AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

Aqua MultiBore® C-Series Ceramic Membrane Applications

Dave Lamphere
Product Manager, Membranes

Protecting the World's Water.

Key Takeaways

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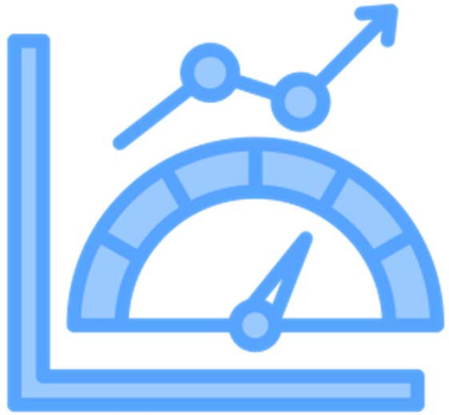
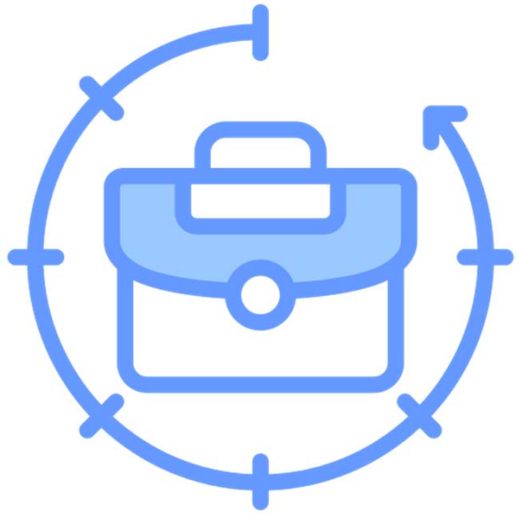
Review Membrane Applications



Demonstrated Best Product Performance



Proven Experience

Presentation Outline

AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

- Review Best Applications
- Experience with Proven Longevity
- Case Studies
- Summary

Membrane Markets and Applications

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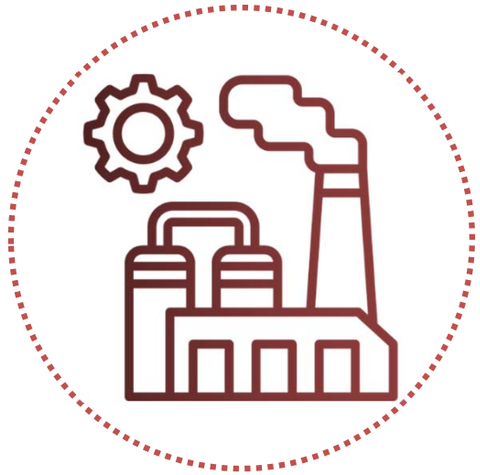
MUNICIPAL

- ❑ Drinking Water
- ❑ Wastewater Reuse



INDUSTRIAL

- ❑ Process Water
- ❑ Wastewater Treatment
- ❑ Hard to Treat Waters

Membrane Applications

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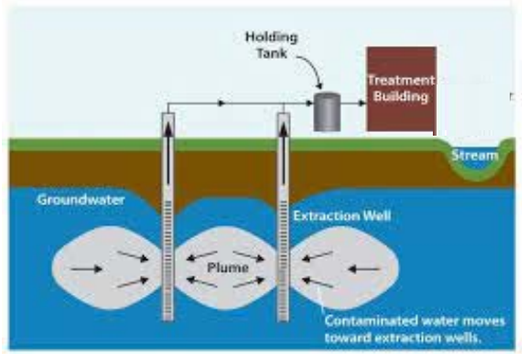
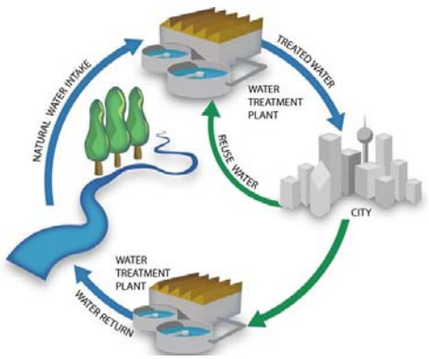


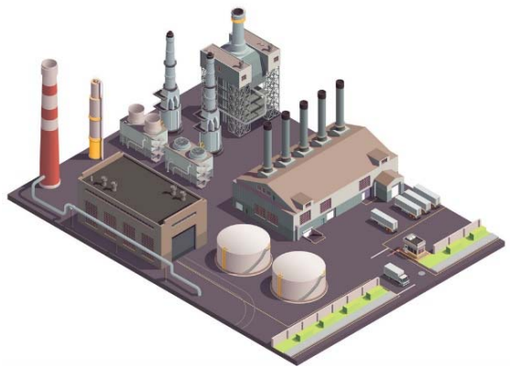
Groundwater



Surface Water



IPR/DPR



Industrial



NF/RO Pre-Treatment

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Best Applications

Leverage C-Series Membrane Advantages

AQUA-AEROBIC SYSTEMS, INC.
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1 LOW OPERATIONAL COST



- ✓ No membrane replacement
- ✓ High permeability, low TMPs
- ✓ Generates less waste

2 EASE OF OPERATION



- ✓ No pinning fibers
- ✓ Handles High Solids
- ✓ Easily cleaned, minimal cleaning

3 LONG LIFE



- ✓ 20 year no-break warranty
- ✓ 60 year life
- ✓ Proven longevity

4 UNIQUE FEATURES



- ✓ Handles high pressure
- ✓ Performs better with pre-ozonated feed

Leverage C-Series Membrane Advantages

AQUA-AEROBIC SYSTEMS, INC.
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- ✓ Generates less waste

Low Operation Cost - Case Study

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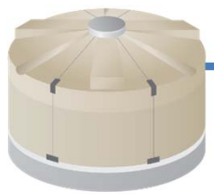
River Water Source



Plate Settler



C-Series Membranes



Clearwell

Distribution

LOCATION

Inman Campobello Water District Inman, SC

PROJECT INFORMATION

Clarified River Water
Pilot Duration = 10 months

COMPETITION

Pressure Polymeric Membranes
Granular Media

Ceramic vs. Polymeric

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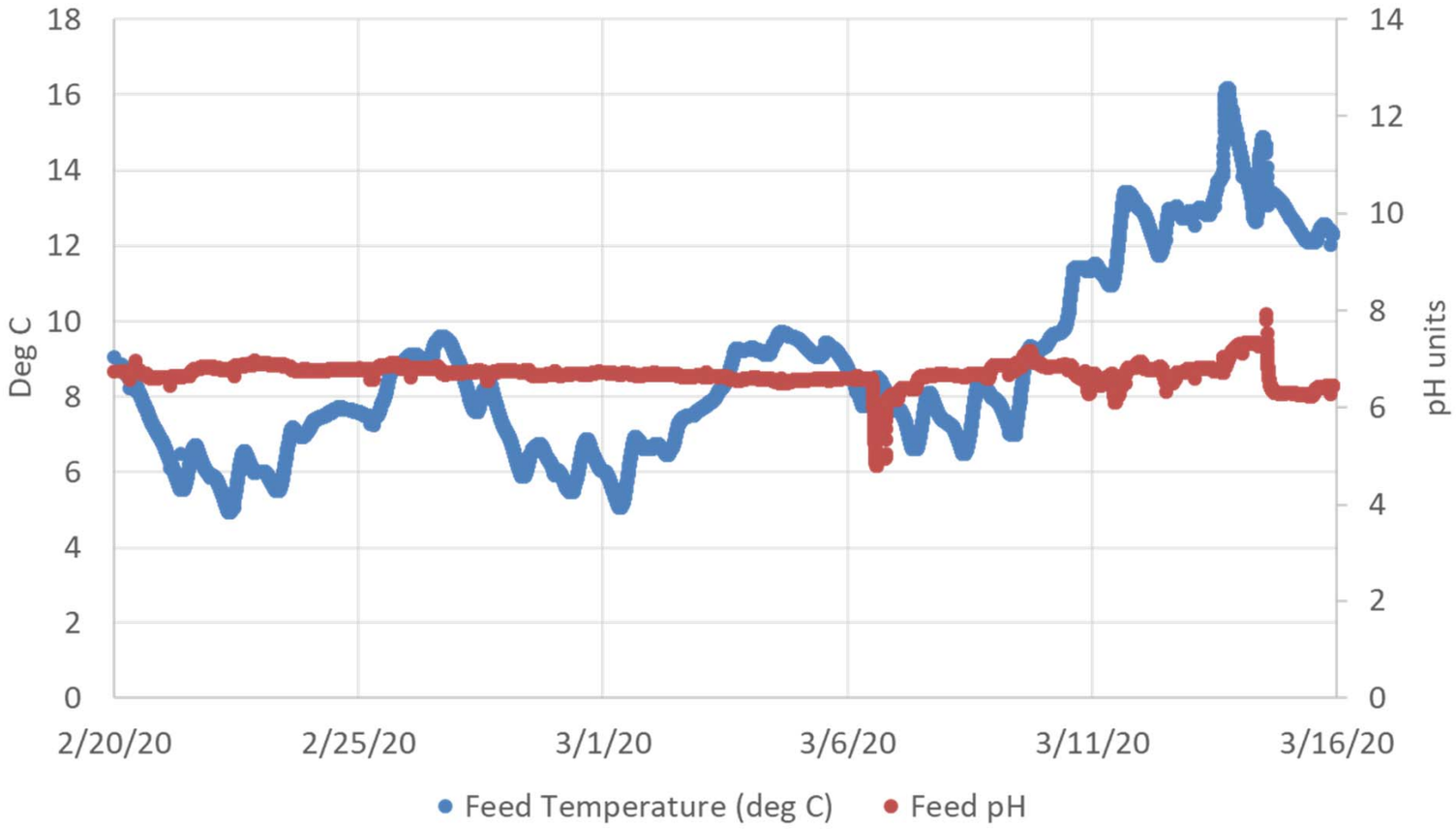
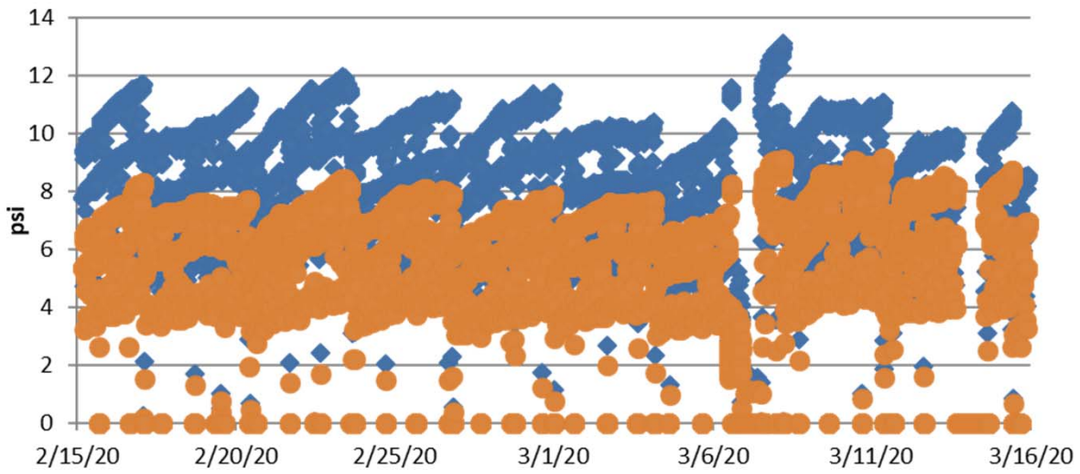
Phase 5 Influent Temperature and pH



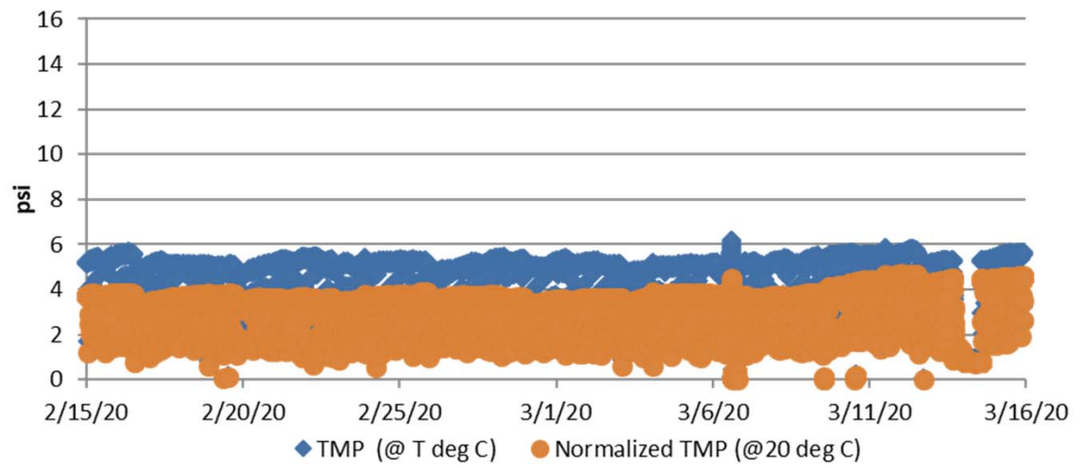
Ceramic vs. Polymeric

Phase 5 TMPs

- Polymeric Membrane at 55 gfd (93 lmh) flux



- Ceramic Membrane at 125 gfd (212 lmh) flux



Ceramic vs. Polymeric

Phase 5 Permeabilities

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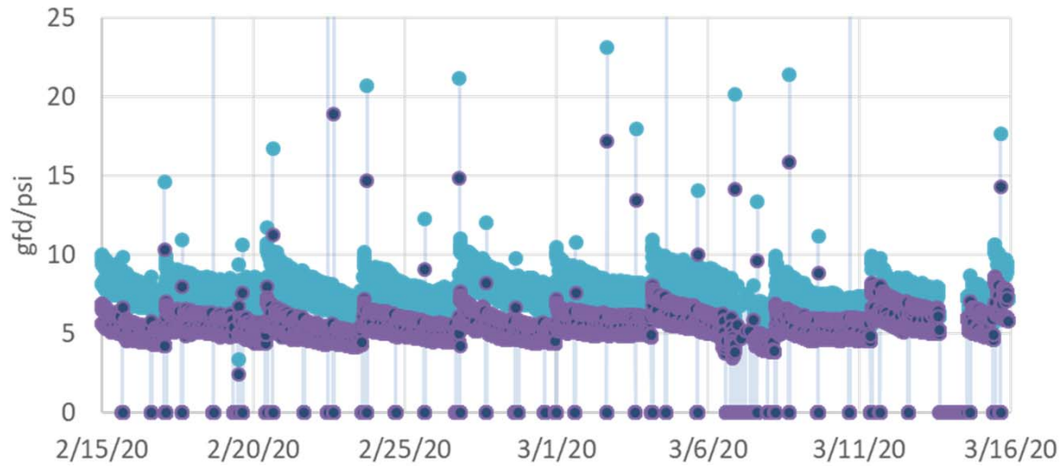
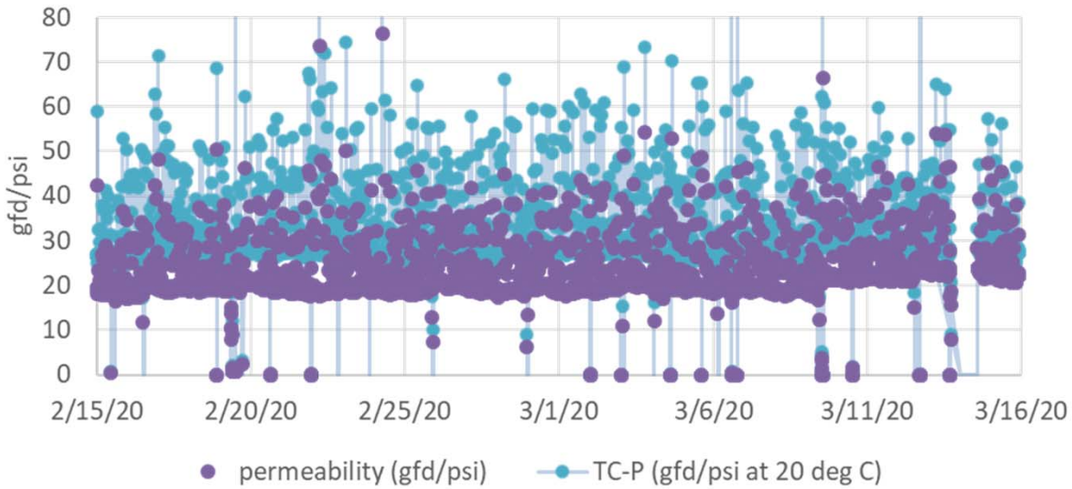
- Polymeric Membrane



- Ceramic Membrane



Ceramic vs. Polymeric

Estimated CIP Frequencies

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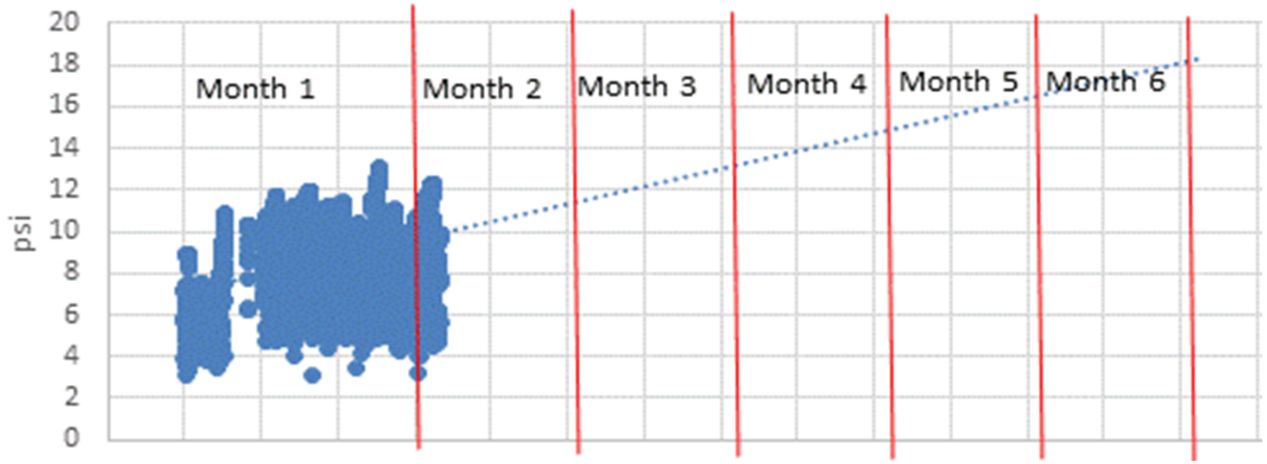
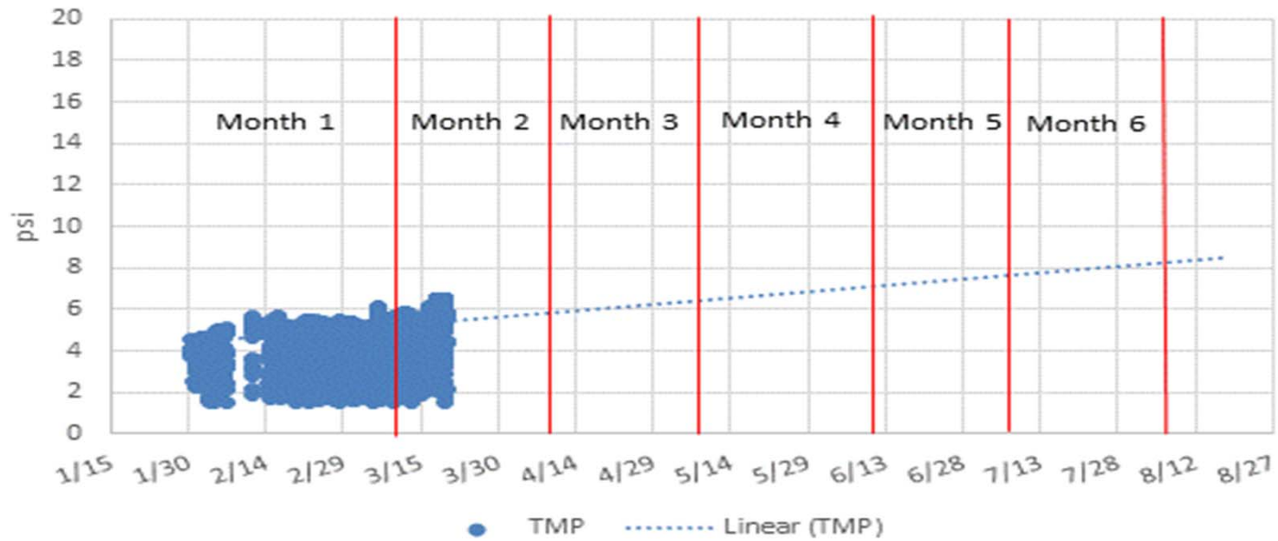
- Polymeric Membrane



- Ceramic Membrane



Low Operation Cost - Case Study

Demonstrated Results

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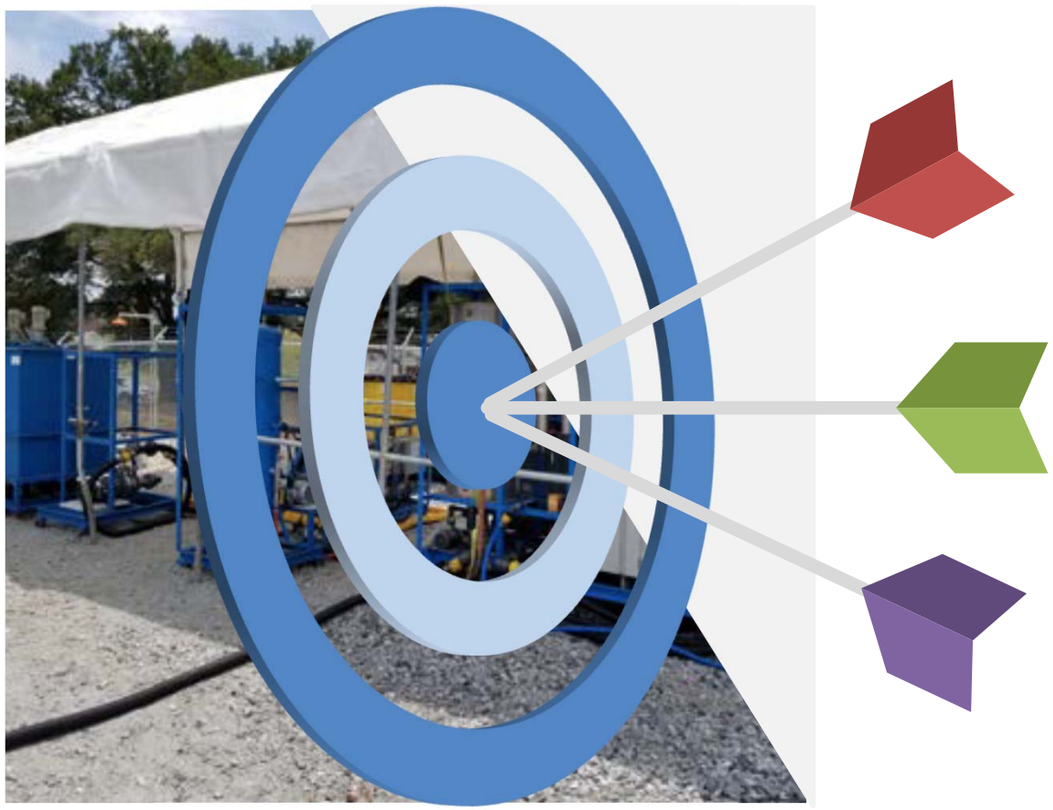

HIGH FLUX

Demonstrate More Than 2x
Polymeric Membrane Flux

LOW TMP

Operating Pressure (TMP): 50%
Lower Than Polymeric Membrane

LOWER CHEMICAL USAGE

Used 33% Less Chemicals for Cleaning

New Installation

Aqua MultiBore® C-Series Ceramic Membranes



Design Points

- System Design = 4 MGD
- (2) Skids of 72 Modules Each
- Start-up Summer 2026

Project Benefits

✓ Polymeric Failures and Pinning

✓ Longer Life

✓ More Resilient to Fouling – easier to operate

✓ Higher Recovery – less waste to deal with

Leverage C-Series Membrane Advantages

AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

1 LOW OPERATIONAL COST



- ✓ No membrane replacement
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2 EASE OF OPERATION



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3 LONG LIFE



- ✓ 20 year no-break warranty
- ✓ 60 year life
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4 UNIQUE FEATURES



- ✓ Handles high pressure
- ✓ Performs better with pre-ozonated feed

Backwash Treatment Application

C-Series Membrane Backwash Treatment

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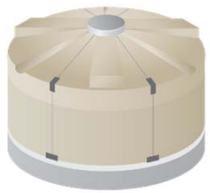
Conventional



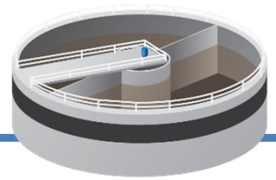


Disinfection



Conventional / Direct Filtration or MF/UF

Clear Well



Spent Filter Backwash Waste

Sedimentation

Backwash Treatment Application

C-Series Membrane Backwash Treatment

AQUA-AEROBIC SYSTEMS, INC.
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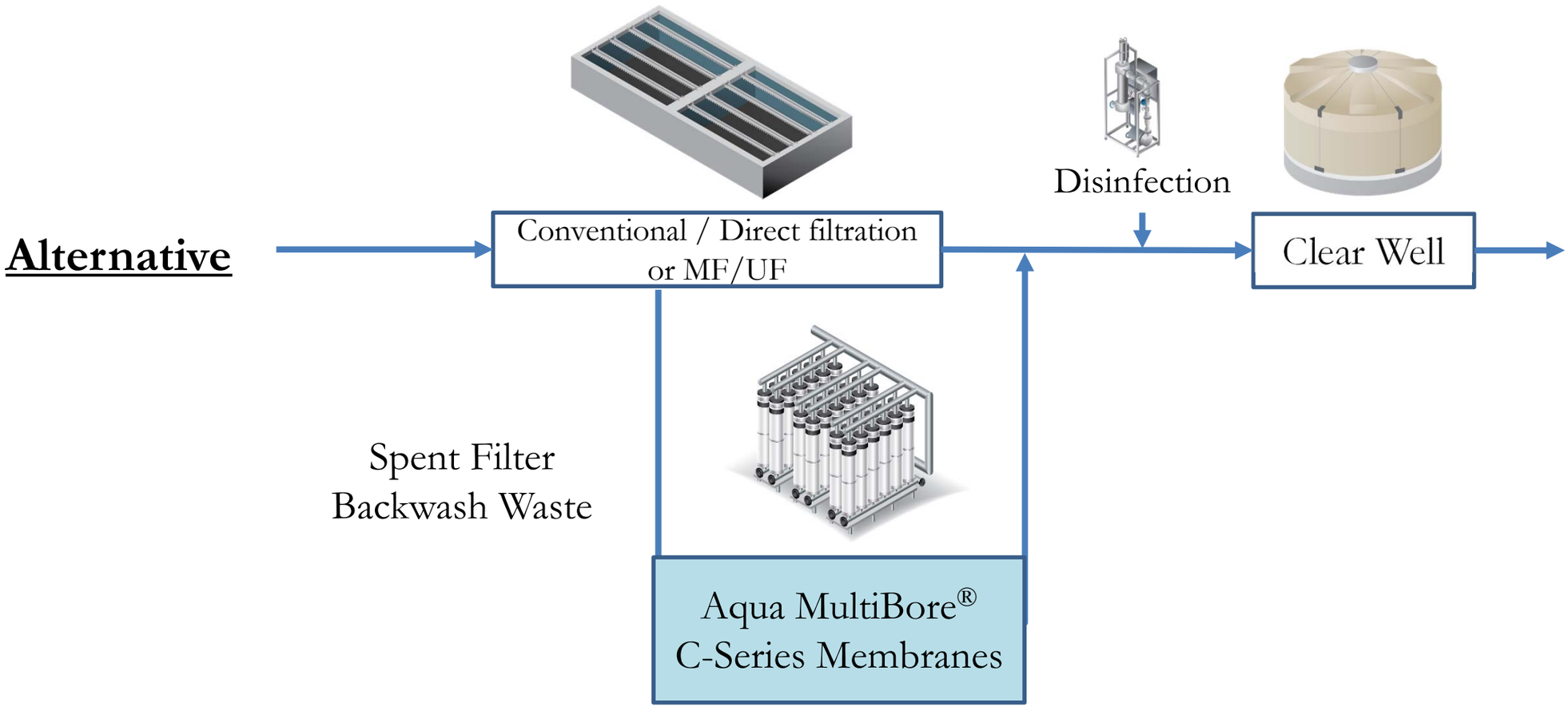

Case Study – Vitens Wierden WTP, Netherlands

AQUA-AEROBIC SYSTEMS, INC.
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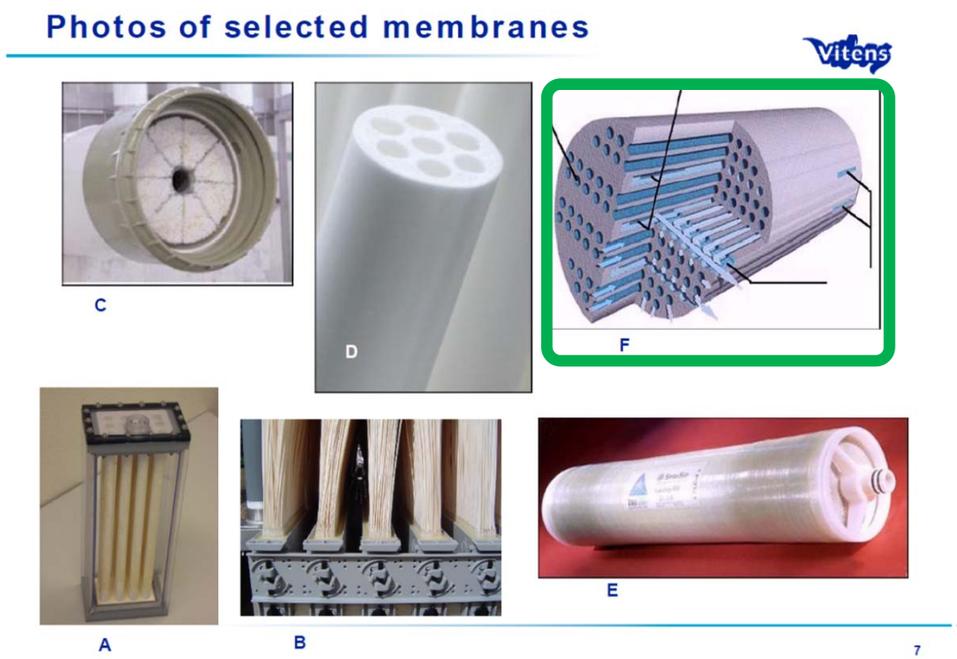
Aqua MultiBore® C-Series was selected to treat filter backwash water from sand filters and achieved >99% recovery of the filter backwash water.

✓ Pilot tested six different types of membranes





Case Study – Vitens Wierden WTP, Netherlands

AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

Results

Vitens

Membranes -->	A	B	C	D	E	F
Polymer		x	x	x	x	
Ceramic	x					x
Submerged	x	x			x	
Pressurised			x	x		x
Inside - out				x		x
Outside - in	x	x	x		x	
Tubular	x	x	x	x		x
Spiral wound					x	
Micro filter	x					x
Ultra filter		x	x	x	x	

Membranes -->		A	B	C	D	E	F
Turbidity		++	++	++	++	++	++
Variations in Q_{feed}		- -	+ +	+ +	+ +	0	-
Stability of process		-	+	-	+	- -	++
Recovery		0	-	0	+	- -	++
Sludge process		+	++	-	+	-	++
Chemical costs	€/m³		0,022		0,010		0,006
Energy costs	€/m³		0,012		0,003		0,003
Total costs	€/m³		0,55		0,42		0,44

Membranes A, C and E did not fulfil the criterion of stable process conditions.

✓ Costs are minimized due to the long life span and low energy costs

High Pressure Case Study - Case Study

AQUA-AEROBIC SYSTEMS, INC.
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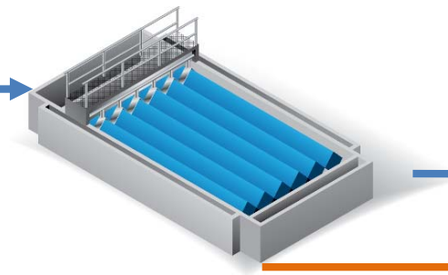
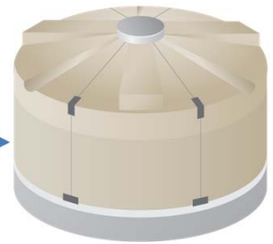
Ground Water
5.79 MGD

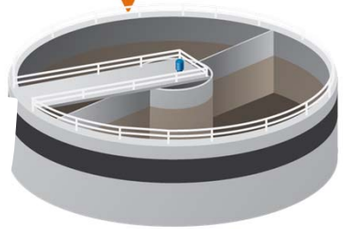


Sand Filter



Storage

Distribution
5.4 MGD



BW Settler &
Sludge Thickener
60.8 MG/year



To Surface Water
60.5 MG/year

High Pressure Case Study - Case Study

AQUA-AEROBIC SYSTEMS, INC.
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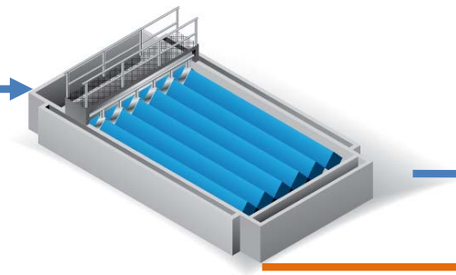
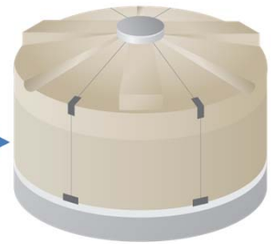
Ground Water
5.79 MGD



Sand Filter



Storage

Distribution
5.65 MGD

Reuse
100.2
MG/yr



C-Series
Membranes
100.4 MG/yr

99%
Recovery

Case Study – Vitens WTP, Netherlands

AQUA-AEROBIC SYSTEMS, INC.
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Design Daily Flow of the plant = 5.4 MGD

BW Water Recovery System = 99%

Membrane Configuration	BW Recovery: 24 Membranes - 12 Element x 2 Racks x 1 Unit
Flux (BW Recovery)	Average: 50 GFD Peak: 70 GFD
Source Water	Ground Water

Aqua MultiBore® C-Series

Backwash Treatment Advantages

- ✓Higher Recovery – more water from same plant
- ✓Less Challenges Due to Spent Filter Backwash Recycle
- ✓Less Wastes
- ✓Less Chemicals
- ✓Higher Integrity - no membrane breakage

AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

Leverage C-Series Membrane Advantages

AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

1 LOW OPERATIONAL COST



- ✓ No membrane replacement
- ✓ High permeability, low TMPs
- ✓ Generates less waste

2 EASE OF OPERATION



- ✓ No pinning fibers
- ✓ Handles High Solids
- ✓ Easily cleaned, minimal cleaning

3 LONG LIFE



- ✓ 20 year no-break warranty
- ✓ 60 year life
- ✓ Proven longevity

4 UNIQUE FEATURES



- ✓ Handles high pressure
- ✓ Performs better with pre-ozonated feed

Proven Long Life

AQUA-AEROBIC SYSTEMS, INC.
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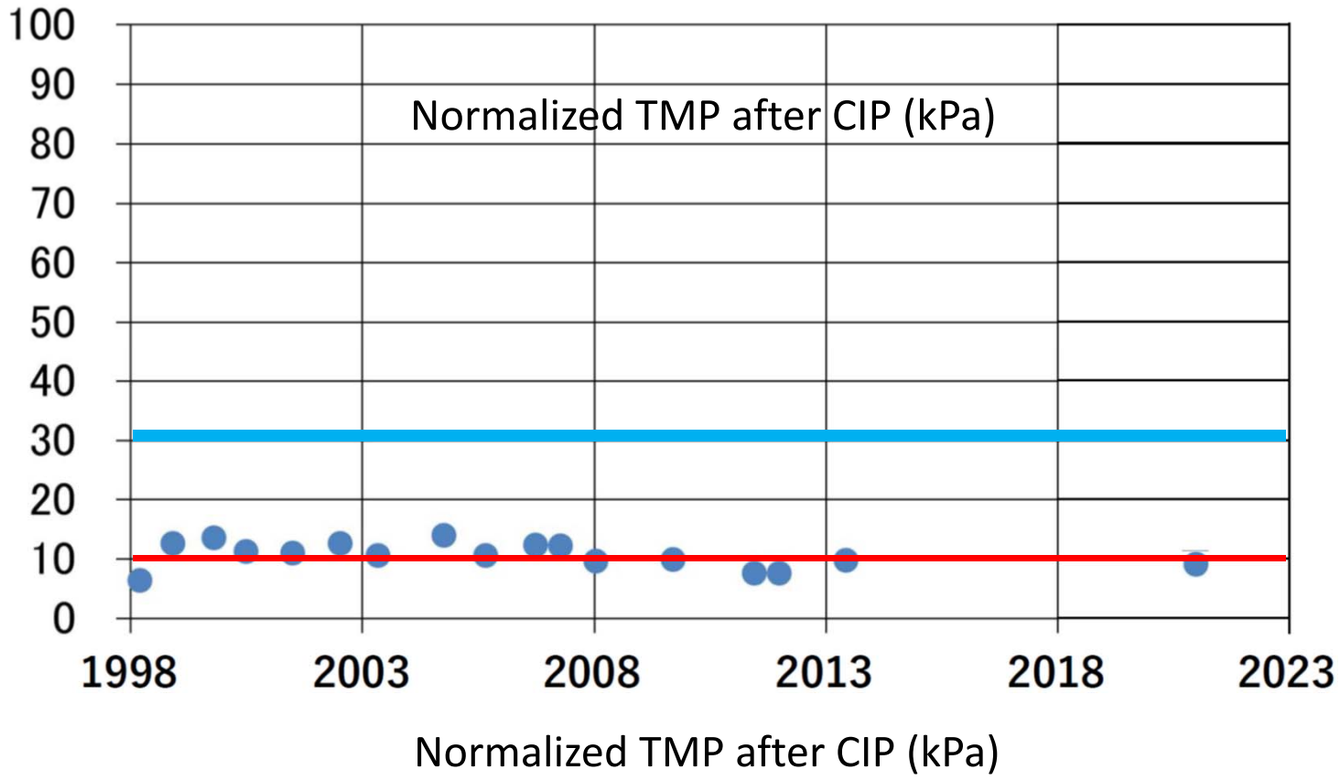
Capacity: 0.2MGD
Source water: River-Bed Water
CIP interval: One Year
Recovery: >99%

DWTP in Kyoto (Start up in 1998)



Operating for

28 years

Membrane replacement suggested TMP

Stable TMP
(No CIP after 2014)

Leverage C-Series Membrane Advantages

AQUA-AEROBIC SYSTEMS, INC.
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RO Pre-Treatment Application

High Pressure Case Study - Case Study

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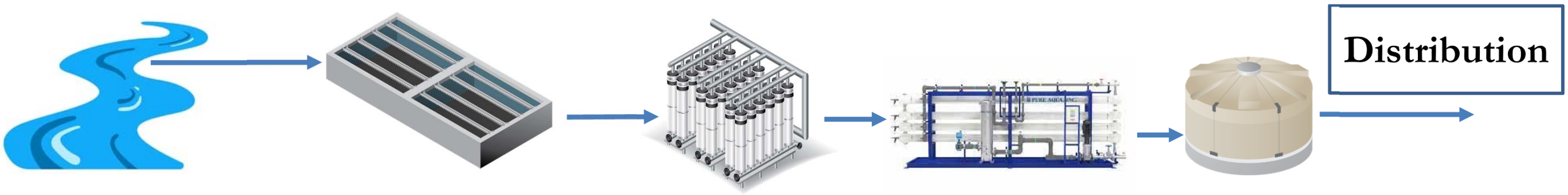

River Water Source → Plate Settler → C-Series Membranes → RO System → Clearwell → Distribution

LOCATION

Bruce Hamler WTF,
Rome, Georgia

PROJECT INFORMATION

Two River Water Sources
Flocculation & Sedimentation
Pilot Duration = 3 months

COMPETITION

Pressure Polymeric
Submerged Polymeric

High Pressure Case Study - Case Study

AQUA-AEROBIC SYSTEMS, INC.
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- Pilot Project Drivers
  - RO Pretreatment for PFAS removal
  - Superior MF Effluent Quality
    - Low SDI
    - Low Residual Al

	SDI	Residual Al (mg/l)
RO Requirment	<3.0	0.10

Improved RO Performance!

Innovative Application

AQUA-AEROBIC SYSTEMS, INC.
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Direct Couple RO Strategy

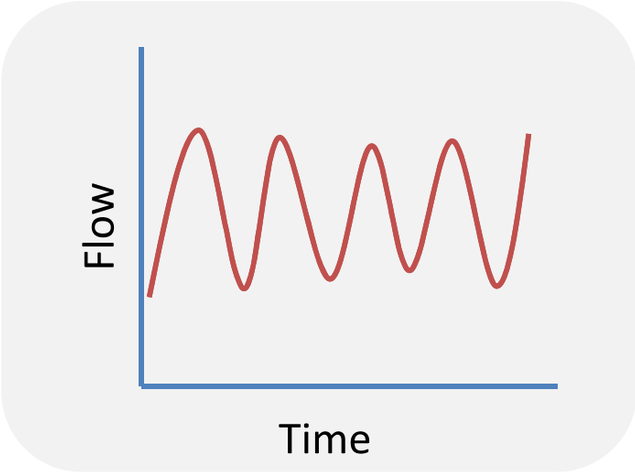
- Ability to **Handle High Pressure**
  - Delivering 30-50 psi downstream of MF
    - **Saves On Downstream Equipment Cost**
      - RO feed pump size
      - No need for break tank or cartridge filters **– Saves $$ on O&Ms**



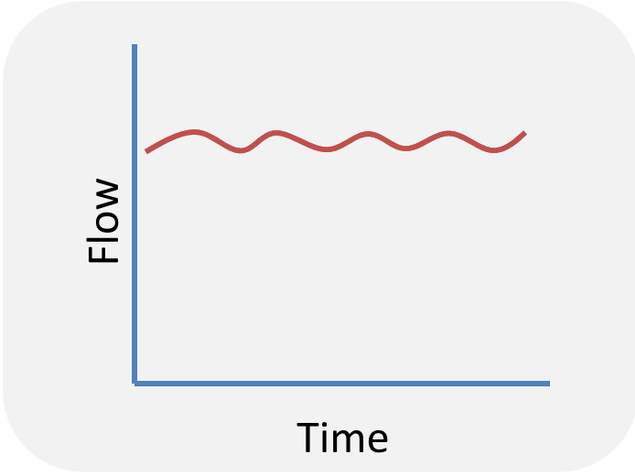
Innovative Application

AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

Typical Membrane System Flow



Constant Flow Design



Unique C-Series System Design

- Row Isolation

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Pre-Ozonated Feed Application

Pre-Ozonated Feed

C-Series Systems Perform Better

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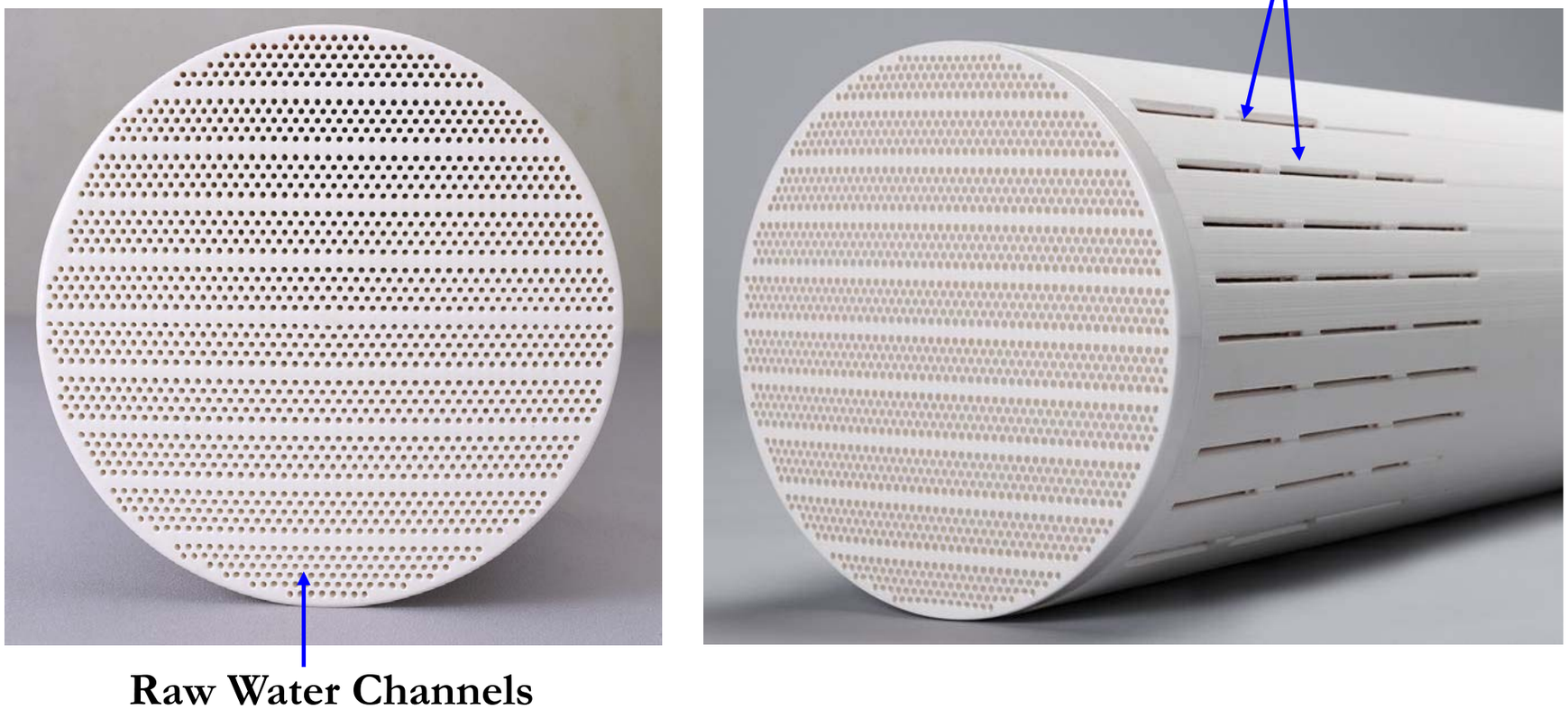

- Single piece of ceramic = ***highly durable***
- No glue or epoxy

Pre-Ozonated Feed

C-Series Systems Perform Better

AQUA-AEROBIC SYSTEMS, INC.
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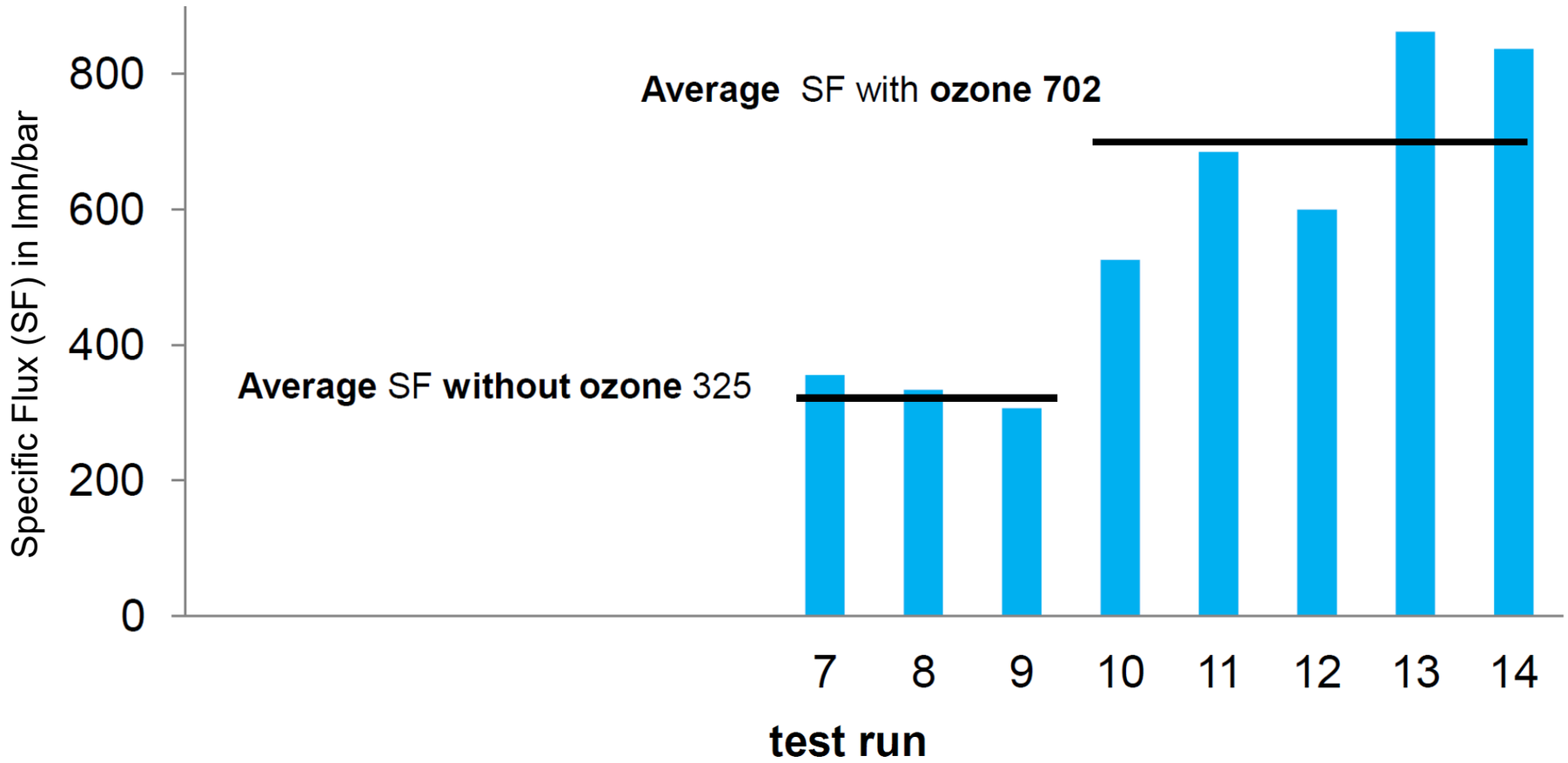

Pre-Ozonated Feed

C-Series Systems Perform Better

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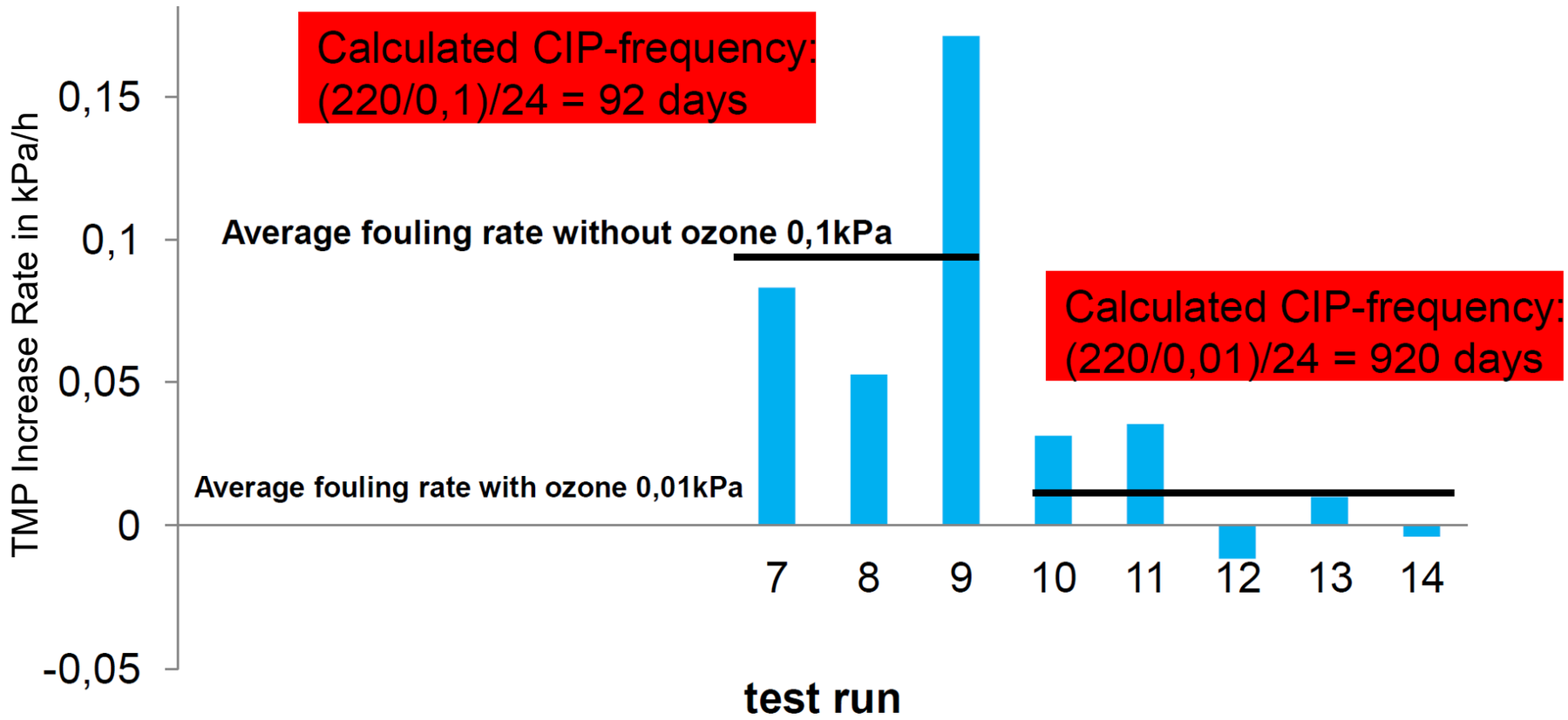

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Industrial Application

Industrial C-Series Application

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Frac Water Treatment Plant

- 0.25 MGD Mobile System allowing reuse of flowback water at different wells
  - Explosion-Proof Feed Skid
  - Membrane Skid with Cross-Flow Recycle Pumps
  - CIP Skid







C-Series Installations

TX Frac Water Treatment Plant

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Sample ID	Total Fe	TDS	pH	TSS >0.7micron	O&G
Untreated	76.8	101,120	7.36	528.0	67.2
Filtrate	<1	101,376	6.94	9.8	<1
Removal %	<98.7	-	-	98.1	>98.5

- More than 98% removal of iron, total suspended solids (TSS), and oil & grease (O&G)
- Flux at 46 gfd (78 lmh)
- TMPs at 7 – 9 psi



AQUA-AEROBIC SYSTEMS, INC.
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Piloting Capabilities

Piloting Capabilities

AQUA-AEROBIC SYSTEMS, INC.
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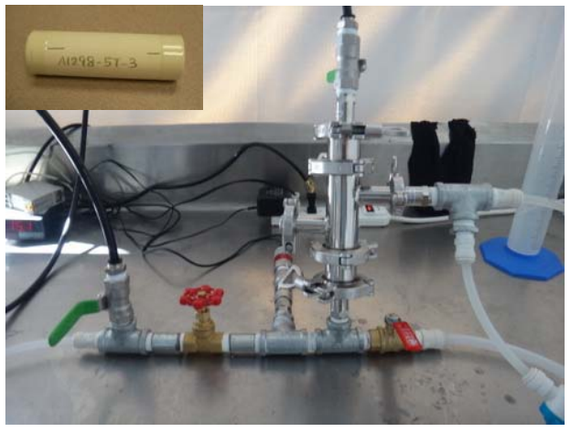
Bench-Scale Testing



- Flow rate: 0.03 gpm (0.11 L/min) at 100 gfd
- Membrane Area:
  - 1” OD x 3” long = 0.44 ft^2
- Manual Single Element System

Small-Flow Pilots



- Uses same membrane as the bench test unit
- Each is fully-automated

Full Scale Pilot



- Flow Rate: 50 gpm
- Flux Rate: 275 gfd
- Full Scale Module
- Fully-Automated
- Skidded and Containerized

Piloting Capabilities

AQUA-AEROBIC SYSTEMS, INC.
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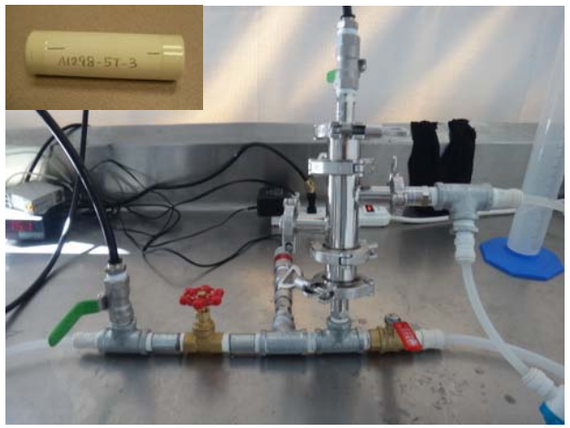
Bench-Scale Testing



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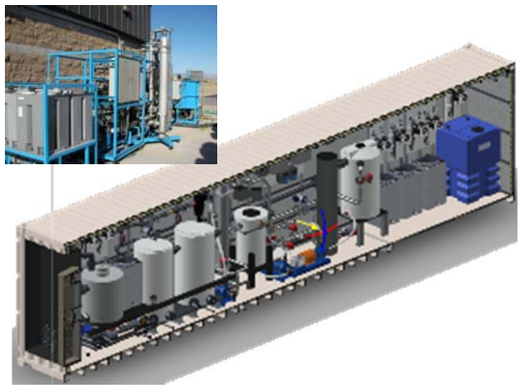
- Each is fully-automated

Full Scale Pilot



- Flow Rate: 50 gpm
- Flux Rate: 275 gfd
- Full Scale Module
- Fully-Automated
- Skidded and Containerized

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Summary

Key Takeaways

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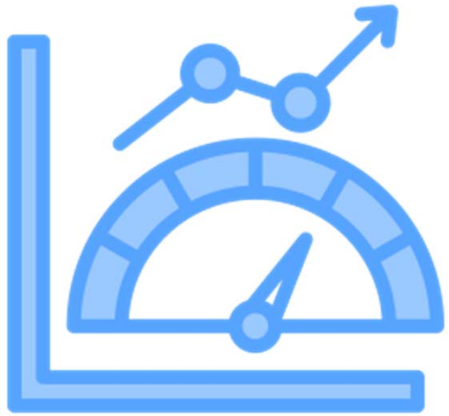
Review Membrane Applications



Demonstrated Best Product Performance



Proven Experience

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Questions & Discussion

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Aqua MultiBore® C-Series Ceramic Membrane Applications

Dave Lamphere
Product Manager, Membranes

Protecting the World's Water.