Technology & Innovation
Keel Robinson, North America Water Reuse Leader

May 13th, 2016
## Agenda

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Who is Xylem?
We Span the Entire Cycle of Water
Diverse Product Portfolio

**SANITAIRES**
- 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
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.
Recent Survey – Californians Support Water Reuse

DROUGHT-WEARY CALIFORNIANS ARE READY FOR RECYCLED WATER*
Residents eager for long-term solutions to water scarcity

- **76%** of survey respondents believe recycled water should be used as a long-term solution, regardless of drought.
- **87%** of respondents SUPPORT using recycled water as an additional source of water.
- **41%** somewhat willing
- **42%** very willing
- **83%** are willing to use recycled water in their everyday lives.

NEARLY 90% of Californians believe the state should continue to invest in recycled water for drinking water even if El Niño brings the expected rainfall.

Californians believe that recycled water should be used as a LONG-TERM SOLUTION for a water-secure future – regardless of potential rainfall from El Niño.

Only 12% will be less concerned about conserving water if El Niño brings the expected rainfall.

Silicon Valley Advanced Water Purification Center

- 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
State of Innovation for Water Reuse
Last 5 Years: A Transition To Potable Water Reuse

Level of Treatment

De Facto Potable Reuse
- Wastewater Treatment
- Surface Water
- Water Treatment Plant

Indirect Potable Reuse
- Advanced Wastewater Treatment
- Aquifer or Reservoir
- Water Treatment Plant

Direct Potable Reuse
- Advanced Wastewater Treatment
- Engineered Buffer
- Water Treatment Plant

Dilution & Response Time
- Dilution = Solution
- Shortest Response Time

Some Examples of Applied Research Successes

- Rediscovery of ozone-based solutions including O₃-BAC
- Taking UV/Cl₂ 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
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?
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
UV/Cl₂ AOP: The New Kid On The Block
UV/H$_2$O$_2$ 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/Cl₂ AOP

- Recent academic research shows that UV/Cl₂ AOP is effective at low pH

- 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$_2$O$_2$ 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/Cl₂ AOP selected
Terminal Island Water Reclamation Plant

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

UV/Chlorine Advanced Oxidation Process
O$_3$-BAC: It’s Like déjà vu All Over Again
What is O₃-BAC?

1. Oxidation
2. Filtration
3. Biological Treatment

1. Inactivation of Pathogens & Oxidation of Organics
2. Removal of TSS and Turbidity
3. Destruction/Removal of TOC, CECs, and DBPs
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
The Value Proposition of O₃-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 O₃-BAC Displace RO?

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

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

- Inf. TOC
- Eff. TOC

Time (h)

O3+BAF
Constant Ozone Dose

Oxelia™ Control
Adjust O3:TOC ratio based on effluent TOC
Pure Water San Diego

- 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

Ozone-Enhanced Biologically Active Filter
Thank You!

Questions?

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