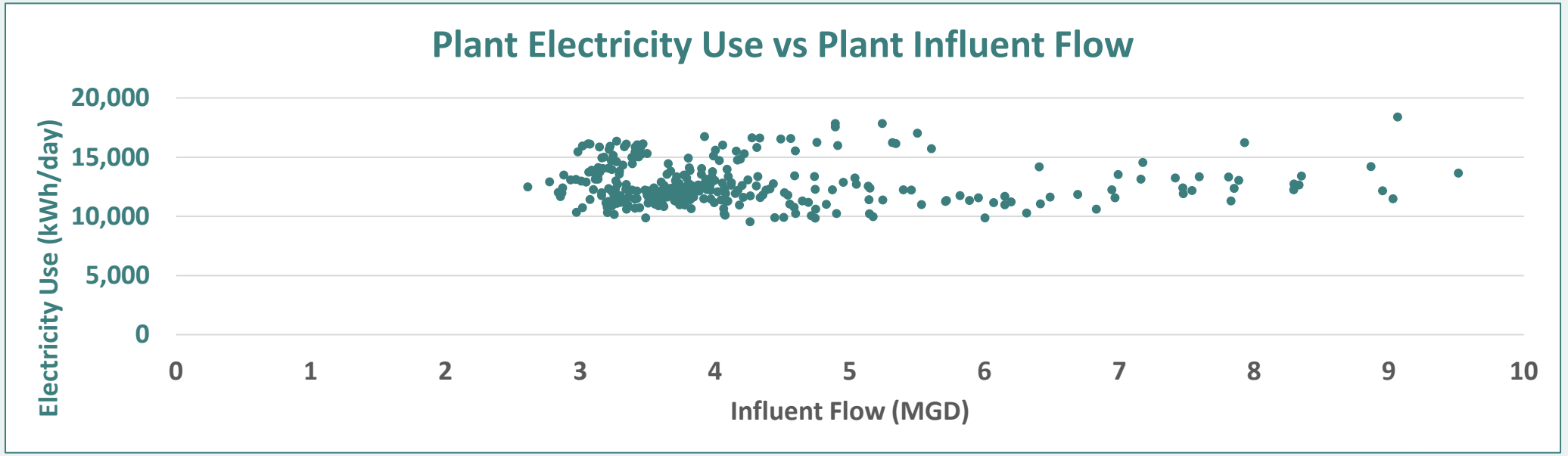
Process Flow Diagram



Baseline Electric Characterization – Total Plant

- Energy use benchmark: 2,360 kWh/MG
  - Not too bad, but higher than expected
- However…
  - Overall plant electric use – barely affected by flow
  - Shouldn't electric use be much higher when flow is much higher?



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Focus of Investigation

Category	Cost	%
Sludge Handling	$84,000	26%
Electrical Building	$126,000	38%
Other Areas	$119,000	36%
Total	**$329,000**	**100%**

- Facility preference to focus on aeration system and blowers
- Already suspected over-aeration & their engineering consultant had proposed changes

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Potential Savings

Measure	Annual Savings	
Optimize Aeration Process	$84,000	26%

Findings

- Over-aerated; 1 blower at lowest speed was still too high for large portion of operating time
- Solution: replace the core of one of the blowers to enable lower airflow operation, cost < $100k

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SCADA Data Analysis

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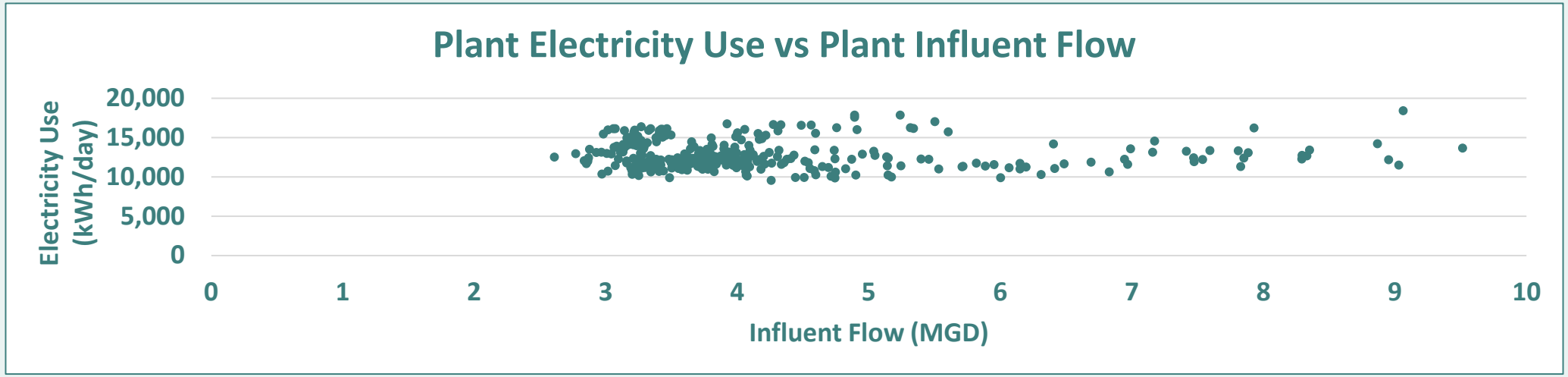
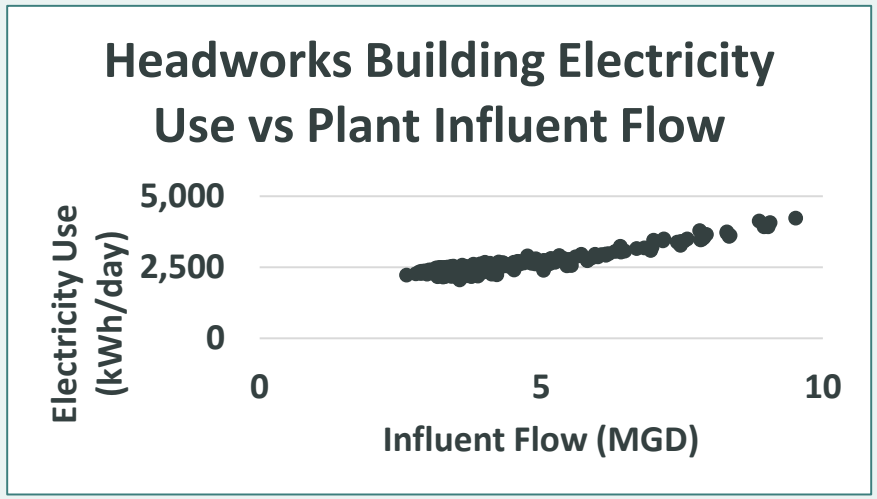
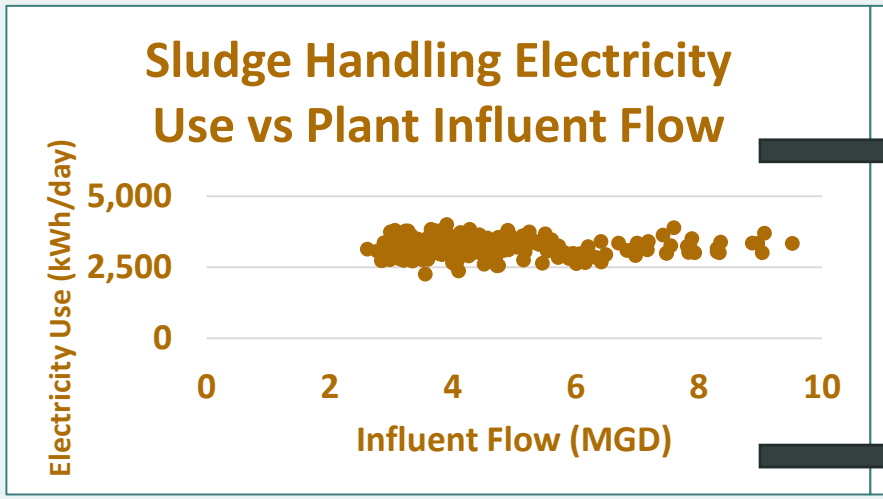
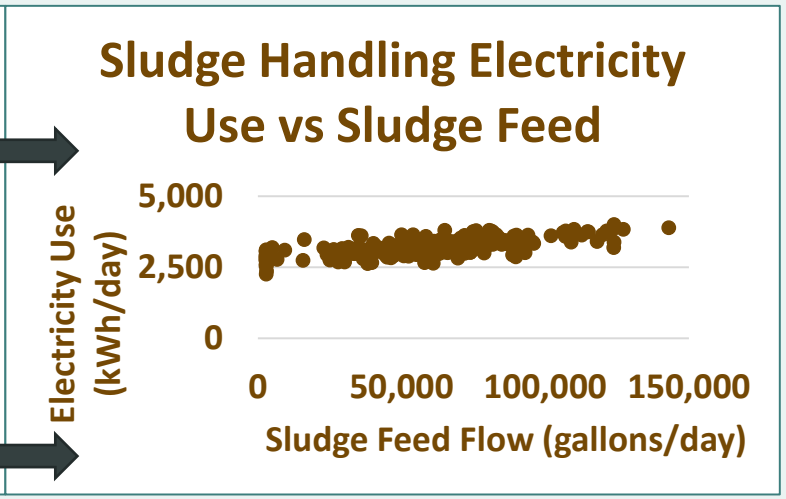
Electric Use Analysis – Plant-Wide & Submeters

- Why doesn't plant electricity use change very much with flow?
- Review electric submeters for first clues – headworks & sludge bldg



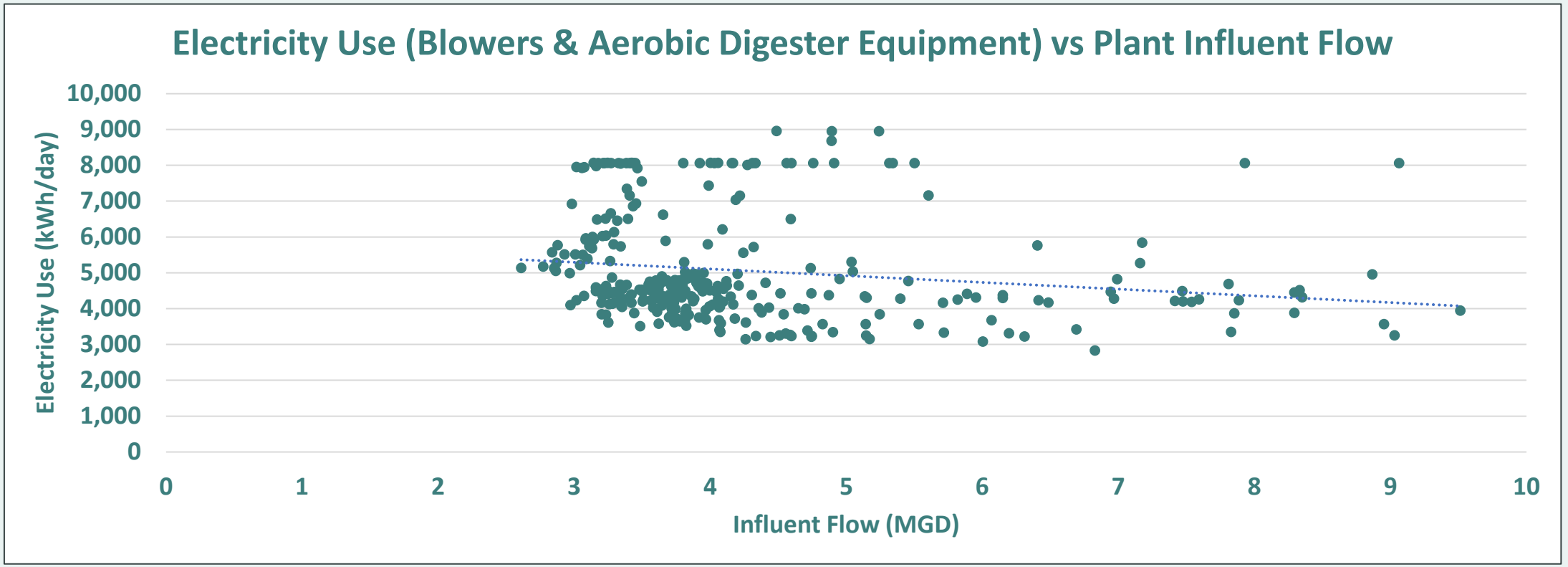






Electric Use Analysis – Plant-Wide & Submeters

- Why doesn't plant electricity use change very much with flow?
- Submeter with the blowers is a surprise → more flow = less electricity



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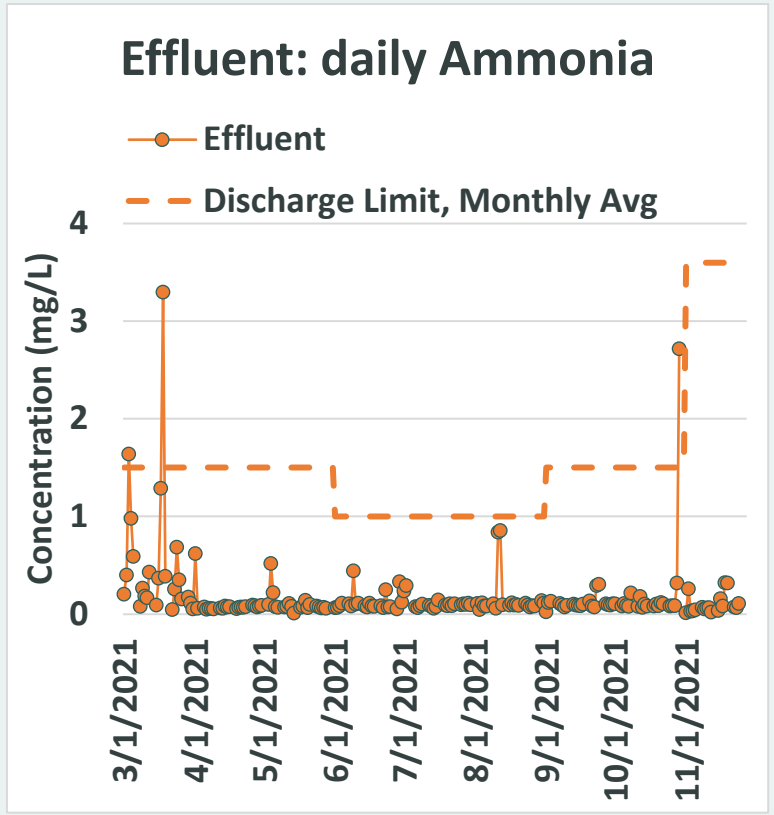
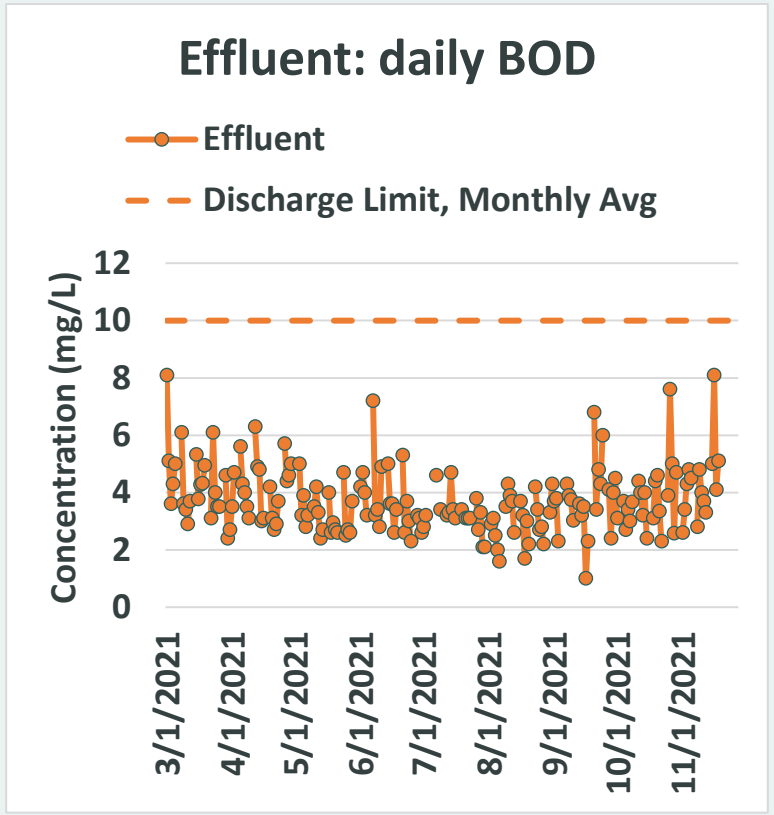
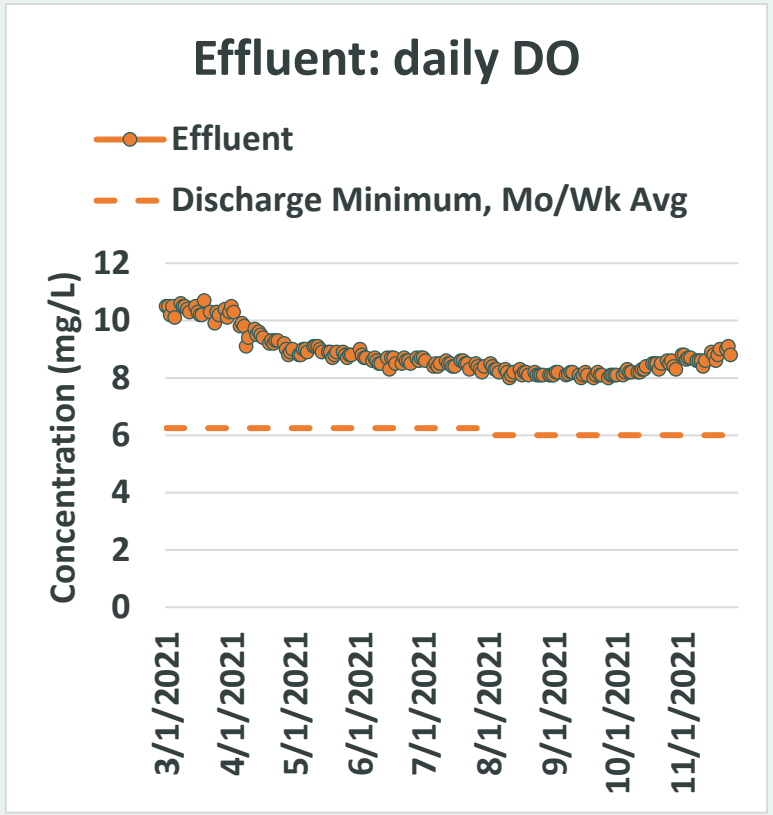
Treated Effluent Summary

Before we go too far… is there room to adjust without compliance risk?

Consistently better than discharge requirements → yes, there's room to adjust.







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Where to go from here?

If flow isn’t the main factor, then maybe nutrient loading matters…

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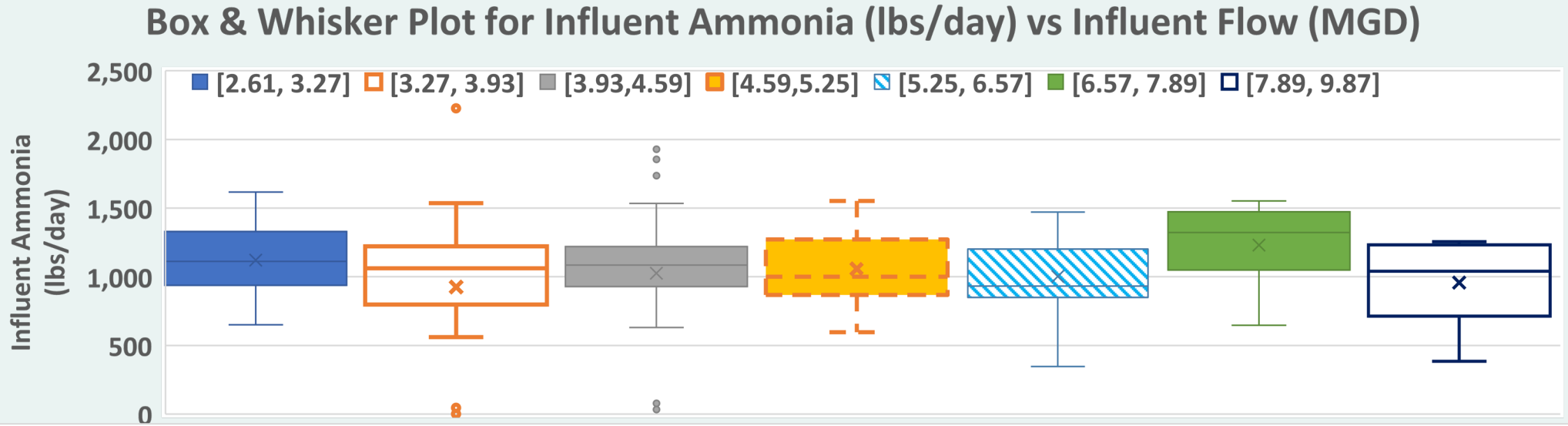
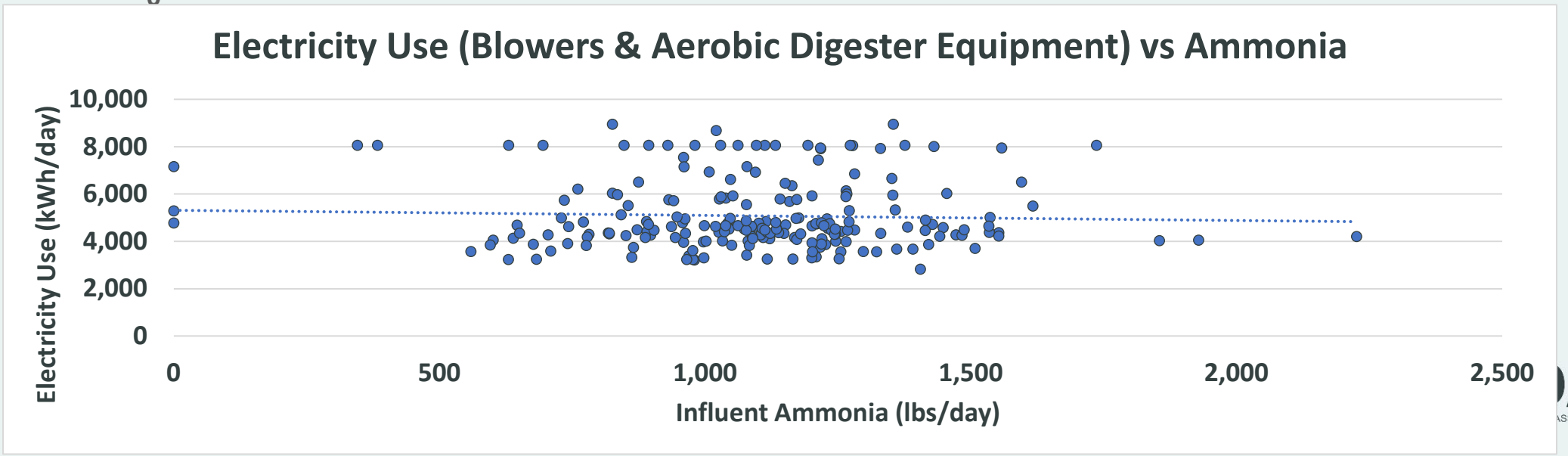
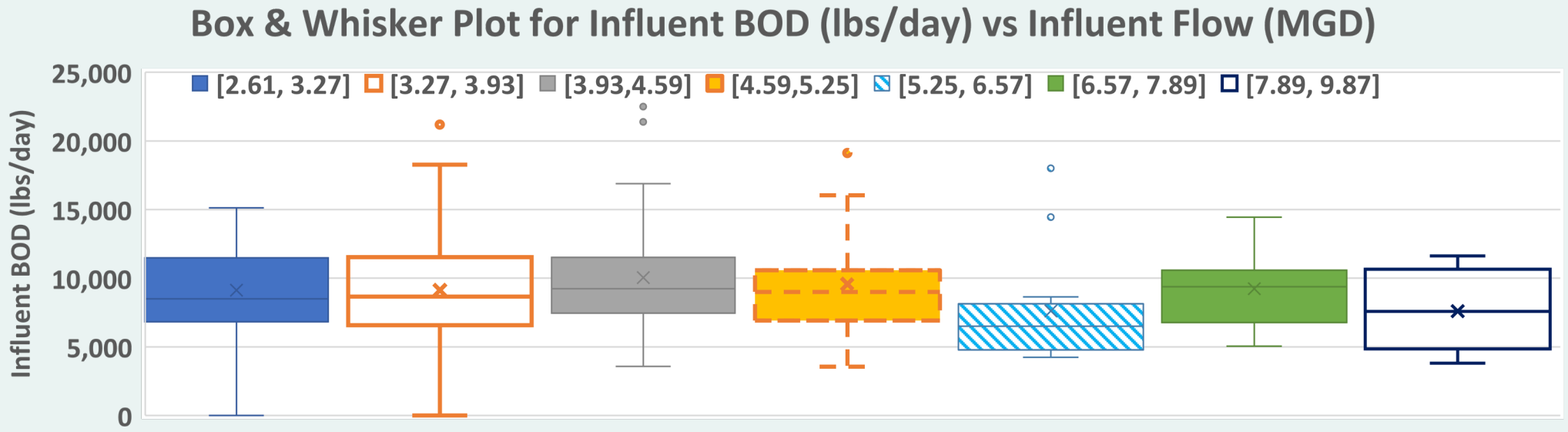
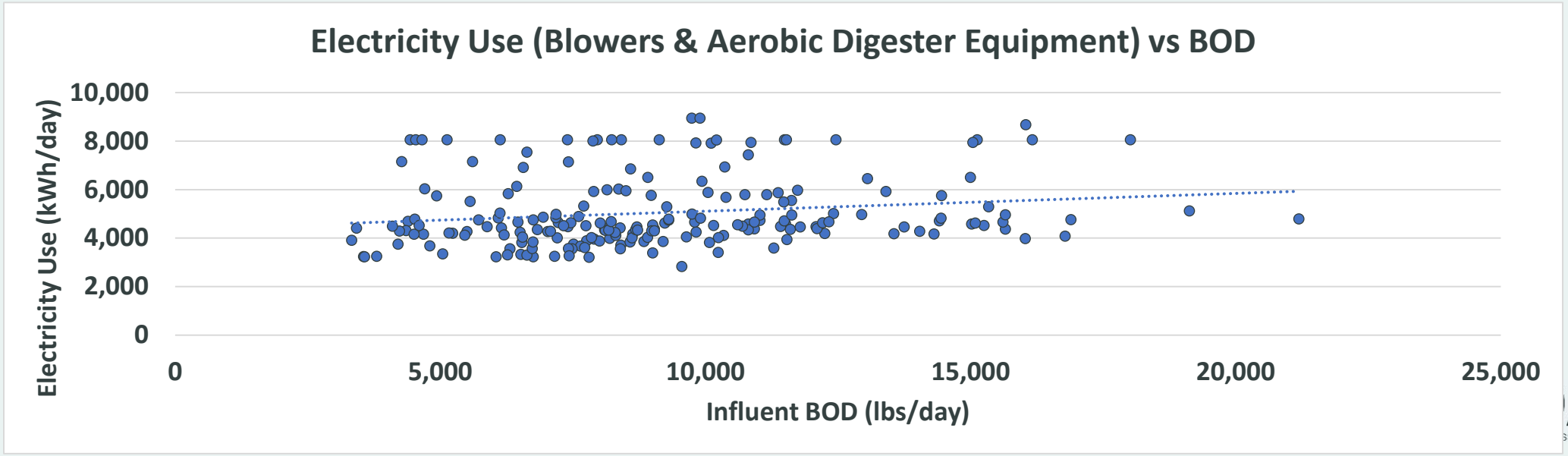
Impact of Ammonia on Aeration Energy (not apparent)





Impact of BOD on Aeration Energy (a little bit)





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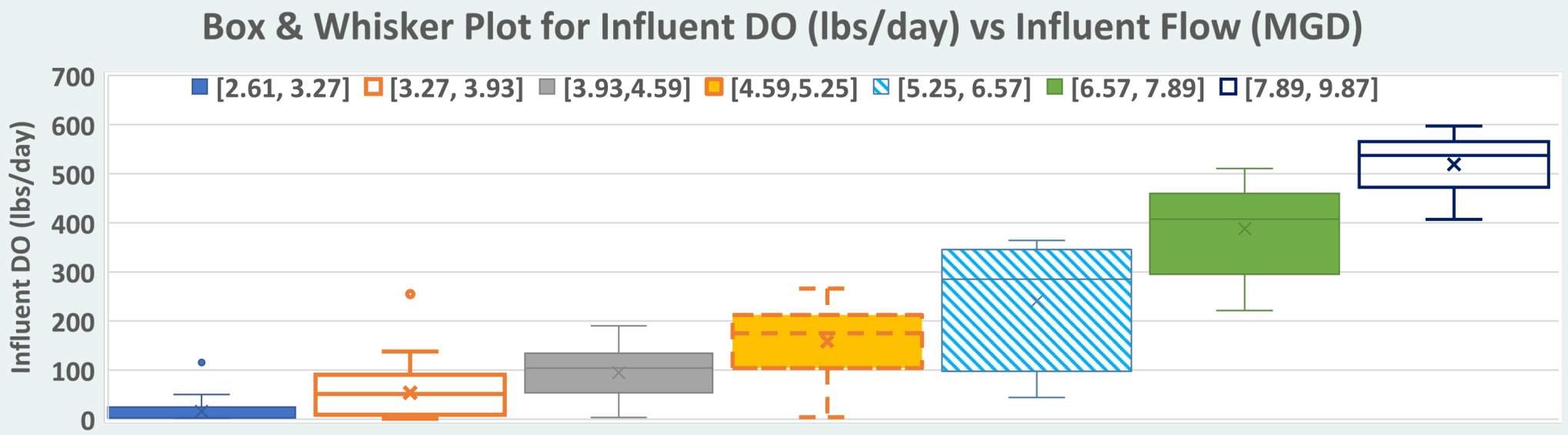
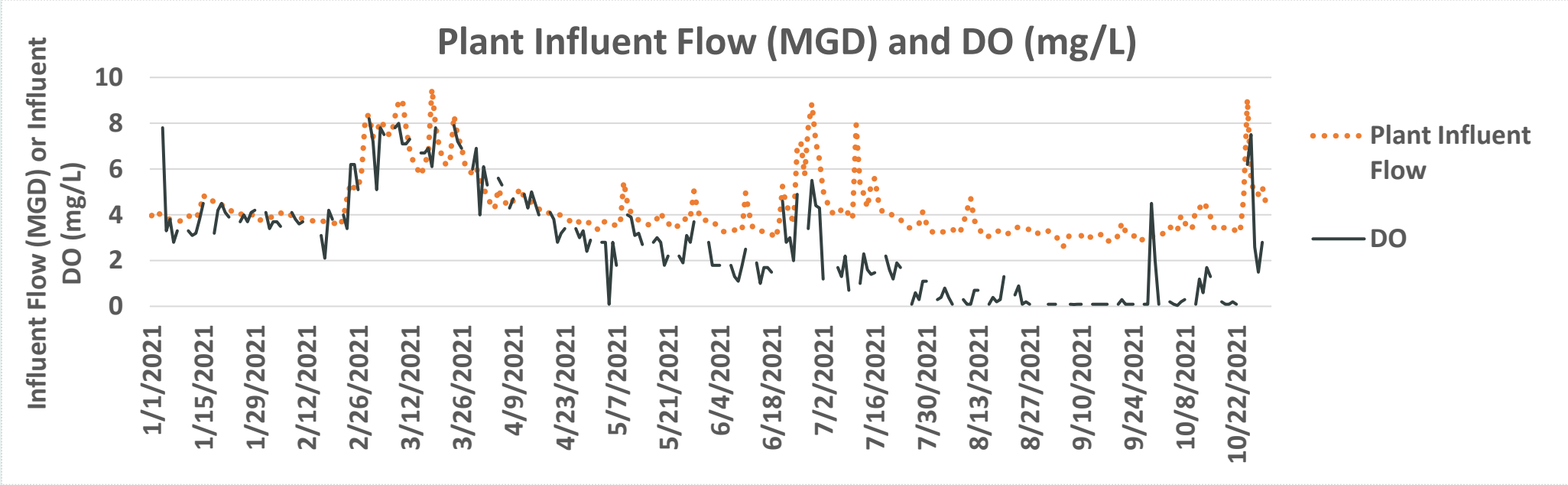
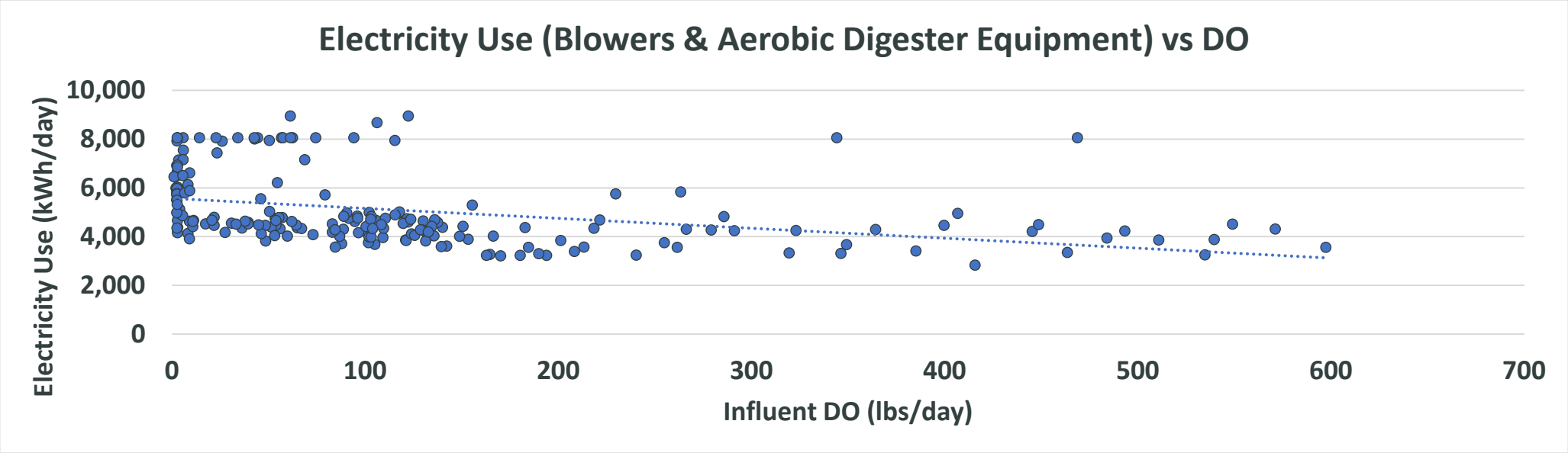
Impact of DO on Aeration Energy (significant)





Impact of DO on Aeration Energy (significant)



Aeration electricity use is higher when influent DO levels are low, and lower when influent DO is higher. This makes sense because if WW has more DO at the start, then it should require less from the blowers.

→So what? How to optimize?

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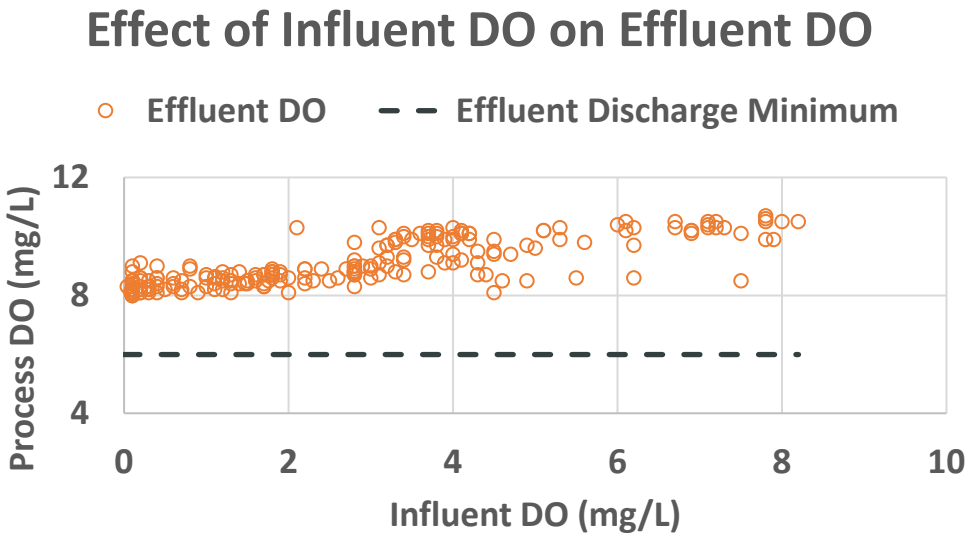
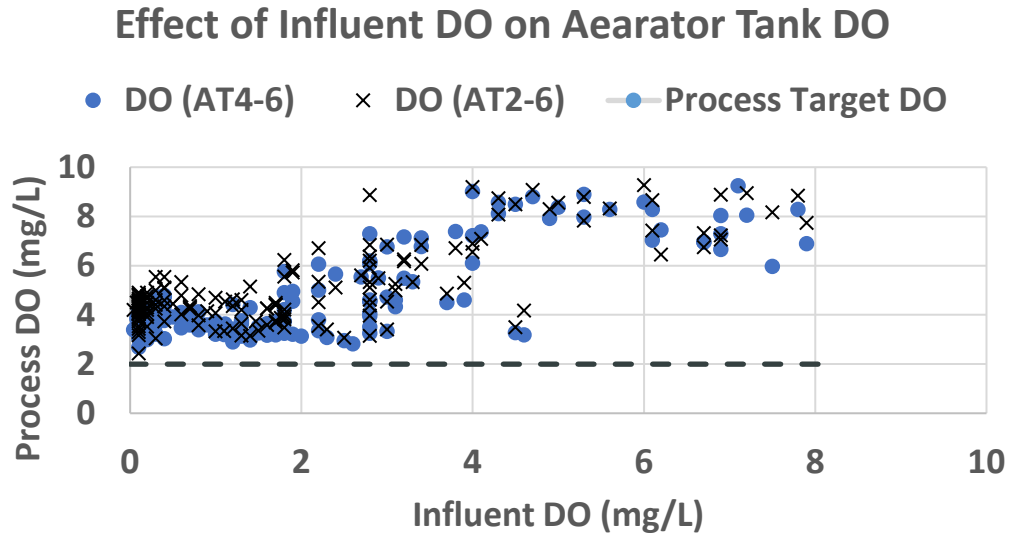
Process Response to Influent DO





- Effluent & process DO steady when influent DO < 2.0 mg/L, otherwise higher than needed.
- Effluent DO and aeration tank DO levels should be constant, across all levels of influent DO. The blowers can't go low enough when influent DO is higher than ~2-3 mg/L → excess aeration.
- Estimated average aeration rate is 190% higher than needed→ 65% savings potential

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Conclusions

- Kishwaukee WRD has potential to save 65% on aeration energy with better turn down on blowers
- Environmental factors (I&I, temperature) influence DO levels of the influent water, ranging from 0-8 mg/L DO
- DO level at the plant influent significantly affects the process, reduces need for aeration
- Engineering design for blowers and aeration should account for occurrence of elevated DO levels at the plant influent, allow more turndown for even lower airflow. Otherwise, the plant wastes money on excess aeration.

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To discuss further contact
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