Aeration Control Strategies for Activated Sludge Plants

January 11th, 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

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 Assessment 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.

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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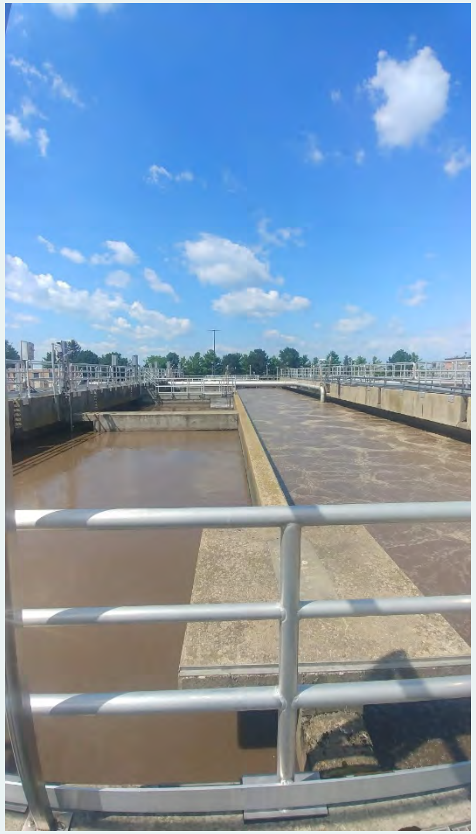
Apply for an Energy Assessment!

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

- Facility information –discharge reports, process flow, etc.
- 2 years of utility bills and DMRs
- We're here to assist!

Step 3: Site Visit Scheduled

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Presentation Sequencing

Today's webinar is one of a series webinars that address wastewater plant operations and controls. Prior webinars have covered:

1. Introduction to Aeration and Energy for Activated Sludge Systems October 10, 2021
2. Introduction to Aeration and Energy for Lagoons October 26, 2021
3. Oxygen Transfer Efficiency for Activated Sludge Plants November 16, 2021
4. Oxygen Transfer Efficiency: diffusers and Aerators-Lagoon Plants Nov. 30, 2021

All presentations can be viewed at: https://smartenergy.illinois.edu/water/

Presentation 1 & 2 Topics

Presentations 1 & 2 provided an introduction to aeration and energy for activated sludge and lagoon systems and addressed:

- Oxygen transfer and transfer rates
- Aeration methods (surface, subsurface, membrane & other)
- Sensing aeration levels (electrochemical, optical, ORP)
- Controlling blowers (manual, automated, time clocks, VFDs)
- Blower efficiency (positive displacement, centrifugal)
- Blower speed control, pressure & turndown ratio

Presentation 3 & 4 Topics

Presentations 3 & 4 provided information on oxygen transfer efficiency for activated sludge and lagoon systems and covered:

- Oxygen Transfer Terms and Factors
- Aeration Technology Comparisons
    - Blower efficiency, turndown, speed control and pressure
- System Considerations
    - Air delivery, distribution and diffusers

Today's presentation: **Aeration Control Strategies for Activated Sludge Plants**

Introduction to Aeration Control

Control Basics

Manual Control: Operator adjusts based on seasonal or daily profiles

- Good for small plants with relatively constant or predictable loads, and limited budgets
- Bad for larger facilities, highly variable flows and nutrient loads, and large I&I flows

Automated Control: Sensors in basins adjust airflow, blower cycling, flow rates, etc… based on measured data points

- Bulk of this presentation
- Range of automation scale
- Economical for larger facilities

Control Basics

Variables and Control Components:

A basic control system requires a few components:

- Controlled variable: the item changed based on system measured responses
- Setpoint/Reference variable: the item being used to measure system response
- Controller: the logic programming that dictates how the controlled variable and setpoint are related
- Disturbance: the factor forcing the controlled variable away from the setpoint.

Control Concepts

Reactive/Feedback Control

Measured change in process drives output from devices

e.g. DO is high in basin, so blower VFD slows as result

Most common control strategy

Predictive/Feedforward Control

Measured values ahead of process calculate required response

e.g. Measured ammonia input to model predicts DO requirement, blower VFD adjusted.

Growing application for high-efficiency systems

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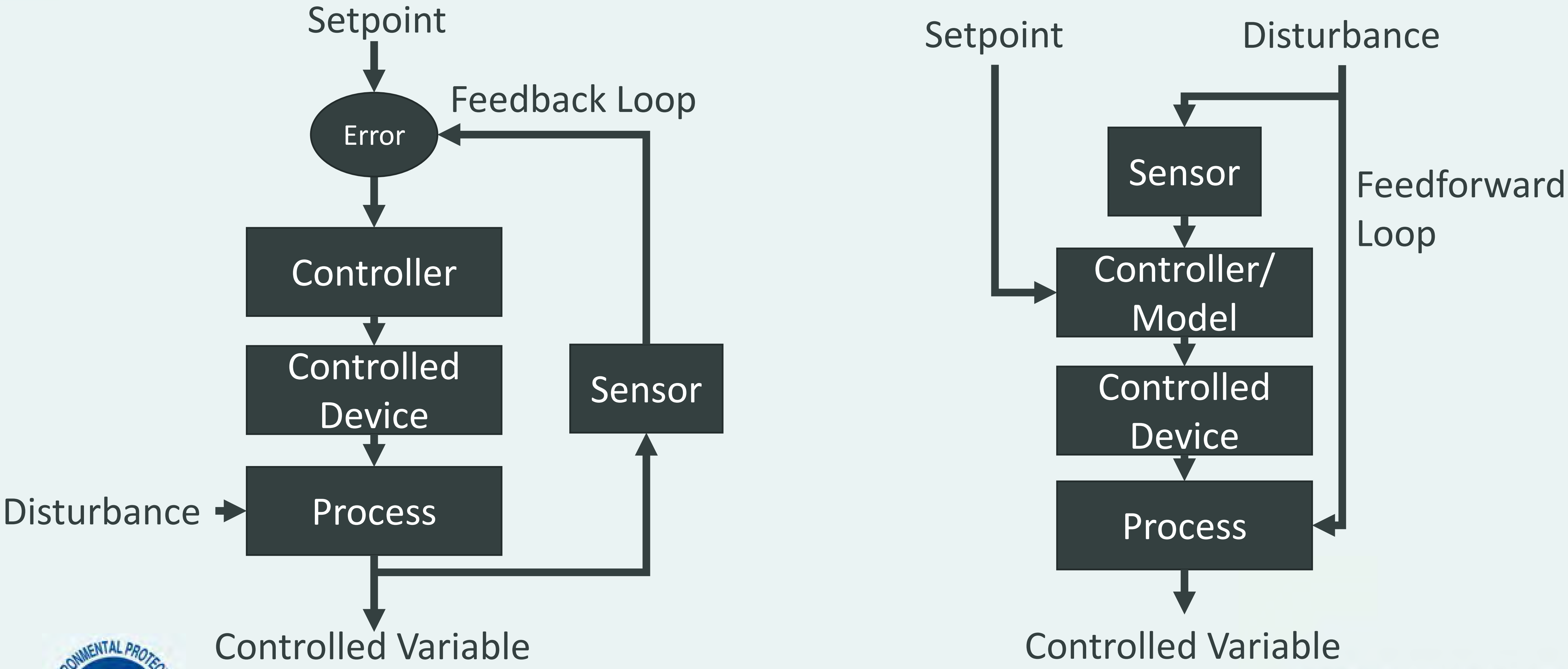
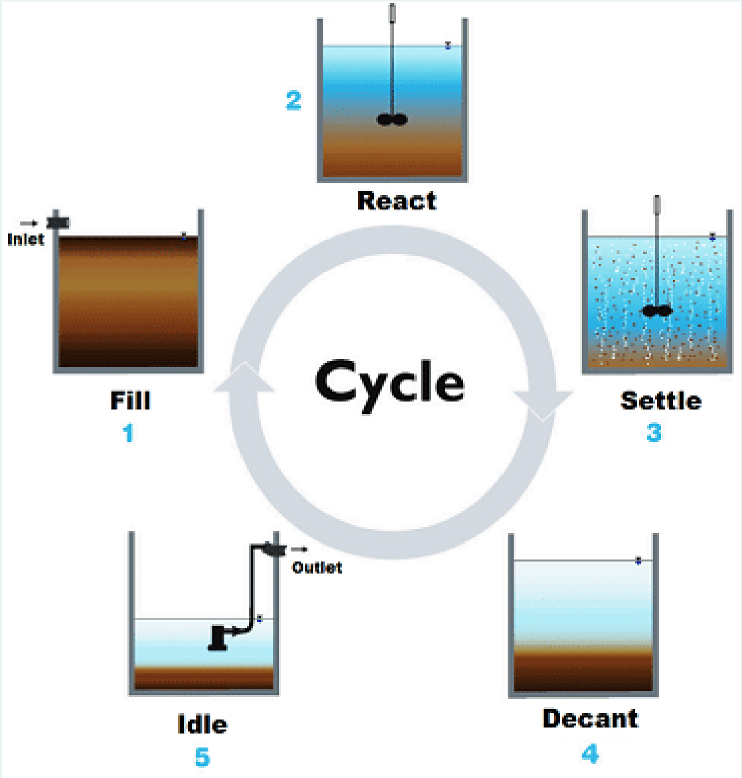
Schematics of Control Concepts



Feedback Control – On/Off Control

- The simplest form of feedback control
- Inexpensive and can be easily retrofitted into existing facilities
- Good for mechanical aeration systems or blower per basin configuration.
- On-off control is most suitable for completely mixed reactors with long hydraulic and solids retention times.
- Control can be improved with additional sensors and programming



Feedback Control – PID Control

- Direct control based on DO
  - Direct adjustment of air supply rate based on DO measurement
  - Direct control most suitable for aeration basins with dedicated air supplies
  - Controlling multiple basins with single air source leads to tuning issues
- Direct control with Ammonium
  - Ammonium sensor replaces DO sensor for control
  - Slower response rate than DO can lead to overshoots and wasted energy
  - Usually most successful with on-off control aeration
  - Usually paired with DO to set range limit on ammonia controller

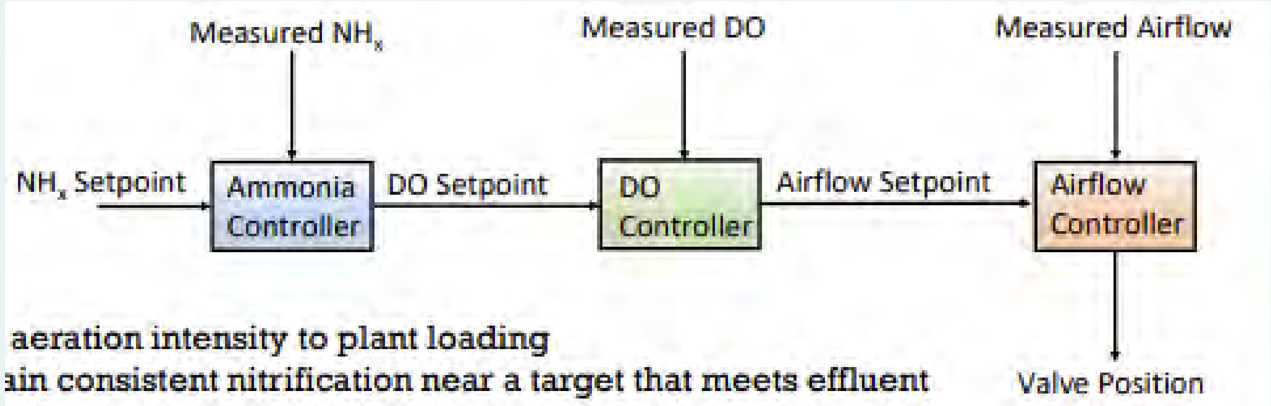


Image source: Water Environment Federation www.wef.org

Feed-Forward Control-Model Control

Best example is Ammonia-based aeration control (ABAC)

- Ammonia sensor in influent samples ammonia level, sets DO target for basins
- Actual DO is not measured, determined by a model
- Model must be accurate for proper function!
- Frequent tuning checks may be necessary, depending on control logic and variations in variables
- Usually recommended pairing with feedback control to correct model errors

Feed-Forward-Cascade Control

Feedforward provides “early warning” of process upset

Feedback provides limits to feed-forward reactions, prevent overcorrections

Corrects feedforward errors due to simplifying assumptions

Goal to maintain at setpoint with feedforward, feedback corrects drift

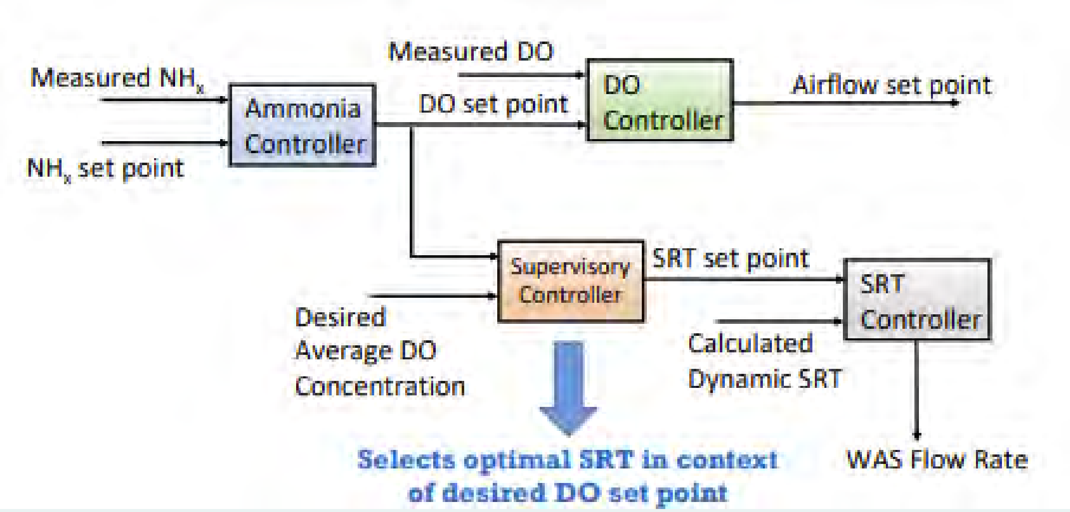


Image source: Water Environment Federation www.wef.org

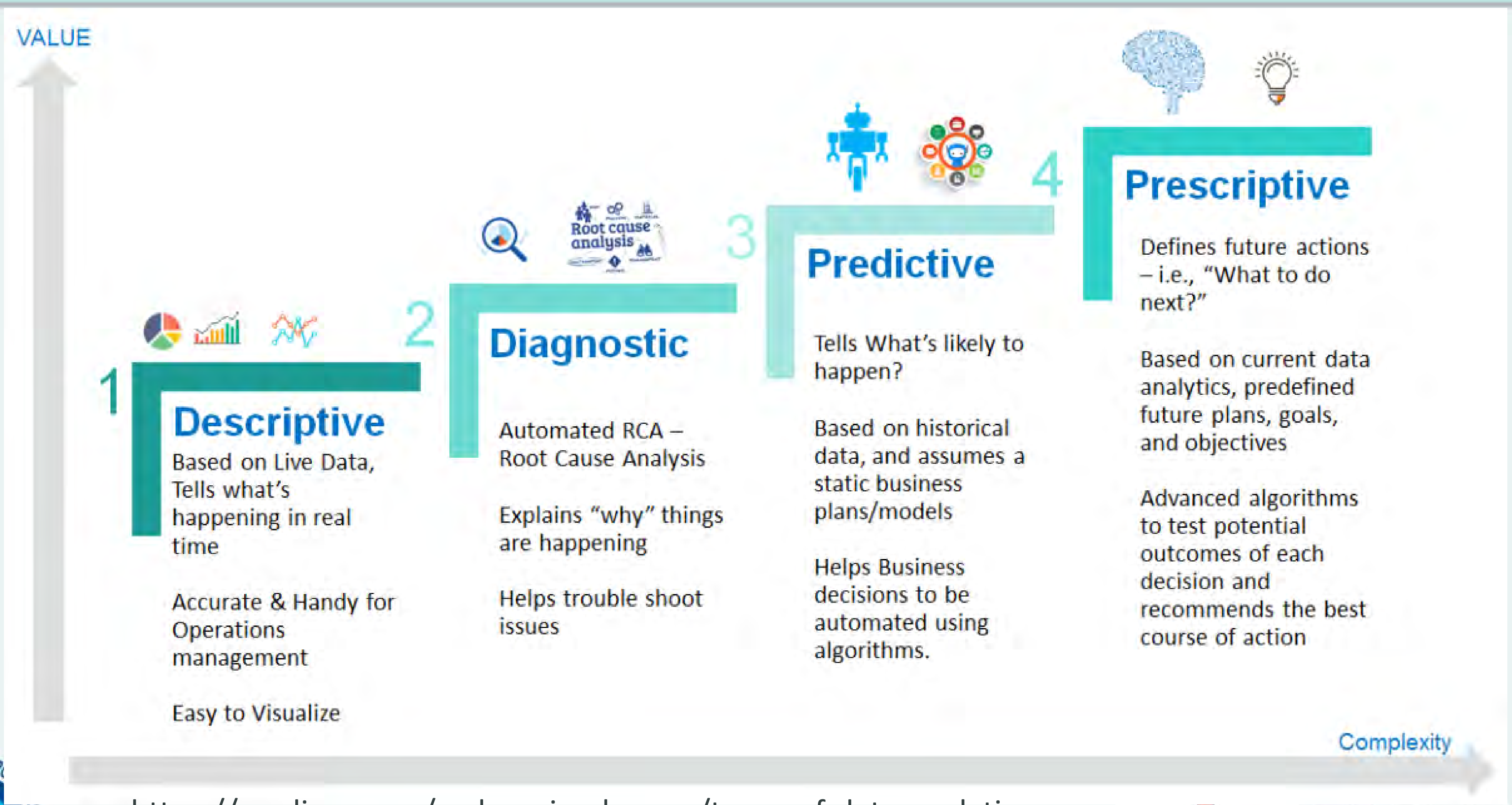
Predictive Controls using AI

- Artificial intelligence software uses real-time operational data compared to historic data to improve efficiency
- AI is a predictive control system that uses a digital twin based on the actual plant design
- Model initially ‘trained’ using historical SCADA data and best management practices from operators
- Digital twin allows comparison between idealized model and actual operation to maintain efficiency over time using historic and current data

Predictive Controls using AI

- The SCADA data used to train AI systems provides historical perspective on plant operation. This forms the basis for *descriptive analytics* in the model.
- The historical data provides information and insight on why processes responded as they did, used to develop *diagnostic analytics*.
- Using the historical data and knowledge of plant behavior is used in *predictive analytics* to predict how it will behave based on inputs.
- Finally, *prescriptive analytics* use predictive analytics to optimize operations. Optimization functions may vary based on cost of operations, nutrient removal, biogas production or other desired factors

4 Types of Data Analytics



https://medium.com/co-learning-lounge/types-of-data-analytics-descriptive-diagnostic-predictive-prescriptive-922654ce8f8f

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Predictive Controls Energy Savings

WWTP in Cuxhaven, Germany (population ~400,000) implemented AI controls to optimize aeration.

- ‘Virtual sensors’ estimate incoming nutrient loads.
- AI ran in parallel to manually operated aeration tanks as control group.
- AI greatly reduced fluctuations in energy required to eliminate one kilogram of load.
- Advanced controls resulted in 30% reduction in aeration energy use or 1.1 million kWh annually and maintained regulatory compliance.

https://www.xylem.com/en-us/making-waves/water-utilities-news/wastewater-treatment-plant-uses-ai-to-reduce-aeration-energy-use-by-30-percent/

Feedback Control

ADVANTAGES	DISADVANTAGES
• Generally, easier to implement • Can respond to complex interactions • Fewer sensors required • Don’t need to build complex model	• Slower/delayed response • Upset by large swings in loading (rapid flow increase, or slug load entering plant) • Control can be destabilized by poor logic or application

Feedforward Control

ADVANTAGES

- Predictive response is faster
- Handles large/rapid upsets better
- Better control for more stringent regulatory limits
- With proper design, more stable control

DISADVANTAGES

- More sensors required
  - Increases maintenance costs
- Limited to situations where control variable has predictable reaction in system
- Usually paired with feedback cascade

Questions?

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

smartenergy.Illinois.edu/water

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U.S. DOE 5001 Ready Wastewater Cohort

- This first-ever DOE 50001 Ready Wastewater Cohort program has a 25-step Navigator program for achieving ISO 50001 certification, provides no-cost technical support and training for groups of sites, called a cohort, for six to twelve months. Cohorts could be a group of sites, such as the municipally owned buildings in a town, or the leadership staff for a single site, such as the administrators for a wastewater treatment plant.

- For more information on the 50001 Ready Wastewater Cohort program, or to get started, visit https://betterbuildingssolutioncenter.energy.gov/iso-50001/tools-expertise-training or contact their help-desk at 50001Ready@lbl.gov.

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CONTROL STRATEGIES FOR ACTIVATED SLUDGE PLANTS

ILLINOIS EPA WEBINAR SERIES

JANUARY 11, 2022

NORESCO

Presenter Profile

Introductions

Zia Qureshi, P.E.
Water/Wastewater
Subject Matter Expert
NORESCO

Experience

- 52+ years
- 500+ projects (environmental, waste management, water, wastewater)
- ESPC Experience – NORESCO, Johnson Controls, Schneider Electric

Education

- BE (Civil) – University of Karachi
- MS (Environmental/Water Resources) – University of Cincinnati

Certifications

- Registered Professional Engineer – TX, MI, KY (inactive)

Typical Engagement

- Business Development – Market Seeding (demand creation)
- Biogas Generation and Cogeneration
- Biosolids Management
- Plant Optimizations
- Performance Enhancements
- Automation & Controls

Topics of Discussion

Feed Back and Feed Forward Strategies

SCADA Versus Distributed Control System

Divesting Mixing from Aeration

Summary

Feed Back and Feed Forward Strategies

Feed Back Overview

Utilizes nonlinear algorithm

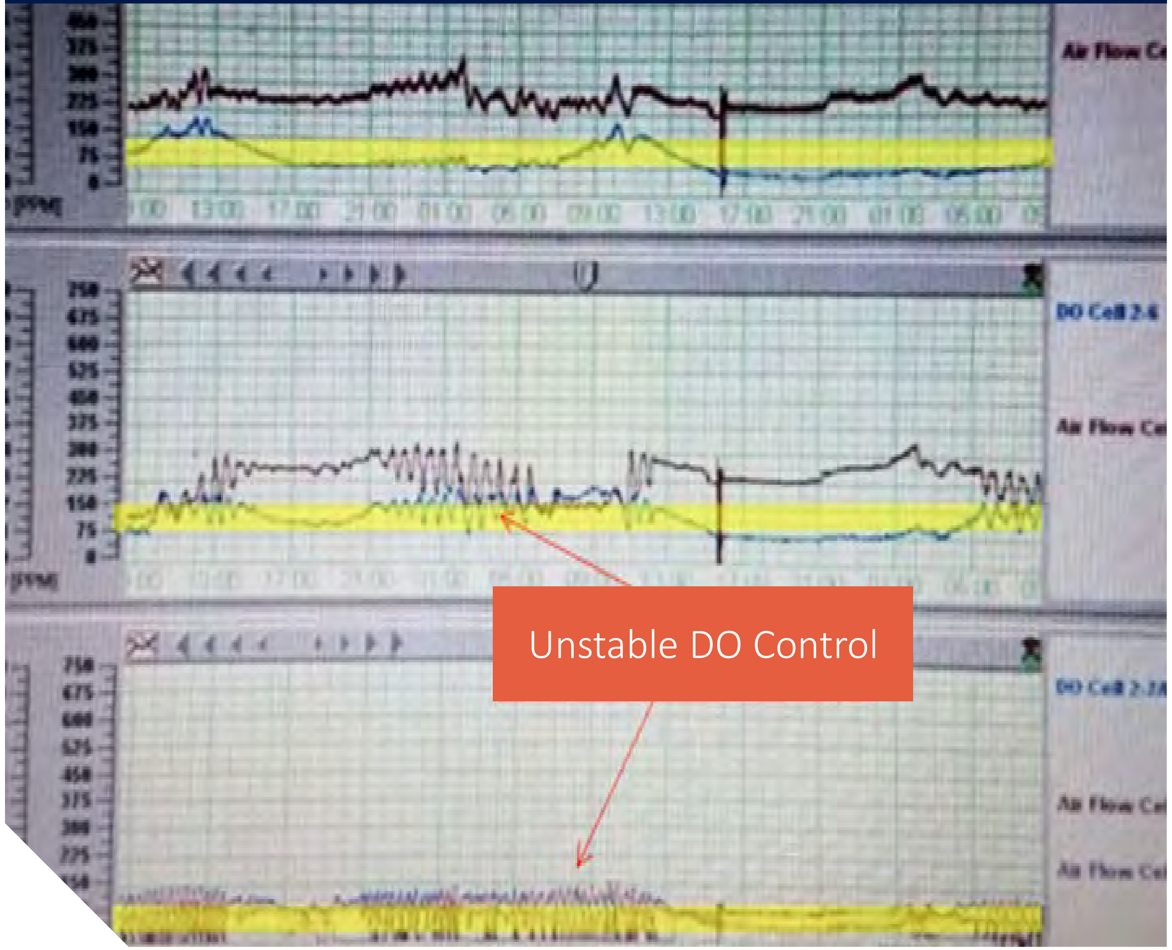
No connectivity to underlying process

Instability and tuning issues

> *"These factors make the PID algorithm poorly suited for DO control."*

Source: Courtesy BioChem (Randy Chann)

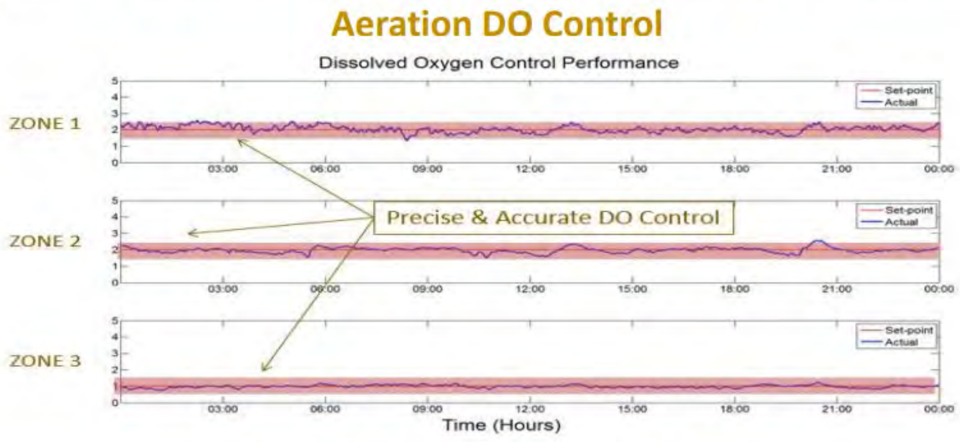
Proportional Integral Derivative (PID) Tuning Issues –
Actual Data: YSI, Missoula, MT WWTP



Feed Forward Overview

1MGD & 10¢ kWh
= 25% reduction
($35k savings)

Toho Water Authority (Cyprus West WRF) 2010

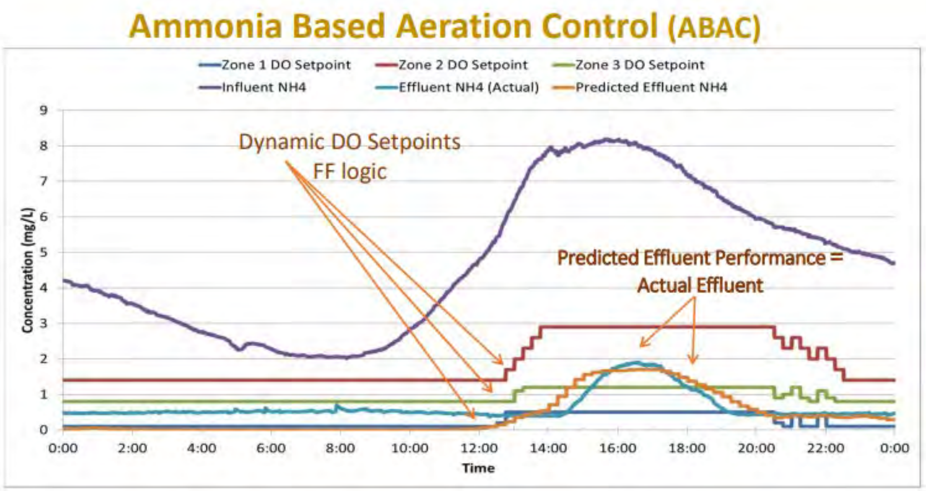


DO varies by no more than 0.5 mg/L from zone setpoint, 95% of the time

Auto-Calibration in real time

No Manual Retuning!

Denver Metro (R. W. Hite WRRF) 2011



Predicted Effluent = Actual Effluent
when tight aeration control provided

Source: Courtesy BioChem (Randy Chann)

Feed Forward Case Study

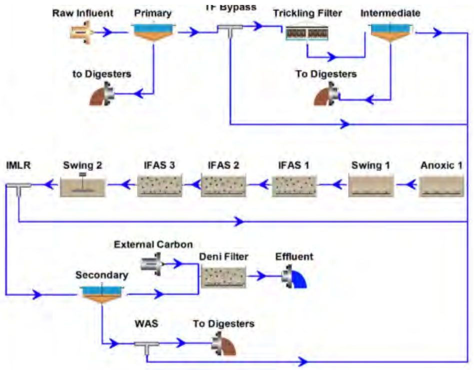
Lebanon, PA

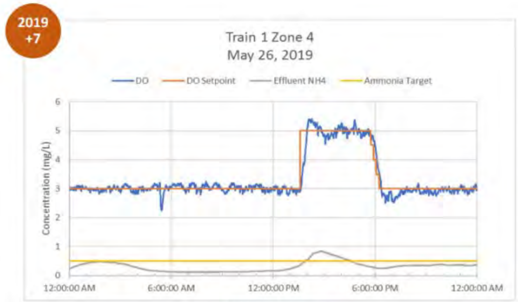
PROCESS OPTIMIZATION

- Denit Carbon Management | TF Bypass
- SRT Management | Oxic SRT Control (Swing Zones) & Total SRT Advisor
- Nit and Denit Optimization | Load based DO Setpoint(s) and IMLR Adjustment
- Lowest Aeration Energy Use | Optimization (V) Algorithm

AERATION CONTROL

- Tight Automation | Zone Specific alpha-f-SOTR Behavior
- Efficient Airflow Control | Tactical Airflow Targets
- Efficient Blower Operation | Airflow Control Logic
- Lowest System Pressure | Dynamic MOV





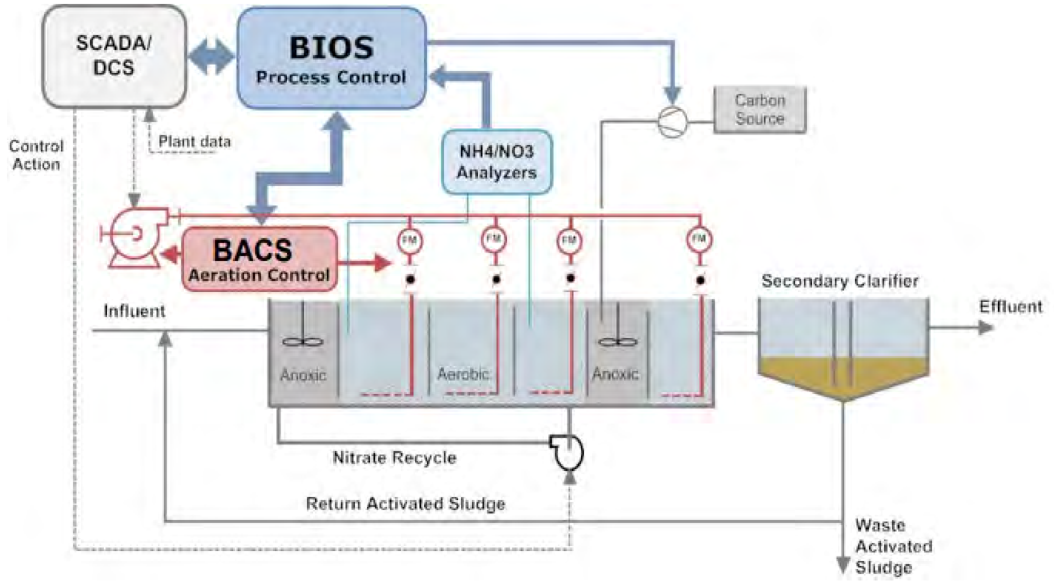
AUTOMATION STABILITY

Guaranteed Automation Performance (0.5mg/L)
No Manual Tuning Requirement

Source: Courtesy BioChem (Randy Chann)

Feed Back Bioprocess Aeration Control System

*Guaranteed automation performance when installed with right-sized equipment, patented (US and CN)



Source: Courtesy BioChem (Randy Chann);

Benefits

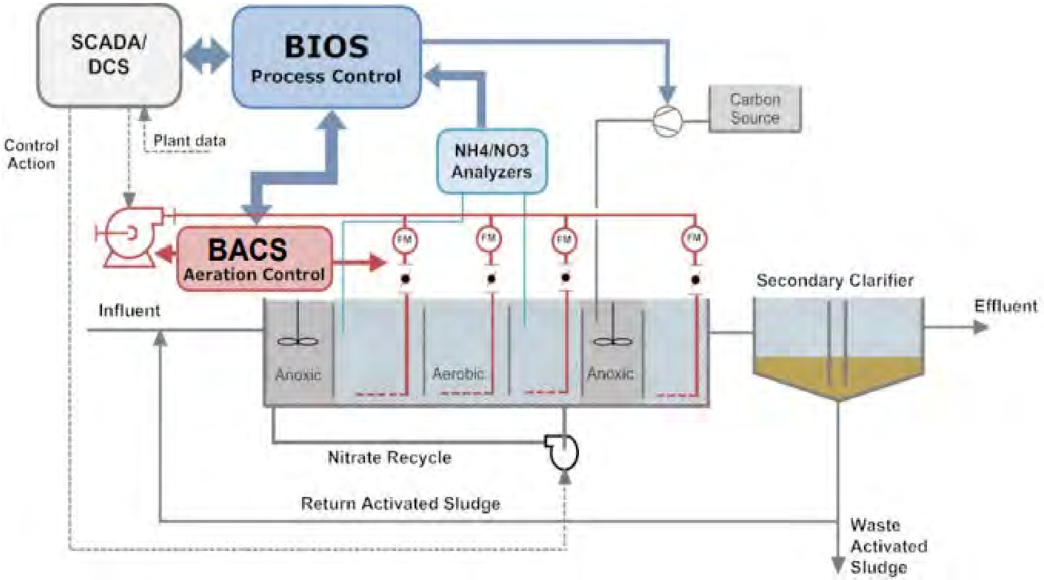
- Precise and accurate automation performance (within 0.5mg/l, 95% of time)
- Supports high demand fluctuations from varying load and changing DO conc
- Maximizes blower capacity and minimizes energy use
- Reduces wear and tear on equipment (actuators, valves, and blowers)
- Supports complex systems and eliminates manual retuning requirements
- Robust uptime performance
- Reliability-centered maintenance prompts
- Direct software upgrade for existing aeration control systems
- Supports all aeration systems

Features

- Tactical, 1st principle model(s)
- Calculates airflow based on zone specific demand, environmental conditions, and real-time operating performance of diffuser components
- Uses predictive logic to determine future requirements
- Blowers operate to a defined airflow output
- Air distribution valves operate in unison and move to a known position
- Stable operations with advanced fault detection and user embedded IR protocols
- Performance trending prompts maintenance

Feed Forward Bioprocess Intelligent Optimization System

*Guaranteed performance with supporting data and instrumentation



Source: Courtesy BioChem (Randy Chann);

Benefits

- Real-time, 24/7 process optimization based on incoming load, environmental conditions, and in situ biologic (microbial) activity
- Process conditions are optimized to operational objectives, and process aeration demand is minimized for all operating strategies
- Biomass inventory advisor prompts when activity rate or changes are required
- Maximizes recovery of nitrate oxygen and alkalinity
- Optimization of conjoined process units for best overall plant operations
- Robust uptime performance

Features

- 1st principle, feed forward, ammonia-based process model
- Continuous recalibrated to mirror in situ process performance
- Adjusts biomass inventory and residual DO concentration(s) to meet treatment objectives. Includes swing zones, number of operating tanks, and DO target for all controlled aerated zones.
- DO setpoints gamed for lowest process aeration demand or daily energy cost
- Direct control of swing zones, mixers, and IMLR flow
- Management of aerations with target DO setpoints
- Advanced fault detection analytics

Summary

Leading edge technologists

- *Feed Forward preference*

Traditionalists

- *Feed Back preference*

SCADA Versus
Distributed Control System

Overview

Supervisory Control and Data Acquisition (SCADA)

- *SCADA is a hardware and software system for monitoring and controlling industrial processes.*
- *Manufacturers can gather and analyze real-time production statistics, control and evaluate alerts, and implement automatic control reactions prompted by certain circumstances or system characteristics using a SCADA system.*

Distributed Control System (DCS)

- *A distributed control system (DCS) is an automated control system that comprises geographically dispersed control systems throughout a facility or control region.*
- *A dedicated controller controls each processing element, device, or group of units in DCS.*
- *DCS is made up of many local controllers that are linked by a rising speed communication network in various portions of the plant security zone.*

	DCS	SCADA
Focus	Focuses on central control of processes.	Focuses on data acquisition.
Ability	DCS can’t endure communication outages.	SCADA can endure communication outages.
Communication Protocols	Support exclusive protocols.	Support open protocols.
Processing Time	Data processing time is slower.	Data processing time is faster.
Specialties	DCS is perfect for managing network operations.	SCADA is great for keeping track of procedures and gadgets.

Summary

SCADA

- *By delivering economically important data to controllers and management, a SCADA system can assist reduce production waste and enhance overall efficiency in your plant.*
- *The data obtained from a SCADA system can help you make data-driven decisions, which can result in increased output production, lower costs, and better data processing.*

DCS

- *DCS is best suited for monitoring and controlling a huge number of ongoing controller parameters in large-scale processing or manufacturing facilities.*
- *The key benefit of separating control duties for dispersed controllers is that the plant can continue to run even if a component of the DCS fails.*

Divesting Mixing from Aeration

Mixing Verses Aeration

If mixing is the goal, why aerate?

- *Technology misapplication - blowers*
- *Aeration and Mixing easily misunderstood*
- *Diffused Aeration – intent oxygen transfer*
- *Diffused Aeration – offers mixing but at a high cost*
- *Customizing mixing and aeration solutions – important performance considerations*

Impacts of Excessive Aeration

Operations

Mixing? Operational must

Grid type diffused aeration:
0.12scfm/sf tank (0.05)

Roll type diffused aeration:
20 to 40scfm/kcf tank

Aeration represents 50-90% of total energy costs

Air delivery by aeration blowers – large HP

Diffused aeration – fine or coarse through discs or panels

Misapplication – utilizing air for mixing processes

Problems due to misapplication of technology:

- Excess aeration, resulting in high energy consumption
- Diffuser fouling and plugging, resulting in high maintenance costs and downtime
- Hair accumulation and ragging, resulting in labor costs and manpower
- High air volume, resulting in high air handling requirements for odor control

Diffused aeration – can mix, at relatively high energy cost

Mixing Basics

Importance

- *Blending, flocculation, homogeneity of liquids, heat transfer*

Operations

- *Rapid (<30 seconds) or continuous (ongoing)*

Continuous rapid mixing

- *AKA flash mixing*

Continuous mixing

- *Holding tank contents in suspension*

Mixing Types

Low HP Units

Static mixer	*High speed induction mixer*	*Pressurized water jet mixer*	*Turbine & propeller mixer*

Summary

Misunderstandings and misapplications of process control strategies

Lack of sophistication in process monitoring

Optimization and efficiency not a focal point

Owner receives designer’s process preference

NORESCO Overview

Who We Are

$5+ Billion delivered in **guaranteed energy savings**

10,000+ **facilities** in the U.S. and worldwide

20 Billion kWh **in electricity** saved or efficiently produced

120 Million MMbtu **of on-site fuel energy saved**

50 Billion gallons of **water saved**

Reducing greenhouse gas emissions by **25 Million** **Metric tons of CO_2**

NORESCO

37+ years of experience

Multi-disciplinary in-house team experienced in all aspects of project funding, development, engineering, construction and operation

Flexible funding and contracting options

Carrier

Company founded in 1915

Extensive global footprint

$18.6 billion net sales*

NORESCO is a Carrier company

*Adjusted for Carve-out and Reclassification Impact. Total Carrier Sales net of ($0.4B) of eliminations.

CONTACT

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Aeration Control Strategies to Reduce Energy at the MWRDGC

Jonathan Grabowy

Managing Engineer

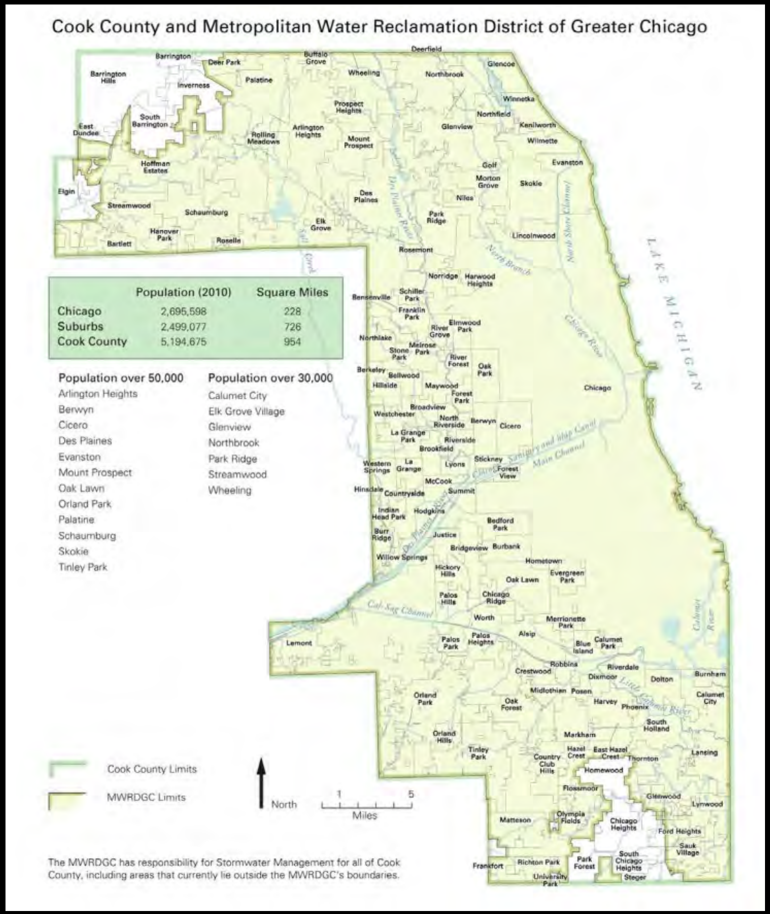
Metropolitan Water Reclamation District of Greater Chicago (MWRDGC)

Outline

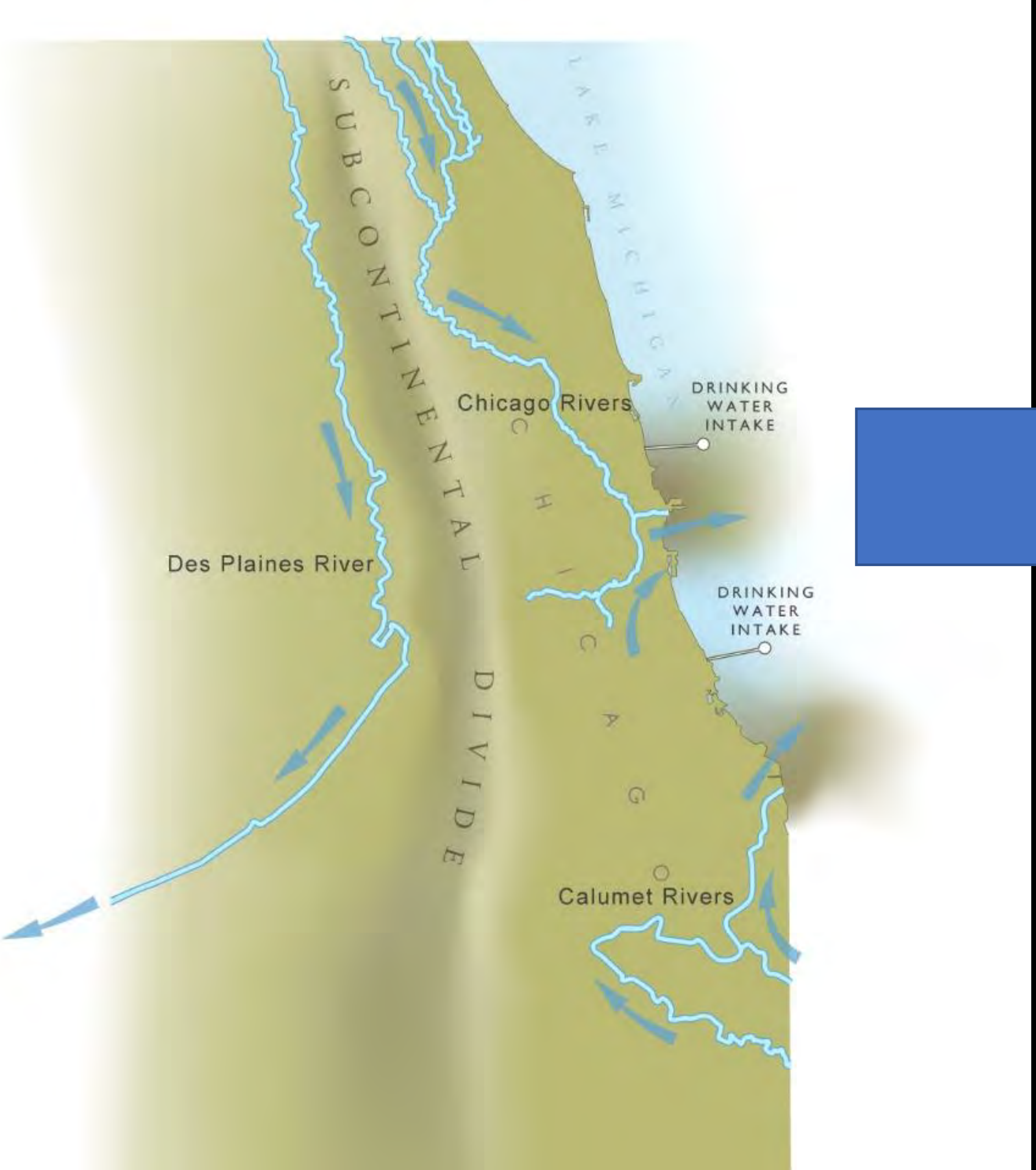
- Background of the MWRDGC
- Agency Goals with Resiliency and the Environment
- Electricity Use
- General Aeration Information
- Tests and Studies
  - Stickney WRP ABAC Test
  - Hanover Park WRP ABAC Test
  - O’Brien WRP Paper Study
  - Future Plans

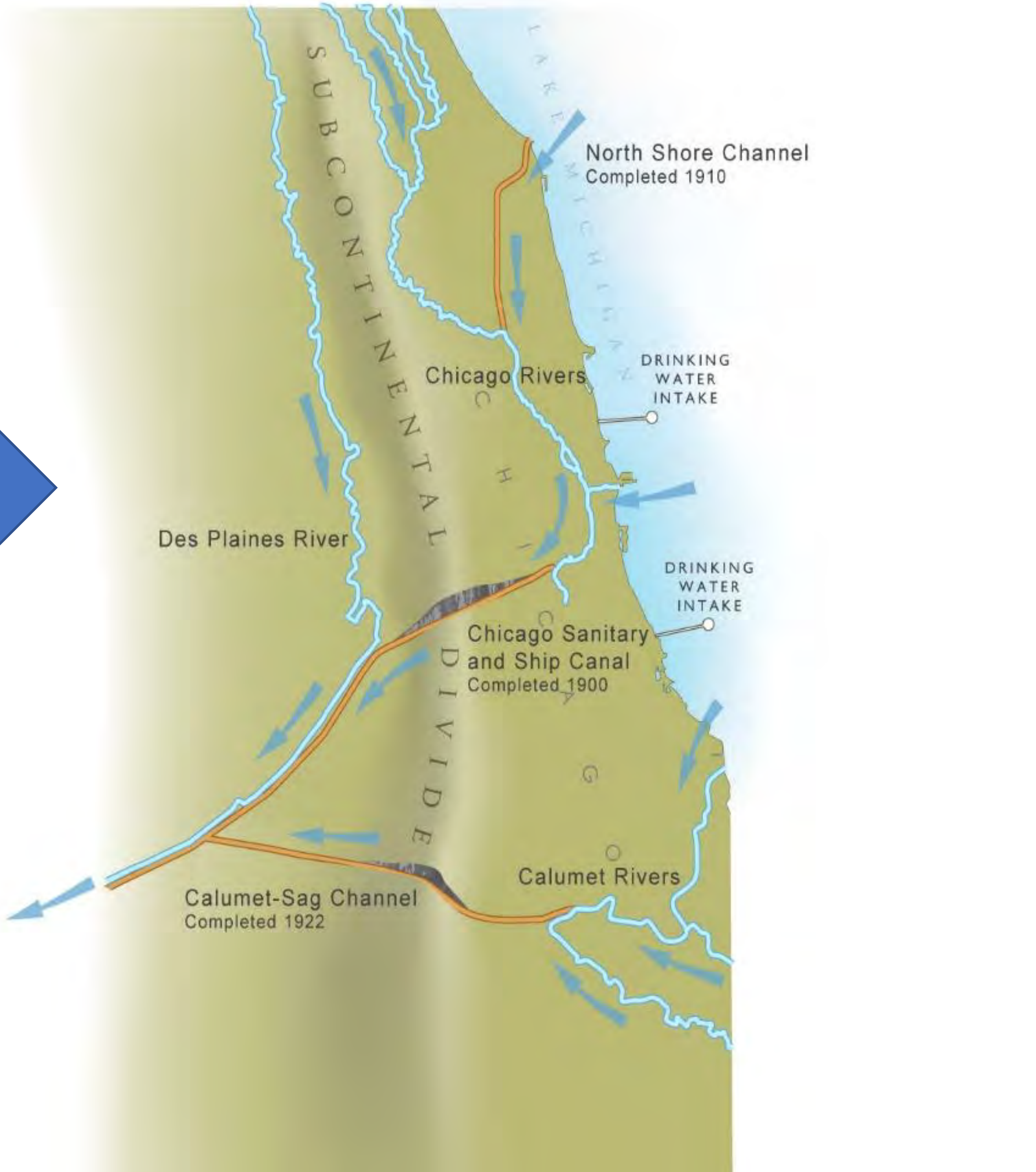
The Metropolitan Water Reclamation District of Greater Chicago

- Created in 1889
- Located in Northeast Illinois
- 92% of Land and 98% of Assessed Valuation of Cook County
- Chicago and 128 Suburbs
- Responsible for Wastewater and Regional Stormwater
- Serves an Equivalent Population of 10.35M (population, industrial, and CSO)

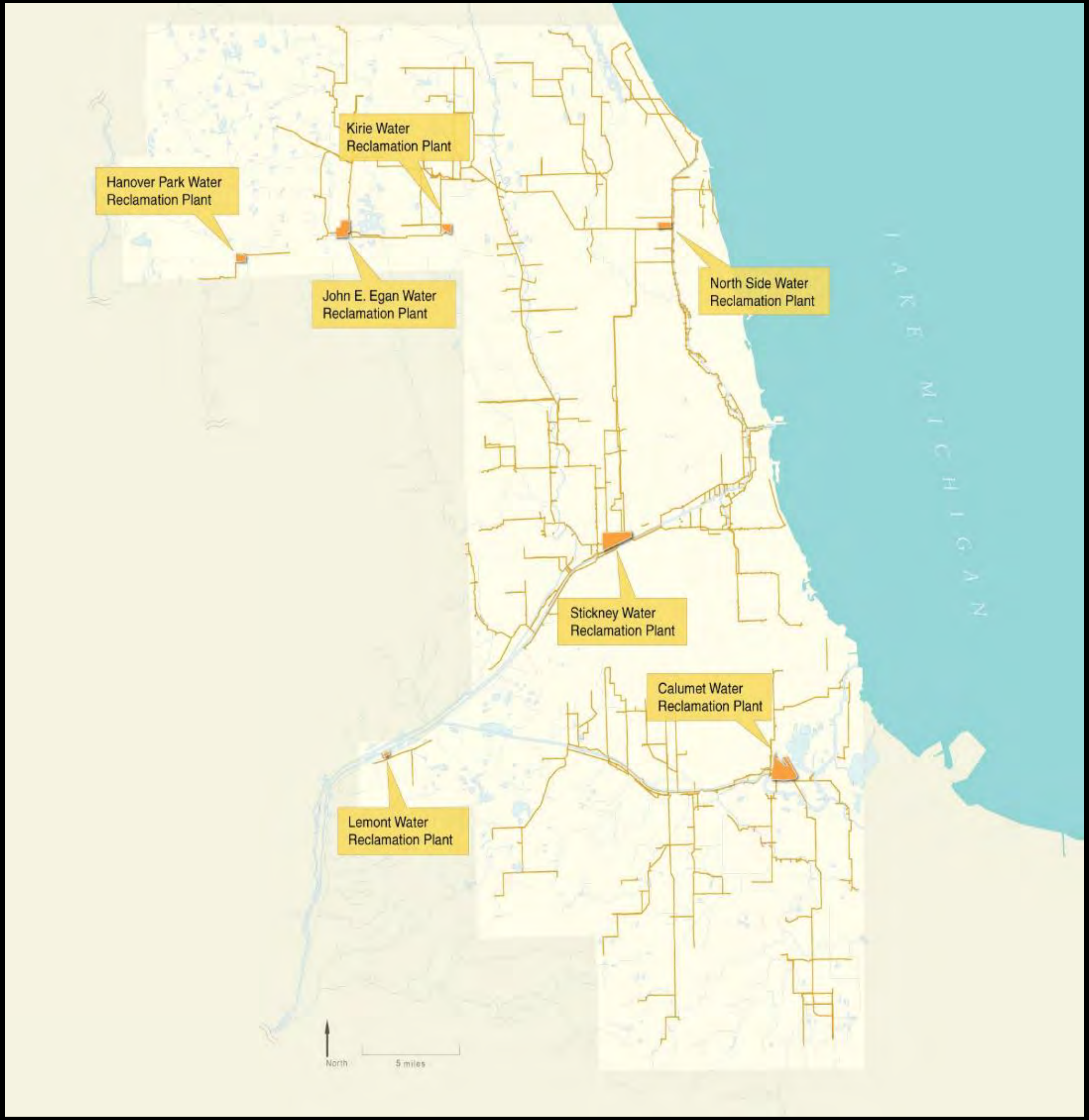


Protecting Our Water Environment





MWRDGC Intercepting Sewers and Water Reclamation Plants



Tunnel and Reservoir Plan

<u>Phase I Tunnels:</u>

Upper Des Plaines
6.6 miles (10.6 km)
Storage: 70 MG (265 ML)

Des Plaines
25.6 miles (41.2 km)
Storage: 405 MG (1,533 ML)

Mainstream
40.5 miles (65.2 km)
Storage: 1,200 MG (4,542 ML)

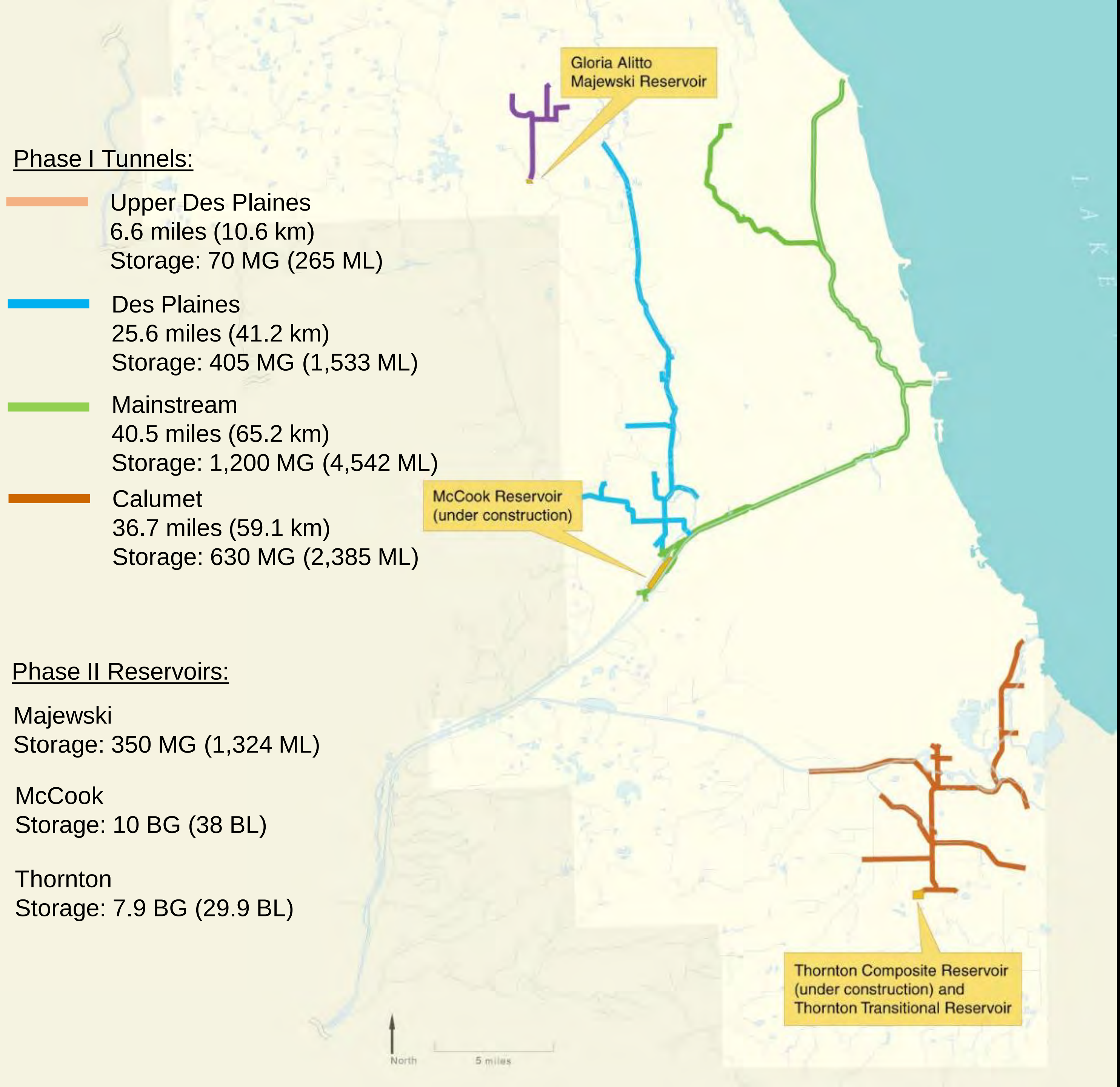
Calumet
36.7 miles (59.1 km)
Storage: 630 MG (2,385 ML)

<u>Phase II Reservoirs:</u>

Majewski
Storage: 350 MG (1,324 ML)

McCook
Storage: 10 BG (38 BL)

Thornton
Storage: 7.9 BG (29.9 BL)



Resiliency At the MWRDGC

Resiliency

It is not just the ability to snap back to where you were before. It is the ability to reshape and improve- to allow the organization to be more resistant to the next set of challenges

Resiliency is Ingrained into the Organization

- The Organization of the MWRDGC focuses on four core areas:
  - **Our Services and Function** – What we were created to do
  - **Our People** – Without a dedicated staff, we cannot accomplish anything
  - **Our Community** – Our purpose is to serve
  - **The Environment** - This encompasses all three above, as well as sets a mode of operations and thinking
- One way the MWRDGC is addressing resiliency is by looking to reduce its environmental footprint, and one pathway is through electricity savings by improving aeration

MWRDGC's Climate Mitigation Goal: Net Zero GHG Emissions

INTERIM TARGETS (from 2005 Level)

Baseline Targets

2025 - 28% Reduction

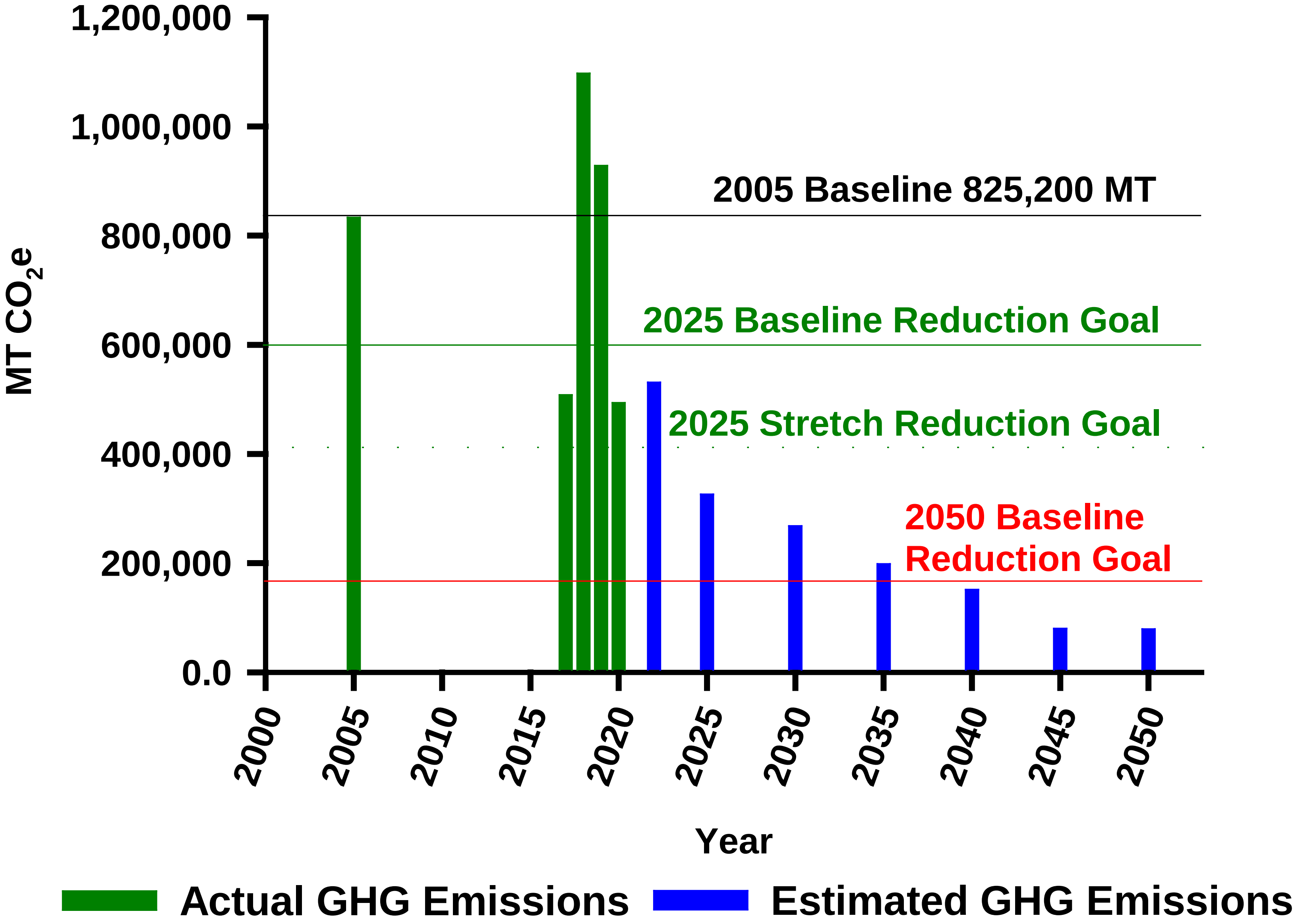
2050 - 80% Reduction

Stretch Targets

2025 - 50% Reduction

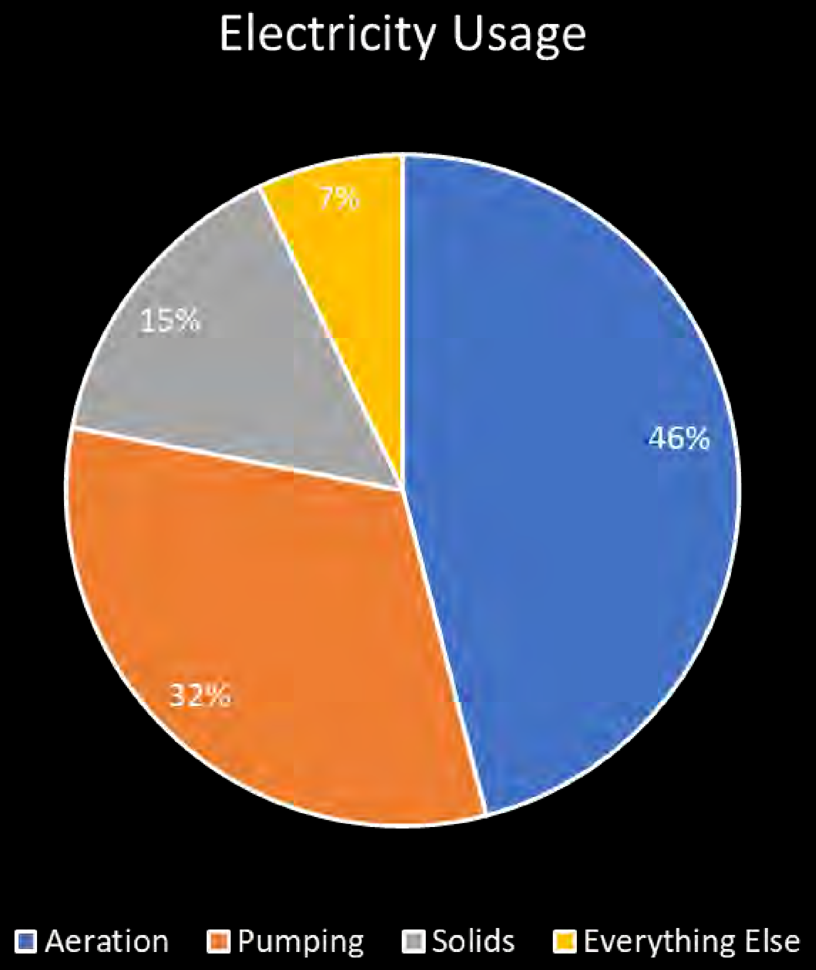
2050 - Achieve Net Zero Emissions

MWRDGC GHG Emissions Reduction Projections



Electricity Use at the MWRDGC

- The 2022 Budget for electricity is approximately $49 Million
- Roughly $22.5 Million is used for aeration
- In 2020, electricity contributed to 211,940 Metric Tons of CO_2E
    - Almost 100,000 CO_2E is from aeration



Aeration is a Necessary Process in Wastewater Treatment

- Increasing oxygen transfer in wastewater treatment, essential for the aerobic organisms (especially with ammonia removal)
- Mixing – keeping solids in suspension
- Scrubbing organics from inorganic grit
- Lifting and moving solids throughout the Water Reclamation Plant
- Potential for Savings in Aeration
    - Installation Dissolved Oxygen (DO) Control and reducing DO
    - Implementing Ammonia Based Aeration Control (ABAC)
    - Conversion from Spiral Roll
    - Granular Sludge (Flow-through and batch processes)

Barriers to Achieving Aerations Savings

- Blower Turndown Capabilities
- Valves
- Mixing Requirements
- Reliable and Robust Sensors
- Treatment Issues
  - Scum
  - Filaments
  - Settling
  - Bias by operators
  - Losing nitrification

Stickney ABAC Test

- A Process Model evaluation showed that there is a potential for 32% savings in airflow via using ABAC
- In 2020, SWRP used approximately $19M in electricity
- SWRP has actuated valves used for DO control, but very limited blower turndown
- Blowers are very large (4,000-10,000 HP, design capacity 70,000-195,000 scfm)
- Blower vane system and controls limit turn down, thus air demand can be rarely matched
- Three ABAC control strategies were evaluated, and one was tested
  - Feedback direct ammonia control
  - Feed-forward ABAC
  - **<u>Feedback cascade ABAC</u>**
- Feedback cascade was selected because
  - Nitrification and DO can be optimized
  - The control algorithm was simple and could be programmed by existing staff

Stickney ABAC Test-Phases

- Phase I – Tested one pair of aerations tanks in each of the 4 batteries at different target effluent ammonia levels (0.75 mg/L, 1.0 mg/L, 1.25 mg/L and 1.5 mg/L)
- Phase 2 –Performed Optimization in one battery
  1. Focused on one battery with a target ammonia of 1.0 mg/L, and an initial minimum airflow of 2,000 scfm for mixing to optimize the system
  2. Changed target ammonia to 1.5 mg/L, and the minimum air was reduced to 1,000 scfm later, with air bumping to prevent solid settling
  3. Change value position limitation to further restrict air flow

SWRP ABAC Test- Results and Observation

- The test showed that there is a potential for air savings of 26% to 28% compared to the existing setup
- Blower limitations are preventing this strategy from realizing electricity savings
- More consistent effluent ammonia levels observed, however ammonia spikes greater than target observed with DO sags
- Spikes were due to infrastructure limitations
- Ammonia sensor require weekly checking and 60 hours per year of maintenance per sensor ($3,300/sensor per year in consumables)
- DO sensors require bi-weekly verification and 25 hours/year for annual sensor maintenance ($750/ sensor per year in consumables)
- Post-aeration needs to be evaluated since this new control scheme may affect permit DO requirements
- It was difficult to tell if there were other treatment issues since the tests were performed on ¼ of a treatment battery

Hanover Park ABAC Test

- Recently a Turbo Blower was installed at the HPWRP, and a test was devised to look at potential for energy savings
- The study was conducted to reduce process air while maintaining NPDES permit compliance
- Original setup had nitrification complete in the first pass (HPWRP has a 2 pass aeration tanks)
- The control tank were set with DO setpoints of 0.5 mg/L in the first pass and 2.5 mg/L in the second pass with a minimum of 200 scfm for mixing in both passes
- The test tank used ammonia readings to establish stepwise DO Setpoints in the first pass with a minimum of 200 scfm. The DO in the second pass was set to 2.0mg/L.

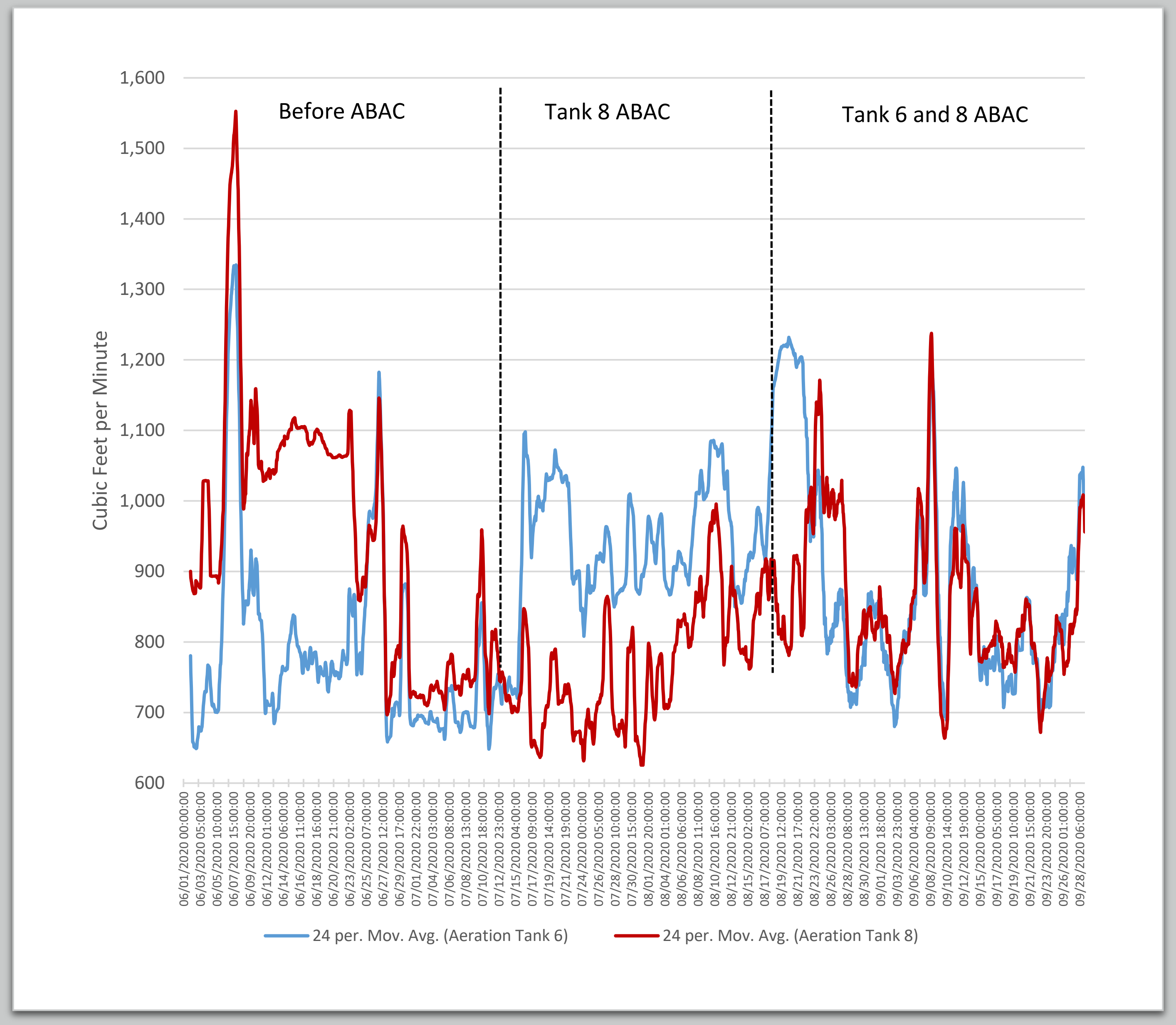
Ammonia	DO Setpoint
<0.5 mg/L	0.25 mg/L
0.5 mg/L<ammonia <0.75mg/L	0.50 mg/L
>0.75 mg/L	1.5 mg/L

Summary of Ammonia and Dissolved Oxygen

Date	Tank #	Initial NH_3-N (mg/L)	Final NH_3-N (mg/L)	Final DO (mg/L)	Mean 1st Pass Air (scfm)	Mean 2nd Pass Air (scfm)	Mean Total Air (scfm)	p-value
7/15/20	6 (Control)	10.3	0.300	3.6	663	231	894	2.40×10^{-05}
	8 (Test)	11.1	0.308	2.0	370	366	736	
7/21/20	6 (Control)	4.7	0.300	6.6	829	207	1,035	7.76×10^{-15}
	8 (Test)	12.3	0.300	1.8	366	369	735	
7/28/20	6 (Control)	5.2	0.300	6.3	676	194	870	3.80×10^{-18}
	8 (Test)	13.4	0.300	1.9	368	304	672	
8/5/20	6 (Control)	7.7	0.300	5.2	722	206	928	3.74×10^{-07}
	8 (Test)	14.0	0.300	2.0	383	444	827	
8/13/20	6 (Control)	13.7	0.300	2.6	444	428	872	3.50×10^{-05}
	8 (Test)	14.3	0.300	1.7	463	333	796	

Hanover Park WRP Air Flow Comparison and Results

- Permit compliance was achieved for both tanks
- Test Showed a 17% reduction in air to aeration batteries
- Filaments could be an issue, so this must be monitored
- There were issues with filaments during test and after
- Properly functioning and calibrated probes are essential
- Low DO at beginning of the tank may be causing settling issues
- Entire plant has since been converted to ABAC – and a conservative annual, calculated savings is estimated to be $33,000
- 2020 Electricity Expenditure was approximately $438,000



Modern Aeration Diffusers – Study and Pilot

- An aeration modeling study was conducted at the O'Brien WRP as part of a Phosphorus Feasibility Study (GPS-X)
- Study compared ceramic plate spiral roll, membrane panels, and membrane disks
  - Simplified the aeration tank layout
  - Simulated a dynamic year
  - Looked at dynamic airflow requirements and yearly energy use difference between diffuser alternatives
  - Estimated net present value for a 20-year life

Modern Aeration Diffusers - Summary

COSTS	MEMBRANE DISC	MEMBRANE PANEL	CERAMIC PLATE
Aeration Equipment & Installation	$10,085,989	$22,742,453	$16,648,290
Aeration Basin Reconfiguration	$9,568,555	$9,568,555	$9,568,555
Subtotal	$19,654,544	$32,311,008	$26,216,845
Contractor Overhead and Profit	$4,913,636	$8,077,752	$6,554,211
Subtotal	$24,568,181	$40,388,760	$32,771,056
50% Contingency	$12,284,090	$20,194,380	$16,385,528
Grand Total	$ 36,852,271	$60,583,140	$49,156,585

DIFFUSER TYPE	DIFFUSER REPLACEMENT COST	ANNUAL ELECTRICITY COST[1]		ANNUAL MAINTENANCE COST[1]	20 YR PRESENT WORTH OF O&M AND REPLACEMENT COSTS	
		DO 1.0 mg/L	DO 2.0 mg/L		DO 1.0 mg/L	DO 2.0 mg/L
Membrane Disc	$485,953	$1,309,374	$1,638,858	$114,276	$24,159,359	$29,647,052
Membrane Panel	$4,211,921	$1,087,988	$1,514,212	$272,745	$26,242,745	$33,359,082
Ceramic Plate	$0	$3,050,260	$3,795,350	$199,659	$54,197,941	$66,623,598

1- Average cost during the design period

Table 4-5 Summary of Life Cycle Costs for Diffuser Alternatives

COSTS	MEMBRANE DISC	MEMBRANE PANEL	CERAMIC PLATE
Capital Cost[1]	$36,852,271	$60,583,140	$49,156,585
20 Year O&M Cost[2]	$35,858,585	$39,098,187	$81,008,585
20 Year Net Present Value	$72,710,856	$99,681,327	$130,174,170

1 – Includes cost of aeration tank reconfiguration from phosphorus removal feasibility study

2 – 20-year O&M cost is based on operation at 2.0 mg DO / L

Next Steps

- Currently MWRDGC has an aeration battery at the Egan WRP that is slated to test a new configuration and plates
- Battery previously had full floor aeration installed in 2000, however it suffered from a number of treatment issues
- Aeration system has been redesigned, and a contract is set to be awarded in summer of 2022 to install improvements to test
- Test will inform the direction of other installations across the MWRDGC
- A turbo blower with turn down is scheduled to be installed at the Egan WRP by 2024

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Questions ?

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