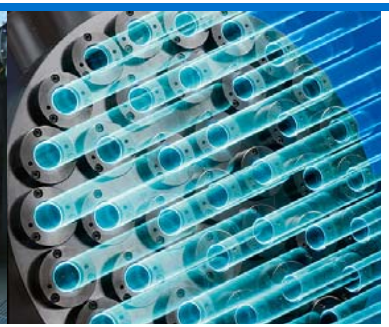
WateReuse Association
Northern California Chapter Meeting
Santa Rosa, CA

Technology & Innovation

Keel Robinson, North America Water Reuse Leader

May 13th, 2016





Agenda

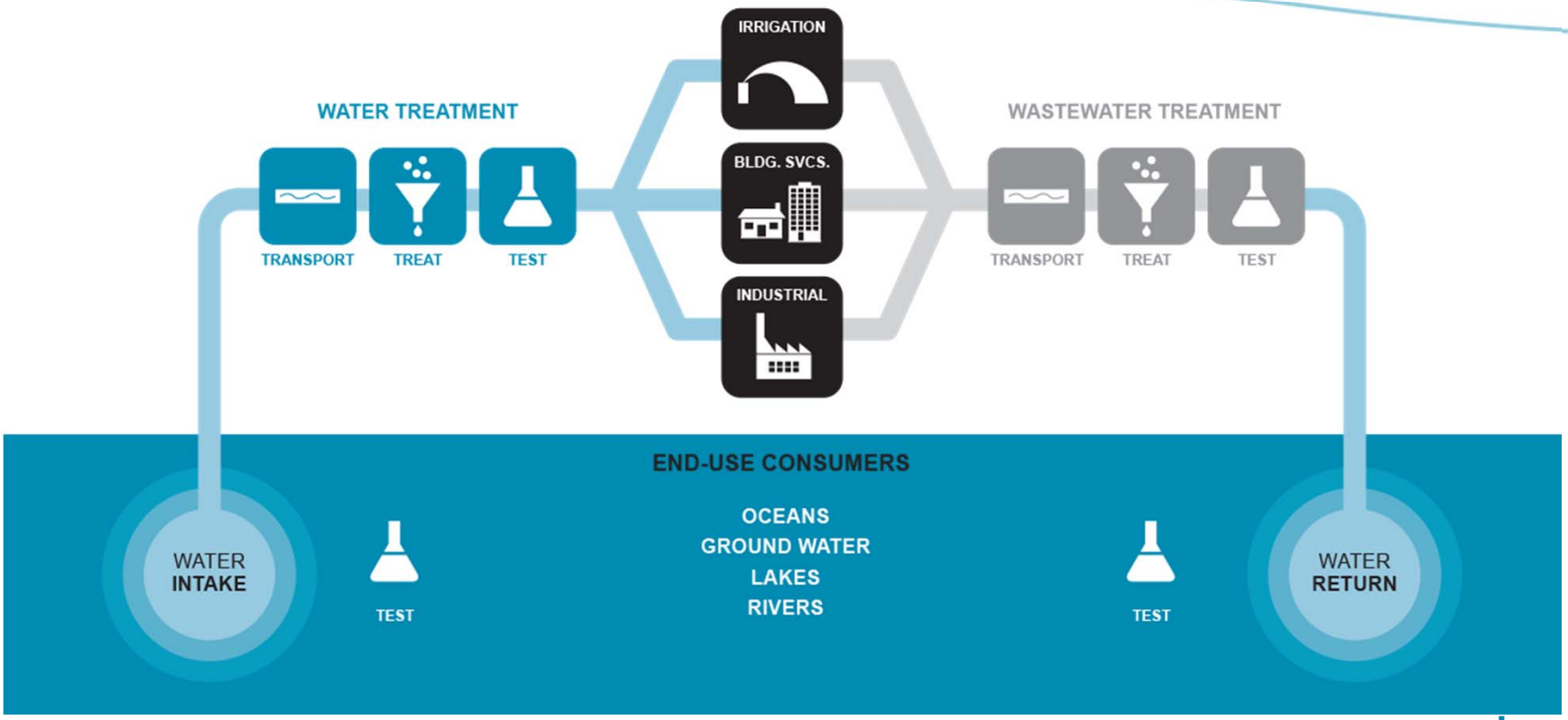
Who is Xylem?
State of Innovation for Water Reuse
UV/Cl_2 AOP: The New Kid On The Block
O_3-BAC: It's Like Déjà Vu All Over Again

xylem

Who is Xylem?

xylem

We Span the Entire Cycle of Water



Diverse Product Portfolio

SANITAIRE

Biological Wastewater Treatment
Diffused Aeration
Sequencing Batch Reactor
Oxidation Ditches
Process Controls

FLYGT

Dry and Submersible Pumps
Mixers
Mechanical Aeration

LEOPOLD

Gravity Media Filtration
Clarification
Dissolved Air Flotation
Ozone-enhanced Biologically Active Filtration

WEDECO

Ultraviolet Disinfection
Ozone Oxidation
Advanced Oxidation Process

FLOWTRONEX GOULDS WATER TECHNOLOGY Bell & Gossett YSI godwin SonTek

xylem

Reuse Thought Leadership: Advancing The Cause

California Drought Summit (July 2015)

Presenting to Members of Congress on Water Reuse in D.C. (June 2015)

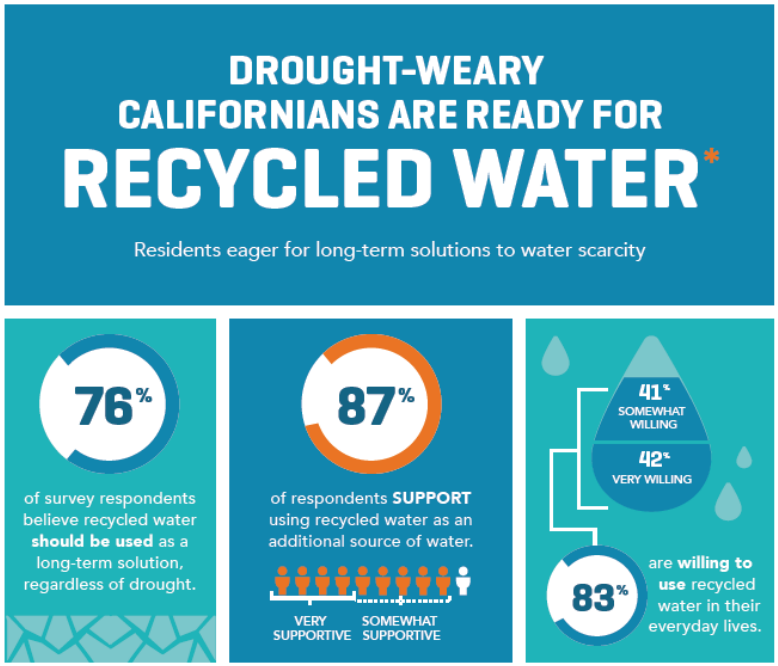
WateReuse Manufacturer of the Year (September 2014)

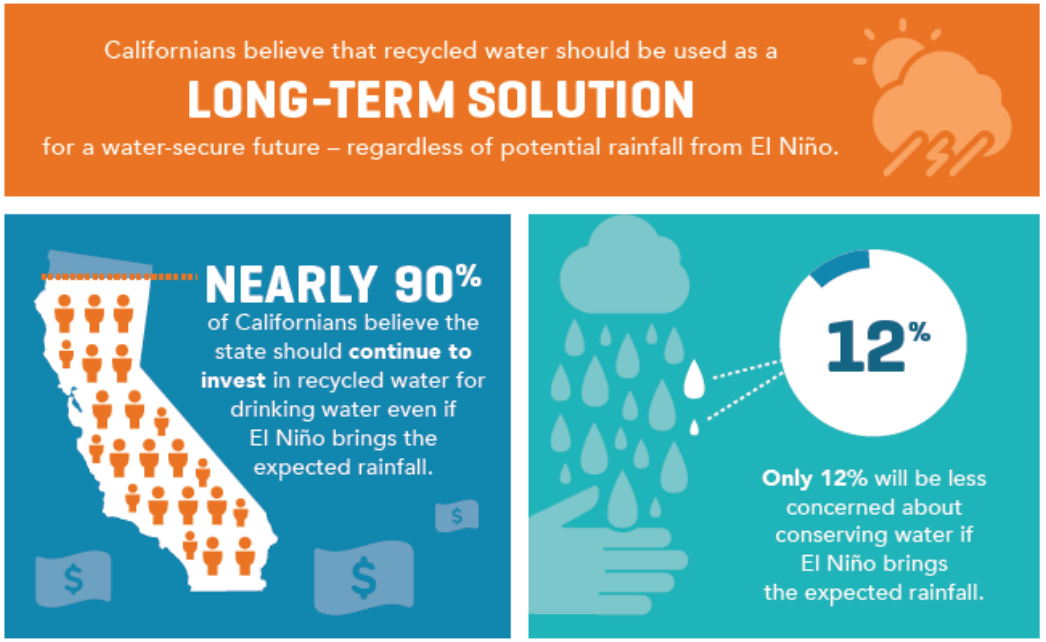
Xylem honored by WateReuse Research Foundation

From Singapore to Stockholm, and all over California, Xylem's water reuse technology is helping communities around the world build a secure water future. At the recent 19th Annual Water Reuse & Desalination Research Conference, the WateReuse Research Foundation honored Xylem for its commitment to water reuse research and developing innovative water reuse solutions.

xylem

Recent Survey – Californians Support Water Reuse





http://www.xylem.com/en-us/expertise/publications/Documents/drought_infographic_single_cropped_rev1.pdf

xylem

Silicon Valley Advanced Water Purification Center

UV Disinfection System (Title 22+)

Santa Clara Valley Water District SM

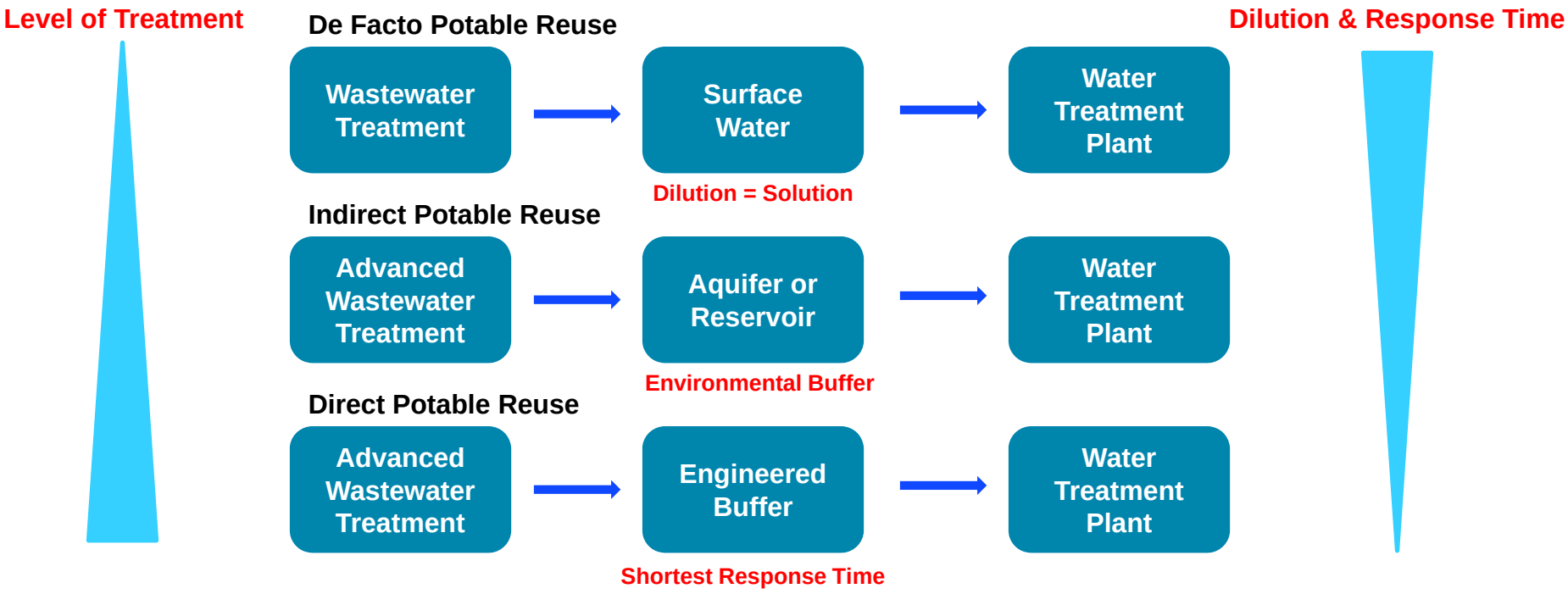
- Silicon Valley Advanced Water Purification Center
- 8 MGD state-of-the-art water reuse facility
- MF-RO-UV treatment train
- High quality non-potable water for irrigation and industrial customers
- Tours available to public

xylem

State of Innovation for Water Reuse

xylem

Last 5 Years: A Transition To Potable Water Reuse



xylem

Some Examples of Applied Research Successes

- ✓ **Rediscovery of ozone-based solutions including O_3-BAC**
- ✓ **Taking UV/Cl_2 AOP from academia to pilot-scale to full-scale**
- ✓ **"Tools in the toolbox" approach to cleverly configure treatment trains that are "fit for purpose"**
- ✓ **Focus on resilience/robustness/reliability/redundancy**
- ✓ **Use of indirect (surrogate) measurements for real time monitoring & control**

WATEREUSE

08-08: Oxidative Technologies to Reduce Fouling of Membranes

11-02: Equivalency of Advanced Treatment Trains for Potable Reuse

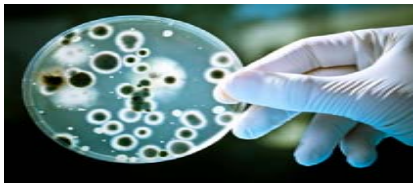
14-12: Demonstrating Redundancy and Monitoring to Achieve Potable Reuse

11-08: Formation of Nitrosamines and PFOAs During Ozonation

xylem

Next 5 Years: Evolving To Implementation and Optimization

- ❑ Continue to lead the regulators
- ❑ TOC of reuse water vs. TOC of drinking water
- ❑ Toxicological relevance of TOrCs
- ❑ On-line Sensors
- ❑ Data management
- ❑ Optimize secondary biological wastewater treatment
- ❑ Resource recovery/energy efficiency/brine disposal
- ❑ Decentralized reuse
- ❑ Industrial reuse
- ❑ Operator training and experience
- ❑ Balancing safety with sustainability
- ❑ What other technologies can emerge?



xylem

Technology & Innovation Challenges and Opportunities

Municipal sector acceptance of new technologies and solutions

Policies that fund and enable innovation (similar to energy sector)

Lack of regulations

Prescriptive and restrictive solutions

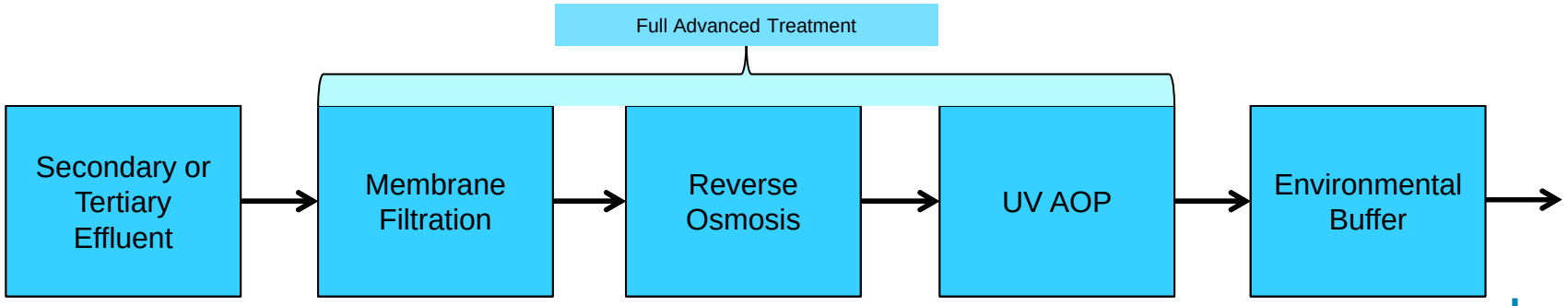
xylem

UV/Cl_2 AOP: The New Kid On The Block

xylem

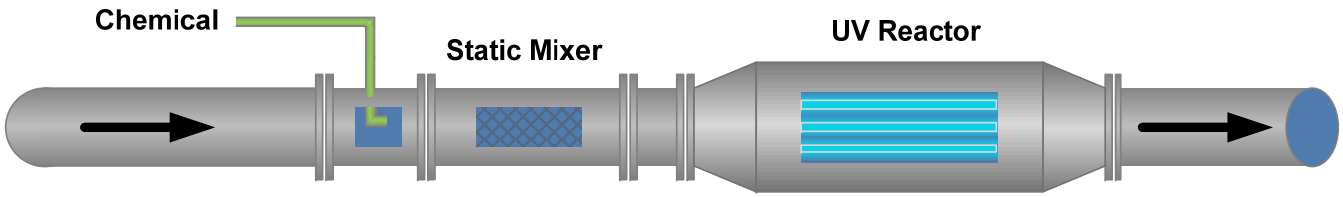
UV/H_2O_2 AOP For Reuse Has Been The Status Quo

- **Has historically been the standard AOP technology for groundwater recharge/indirect potable reuse in California with multiple successful installations in operation today (e.g. Orange County, West Basin, WRD)**
- **Also used in drinking water for taste & odor and in groundwater remediation applications**
- **Hydrogen peroxide is relatively expensive and not readily used at WWTPs**
- **The photolysis of hydrogen peroxide is inefficient as only about 10% of the chemical is consumed in the UV AOP reaction; thus, incurring significant residual quenching costs**



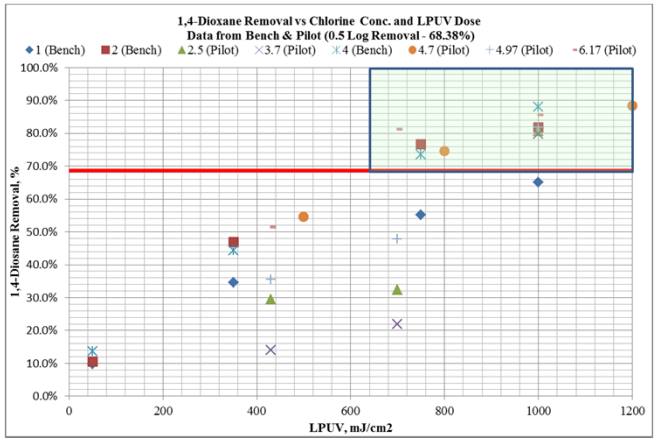
Introducing UV/Cl_2 AOP

- **Recent academic research shows that UV/Cl_2 AOP is effective at low pH**
  - Watts, M. & Linden, K., 2007. Chlorine Photolysis and Subsequent OH Radical Production During UV Treatment of Chlorinated Water. Water Res., 41:13:2871
  - Watts, M., Rosenfeldt, E,. & Linden, K., 2007. Comparative OH Radical Production Using UV-Cl2 and UV-H2O2 Processes. Jour Supply Water Res Technol - AQUA., 56:8:469
  - Watts et al. 2012. Low pressure UV/Cl2 for advanced oxidation of taste and odor. Journal-AWWA
- **Reverse osmosis for FAT produces a low pH permeate (~5.5)**
- **Sodium hypochlorite (chlorine) is readily used at most WWTPs**
- **Residual chlorine after FAT may be desirable for additional pathogen credit and/or secondary disinfection**

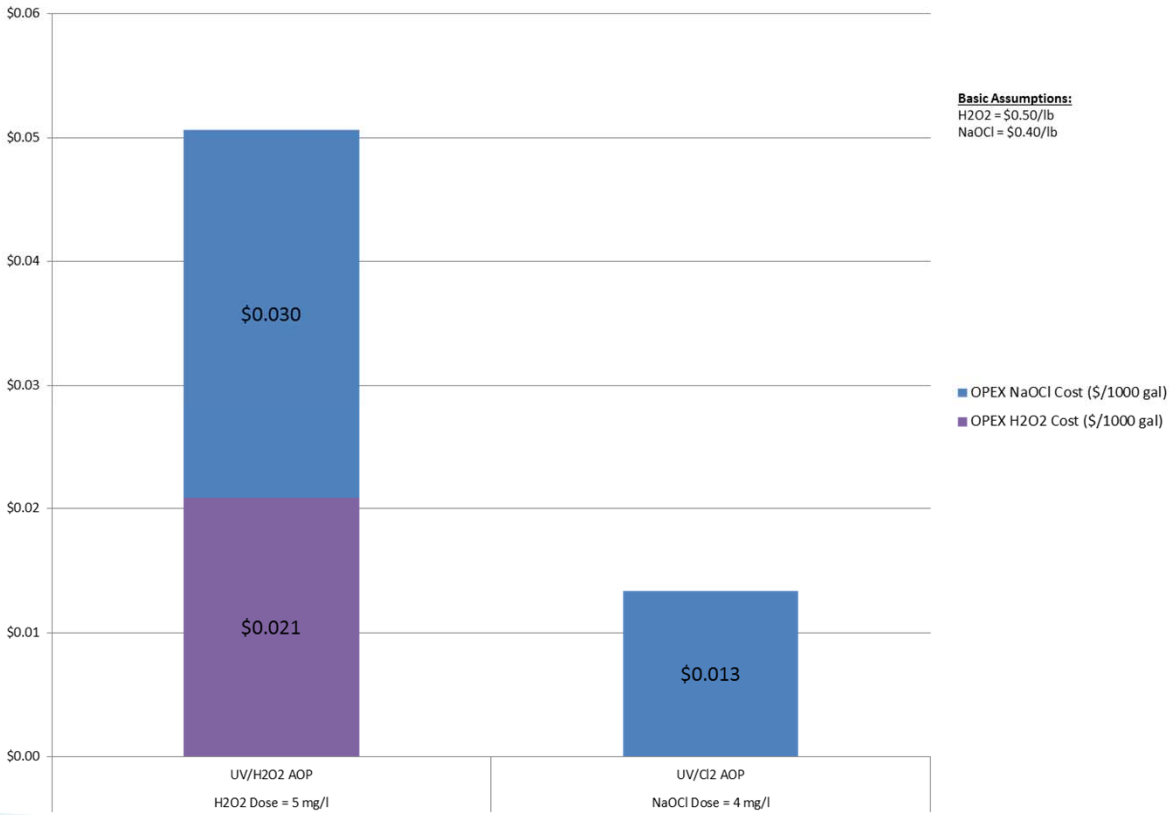


Pilot-Scale Testing at TIWRP

- **Tested multiple AOPs including UV/H_2O_2 vs. UV/Cl_2**
- **Both AOPs achieved the treatment objective at similar UV doses**
  - **0.5 log removal of 1,4-Dioxane**
  - **<10 ppt of NDMA**
- **UV/Cl_2 AOP did not produce any significant disinfection by-products**



Technology Selection/Investment Decision at TIWRP



- **$3.3M in chemical savings over 20 years**
- **NaOCl already on-site**
- **Additional pathogen barrier/credit for FAT**

✓ **UV/Cl_2 AOP selected**

xylem

Terminal Island Water Reclamation Plant

UV/Chlorine Advanced Oxidation Process

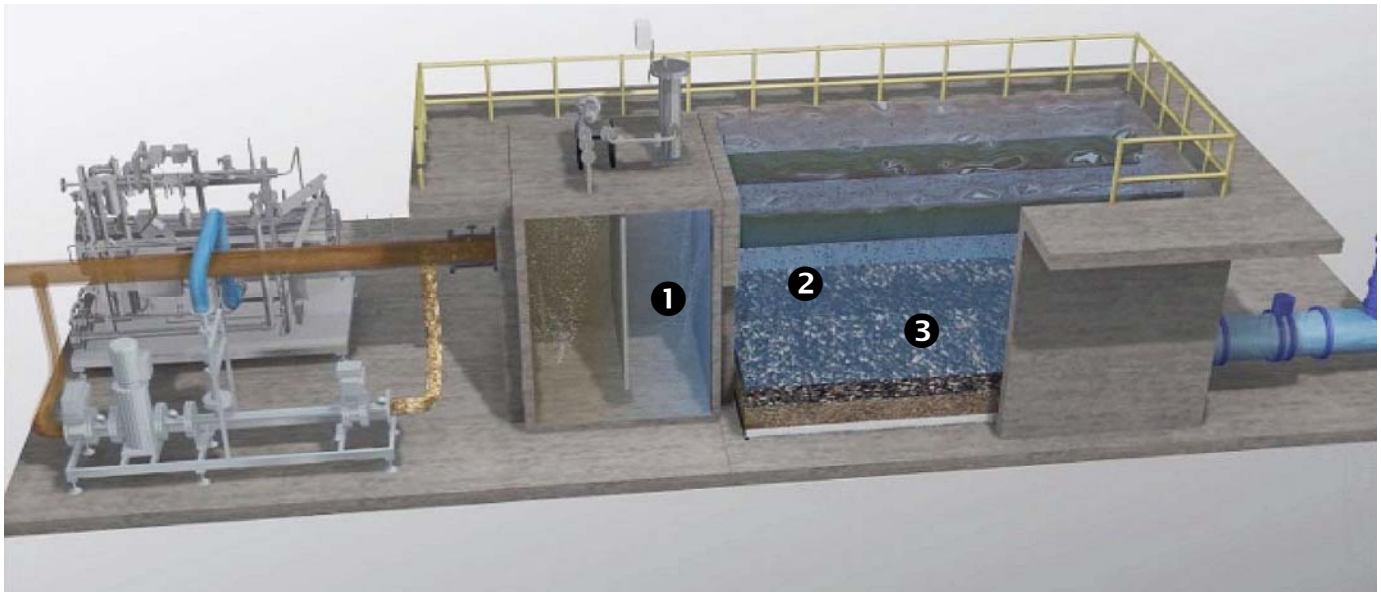
- Terminal Island Water Reclamation Plant
- 12 MGD indirect potable reuse facility (FAT)
- Groundwater recharge
- First ever full-scale UV/chlorine AOP
- Installation in 2016

O_3-BAC: It's Like déjà vu All Over Again

xylem

What is O_3-BAC?

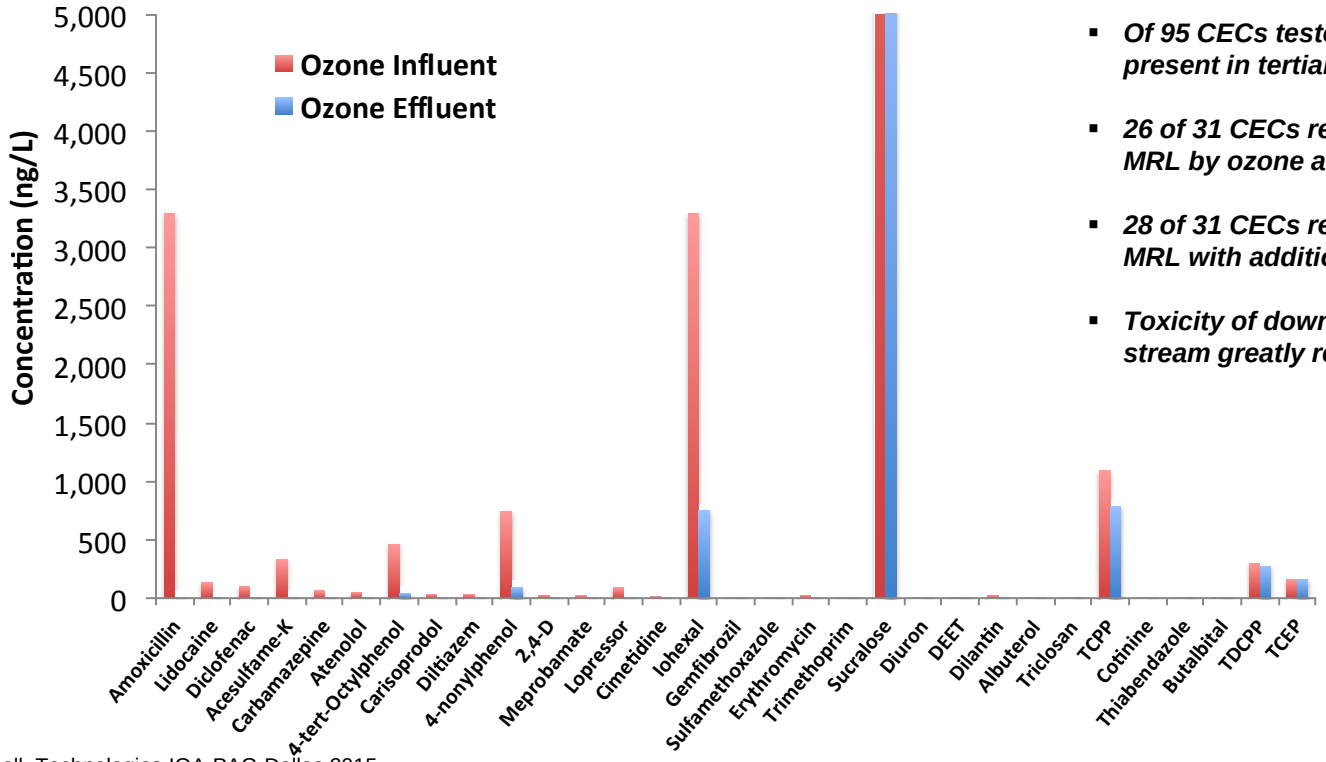
1. Oxidation → 2. Filtration → 3. Biological Treatment



❶ Inactivation of Pathogens & Oxidation of Organics ❷ Removal of TSS and Turbidity ❸ Destruction/Removal of TOC, CECs, and DBPs

xylem

CECs



- ***Of 95 CECs tested, 31 were present in tertiary effluent***
- ***26 of 31 CECs removed below MRL by ozone alone***
- ***28 of 31 CECs removed below MRL with addition of BAC***
- ***Toxicity of downstream RO brine stream greatly reduced***

Ref: Trussell Technologies IOA-PAG Dallas 2015

xylem

The Value Proposition of O_3-BAC for Reuse

- ~40% TOC removal across O3-BAC system
- Ozone excellent at removing a majority of CECs
- BAC (after ozone) provides additional barrier for most challenging CECs and oxidation byproducts
- O3-BAC significantly reduces organic fouling of UF membranes
- O3-BAC improves quality of RO concentrate
- O3-BAC satisfies California criteria for AOP

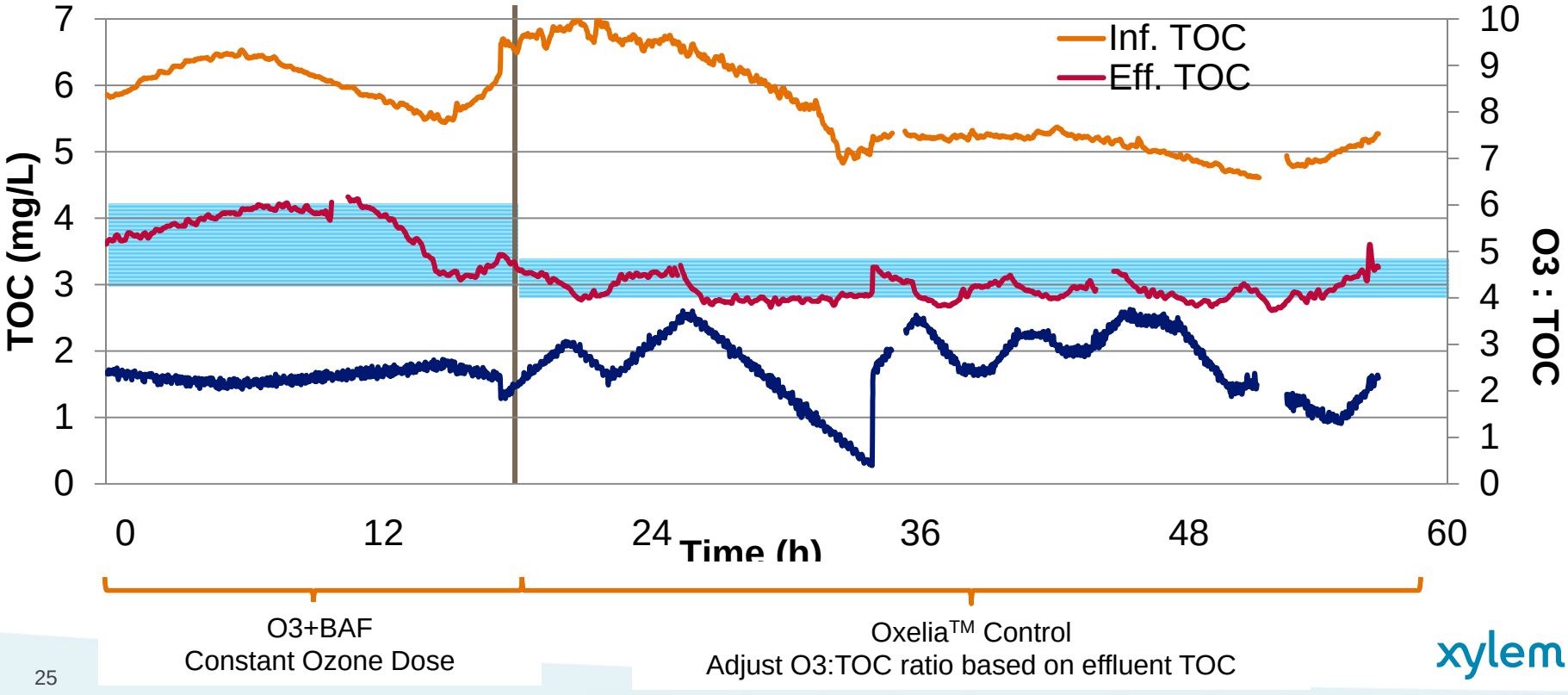
Can O_3-BAC Displace RO?

	MF-Ozone-BAF	MF-RO-AOP
Installed capital cost	~ 40% lower	High
Annual operation and maintenance cost	~ 50% lower	High
Energy	Low	High
Consumables	Low (GAC does not need to be replaced)	No (RO membranes must be replaced)
Residual Management	Minimal	Yes
TDS/Salinity Removal	No (use partial RO treatment if needed)	Yes
Destroys TOrCs and TOC	Yes	No (creates a residual waste stream)
NDMA	UV photolysis (use as needed)	Removed

xylem

Importance of Sensors and Process Control

Effluent TOC Control reduces effluent TOC fluctuation and achieves lower effluent TOC value



Pure Water San Diego

THE CITY OF SAN DIEGO

Ozone-Enhanced Biologically Active Filter

- North City Water Reclamation Plant
- 1.5 MGD Demonstration Plant
- O3 + BAC + MF + RO + AOP for Lake Miramar
- Surface water augmentation (drinking water)
- First full-scale demo of O3 + BAC for reuse in CA
- Evaluating design for 36 MGD reuse plant to address water needs

xylem

The End of Our Presentation

Thank You!

Questions?

keel.robinson@xyleminc.com

xylem