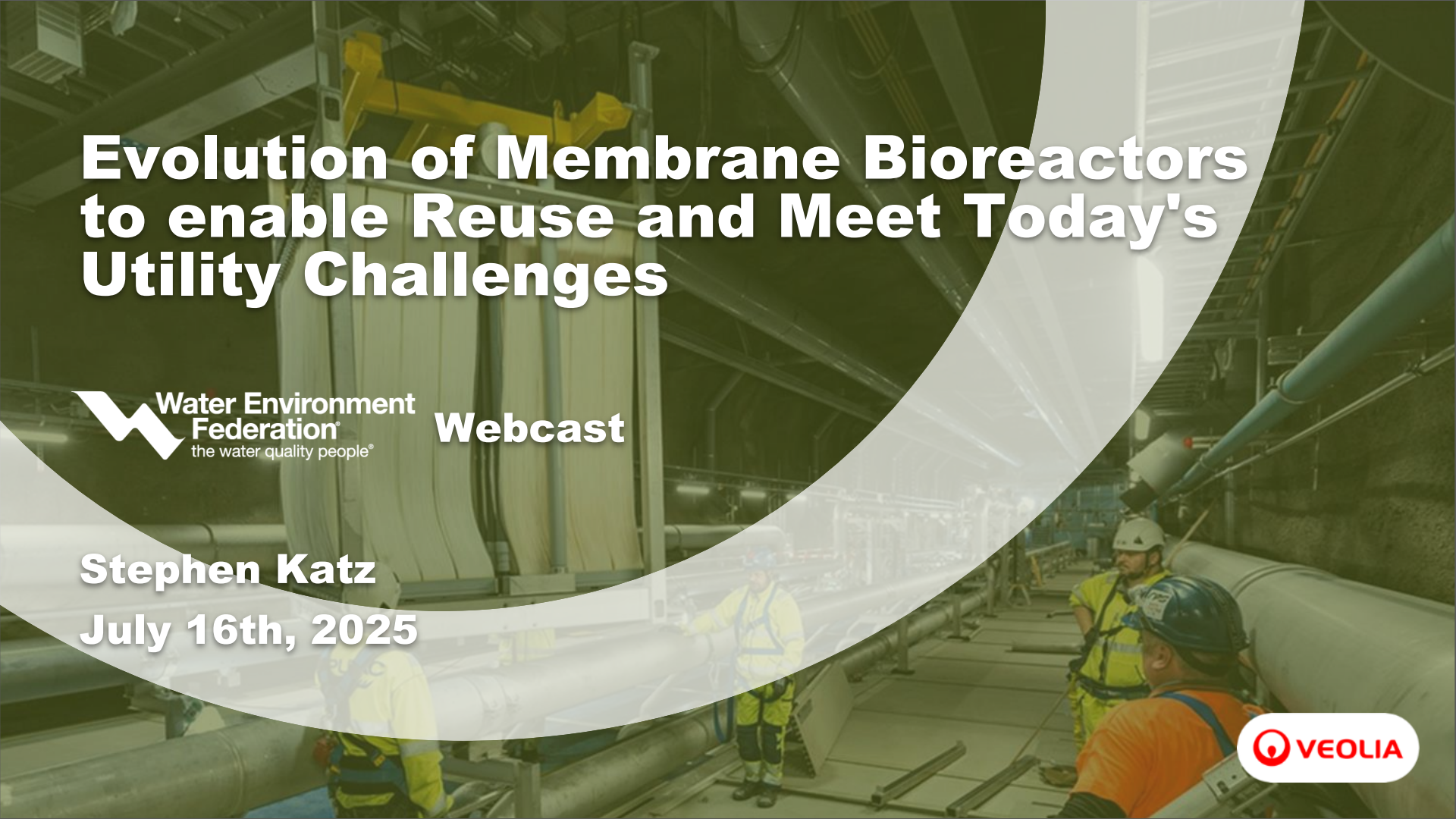
Evolution of Membrane Bioreactors to enable Reuse and Meet Today's Utility Challenges

Water Environment Federation
the water quality people®

Webcast

Stephen Katz

July 16th, 2025



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Stephen Katz

Business Development and Large Programs Director
Veolia

Today's Presenter

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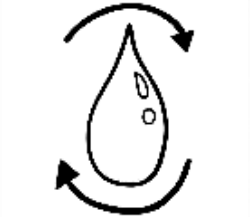
Today's Webcast

- MBR Introduction & Progression
- Trends in Treatment & Future Needs
  - Adoption at Scale
  - Enabling Water Reuse
  - Process Design and Application Evolution
- ZeeWeed Advancements
- Q&A Discussion



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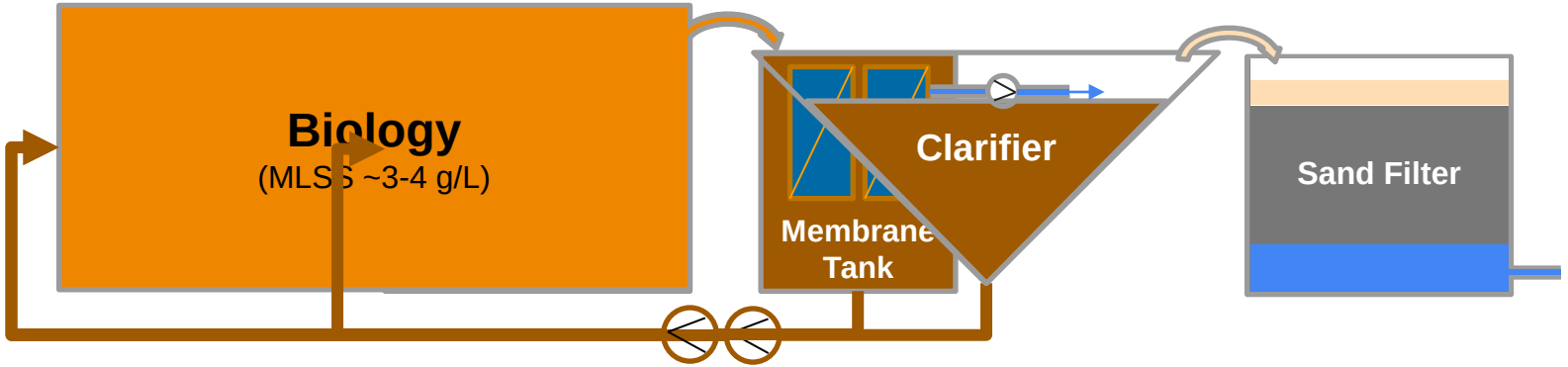
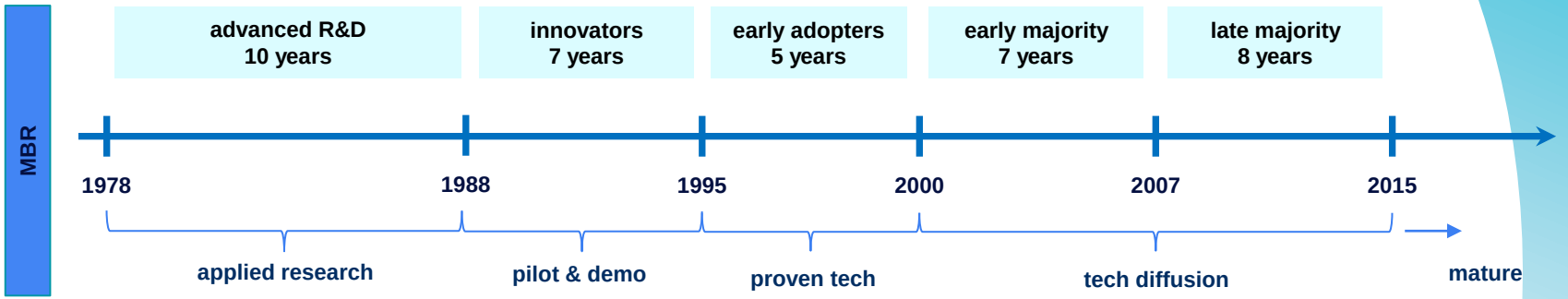
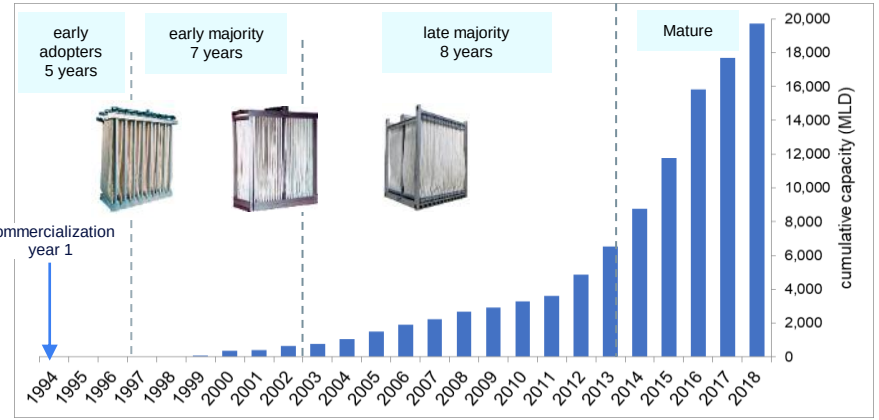
DIFFERENCES BETWEEN CAS & MBR



- Membrane filtration replaces clarifier & tertiary filtration
- Suction pressure drives filtration process instead of sedimentation
- Smaller biology due to higher mixed liquor suspensed solids (MLSS)

Maturation of MBR Technology





- Disruptive change to the function of treatment – separation process
- Value driven adoption

MBR Drivers

- Reliable Performance
- Footprint
- Nutrient Removal
- Disinfection Capability
- Cost of Implementation
- Feed to Downstream Unit Ops
- Reuse

What Does An MBR Look Like?

Adoption at Scale

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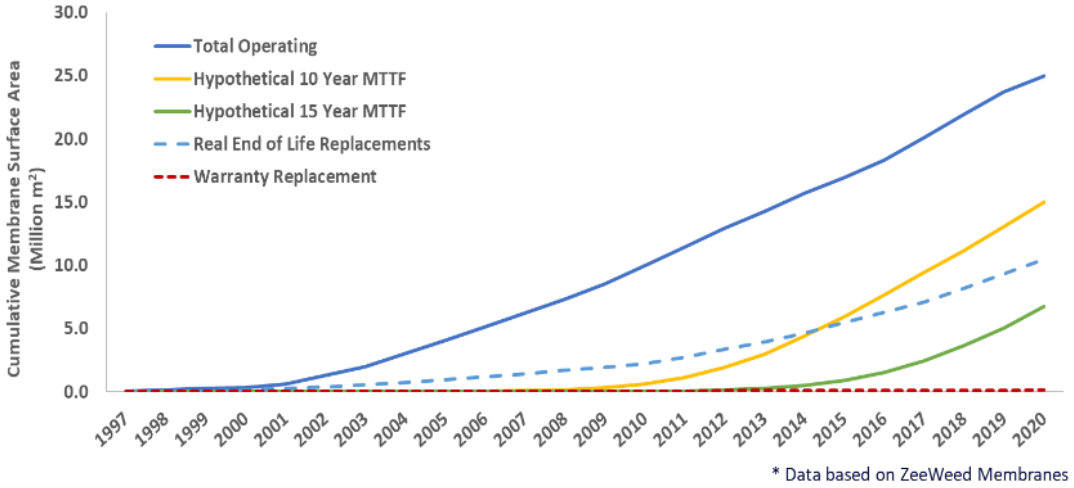
Proven Robustness and Membrane Life

Aggregate Membrane Life Study



Showed 12.5+ year average municipal membrane life

Source: P. Cote, et al., Hollow fiber membrane life in membrane bioreactors (MBR), Desalination (2012)

the good: Traverse City, MI 15+ year membrane life

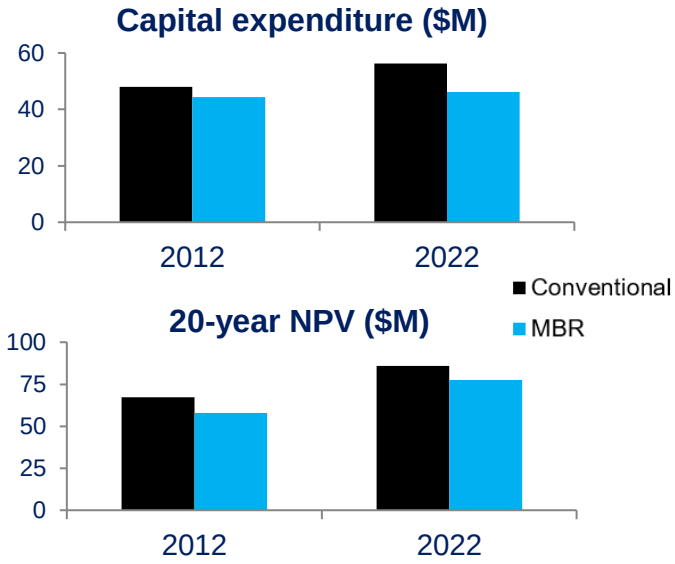
the less good: consistently high effluent water quality and a 10.5 year life

Cost of Ownership MBR vs. CAS

MBR Offers ….

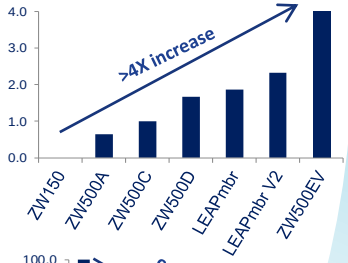
Total cost of ownership less than CAS for enhanced nutrient removal and water reuse

Requires less land, concrete and equipment installation



Changes to MBR CAPEX…

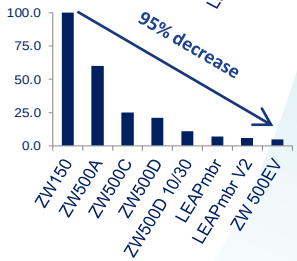
- Product Costs
- Technology Innovation
- Wrap Around Costs
- Construction Cost Increase



ZW Relative Surface Area Change

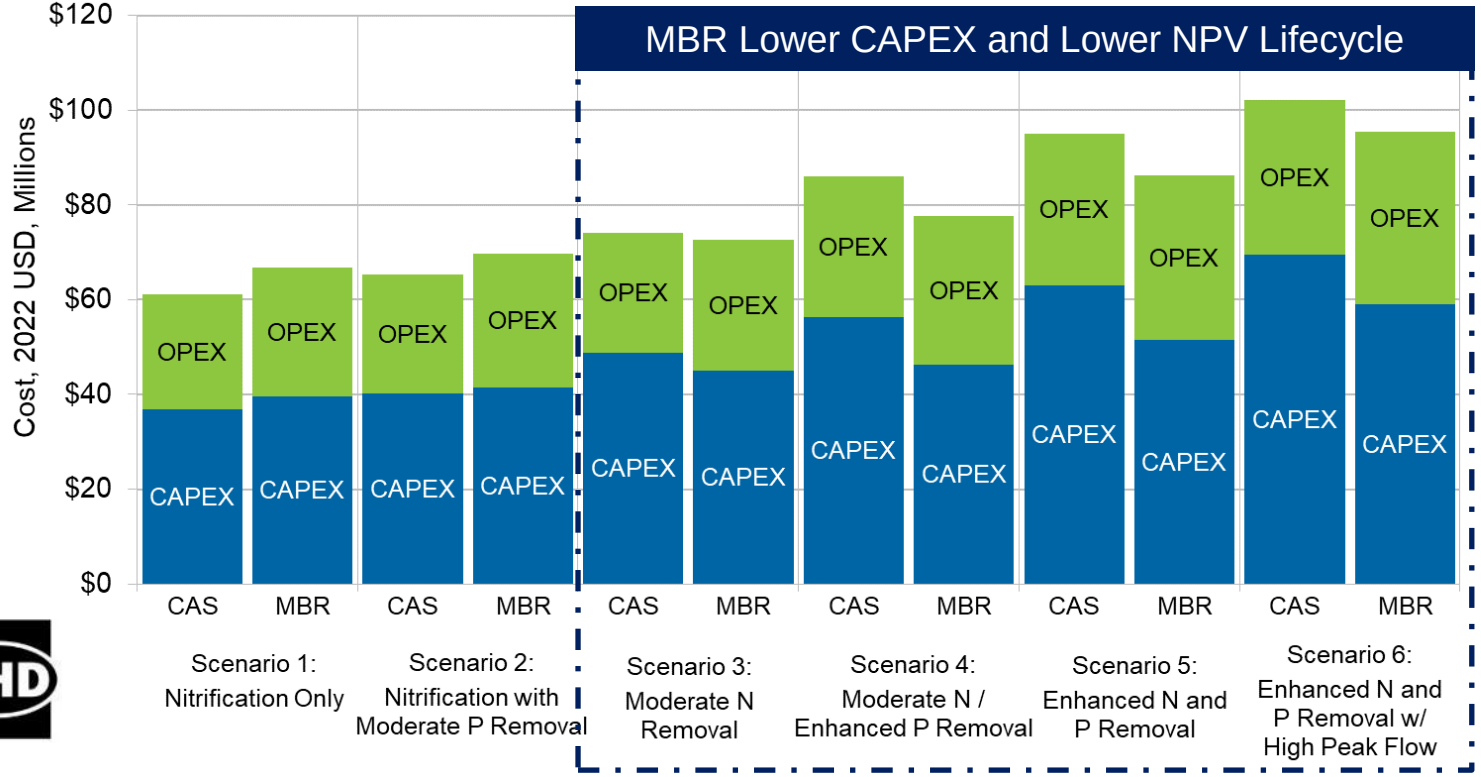
Changes to MBR OPEX…

- Technology Innovation
- Optimized Design & Operation
- Proven 12+ Year Membrane Life



ZW Relative Membrane Aeration Demand

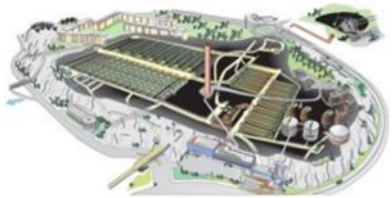
MBR vs. CAS Lifecycle Cost Analysis



Source: Young et al. (2023) "MBRs are more cost effective than ever before!" Proceedings from Water Environment Federation, WEFTEC 2023

Large MBRs Built Around the Globe

Henriksdal WWTP, Sweden
ADF 142 MGD & MDF 228 MGD
Start-up Ph 1 2020 / Ph 2&3 2025



Euclid WWTF, Ohio, USA
ADF 22 MGD & MDF 66 MGD
Start-up 2023

Riverside WQCP, CA, USA
ADF 32 MGD & MDF 48 MGD
Start-up 2016

Seine Aval WWTP, France
ADF 59 MGD & MDF 92 MGD
Start-up 2017

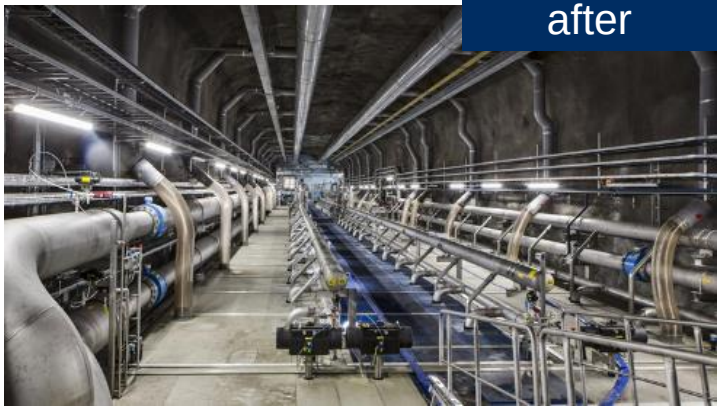
Brussels Sud WWTP, Belgium
ADF 23 MGD & MDF 44 MGD
Start-up 2017

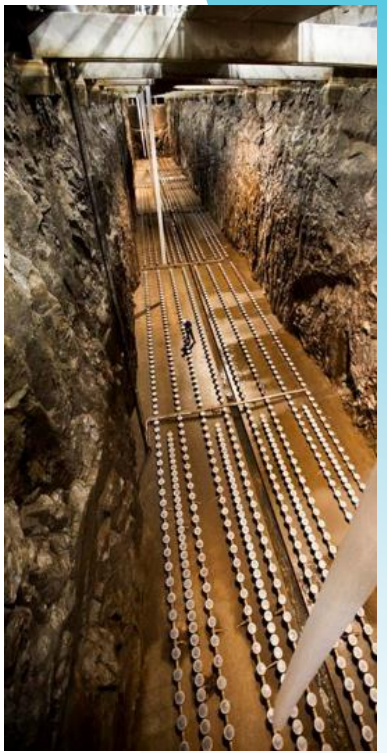
Luo Fang WWTP, China
ADF 106 MGD & MDF 122 MGD
Start-up 2018

Henriksdal WWTP

Average Flow: 536 MLD **Max Day Flow: 864 MLD**

- Plant built in rock formation with residential buildings built on top
- Biology reconfigured to include P & N removal
- Membranes retrofitted secondary clarifiers





Enabling Reuse

The continuum of water recycling

High Quality Effluent Ideal for Reuse

Parameter	Conventional Effluents	Water Reuse Standard	MBR Achieves
TSS	25 - 50 mg/L	< 2 mg/L	✔
Turbidity	10 - 30 NTU	< 0.2 NTU	✔
BOD	25 - 50 mg/L	< 2 mg/L	✔
TDS	N/A	< 500 mg/L	N/A
Nitrogen	10 - 30 mg/L	< 10 mg/L	✔
Phosphorus	1 - 30 mg/L	0.1 - 2 mg/L	✔
E. Coli & Coliforms	10^5 - 10^7 cfu/ 100 mL	< 20 cfu/ 100 mL	✔
Virus & Protozoa	0-2 Log	Regional	5-6 Log

Gold Standard for Non-Potable Reuse

Meets:

- Many state regs including California Title 22 Code of Regulations
- WHO standards for unlimited irrigation

Disinfected Filtered Effluent

- Allowance to turn off downstream disinfection (UV or Cl) for discharge in certain states/provinces
- Meets EU Bathing Water Directive

Clarity on Pathogen Crediting for IPR/DPR

Construct in Advanced Reuse

Key focus on pathogen removal for Public Health protection in potable recycling

Pathogen Requirements in Flowsheet

12–log virus
10-log Crypto
10-log Giardia

Baseline Credits Available

Industry has adopted predefined conservative credit levels

1 Virus / 2.5 Protozoa

Why it is important

- Enables MBR + RO + UVAOP
- Programs proceed with certainty and without heavy regulatory burdens

Morro Bay, CA & Santa Monica, CA

WRF 4997 Membrane Bioreactor Validation Protocols for Water Reuse

Released Jan '21

Path to Higher Credits

MBR proven to achieve higher removals

Why it is important

- Enables DPR configurations
- Additional operational flexibility

Note: Path includes higher monitoring and sampling burden

Potable Reuse in Action

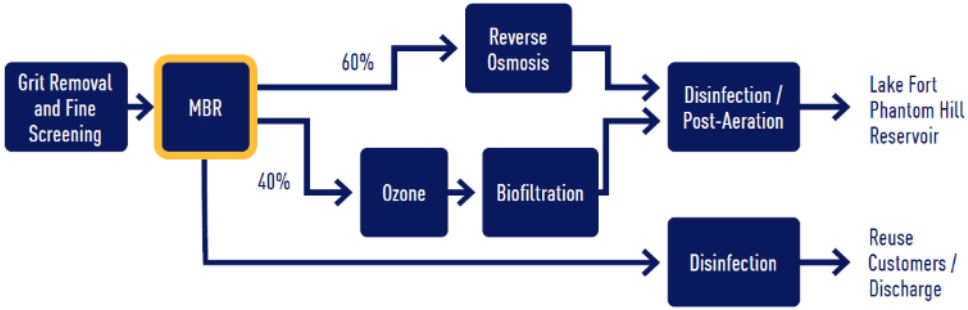
Location: Abilene, TX, USA
Start Date: 2015 (expanded in 2020)
Water Use: indirect potable reuse (IPR)

Challenge: Reservoirs in drought-stricken areas were hitting critically low levels of less than 30% of their capacity.

Solution: As the first phase of a drought response initiative to combat these conditions, the City of Abilene moved to upgrade its treatment infrastructure to enable the city to replenish the water levels in Lake Fort Phantom Hill, one of the City's key reservoirs.

Results: The treatment process replenishes the reservoir with 7 million gallons of advance treated water a day

Hamby Water Reclamation Facility Flowsheet



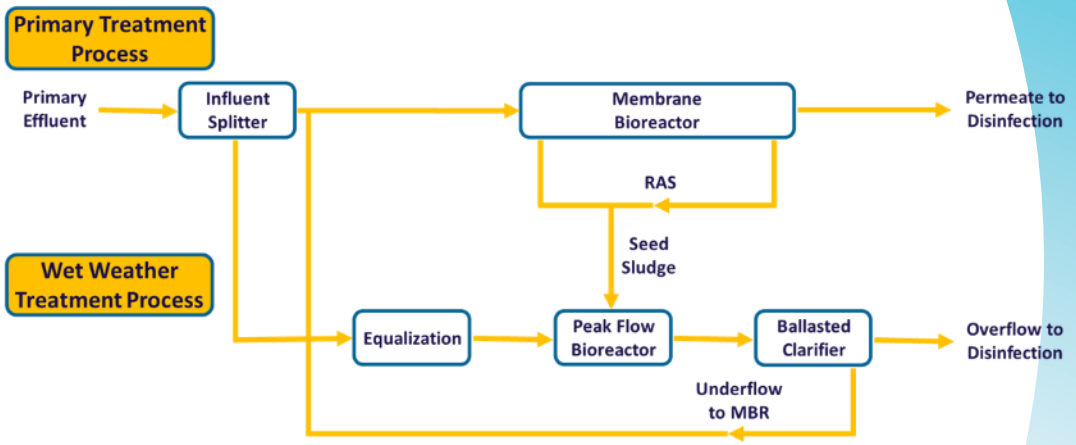
Process Design & Application Evolution

Enabling Wet Weather Flows

Cox Creek WRF

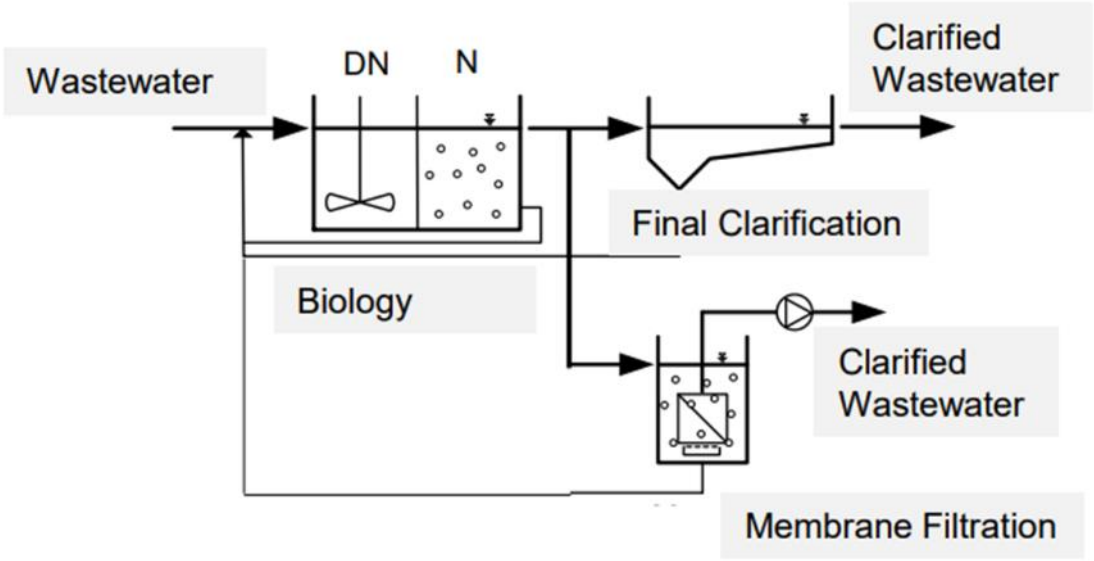
Commissioned June 2017

- 15 MGD average daily flow & 45 MGD peak flow, including significant I&I
- MBR facility was optimally designed for routine peaking events to minimize capital and operating costs
- wet weather flow facility is utilized to treat infrequent peak flow events
- MBR RAS is used to seed the peak flow bioreactor



Hybrid MBRs

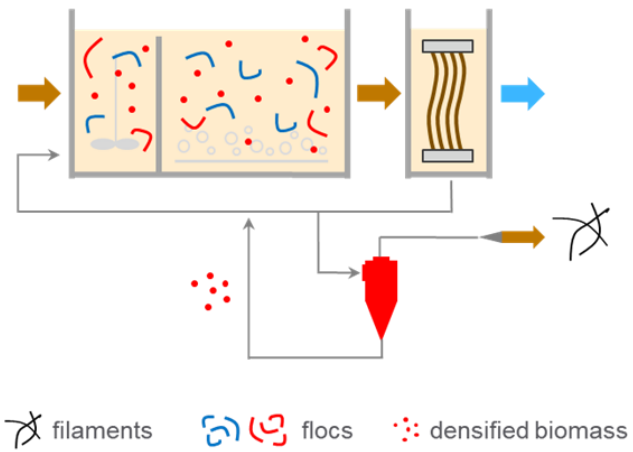
Using Membrane Filtration in same biology as clarifiers



Value:

- Incremental hydraulic and nutrient load increase
- Footprint savings
- High quality effluent for reuse
- Decouple settling from performance

Introducing memDENSE MBR



SELECTIVE WASTING - removal of light biomass fraction

- foulants, colloids, pin floc
- nuisance bacteria, filaments

Ddensification - retention of dense biomass fraction

- improved filterability
- nutrient removal specialists

Reduces operating cost by tailoring mixed liquor characteristics to optimize membrane & biological performance

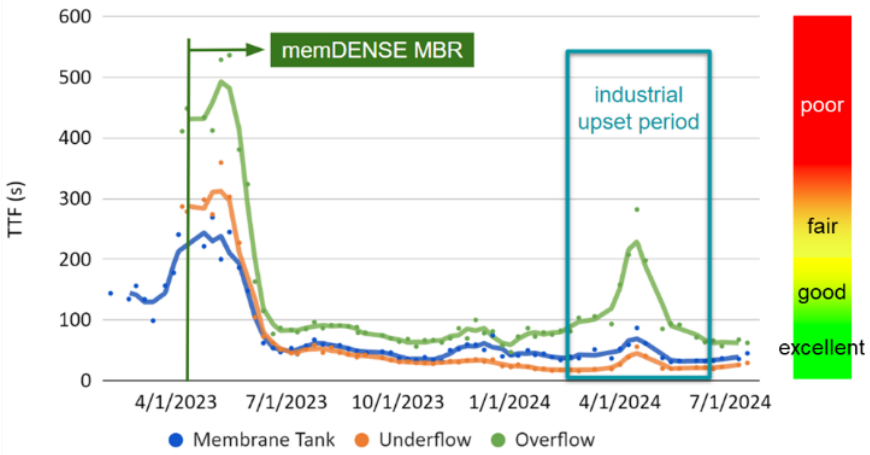
memDENSE Operation

Detroit Lakes WWTP, MN

After a year of operation:

- Filaments were washed out, decreasing foam events
- Filterability & permeability improved

Filterability Impacts



- TTF higher in overflow, constantly removing fouling components
- Responds to upset conditions
- Membrane tank filterability remains stable

Foam Control

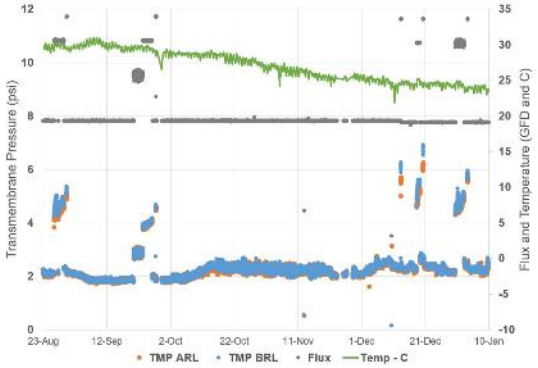
Selective wasting removes foam causing filaments

Biology Operating Window

Looking at biological parameters that support total cost of ownership savings

- SRT improvements
- Air transfer
- Alternative nutrient controls
- Enabling Bio-P

Successful testing of 4.7d Aerobic SRT at Pilot Facility in California



ZeeWeed Advancements

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ZW500EV … Next Generation MBR

Key features

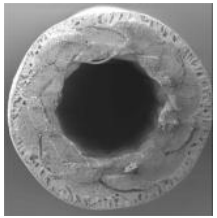
1. **Membrane surface area to cassette volume optimized.**
2. **Aeration distribution optimized for most efficient air scouring.**
3. **Pulse aerator volume increase for most efficient air scouring.**
4. **Permeate collection on the outside, easy access to all the seals.**
5. **Module install/removal made simpler.**
6. **Module and cassette robustness further increased.**

Key Benefits

- >25% Savings on Membrane Tank Construction
- > 30% Footprint Savings
- >15 Year Product Life
- Improved Pulsed Aeration with ~20% Air Savings
- >60% Fewer Parts and Improved Handling Features

ZeeWeed 500EV

64 & 56 module configurations



Same Reinforced ZeeWeed Membrane Fiber from 500D

Version Available for Drop-in 500D Retrofit

Industry Leading Manufacturing and Quality

Design and Testing of Product Started in 2017

New Design Offers Simplicity for Service

10+ Full Scale Installations in Operation

Introducing On Demand Mobile MBR

Deployable for:
Emergency Situations
Bridging Construction Programs
Temporary Treatment Needs

- Self-contained system
- ZeeWeed 500 reinforced membrane
- Applicable for reuse or discharge
- Integrated drum screen and biological treatment equipment
- Digitally enabled with InSight*
- Designed to meet standard over-the-road dimensions

Capacity: 80,000 – 100,000gpd

Deployed in City of Malibu to support the rehabilitation of a WWTP which was damaged from the 2018 Woolsey Wildfire

- Deployed and processed wastewater in 60 days
- Integrated with minimal disruption
- Allowed for operation of the impacted rehabilitation center

Not Your Grampa's MBR

- Maturity driving innovation
- Reductions in total cost of ownership
- Enabling all types of reuse
- Technology scaling for implementation in the largest facilities
- Operational windows and applications being expanded

Q&A Discussion

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THANK YOU!

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