

# Operation of the Membrane Bioreactor for Municipal Wastewater Treatment

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# Presentation Objectives

- Introduce technology configuration
- Define process terminology
- Discuss process performance
- Outline process control/monitoring/troubleshooting
- Summarize maintenance requirements

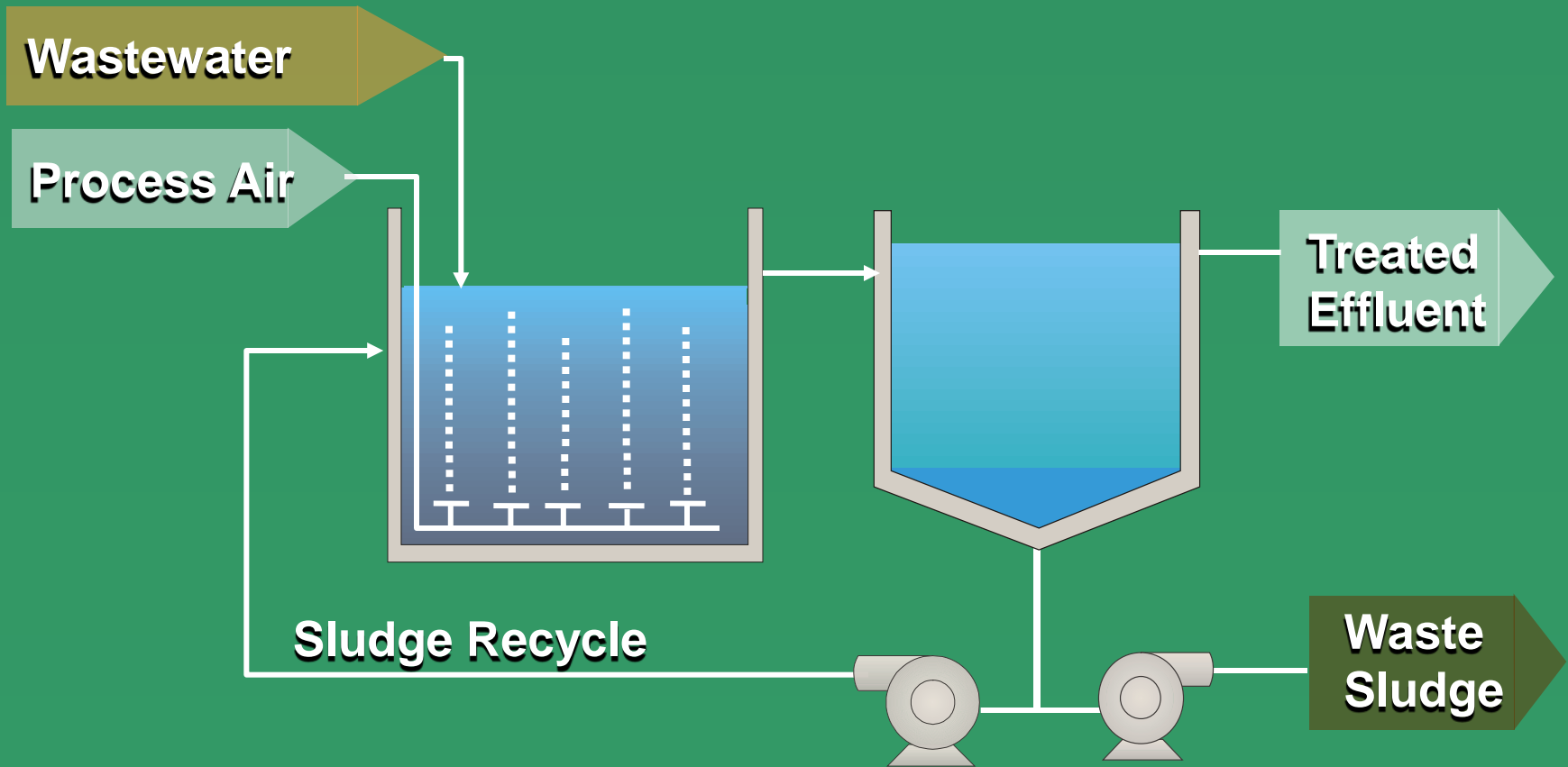
## Current Membrane Bioreactor Manufacturers

- Zenon (Canada)
- USFilter (Australia, USA)
- Kubota (Japan)
- Mitsubishi (Japan)

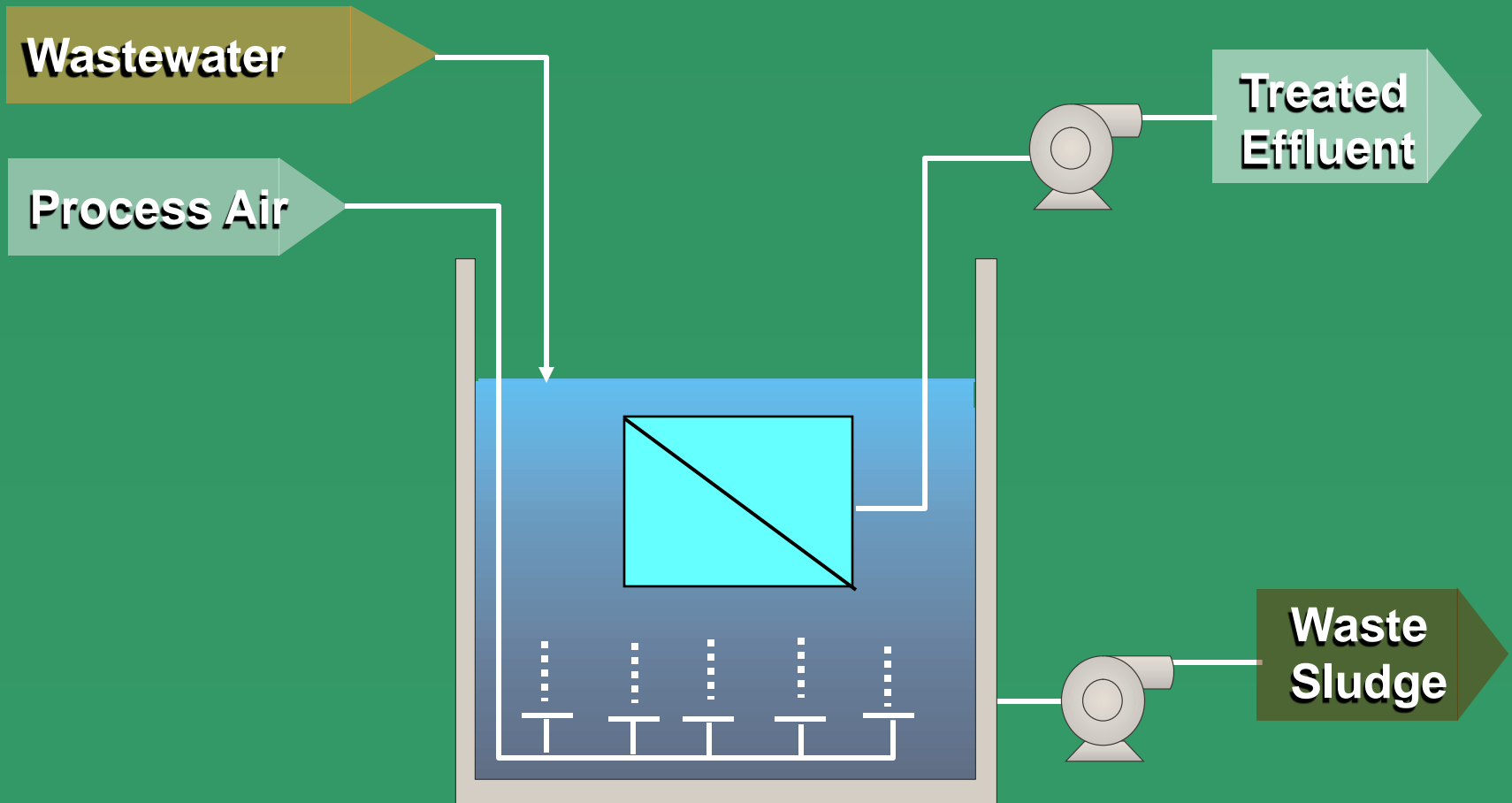
## Current Membrane Bioreactors in the Pacific Northwest

- Tulalip Facility - Marysville, WA [Enviroquip/Kubota]
- Duvall, WA [Zenon in construction]
- Stevens Pass, WA [USFilter in construction]
- Bandon Dunes, OR [Enviroquip/Kubota installed]
- Port Orchard, WA [Zenon in design]

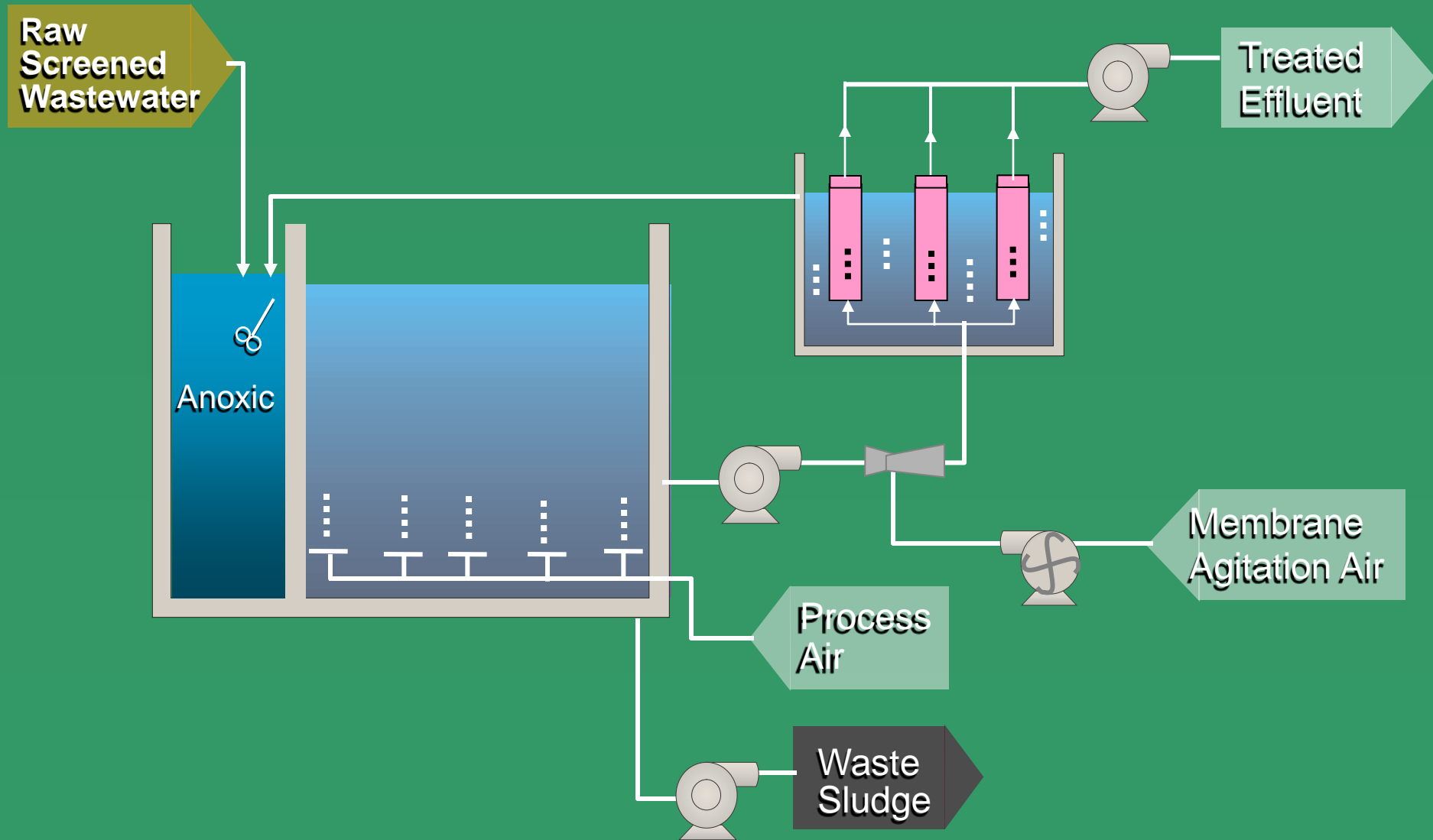
# Conventional Activated Sludge



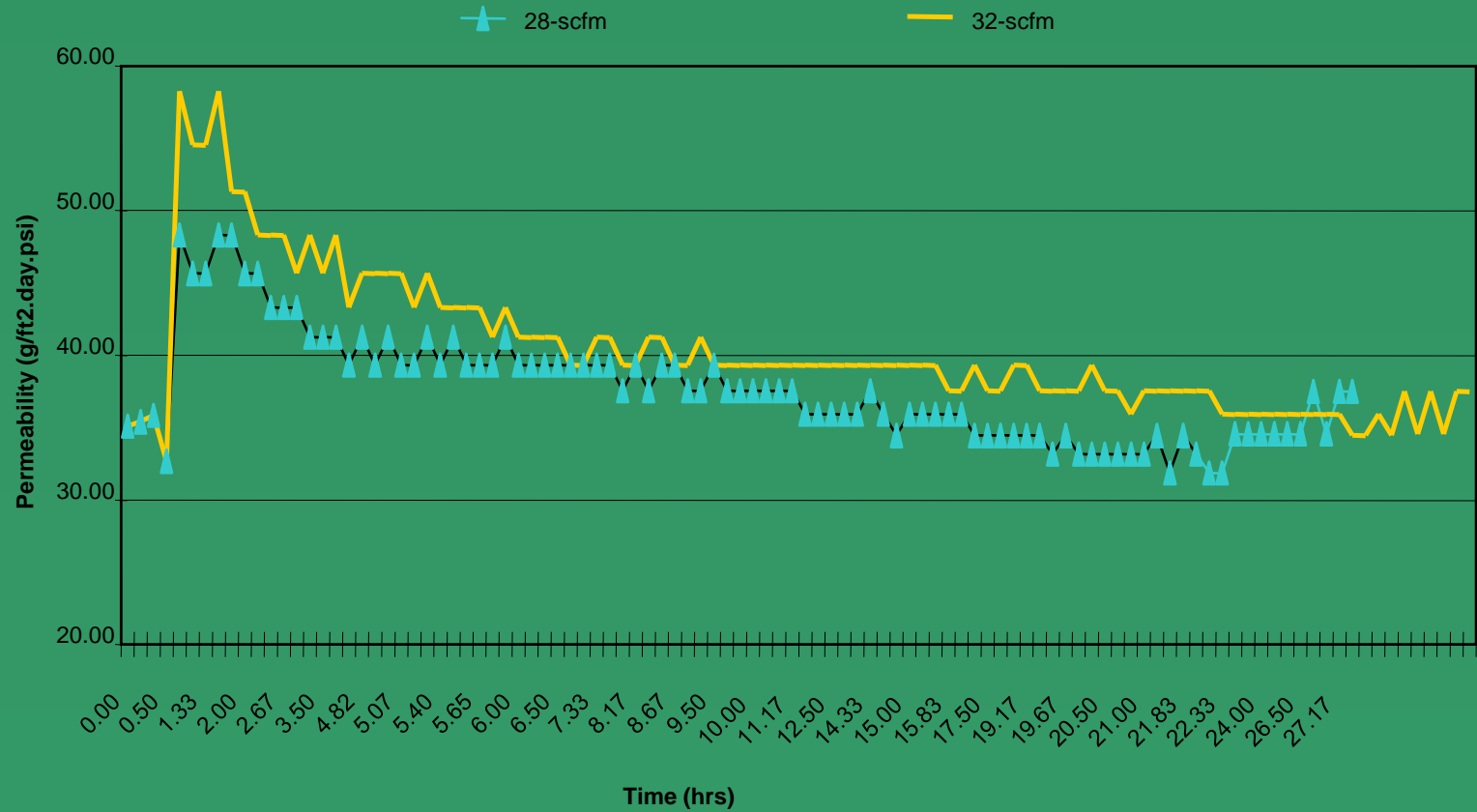
# General MBR Concept



# US Filter System Concept



# Permeability at Peak Flow Conditions (2Q-28 gfd)





## Membrane Bioreactor (Membrane Characteristics)

- Polymeric material construction
- Hollow fiber or plate
- Pore size ranging from 0.035 to 0.4 micron
- Effluent = permeate or filtrate

## Membrane Classification

Size, Microns	Ionic Range	Molecular Range		Macro Molecular Range		Micro Particle Range	Macro Particle Range	
	0.001 (nanometer)	0.01	0.1	1.0	10	100	1000	
Molecular Weight (approx..)	100	1,000	100,000	500,000				
Relative Sizes	<p><b>Dissolved Salts (ions)</b></p> <p><b>Organics (e.g., Color)</b></p>		<p><b>Viruses</b></p>		<p>Bacteria</p>	<p>Algae</p>		<p>Sand</p>
Separation Process	<p>Reverse Osmosis</p> <p>Nano filtration</p>	<p>Ultrafiltration</p>		<p>Microfiltration</p>		<p>Conventional Filtration (granular media)</p>		

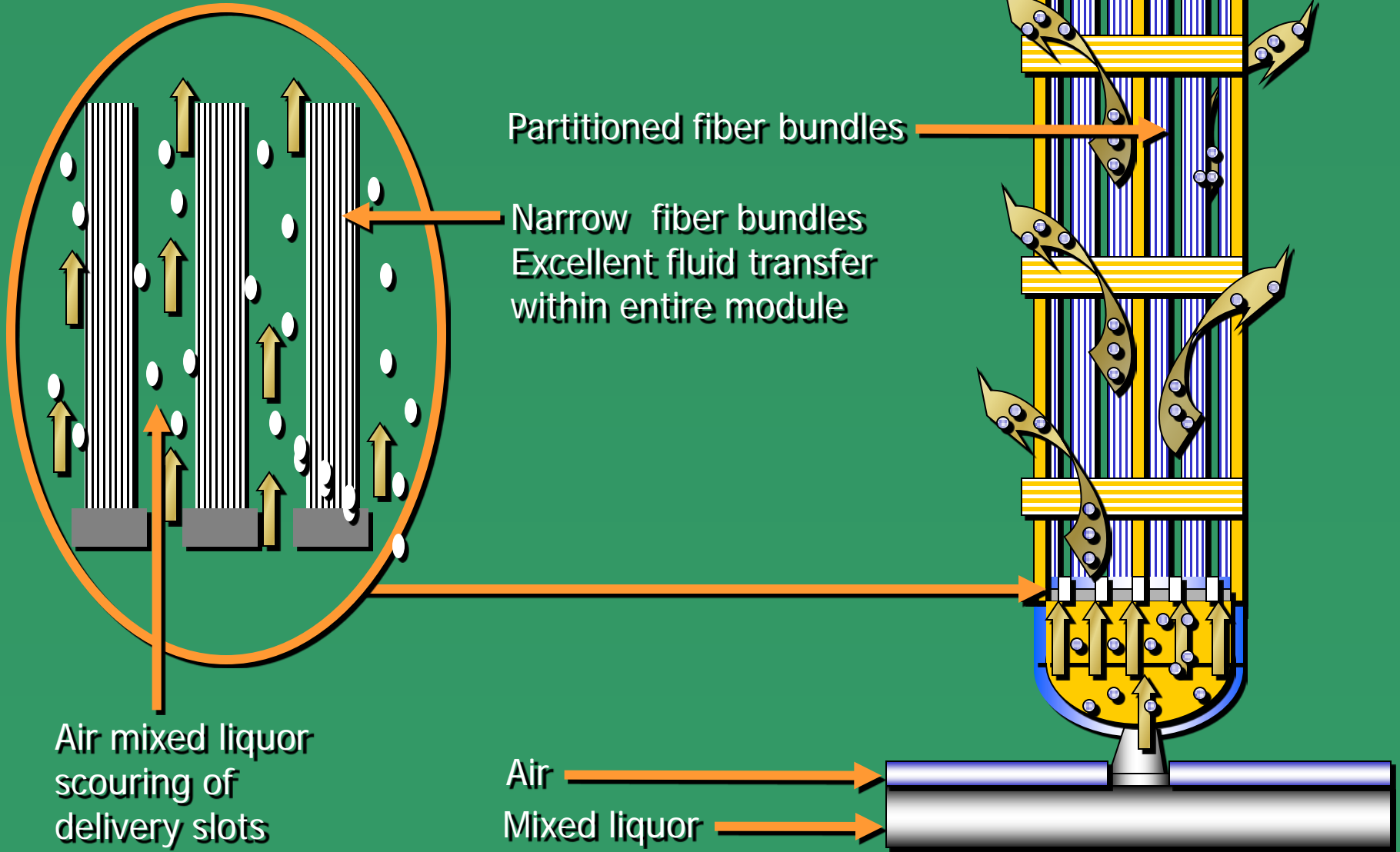


**Membrane Bioreactor (MBR)**

WOW 2004

# USFilter MF Module

*(Patent Pending)*





WOW 2004





WOW 2004



## Membrane Bioreactor Process Terminology

- Membrane characteristics
- Flux
- Transmembrane Pressure (TMP)
- Permeability
- Backpulse and Relaxation
- Cleaning (Maintenance and CIP)

## Membrane Bioreactor (Flux)

Flow of a liquid through a specific membrane surface area

$$\text{Flux (gfd)} = \text{permeate flow (gpd)} / \text{surface area (ft}^2\text{)}$$





## Membrane Bioreactor (Transmembrane Pressure and Permeability)

Driving force (pressure drop) to generate flow across membrane

$$TMP \text{ (psi)} = \textit{static pressure (psi)} - \textit{dynamic pressure (psi)}$$

Performance parameter used in process monitoring

$$\textit{Permeability (gfd/psi)} = \textit{flux (gfd)} / \textit{TMP (psi)}$$

## Membrane Bioreactor (Backpulse and Relax)

- Backpulse Mode
  - reverse process flow
  - remove solids from membrane
  - 1 minute every 12-15 minutes
- Relax Mode
  - stop filtration flow
  - 1 minute every 9-12 minutes

## Membrane Bioreactor Performance (source: pilot testing)

USFilter

Zenon

Enviroquip/Kubota



### Operating Conditions

SRT Range - 6 to 50 days

MLSS Range - 4,000 to 12,000 mg/L

## Membrane Bioreactor Pilot Testing Effluent Quality

	Kubota	Zenon	USFilter	KC - CAS
Turbidity (NTU)	0.14	0.02	0.11	5 – 10
TSS (mg/L)	1.4	2.2	2.6	10 – 20
VSS (mg/L)	0.9	1.4	1.8	8 – 16
COD (mg/L)	21.3	86.1	53.8	40 – 80
BOD (mg/L)	NA	2.3	5.8	10 - 20
TOC (mg/L)	7	8	NA	NA
FOG (mg/L)	5	NA	NA	10

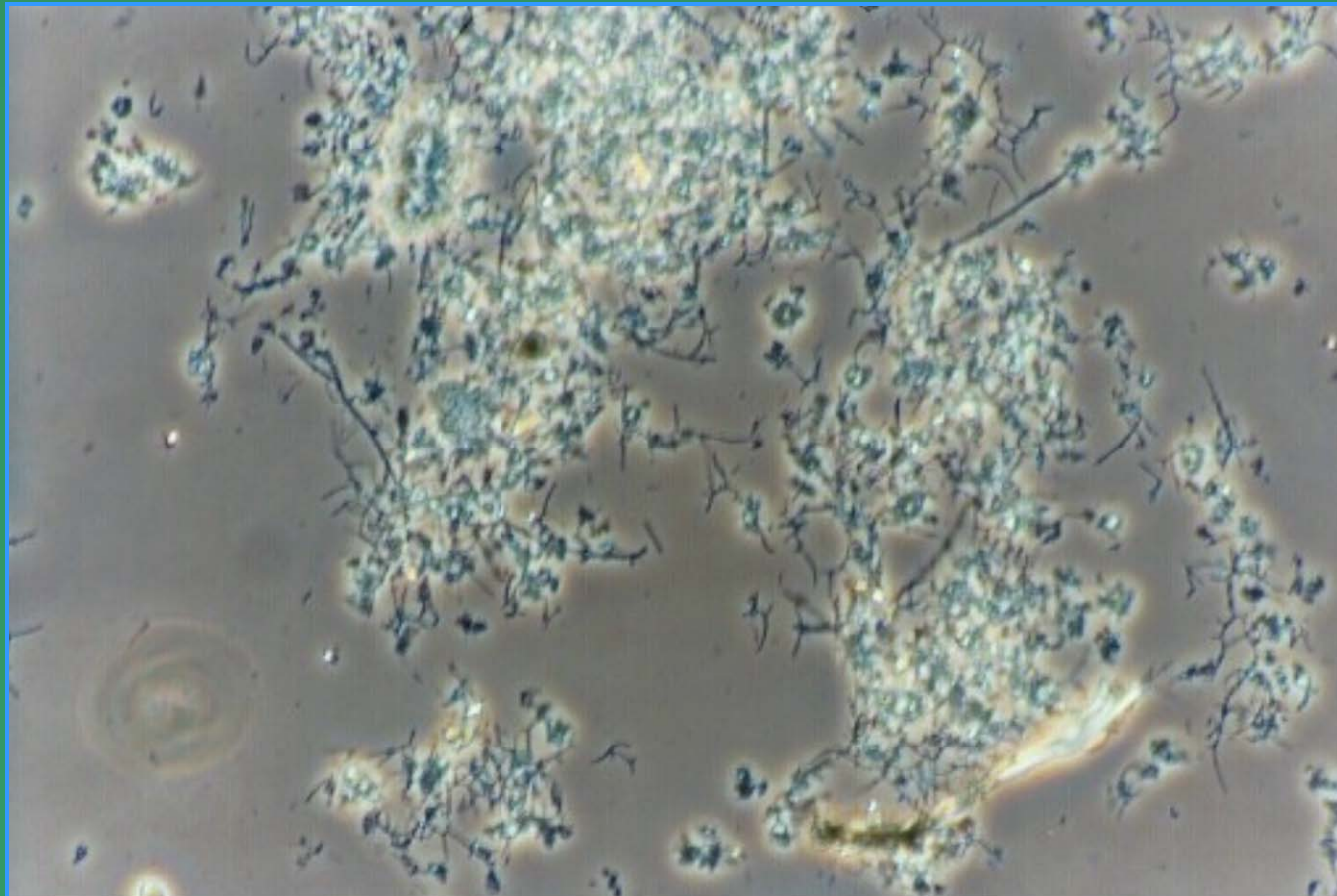
	Kubota	Zenon	USFilter	KC - CAS
TC (cfu/100mL)	nd	1.4e+3	6	NA
HPC (cfu/100mL)	2.2e+5	8.8e+5	1.1e+4	NA

## Membrane Bioreactor (Monitoring Parameters)

1. Air scour flow rate
2. TMP / Permeability
3. Flux
4. Turbidity
5. Temperature
6. Sludge viscosity
7. Sludge filterability
8. Capillary suction test
9. Mixed liquor concentration

# MLSS SAMPLE

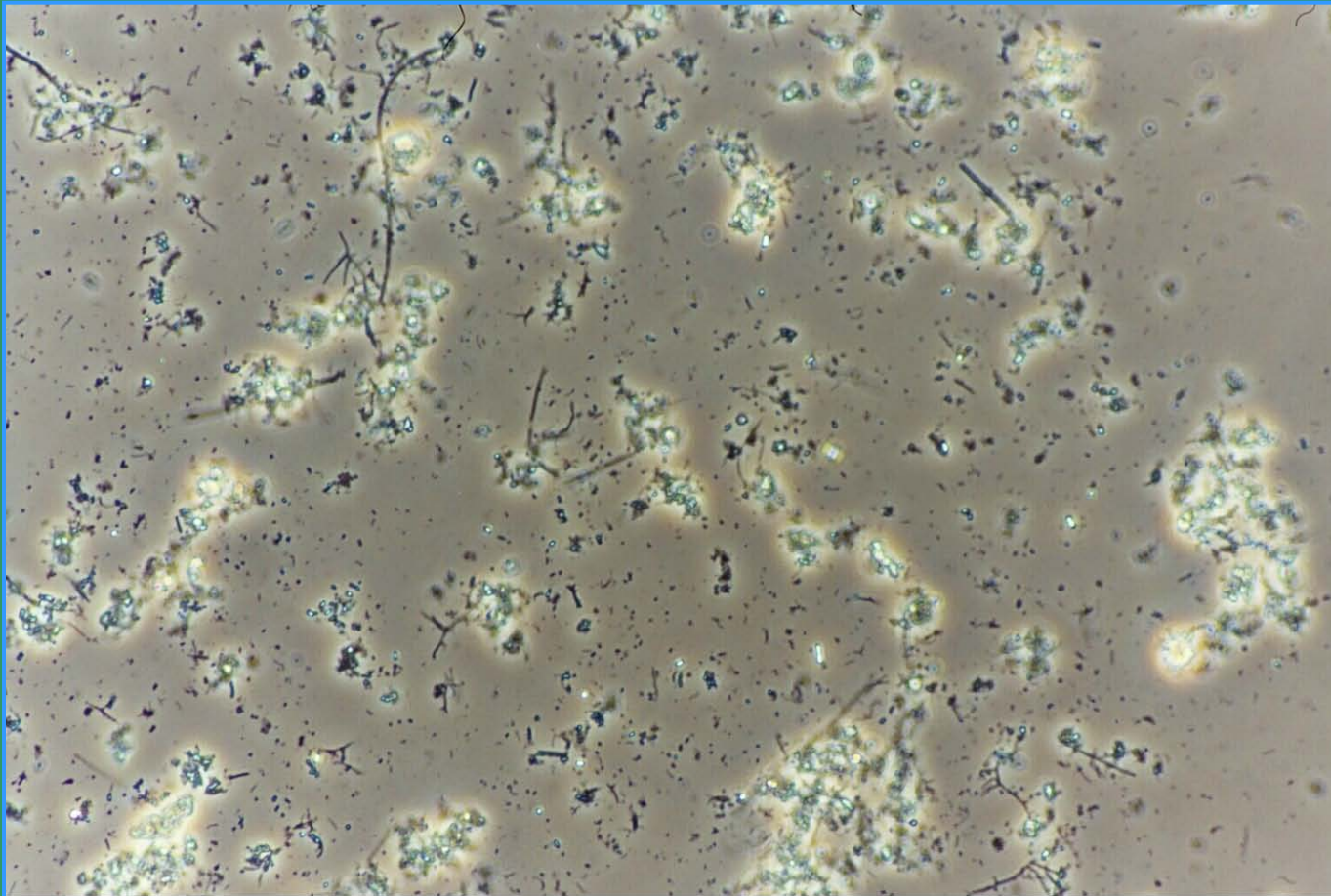
SRT = +/- 15 days, Filterability = 8mL/5min





# MBR MLSS SAMPLE

SRT = +/- 50 days, Filterability = 4mL/5min



## Membrane Bioreactor (Process Control)

### 1. Aeration

- in membrane tank: minimize fouling
- In aerobic tank: control biological process
- in combined tank: both



## Membrane Bioreactor (Process Control)

### 2. Cycle length

- filtration time, relax/back pulse time
- cycle too long → fouling
- cycle too short → low net flux

### 3. Wasting rate

- control SRT and/or MLSS

## Membrane Bioreactor (Process Control)

### 4. Mixed liquor recycle

- nitrification/denitrification process
- optimum membrane environment

### 5. Filtration rate

- optimum value varied for each specific process
- affect by temperature, rapid increase of TMP, peak flow

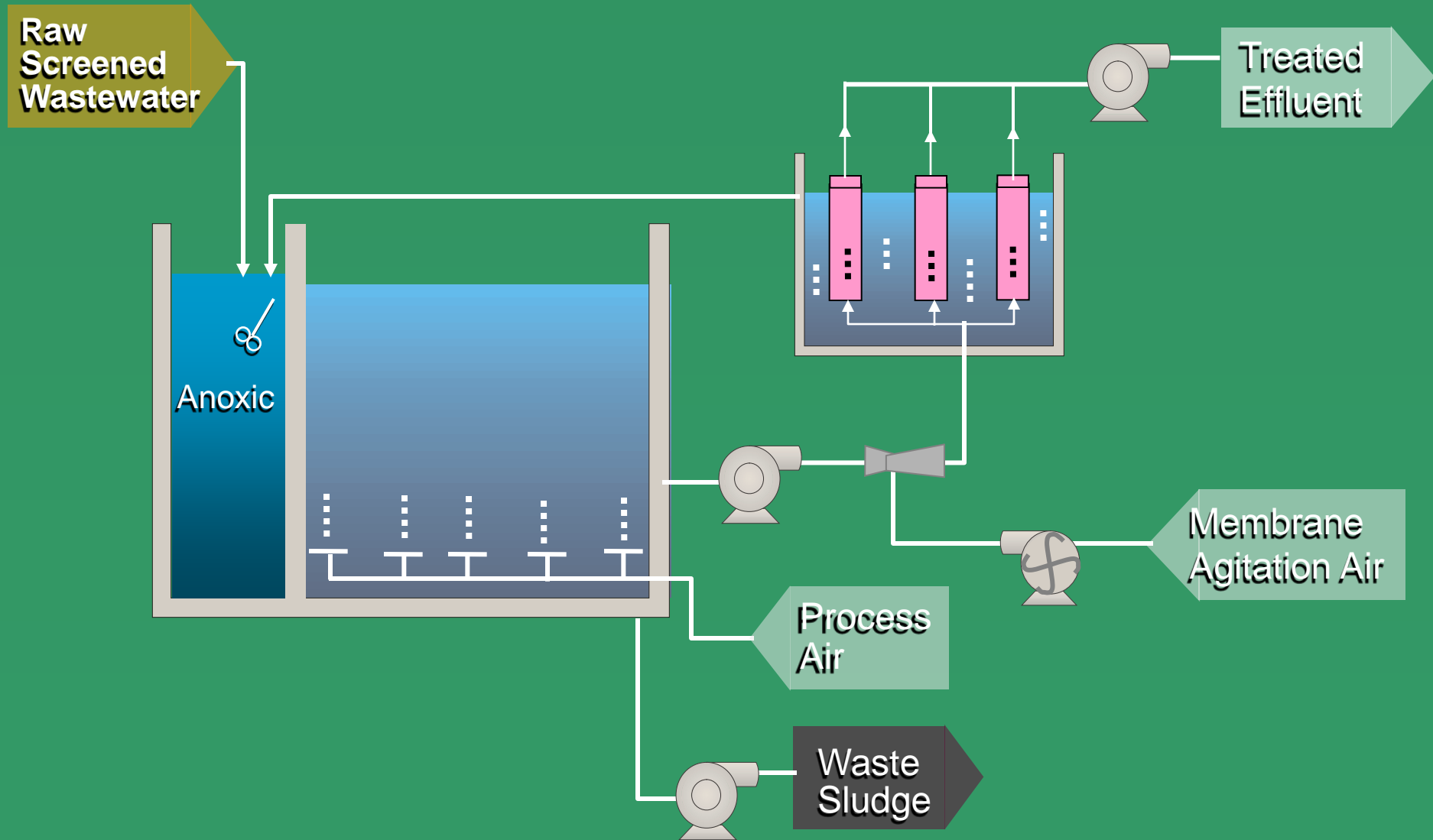
## Membrane Bioreactor (Cleaning)

- Cleaning efficiency determined by comparing permeability recovery after each clean
- Cleaning frequency depends on the membrane type and operating conditions
- TMP and permeability indicates the need for cleaning
- Automatic in full scale installations

## Membrane Bioreactor (Cleaning Options)

- Maintenance clean
  - weekly 100 ppm sodium hypochlorite solution backpulsed through membrane
  - citric acid instead of sodium hypochlorite for inorganics
- Recovery clean (CIP)
  - 6 month 500 - 1000 ppm sodium hypochlorite solution soak

# Membrane Bioreactor (Maintenance)



## Membrane Bioreactor (Process Troubleshooting)

- Maintenance clean
  - weekly 100 ppm sodium hypochlorite solution backpulsed through membrane
  - citric acid instead of sodium hypochlorite for inorganics
- Recovery clean (CIP)
  - 6 month 500 - 1000 ppm sodium hypochlorite solution soak

## Membrane Bioreactor Pilot Testing Additional Assessment

- Hydraulic peaking events
- Fate of metals
- Fate of organics
- Effluent chlorine demand

## Membrane Bioreactors Industry Research

- Pre-Treatment
- Membrane Fouling and Cleaning
- alpha factor and energy consumption
- Effluent Quality (nutrients)
- Sludge Treatment
- Fate of metals
- Fate of organics



## Membrane Bioreactors Resources

- Water Environment Research Foundation (WERF) website
- American Water Works Association (AWWA) website
- International Water Association (IWA) STOWA report
- King County Technology Assessment Program Reports
- Water Environment Federation Conference Proceedings
- Vendor websites

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Questions