Potable Reuse: The Future is Now

Eva Steinle-Darling, PhD, PE*
*TX PE #113317

TACWA / Austin Water

22 March 2024

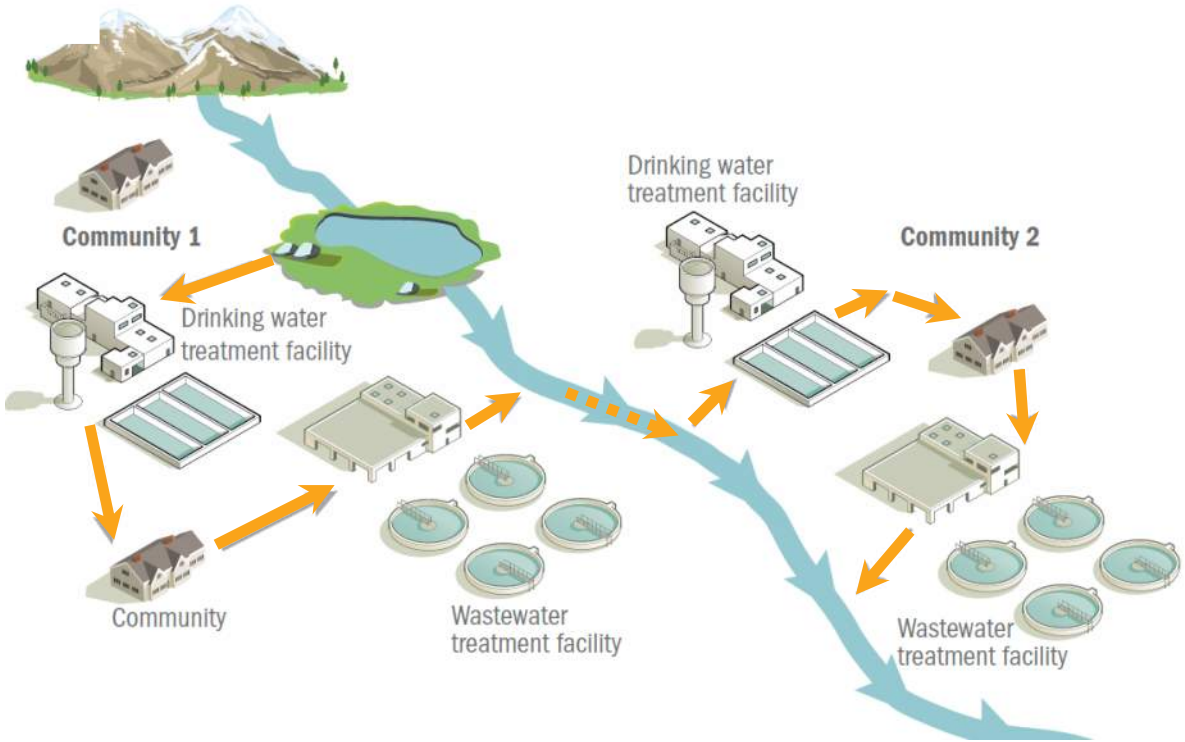
Agenda

1. Intro to Potable Reuse
2. Risks with *De Facto* Reuse
3. Advanced Treatment Alternatives
4. Potable Reuse Case Studies
5. Public Education and Outreach

01 Intro to Potable Reuse

Let's Acknowledge an Important Reality:

- ***De Facto* (unplanned) potable reuse has occurred since the beginning of time.**



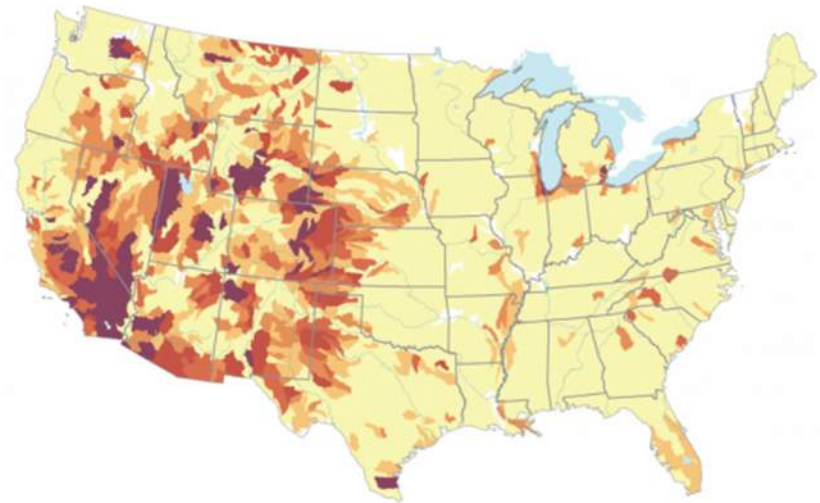
From AWWA Potable Reuse 101

Example:
Trinity River (Texas)

http://nas-sites.org/waterreuse/files/2012/09/trinity.jpg

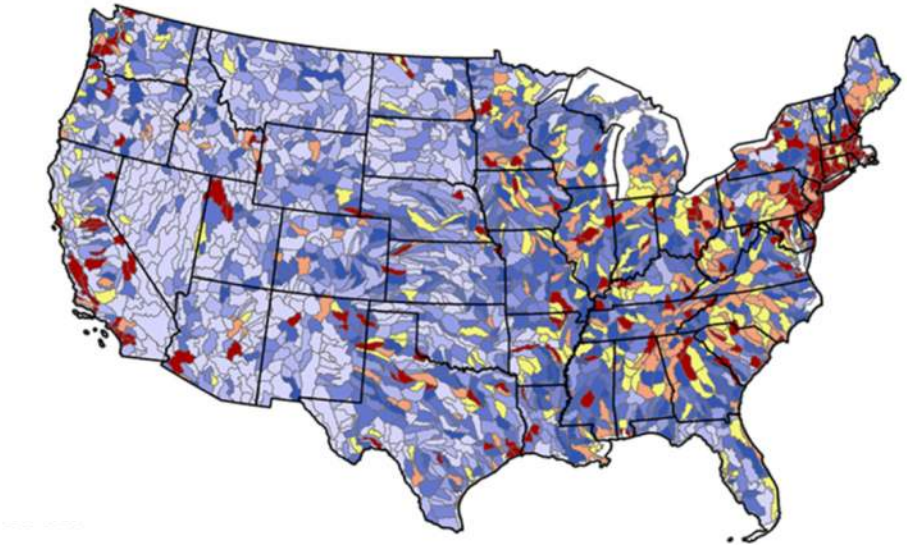
Major Change Drivers in our Nations Water Systems:

1. Water Supply Scarcity



Source https://www.globalchange.gov/browse/multimedia/water-stress-us

2. Discharge Avoidance (Nutrients)

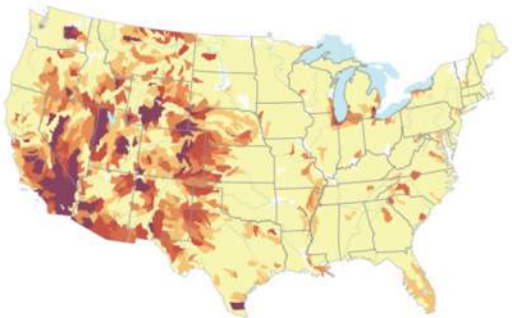


Source: Sabo et al, 2021 at https://iopscience.iop.org/article/10.1088/2515-7620/abf296

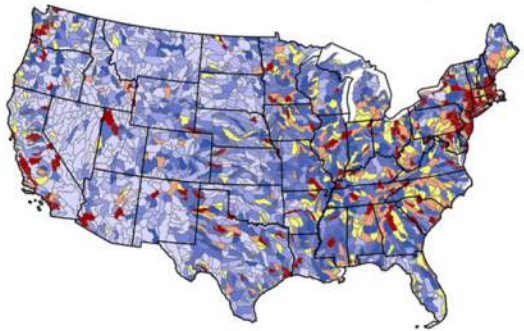
The Obvious Solution to both Problems: Water Reuse

Intentional!

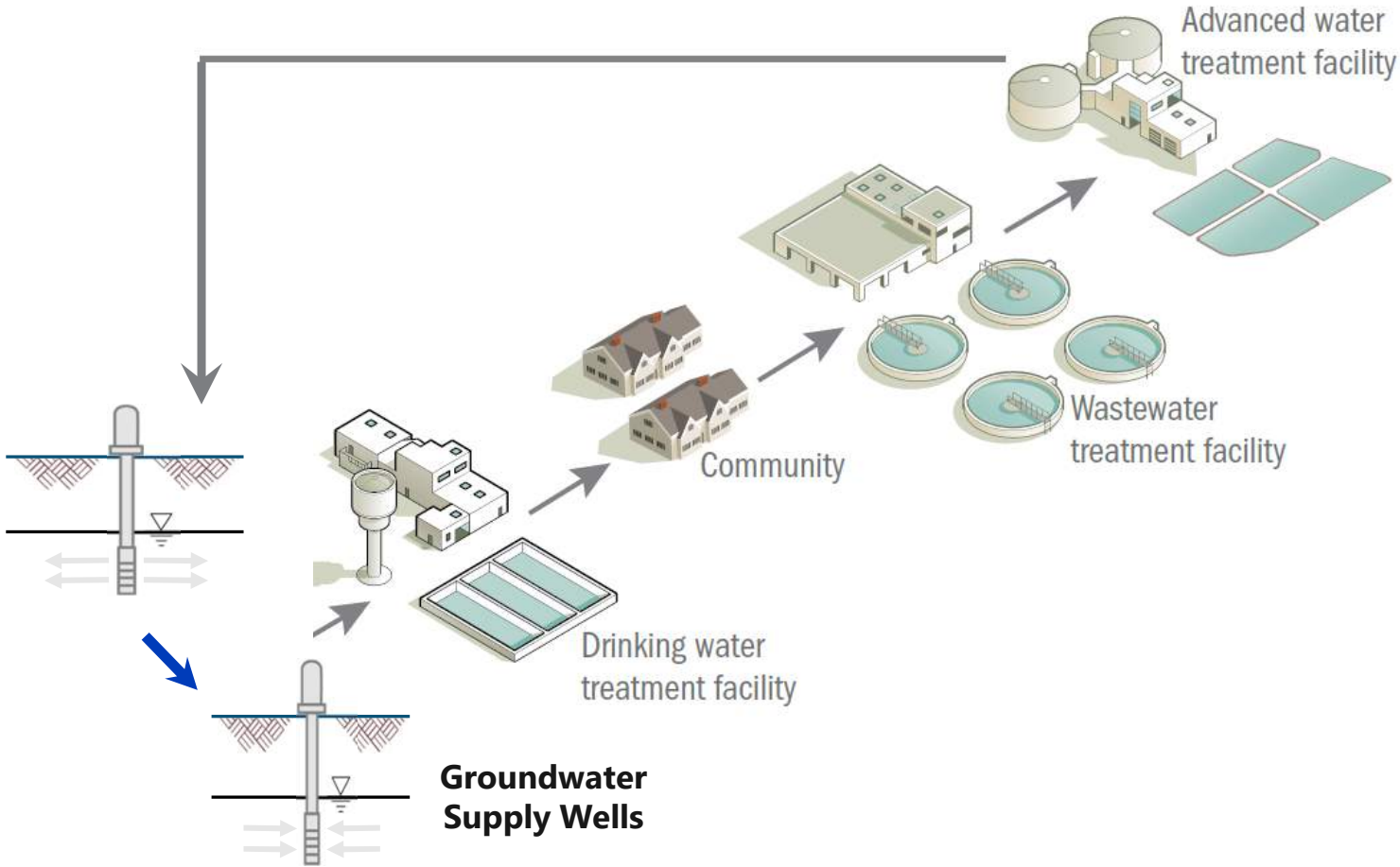
1. **Water Supply Scarcity**



2. **Discharge Avoidance (Nutrients)**

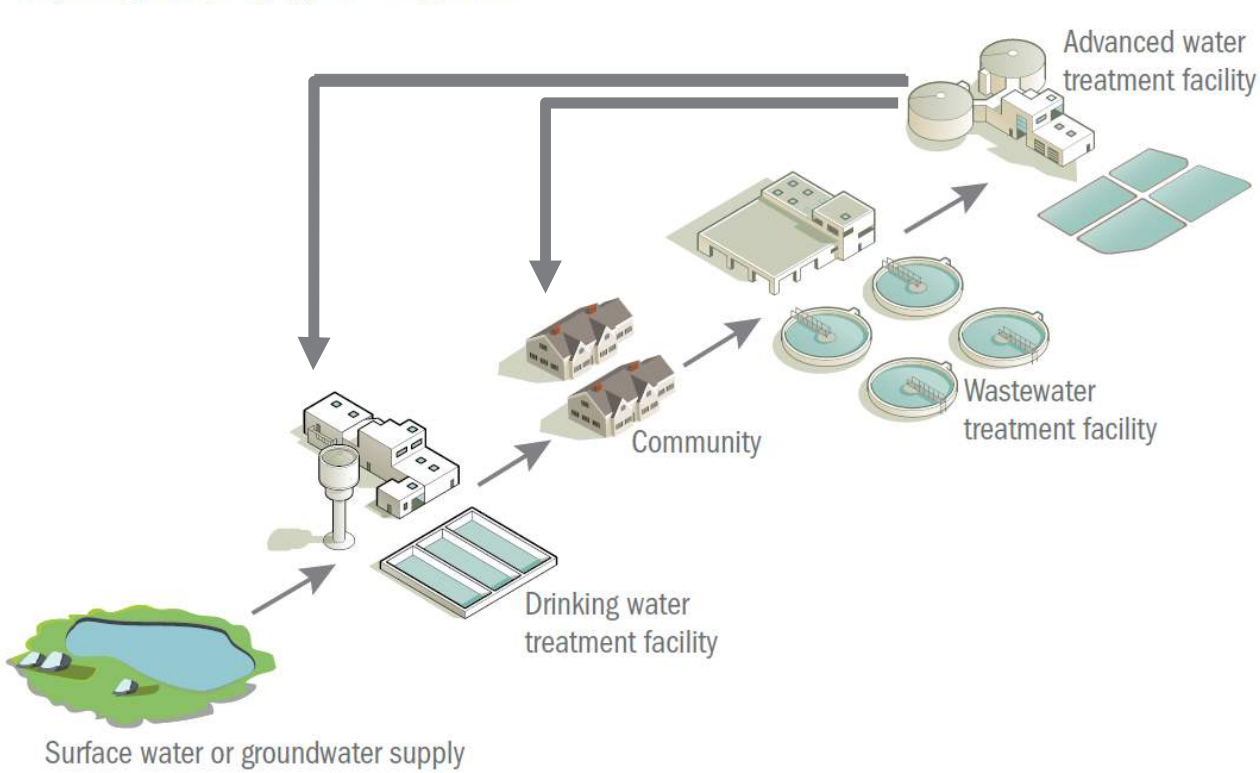


“Indirect Potable Reuse” signals *Intention* to Reuse



From AWWA Potable Reuse 101

“Direct Potable Reuse” Intensifies the Cycle



From AWWA Potable Reuse 101

There is a Gap in Federal Regulation

Clean Water Act

- Protects *receiving environment*
- Minimal focus on downstream use as drinking water supply
- Uses different parameters to define water quality, e.g.:
  - BOD
  - TSS
  - Bacteria

Safe Drinking Water Act

- Protects public health
- Assumes source water quality without wastewater influence
- Uses different parameters to define water quality, e.g.:
  - TOC
  - Turbidity
  - Virus, Crypto & Giardia

Regulatory Uncertainty now Managed by TCEQ Guidance: *WateReuse Texas wins Advocacy Award!*

RG-634 • November 2022
TCEQ Water Supply Division

Direct Potable Reuse for Public Water Systems

Introduction

Senate Bill 905 from the 87th Legislative Regular Session required the Texas Commission on Environmental Quality (TCEQ) to develop a regulatory guidance manual outlining agency rules that apply to direct potable reuse. This guidance manual explains how direct potable reuse (DPR) is regulated in Texas and what is required for a public water system to receive approval of a DPR project.

Purified Recycled Water Projects Around the World

carollo

Click highlighted projects for details.

OREGON
1. **Clean Water Services Pure Water Demonstration**
   Hillsboro, OR

UTAH
2. **PureSoJo Non-RO DPR Demonstration Facility**
   South Jordan City, UT

COLORADO
3. **Regulatory Framework, Outreach Plan, and PureWater Colorado Demonstration**
   Colorado Water Conservation Board, CO
4. **DPR Planning Support and Treatment Evaluation**
   City of Aurora, CO
5. **Mobile Demonstration of Carbon-based Advanced Treatment DPR Process Train**
   Colorado Springs Utilities, CO

ARIZONA
6. **Phoenix Advanced Purified Water Plan**
   City of Phoenix, AZ
7. **Advanced Water Purification Facility Pre-Feasibility Study**
   City of Phoenix, AZ
8. **Direct Potable Reuse Guidance in Arizona**
   WateReuse Arizona and AZ Water Association, AZ
9. **AZ Pure Water Mobile DPR Demo**
   Pima County Southwest Water Campus, AZ

NEW MEXICO
10. **Rio Rancho Pure**
    Rio Rancho, NM
11. **Santa Fe Water Reuse Feasibility Study and Return Flow Pipeline**
    City of Santa Fe, NM
12. **New Mexico DPR Regulations**
    New Mexico Environment Department, NM

TEXAS
13. **Advanced Water Purification Facility (DPR)**
    El Paso Water, TX
14. **DPR Advanced Treatment Process and Water Quality Confirmation Testing**
    Texas Water Development Board, Big Spring, TX
15. **DPR Feasibility Study and Water Reclamation Facility Design**
    City of Dripping Springs, TX

OKLAHOMA
16. **Multi-Use Water Reuse Feasibility Study**
    City of Guymon, OK
17. **2060 Strategic Water Supply Plan**
    City of Norman, OK

TENNESSEE
18. **Advanced Purification Project**
    City of Spring Hill, TN

NORTH CAROLINA
19. **DPR Evaluation in WWMP**
    Cape Fear Public Utility Authority, NC

INTERNATIONAL
20. **Mekerot (Israel) Shafdan Effluent Enhanced Treatment for IPR Quality**
    Israel
21. **Validation Panel for IDE's SARP Water Reuse Technology**
    Israel
22. **Ministry of Economy, Trade, and Industry of Japan (METI)**
    Japan
23. **Water Corporation of Western Australia**
    Perth, Australia
24. **Stormwater to Potable Feasibility Study**
    Confidential Utility, Australia
25. **Purified Recycled Water Strategy Workshop**
    Rous County Council, NSW
26. **Confidential State Regulator**
    Australia

Around the World | California | Florida

Purified Recycled Water Projects in California

carollo

Click highlighted projects for details.

FULL-SCALE PROJECTS

1. **Indirect Potable Reuse System**
   City of Morro Bay
2. **Central Coast Blue**
   City of Pismo Beach
3. **Carpinteria Advanced Purification Project**
   Carpinteria Valley Water District
4. **WaterPure IPR/DPR Studies, Demonstration Facility, Basis of Design and Permitting**
   City of Ventura
5. **Los Angeles Groundwater Replenish Project's Advanced Water Purification Facility**
   City of Los Angeles
6. **Hyperion 100% Water Recycling Implementation**
   City of Los Angeles Bureau of Sanitation (LASAN)
7. **Terminal Island Water Reclamation Plant**
   City of Los Angeles Bureau of Sanitation (LASAN)
8. **Process Water Recycling Design Build Project**
   Rancho Cucamonga
9. **Regional Recycled Water Advanced Purification Center Design and Testing**
   Metropolitan Water District of Southern California
10. **West Basin Municipal Water District**
    Membrane Design
11. **Groundwater Replenishment System Final Expansion**
    Orange County Water District and Orange County Sanitation District
12. **Padre Dam MWD/East County IPR Program**
    Padre Dam MWD
13. **Pure Water Program**
    City of San Diego

RESEARCH AND PLANNING STUDIES

1. **Pure Water Roseville**
   City of Roseville
2. **Direct Potable Reuse Feasibility Study**
   Central Marin Sanitation Agency and the Marin Municipal Water District
3. **Tri-Valley Potable Reuse Feasibility Study**
   Tri-Valley Water Agencies of CA
4. **The Rainbow Project Planning and Schematic Design**
   FMCAC/SFAI
5. **South Bay Purified Water Project**
   SFPUC and Cities of San Jose and Santa Clara
6. **PureWaterSF Building-Scale DPR Demonstration**
   San Francisco Public Utility Commission
7. **Renew Water**
   in collaboration with the City of Palo Alto
8. **Potable Reuse Planning, Research, and Grant Funding**
   Valley Water
9. **Groundwater Replenishment Feasibility Study and Pilot Testing**
   Soquel Creek Water District
10. **Monterey One Water**
    City of Monterey
11. **Potable Reuse Implementation Plan**
    City of San Luis Obispo
12. **Central Coast Blue**
    City of Pismo Beach
13. **Groundwater Recharge Evaluation**
    Laguna County Sanitation District
14. **Recycled Water Market Assessment**
    City of Santa Barbara
15. **Countywide Potable Reuse Evaluation**
    County of Santa Barbara
16. **Enhanced Recycled Water Feasibility Study**
    Montecito Water and Sanitary Districts
17. **WaterPure IPR/DPR Studies, Demonstration Facility, Basis of Design and Permitting**
    City of Ventura
18. **Recycled Water Retrofit Program**
    City of Oxnard
19. **Hyperion 100% Water Recycling Implementation**
    City of Los Angeles Bureau of Sanitation (LASAN)
20. **Terminal Island Water Reclamation Plant**
    City of Los Angeles Bureau of Sanitation (LASAN)
21. **Pure Water Project: Las Virgenes-Triunfo**
    Las Virgenes Municipal Water District
22. **Regional Recycled Water Advanced Purification Center Design and Testing**
    Metropolitan Water District of Southern California
23. **West Basin Municipal Water District**
    Membrane Design
24. **National Water Research Institute – Framework for Direct Potable Reuse**
    Orange County
25. **National Water Research Institute – Implementation of Direct Potable Reuse, A Guide for California Water Utilities**
    Orange County
26. **Lower Santa Margarita Water Supply Reliability Pilot Project**
    Fallbrook Public Utility District
27. **Encina Wastewater Authority**
    City of Carlsbad

Purified Recycled Water and Advanced Treatment Projects in Florida

carollo

Click highlighted projects for details.

POTABLE REUSE PROJECTS

1. **Florida Potable Reuse Commission**
   WateReuse Florida and Water Research Foundation Regulatory Framework Development
2. **Potable Reuse Treatability Study and Pilot**
   Clay County Utility Authority
3. **pureALTA Potable Reuse Pilot Study and Demonstration Facility**
   City of Altamonte Springs
4. **EWRF Potable Reuse Feasibility Study and Basis of Design**
   Orange County Utilities
5. **Indirect Potable Reuse Feasibility Study**
   Central Florida Tourism Oversight District
6. **IPR Feasibility Study and Soil Aquifer Treatment Pilot at 160-Ac RIBs Site**
   Toho Water Authority
7. **Tampa PURE**
   City of Tampa
8. **One Water Polk**
   Polk County Utilities
9. **Pilot Plant for Recharging the Biscayne Aquifer**
   Miami-Dade County

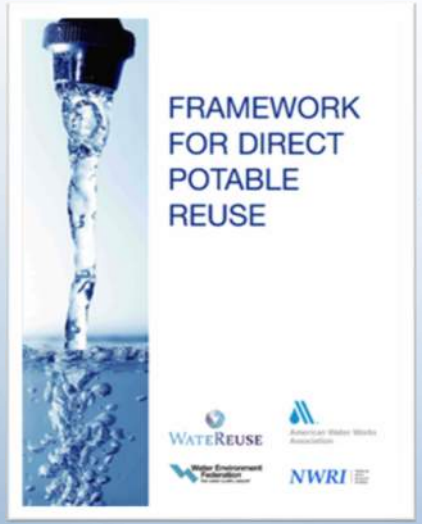
OTHER ADVANCED TREATMENT DESIGNS

1. **WTP No.2 Expansion RO Design and WTP No.3 RO Design**
   City of Palm Coast
2. **WRWSF Ozone Treatment Pilot Study**
   Orange County Utilities
3. **Regional WTP 30mgd RO Design**
   Polk County Utilities
4. **David L. Tippin WTF SIX Design and David L. Tippin WTP Ozone Improvements Design**
   City of Tampa
5. **WTP #2 RO Design and Lithia Hydrogen Sulfide Removal**
   City of Clearwater
6. **WTP Expansion RO Design**
   SunFun Resort
7. **Venice Gardens WTP Expansion RO Design**
   Sarasota County Utilities
8. **Babcock Ranch WTP RO Design**
   Kitson & Partners
9. **Pinewoods WTP Expansion RO Design and North Lee County WTP Expansion RO Design (2011,2021)**
   Lee County Utilities
10. **Sawgrass WTP RO Design and Springtree WTP RO Design**
    City of Sunrise
11. **Golden Gate WTP Expansion RO Design**
    FGUA
12. **Northeast Regional WTP RO Design**
    Collier County
13. **Stock Island WTP RO Design**
    FKAA

IMPLEMENTATION OF DIRECT POTABLE REUSE

A GUIDE FOR ~~CALIFORNIA~~ ALL U.S. WATER UTILITIES

FINAL | MARCH 2021



See also: https://www.youtube.com/watch?v=6psFbRrMAJg

VENTURA WATER

Valley Water

LA DWP Los Angeles Department of Water & Power

San Francisco Water Power Sewer

NWRI NATIONAL WATER RESEARCH INSTITUTE

carollo Engineers...Working Wonders With Water®

13 KEY COMPONENTS TO IMPLEMENT POTABLE REUSE PROJECTS

1. Project Definition
2. Technical, Managerial, and Financial Capability
3. Interagency Agreements
4. Outreach and Education
5. Wastewater Source Control
6. Wastewater Treatment
7. Multiple Treatment Barriers
8. Pathogen Control and Monitoring
9. Chemical Control and Monitoring
10. Operations
11. Water Quality Management
12. Emerging Issues
13. Collaboration to Spur Innovation

+ Case Studies

02

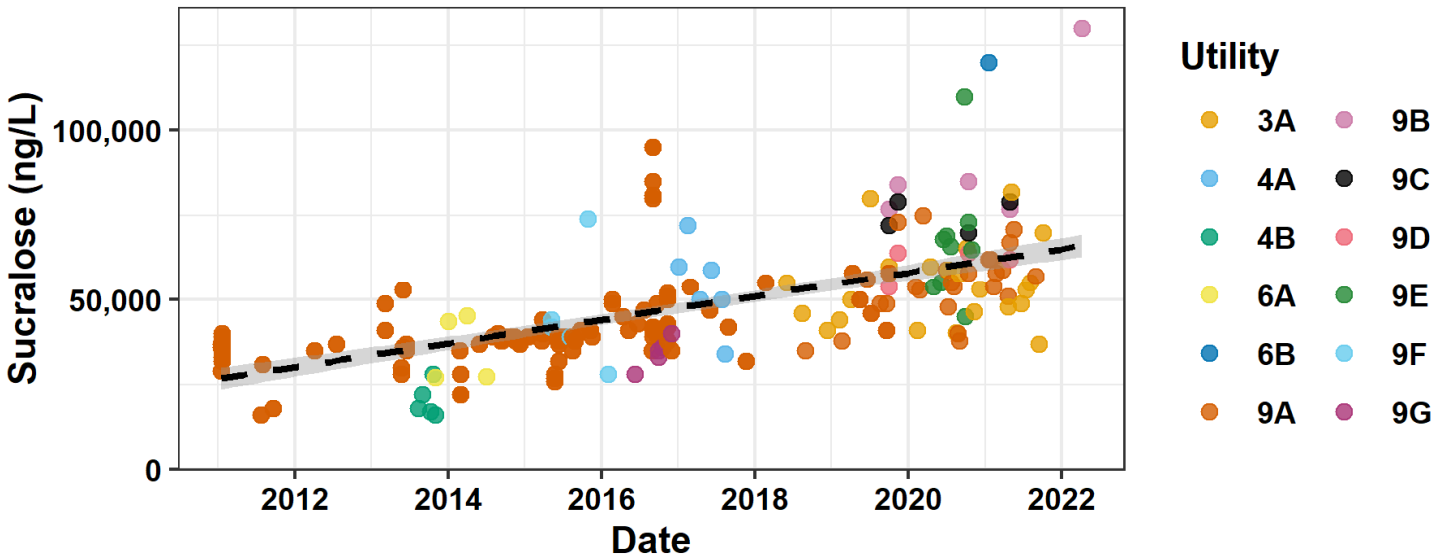
PFAS Illustrates *De Facto* Reuse Risk

Or: Why you should consider Advanced Treatment

Trinity River Sampled for PFAS and sucralose for WRF 5082

Nearly 15 million people, >4% of US population rely on the Trinity as a drinking water supply.

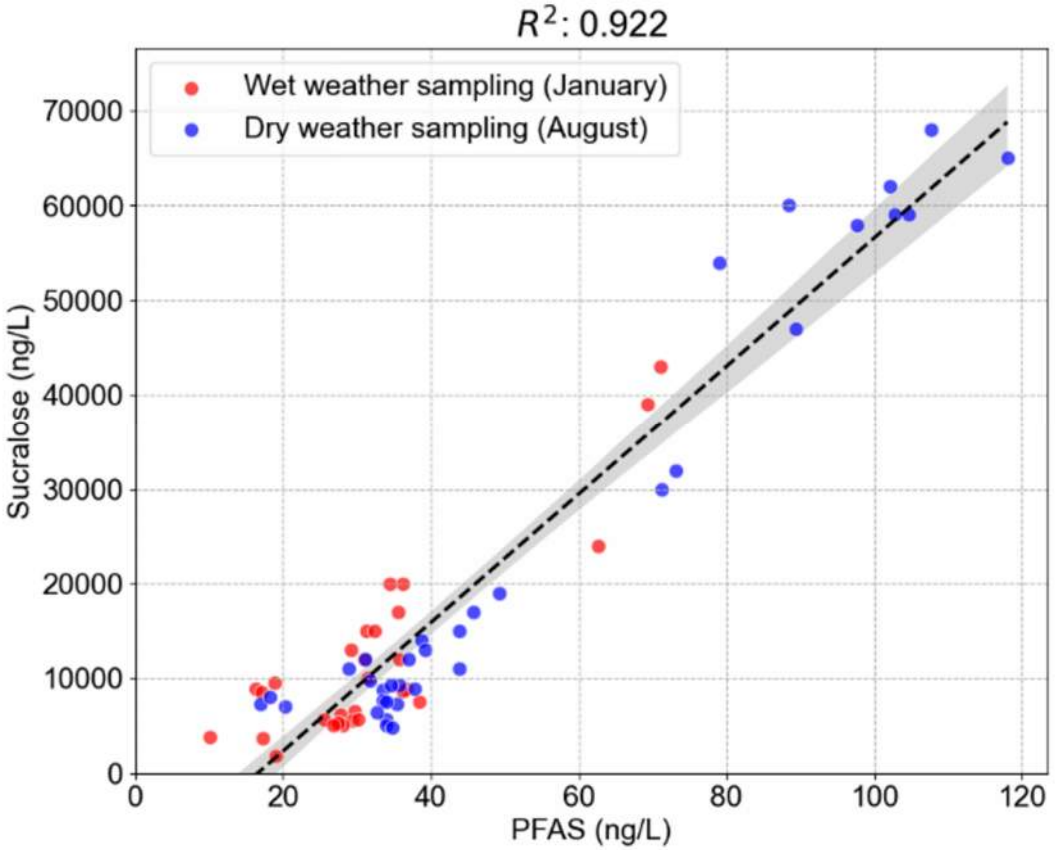
Sucralose is a wastewater effluent tracer



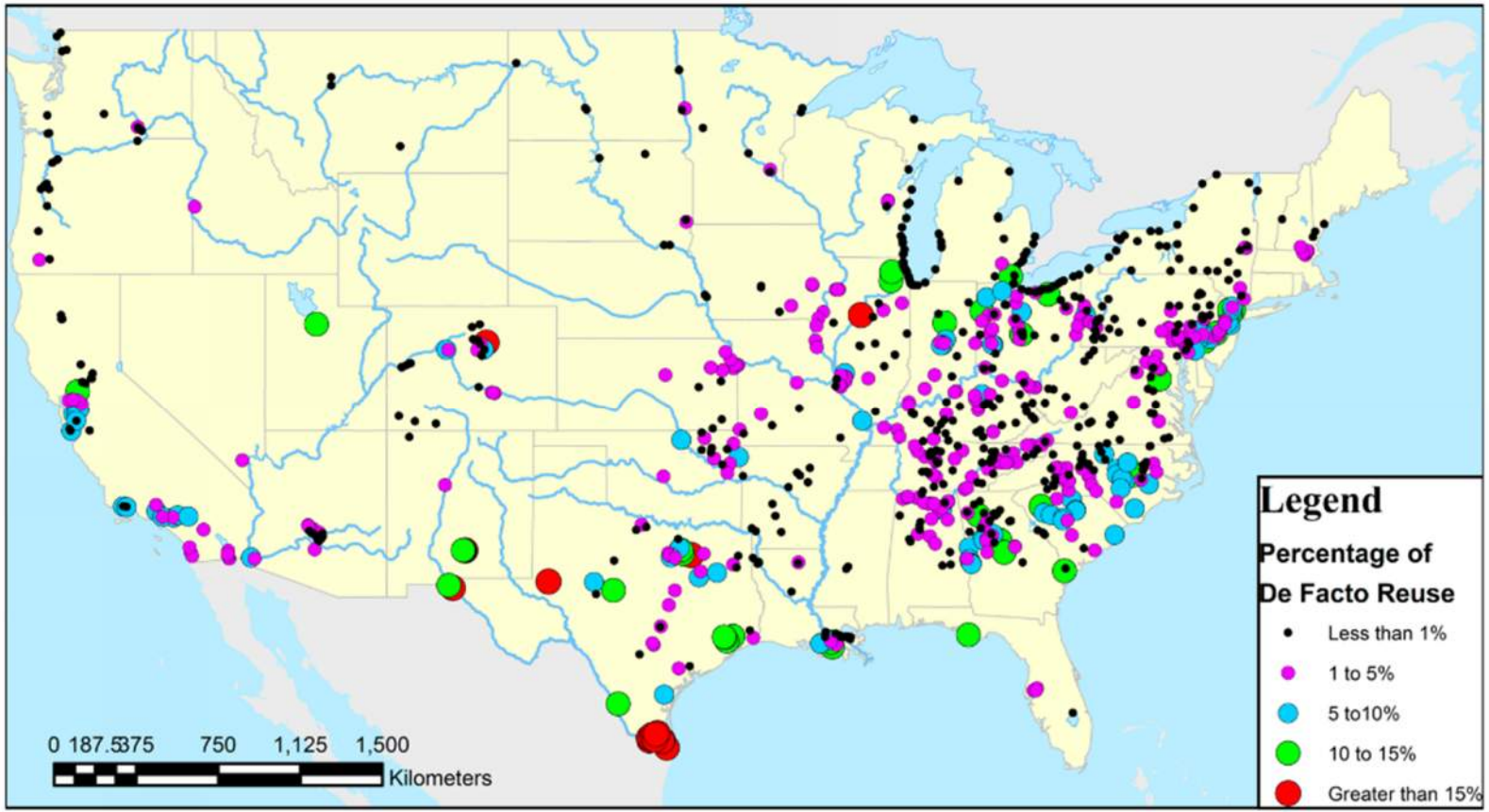
- Non-toxic
- Highly persistent in wastewater treatment and the environment

- High concentrations in wastewater effluent (≥50,000 ng/L)
- Consistent concentration among WWTPs

Measured PFAS correlated strongly with sucralose in the river, Ergo: Most PFAS in Trinity is wastewater-derived



Many more rivers in the US with this issue



Graph from Rice and Westerhoff, 2015. *Environ. Sci. Technol.* 49, 982–989 DOI:10.1021/es5048057

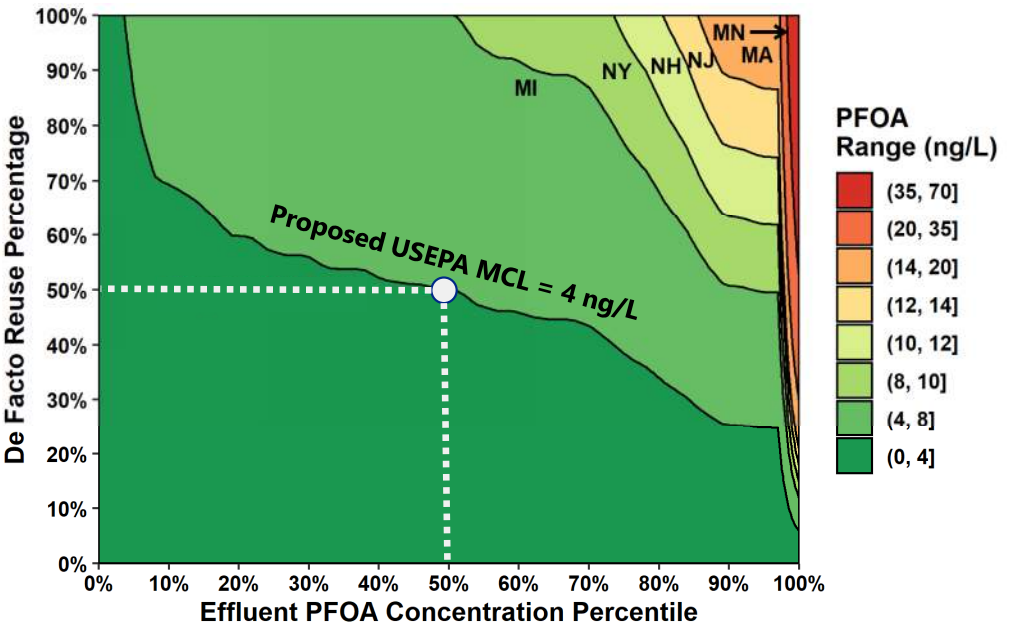
Impact of Effluent PFAS on Surface Waters Across the US

EXAMPLE

Drinking water intake with:

- » Median WW effluent PFOA upstream and
- » 50% *de facto* reuse
- » PFOA ≈ 4 ng/L proposed MCL

REMEMBER:
WWTPs are not the original source of PFAS



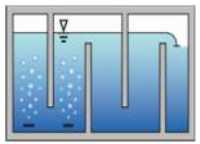
Data from: Schaefer et al. 2022. *Occurrence of PFAS Compounds in U.S. Wastewater Treatment Plants* (WRF 5031); analysis completed as part of WRF 5082 (Steinle-Darling et al, *in press)*.

03

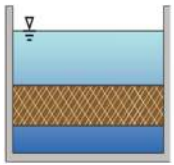
Advanced Treatment Alternatives for Potable Reuse

Membrane-Based Advanced Treatment

Supporting Process:



Ozone

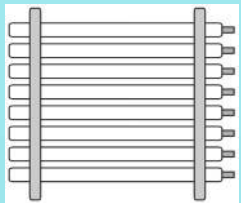


Biofilters

MF / UF for RO preteatment

Core MBAT Processes:

RO



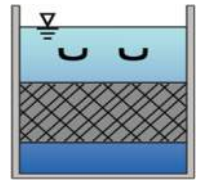
TDS and CECs Reduction

AOP

Polishing (NDMA e.g.)

Supporting Processes:

GAC



Chlorine Disinfection

Graphics credit: WRF 4833 Series Fact Sheet on Membrane-Based Advanced Treatment (Steinle-Darling et al, 2023)

MBAT Examples in Potable Reuse

Surface Water Augmentation
The Hamby Water Reclamation Facility in Texas advanced-treats water with RO *and* ozone/BAC before being discharged to Lake Fort Phantom Hill, the City's of Abilene's drinking water supply.

Groundwater Recharge
The Orange County Water District in California has been operating its Groundwater Replenishment System since 2008 and was recently expanded to 130 mgd.

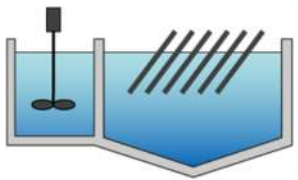
Coming soon!
Direct Potable Reuse
The Metropolitan Water District of Southern California and the Sanitation Districts of LA County operate an MBR, RO, and UVAOP demo project to support a future 150 mgd Regional Recycled Water Advanced Purification Center.

Direct Potable Reuse
In 2013, the Colorado River Municipal Water District in Texas started operating the first DPR facility in the U.S. Their Raw Water Production Facility uses an RBAT approach consisting of MF, RO, and UVAOP.

Graphics credits: Modified from WRF 4833 (Steinle-Darling et al. 2023)

Carbon-Based Advanced Treatment

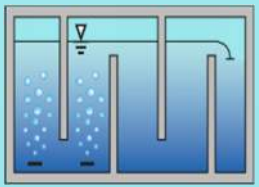
Supporting Process:



Coagulation, Flocculation, and Sedimentation address high influent TOC

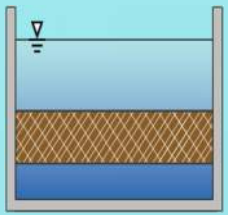
Core CBAT Processes:

Ozone



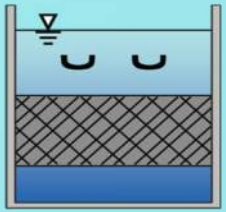
Disinfection & AOP with EfOM

BAC



TOC and CECs Reduction

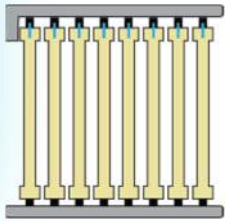
GAC



Polishing (PFAS e.g.)

Supporting Processes:

UV Disinfection



MF / UF for protozoa removal

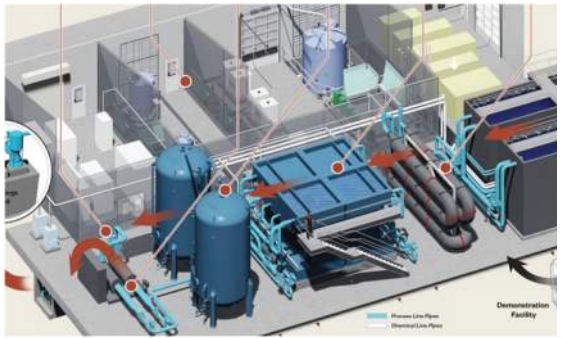
Chlorine Disinfection

Graphics credit: WRF 4833 Series Fact Sheet on Carbon-Based Advanced Treatment (Steinle-Darling et al, 2023)

CBAT Examples in Potable Reuse

Surface Water Augmentation
The 60 mgd F. Wayne Hill Water Resources Center in Gwinnett County, GA has been purifying wastewater with the CBAT approach for introduction into Lake Lanier since 2010.

Groundwater Recharge
El Paso's 12 mgd Fred Hervey WWTP has been recharging groundwater with CBAT purified water since 1985



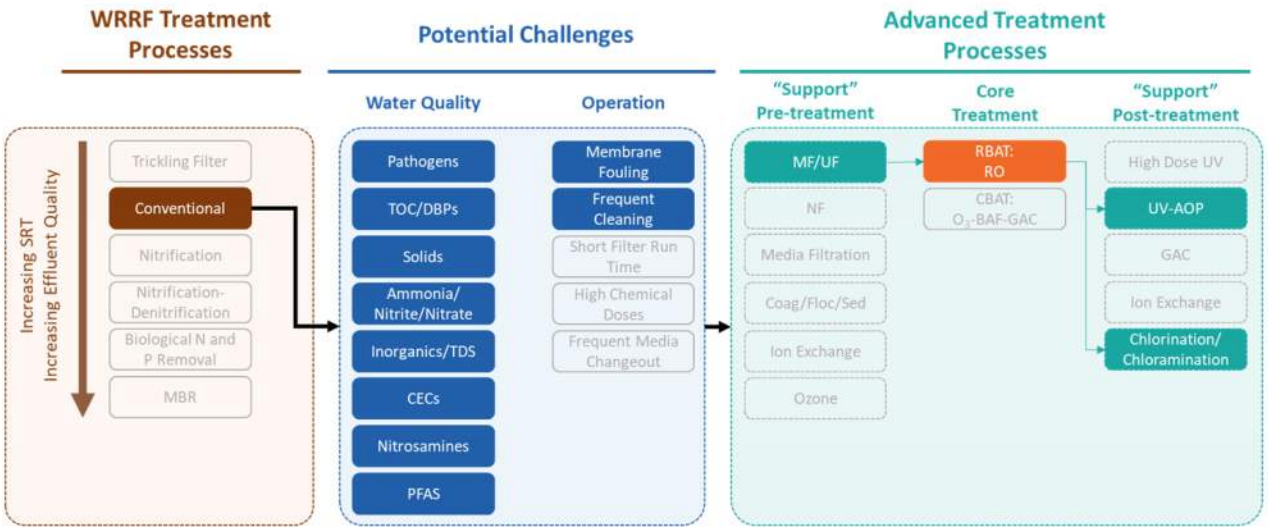
Coming soon!
More CBAT for Recharge
HRSD's SWIFT program will ultimately produce 120 mgd of purified water to supplement the Potomac Aquifer and protect the Chesapeake Bay.

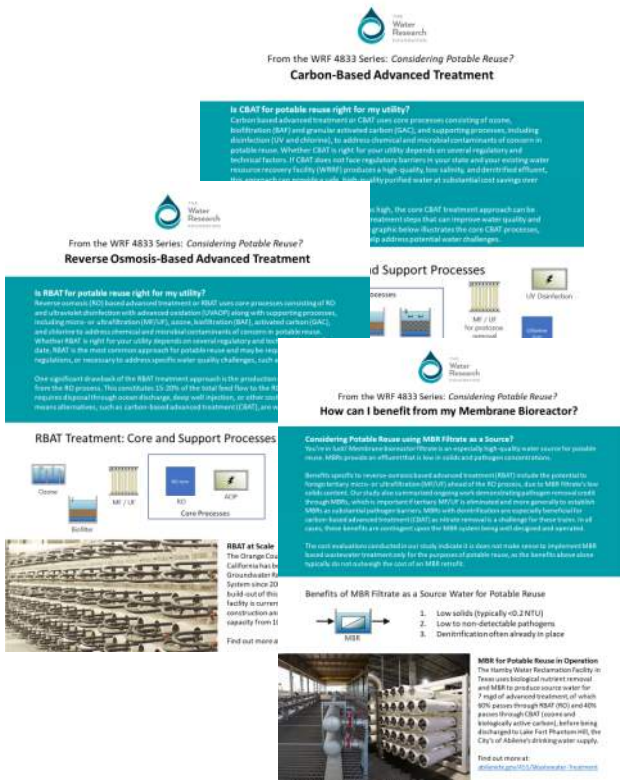
Coming soon!
Direct Potable Reuse
In 2017, the City of Altamonte Springs, FL implemented pureALTA, an award-winning direct potable reuse (DPR) demonstration facility using the CBAT approach.

Graphics credits: Modified from WRF 4833 (Steinle-Darling et al, 2023) for Gwinnett, pureALTA) Parkhill Smith and Cooper web site (El Paso), HRSD (SWIFT virtual tour)

WRF 4833: Selecting the Right Treatment Approach

- Examines treatment holistically: WW → AWTP
- Assesses common combinations, weaknesses, and mitigations
- Evaluates cost trade-offs between improving WWTP vs. AWTP
- Provides detailed research report AND accessible guidance





Steinle-Darling (Carollo) PI, Co-PIs from Hazen, Southern Nevada Water Authority and Metropolitan Water District of Southern California

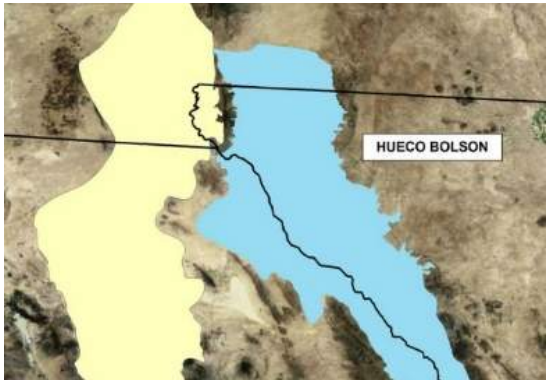
04

Case Studies

El Paso, TX

Membrane-Based Advanced Treatment for Direct-to-Distribution DPR

El Paso Water relies on a diverse water supply portfolio to meet demands



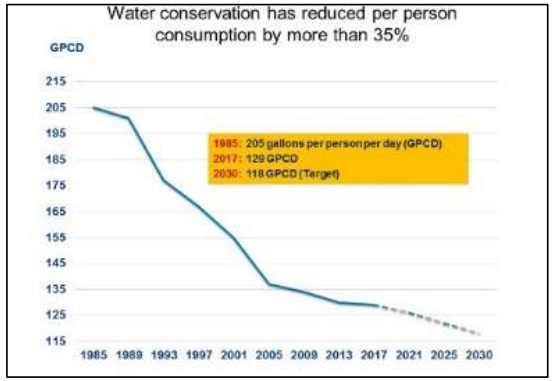
Groundwater

Surface Water

Desalination

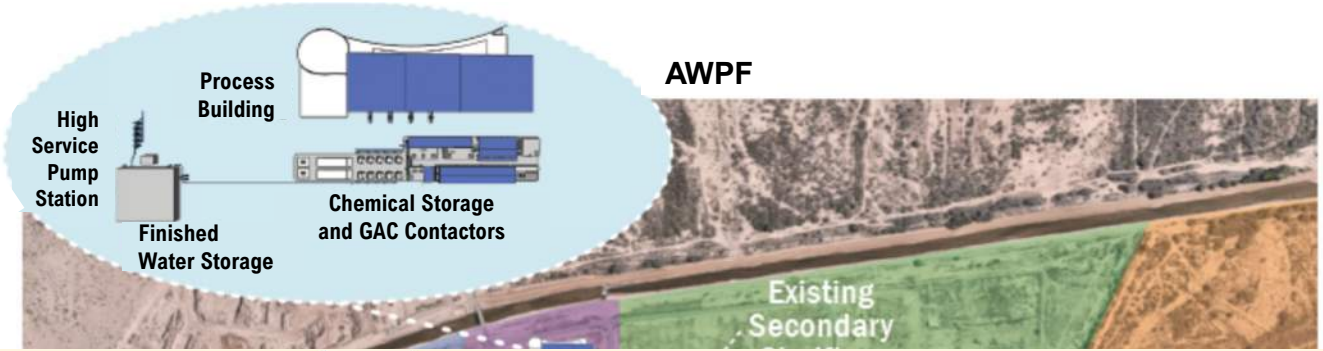
Non-Potable Reuse

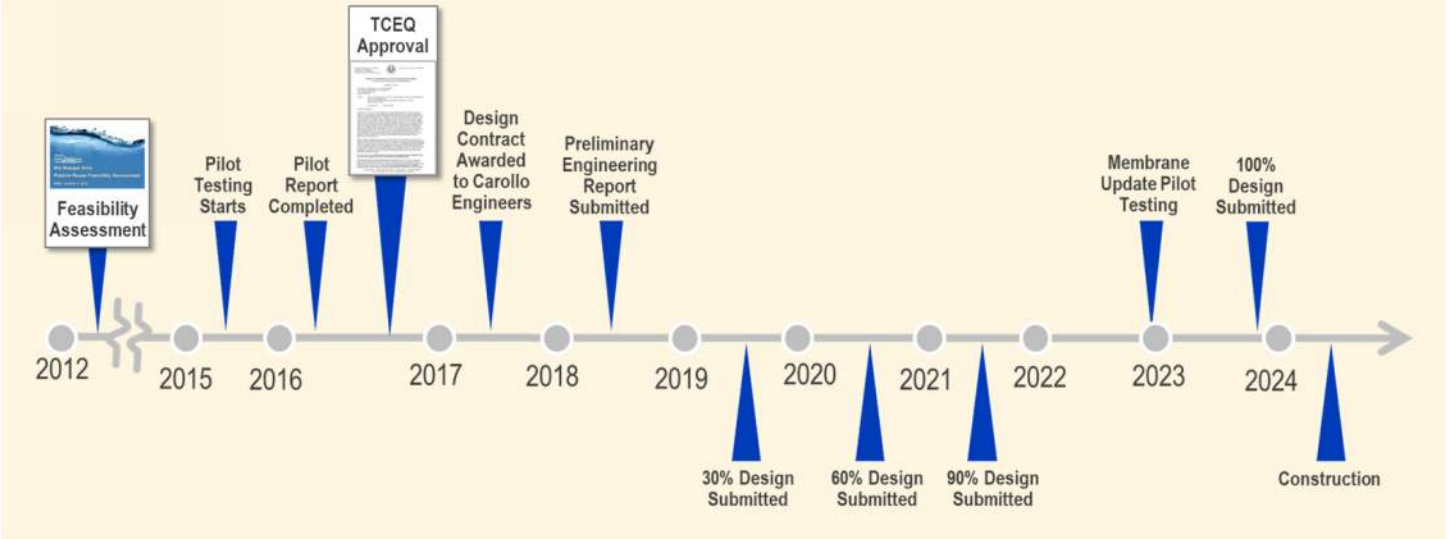
Indirect Potable Reuse



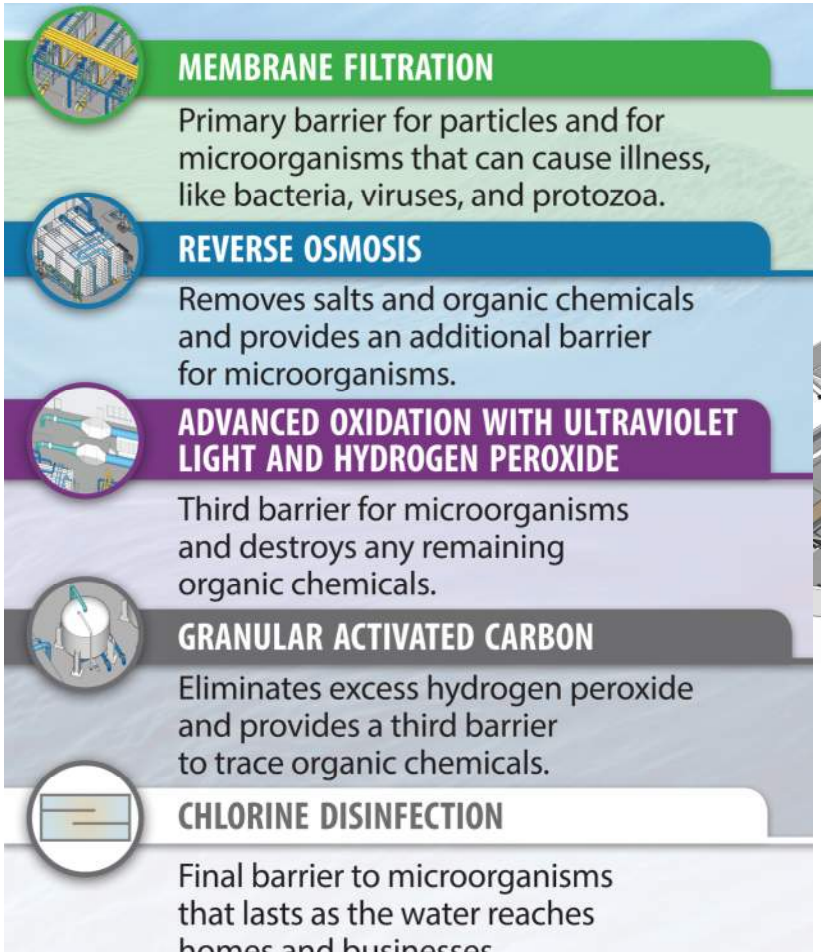
Conservation

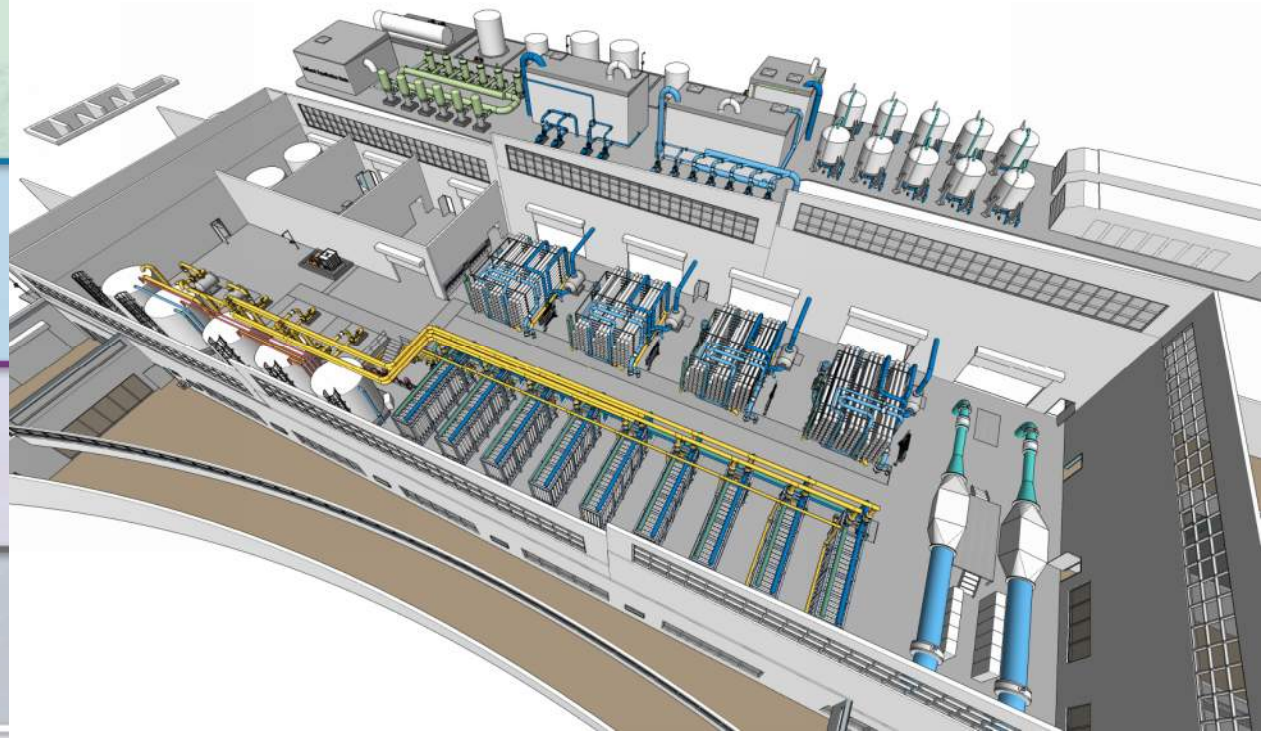
A new *direct-to-distribution* potable reuse treatment facility provides a sustainable supply





AWPF provides multiple treatment barriers



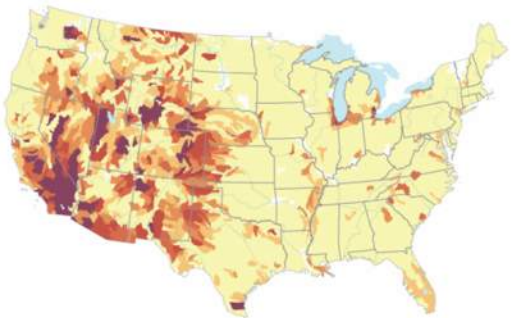


Hampton Roads Sanitation District, VA:

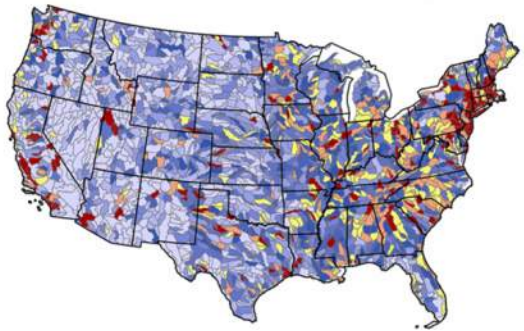
Full-Scale Carbon-Based Advanced Treatment for IPR

Remember this slide?

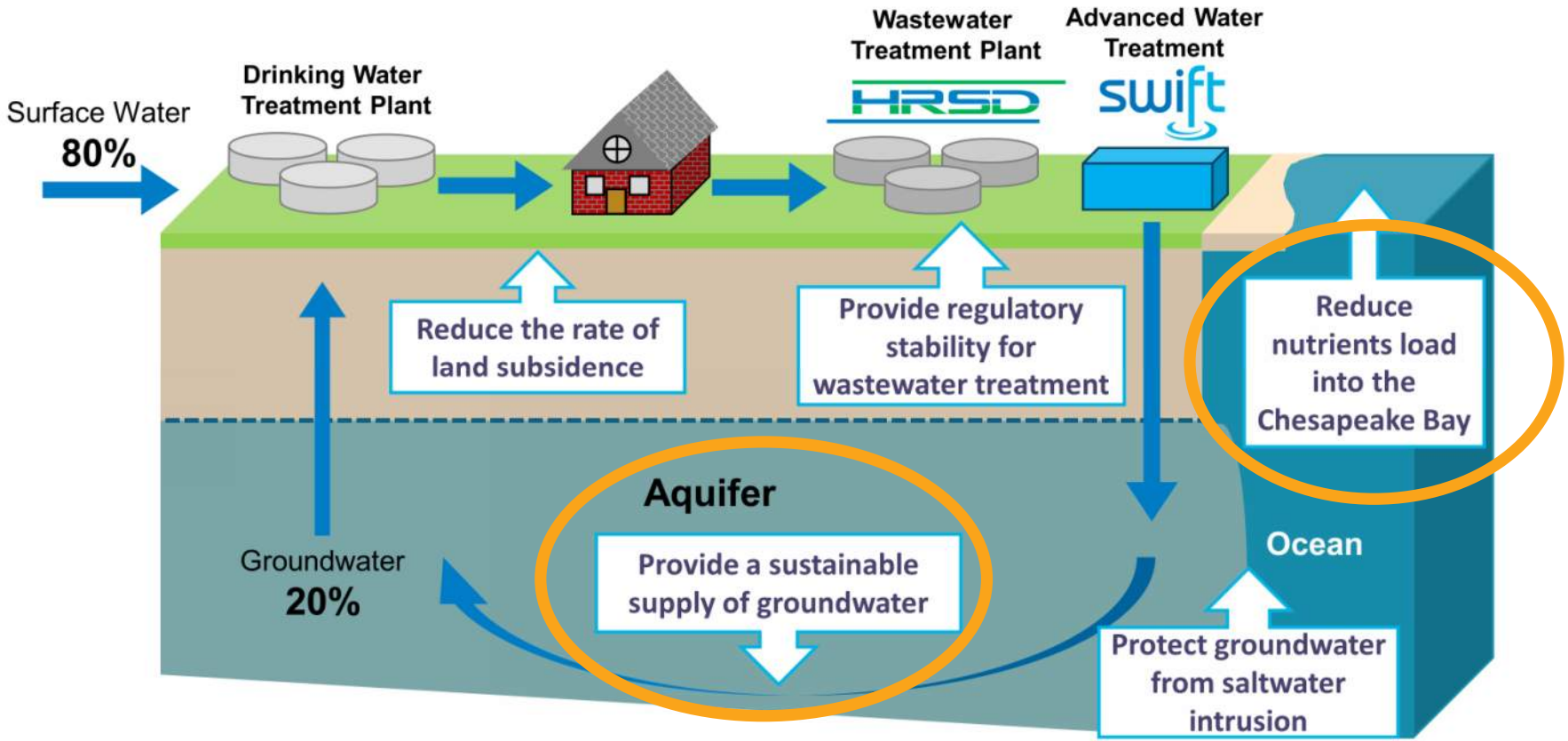
1. **Water Supply Scarcity**



2. **Discharge Avoidance (Nutrients)**

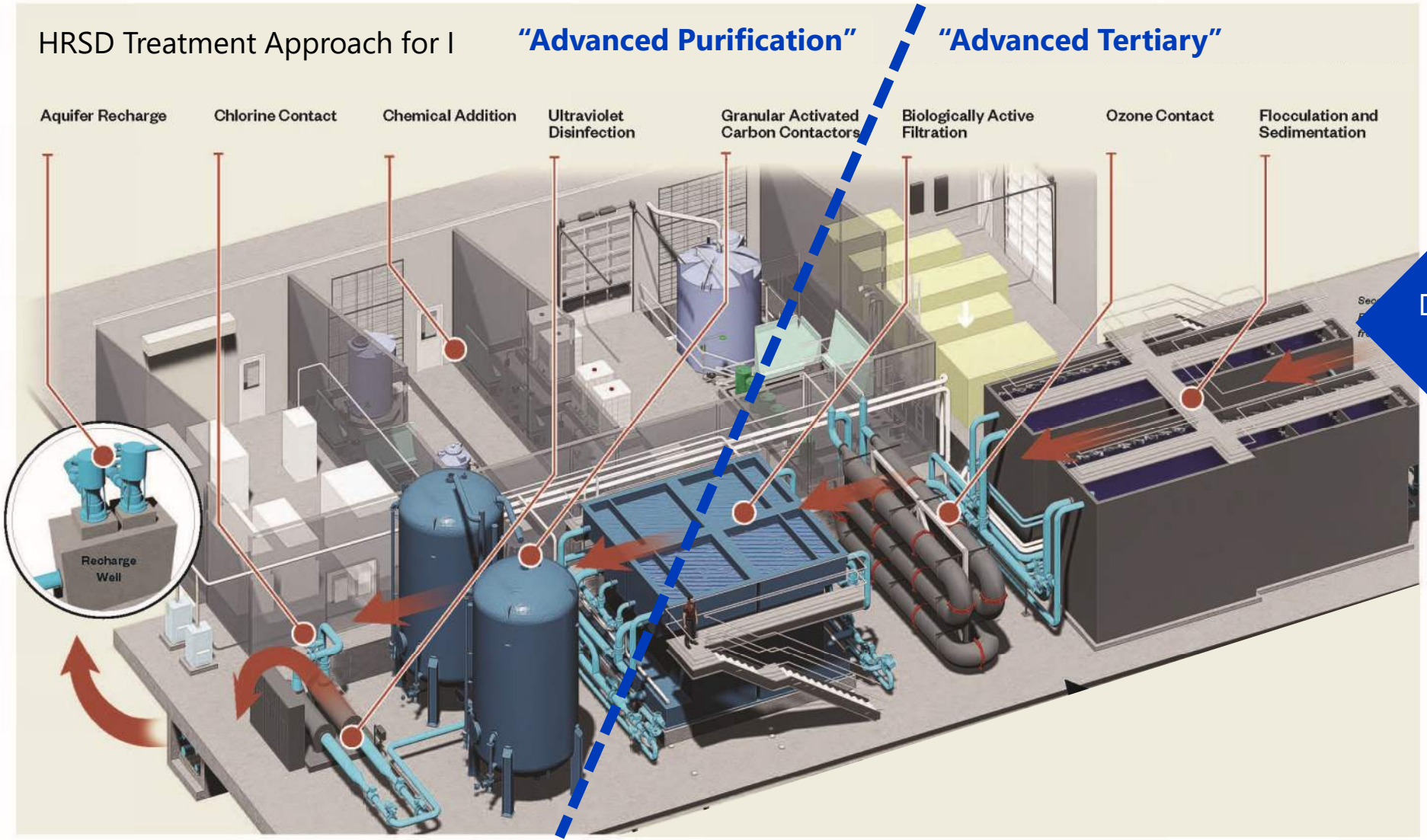


HRSD SWIFT: Project Drivers



Graphic courtesy of Germano Salazar-Benitez, HRSD

HRSD Treatment Approach for I



Courtesy of Hampton Roads Sanitation District web site: https://www.hrsd.com/swift/Advanced-Water-Treatment-Process

Two Major Drivers for HRSD SWIFT Program

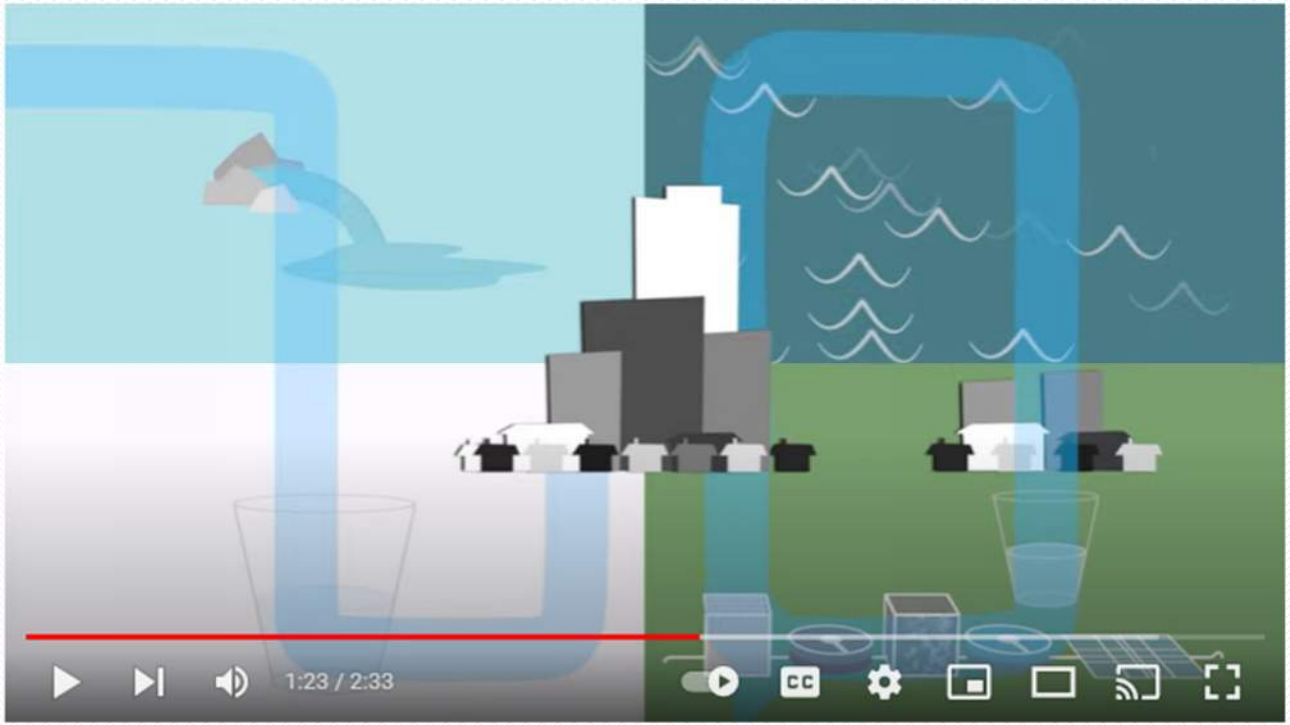
1. **Reduce nutrient discharges**
   - » "Advanced tertiary" achieves this
2. **Augment water supplies**
   - » Requires additional purification

Together, the treatment train provides robust removal of:

- » Nutrients that could affect surface water quality
- » Pharmaceuticals, personal care products, and other CECs
- » Organics that form disinfection byproducts in drinking water
- » Pathogens like virus, *Cryptosporidium* and *Giardia*

05

Public Education and Outreach

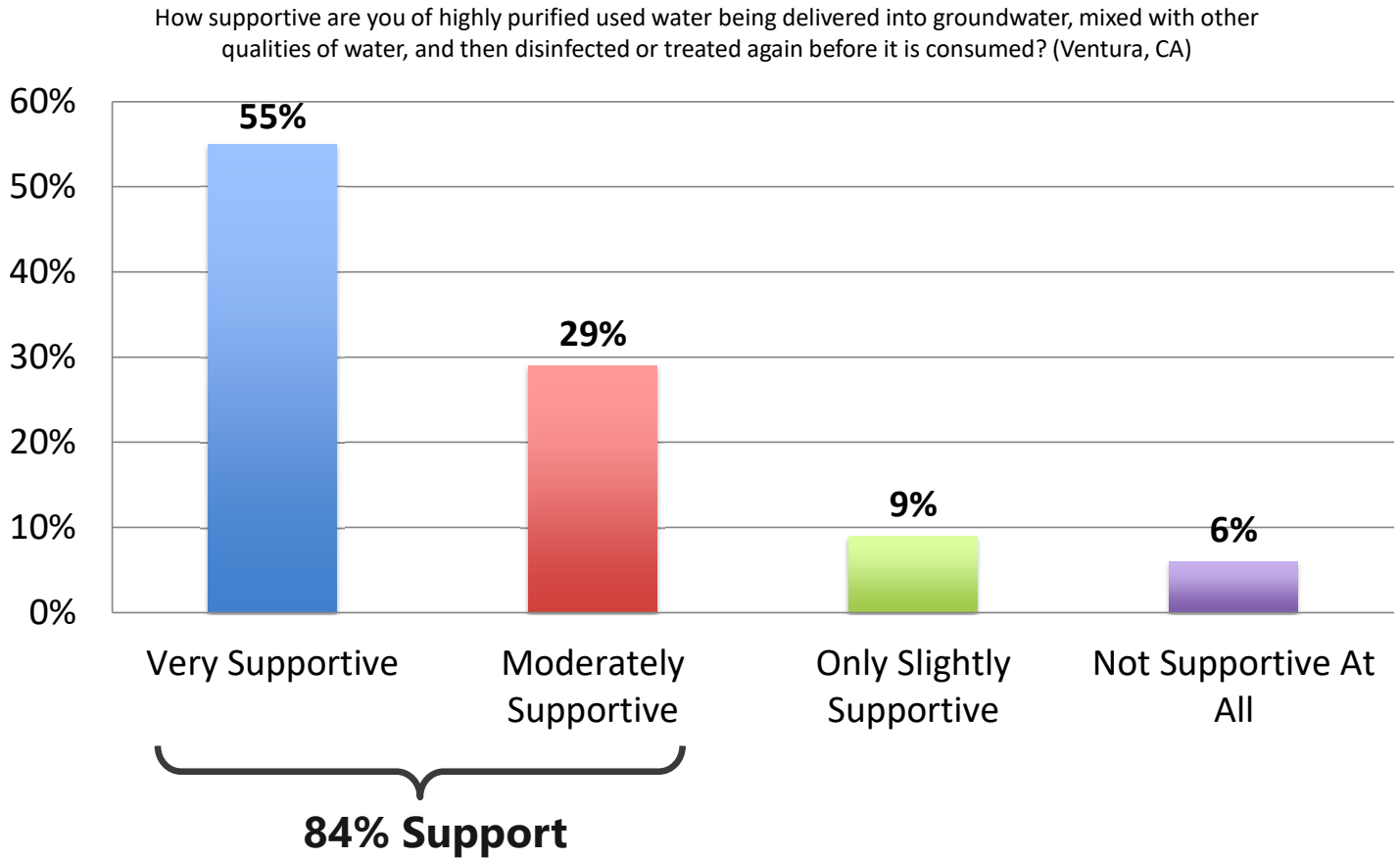


https://youtu.be/RwrYFJEJSQ0

"The Ways of Water"

Provides Context about Potable Reuse without Stigmatizing Language

Post-Animation Survey Results Show that Customers are Supportive of Potable Reuse



Public Tours of Pilot/Demo Facilities Help Educate

Florida

Colorado

California

Tackling Perception, One Beer at a Time

- First beer brewed from reclaimed water
- By Clean Water Services near Portland, OR
- Treatment design support provided by Carollo


THE FUTURE OF
WATER
HERE
PURE SoJo
March 21, 2024
PURE SoJo
SAFE RELIABLE SUSTAINABLE

Questions about Potable Reuse: The Future is Now ?

Eva Steinle-Darling, PhD, PE
esd@carollo.com | 512-427-8118

TACWA / Austin Water

22 March 2024

00

Extra Slides

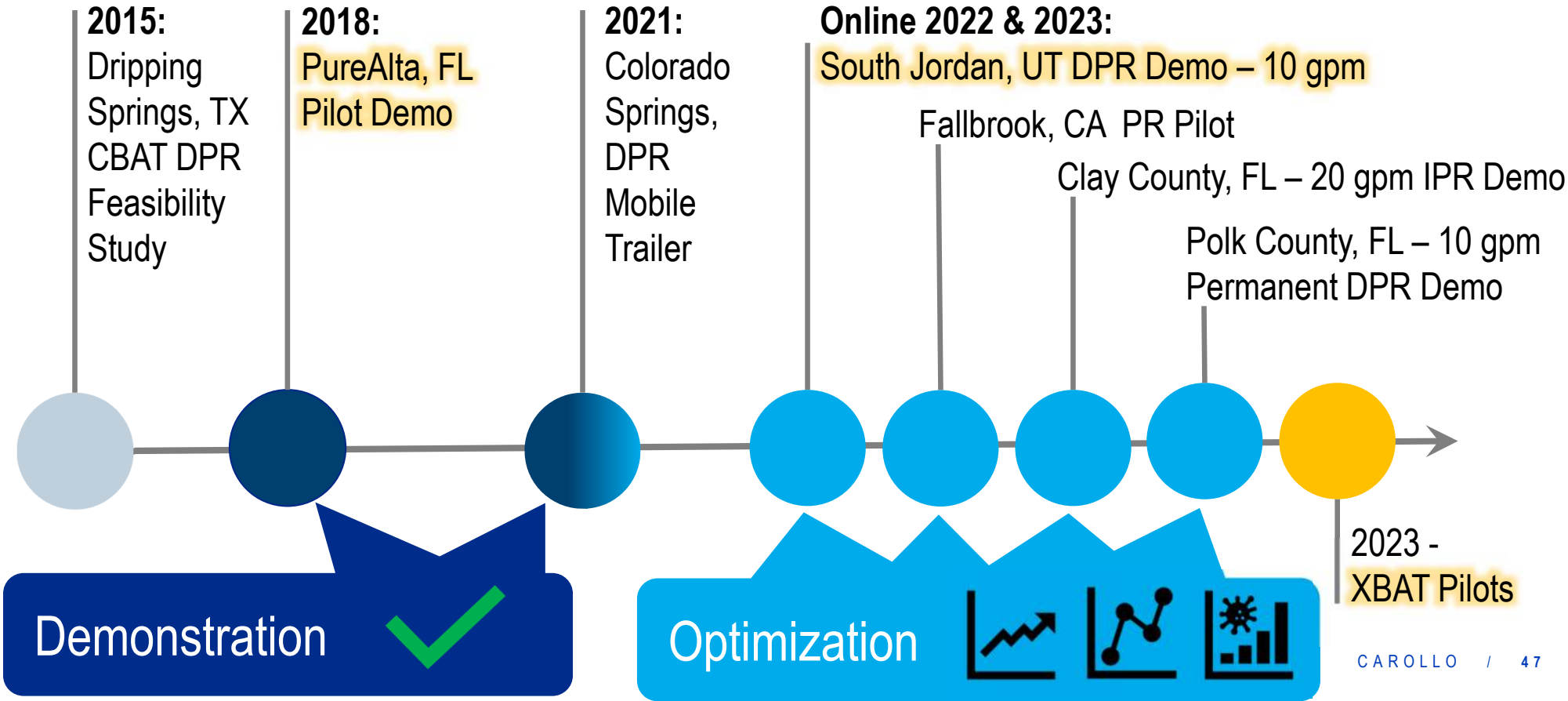
00

Continuing Innovation is Critical to Progress

XBAT: Remove Salt without RO?

A New Treatment Paradigm

Carollo's ~~Demo~~ Optimization Projects Solidify CBAT approach for DPR



CBAT Advantages

1. No RO concentrate produced!
2. Lower energy consumption vs. RO
3. Destruction of CECs
4. PFAS sequestration built-in (GAC)

Also: MF/RO pre-treatment benefits!

If salt is not an issue, let's not make it one!

CBAT Challenges

1. Does not remove salt!
2. Other inorganic constituents:
   - » nitrate not removed
   - » bromide + ozone → bromate
3. Perceived track record vs. RO

XBAT: A New Paradigm for CBAT?

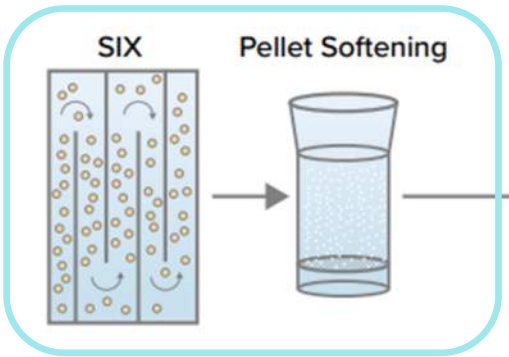
(Ion eXchange Based Advanced Treatment)

1. Suspended Ion Exchange (SIX)
- Reduces TOC
- Exchanges anions (NO_3^-, Br^-, e.g.)

2. Regeneration with Bicarbonate
- Avoids addition of Cl^- / TDS
- Less corrosive (lower CSMR)
- Waste (<1%) more benign

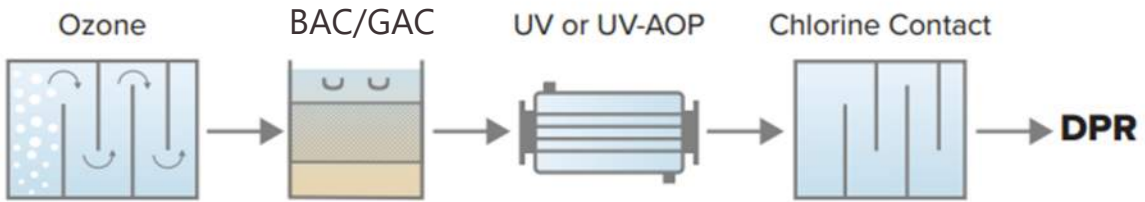
3. Softening
- Precipitates hardness
- Reduces total TDS

XBAT Pre-Treatment



Reduces TDS, nitrate, TOC, bromide.

Typical CBAT Train:



→ Reduces O_3 dose.
→ Avoids bromate.

XBAT: A New Paradigm for CBAT?

(Ion eXchange Based Advanced Treatment)

1. Suspended Ion Exchange (SIX)
- Reduces TOC
- Exchanges anions (NO_3^-, Br^-, e.g.)

2. Regeneration with Bicarbonate
- Avoids addition of Cl^- / TDS
- Less corrosive (lower CSMR)
- Waste (<1%) more benign

3. Softening
- Precipitates hardness
- Reduces TDS

Bench testing results

	Parameter	Units	Influent	% Removal (average over 50 regeneration cycles)
Organics	TOC	mg/L	7.3	47%
	UVA 254 nm	cm^{-1}	0.161	68%
Anions	Alkalinity	mg/L as $CaCO_3$	108	--
	Chloride	mg/L	123	70%
	Sulfate	mg/L	117	98%
	Nitrate	mg/L as N	7	83%
	Bromide	µg/L	267	82%
	TDS	**mg/L**	**605**	**55%**

USBR "Pitch to Pilot" with pellet softening recently wrapped up.

00

Extra Case Studies

Big Spring, TX

Membrane-Based Advanced Treatment for DPR

First to DPR in the US:
Raw Water Production Facility in Big Spring, TX

Microfiltration | Reverse Osmosis | UV Advanced Oxidation

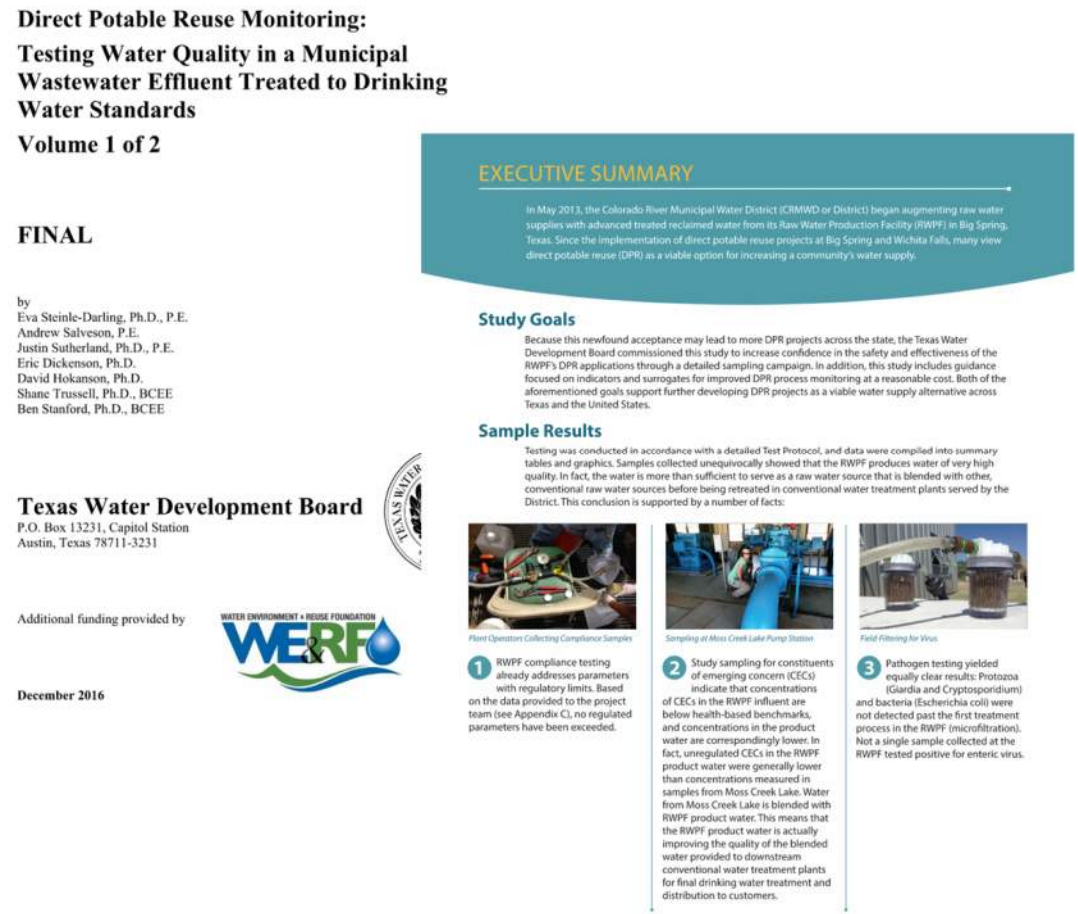
Summary of TWDB Study Findings

Showed successful removal of:

- Pathogens
- Pharmaceuticals
- PFAS
- Disinfection byproducts
- Primary contaminants (MCLs)
- Many surrogates

Also documented:

- DPR monitoring &
- RO integrity monitoring approaches



Direct Potable Reuse Monitoring:

Testing Water Quality in a Municipal Wastewater Effluent Treated to Drinking Water Standards

Volume 1 of 2

FINAL

by
Eva Steinle-Darling, Ph.D., P.E.
Andrew Salveson, P.E.
Justin Sutherland, Ph.D., P.E.
Eric Dickenson, Ph.D.
David Hokanson, Ph.D.
Shane Trussell, Ph.D., BCEE
Ben Stanford, Ph.D., BCEE

Texas Water Development Board
P.O. Box 13231, Capitol Station
Austin, Texas 78711-3231

Additional funding provided by

WATER ENVIRONMENT + REUSE FOUNDATION WE&RF

December 2016

EXECUTIVE SUMMARY

In May 2013, the Colorado River Municipal Water District (CRMWD or District) began augmenting raw water supplies with advanced treated reclaimed water from its Raw Water Production Facility (RWPF) in Big Spring, Texas. Since the implementation of direct potable reuse projects at Big Spring and Wichita Falls, many view direct potable reuse (DPR) as a viable option for increasing a community's water supply.

Study Goals

Because this newfound acceptance may lead to more DPR projects across the state, the Texas Water Development Board commissioned this study to increase confidence in the safety and effectiveness of the RWPF's DPR applications through a detailed sampling campaign. In addition, this study includes guidance focused on indicators and surrogates for improved DPR process monitoring at a reasonable cost. Both of the aforementioned goals support further developing DPR projects as a viable water supply alternative across Texas and the United States.

Sample Results

Testing was conducted in accordance with a detailed Test Protocol, and data were compiled into summary tables and graphics. Samples collected unequivocally showed that the RWPF produces water of very high quality. In fact, the water is more than sufficient to serve as a raw water source that is blended with other, conventional raw water sources before being retreated in conventional water treatment plants served by the District. This conclusion is supported by a number of facts:

Plant Operators Collecting Compliance Samples

1 RWPF compliance testing already addresses parameters with regulatory limits. Based on the data provided to the project team (see Appendix C), no regulated parameters have been exceeded.

Sampling at Moss Creek Lake Pump Station

2 Study sampling for constituents of emerging concern (CECs) indicate that concentrations of CECs in the RWPF influent are below health-based benchmarks, and concentrations in the product water are correspondingly lower. In fact, unregulated CECs in the RWPF product water were generally lower than concentrations measured in samples from Moss Creek Lake. Water from Moss Creek Lake is blended with RWPF product water. This means that the RWPF product water is actually improving the quality of the blended water provided to downstream conventional water treatment plants for final drinking water treatment and distribution to customers.

Field Filtering for Virus

3 Pathogen testing yielded equally clear results: Protozoa (Giardia and Cryptosporidium) and bacteria (Escherichia coli) were not detected past the first treatment process in the RWPF (microfiltration). Not a single sample collected at the RWPF tested positive for enteric virus.

Altamonte Springs, FL

First Carbon-Based Advanced Treatment Demo for DPR

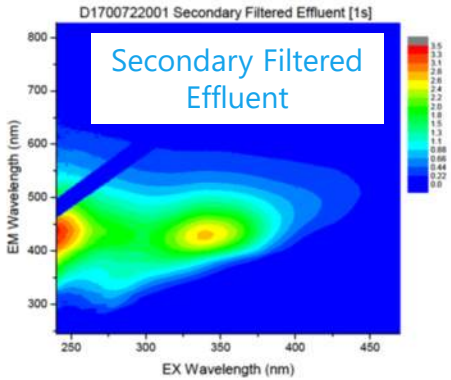
Goal: Prove that Advanced Treatment can meet water quality goals *without RO*

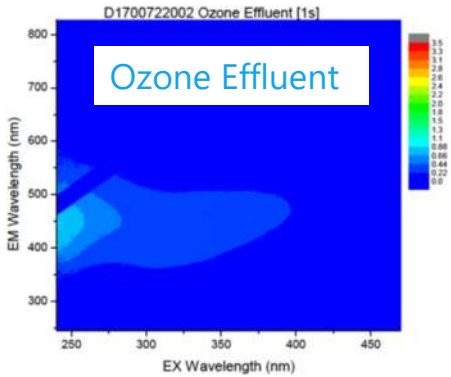
Designing Advanced Treatment for Water Quality Success *without RO*

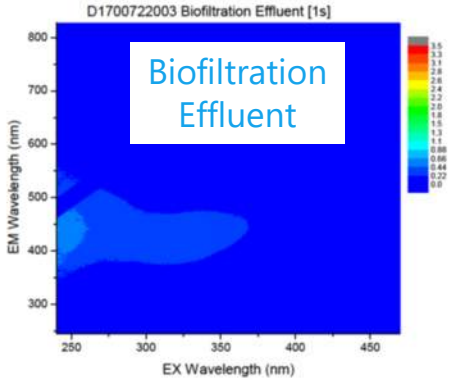
Ozone

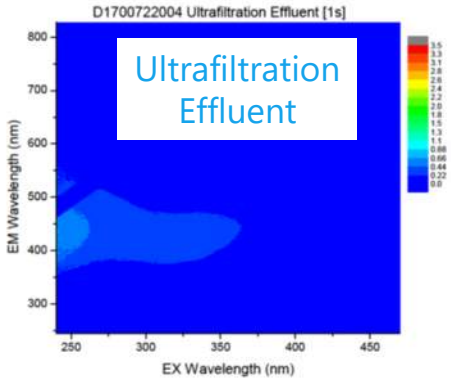
BAC UF GAC UV(AOP)

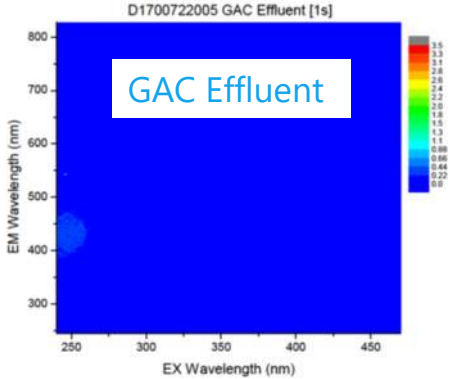
Fluorescence Images Show Decreasing “Fingerprint”

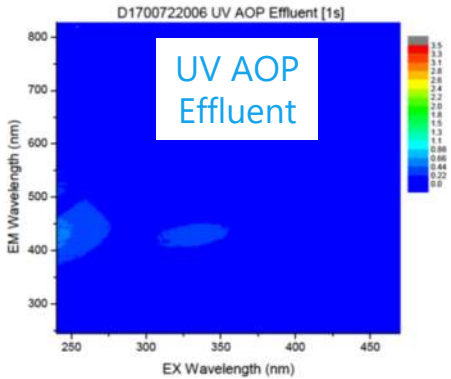




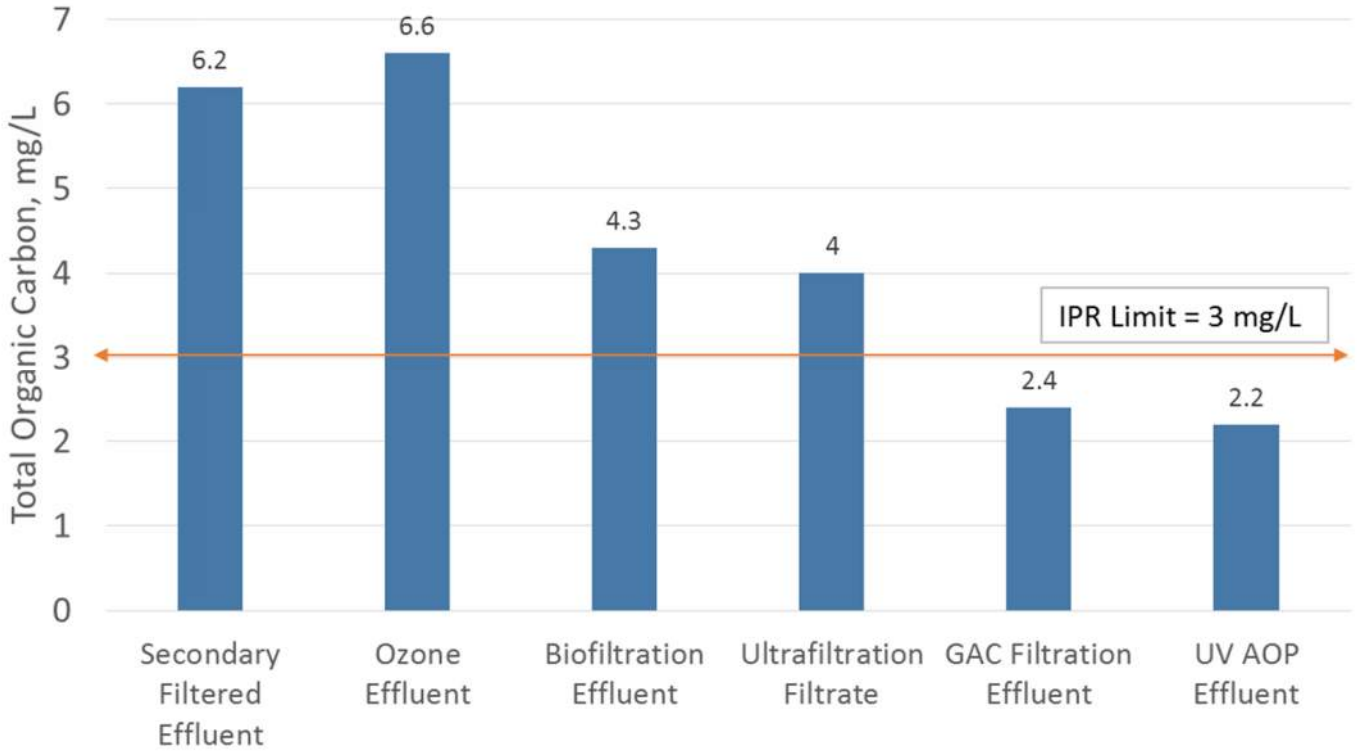




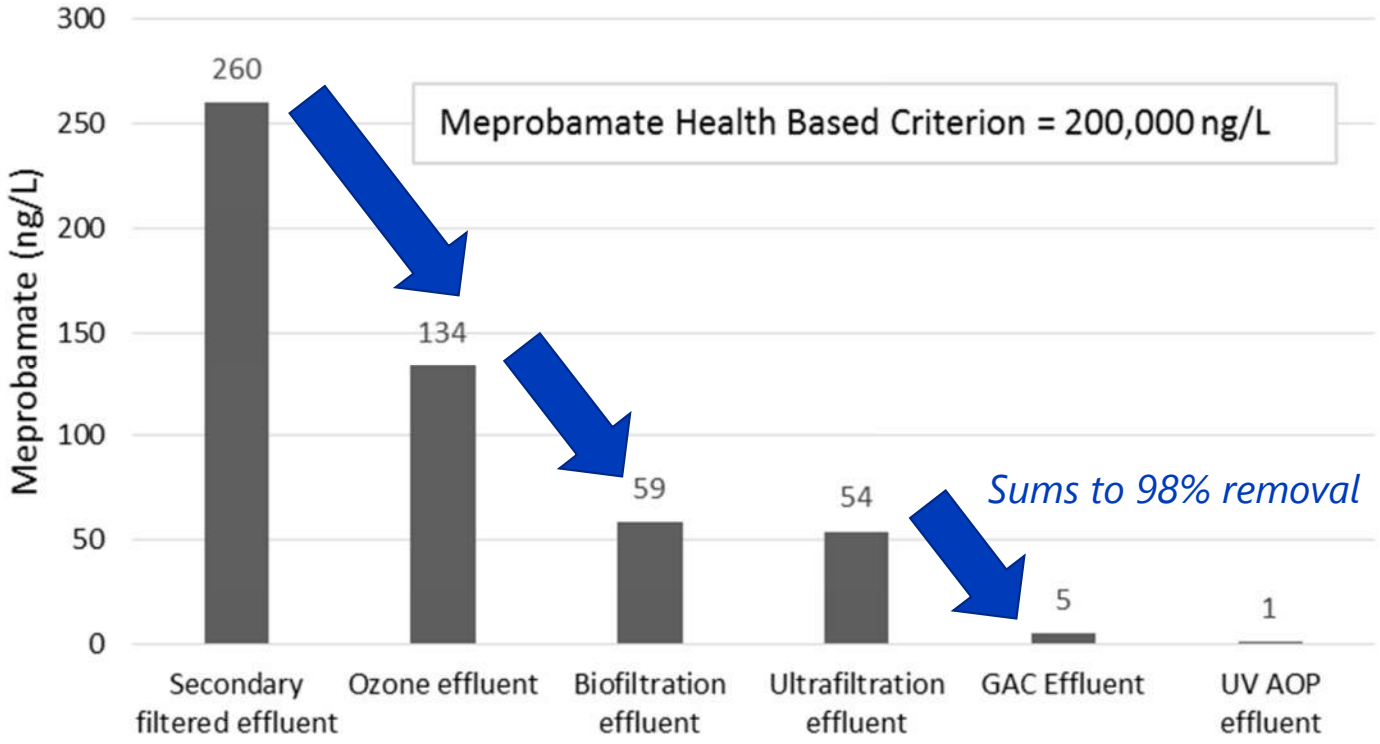




Both O_3/BAF and GAC Needed to Meet Florida IPR Requirements for TOC



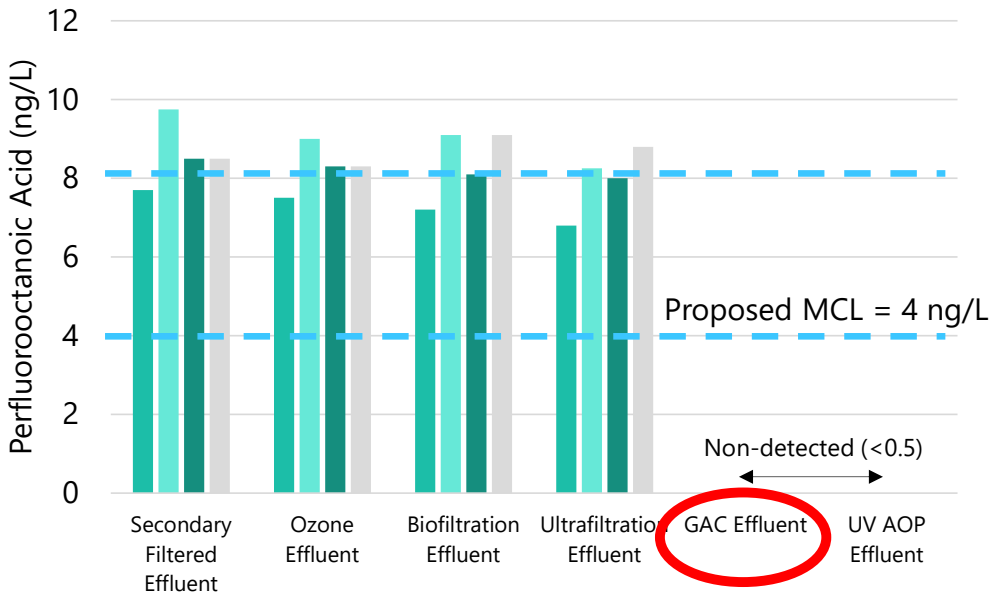
CECs & PFAS are removed through a combination of Ozone, BAF, and GAC



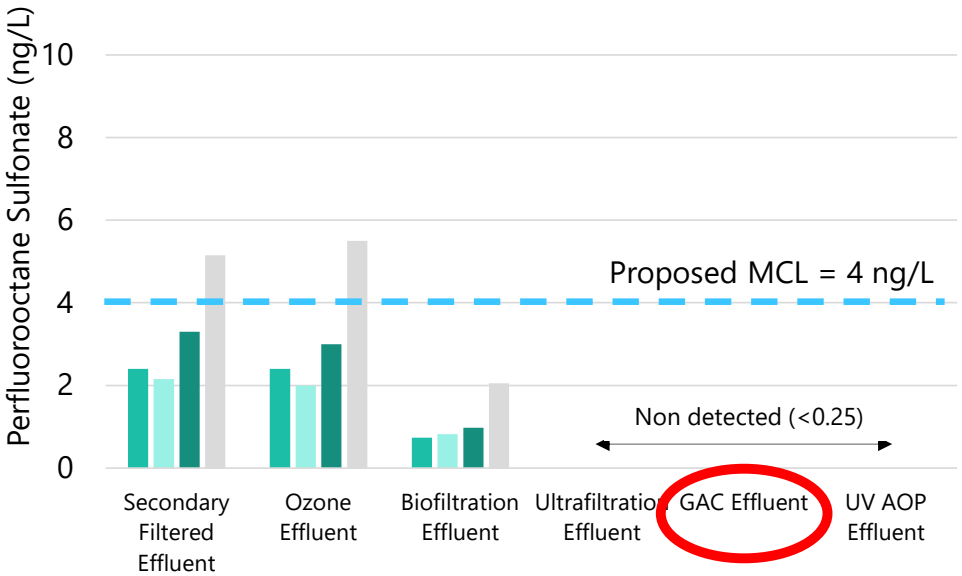
Anxiolytic: Treats tension, anxiety, nervousness

CECs & PFAS are removed through a combination of Ozone, BAF, and GAC

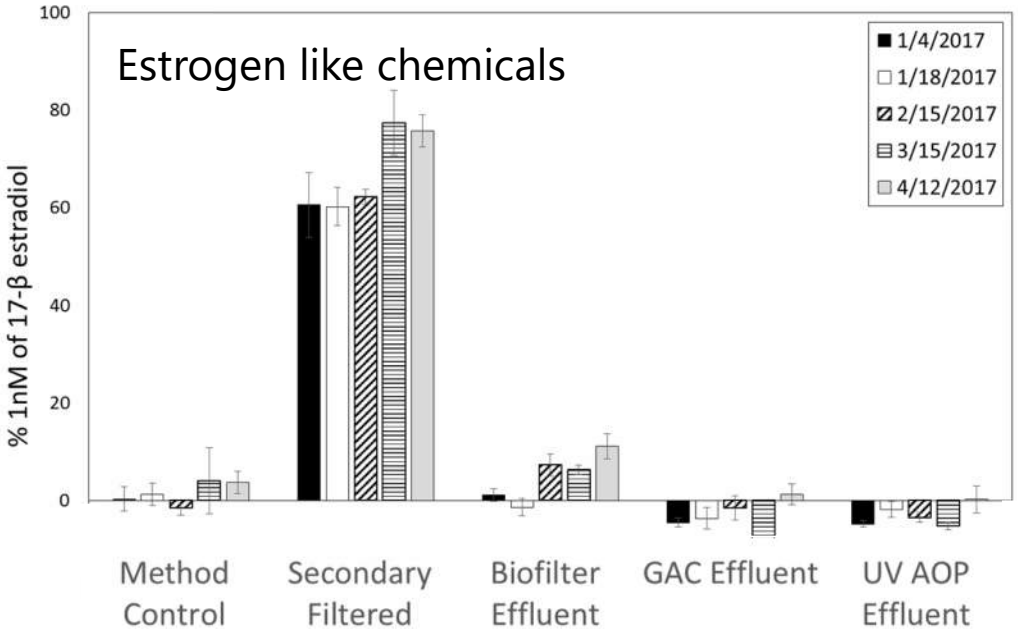
PFOA

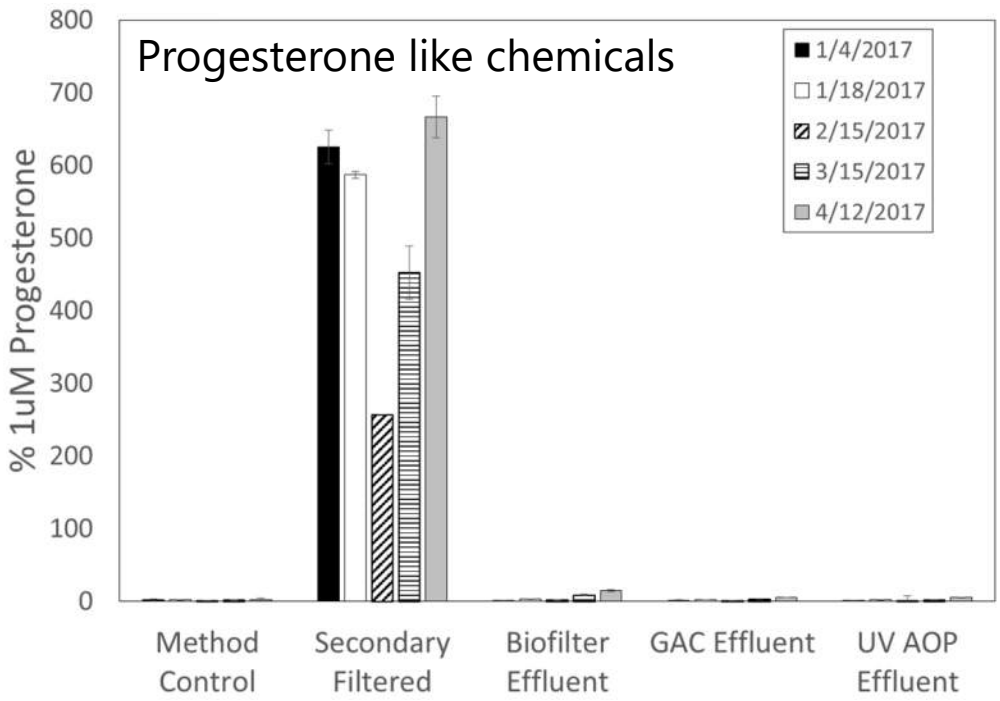


PFOS



Bioassays indicate bioactivity of hormones & drugs is eliminated through treatment



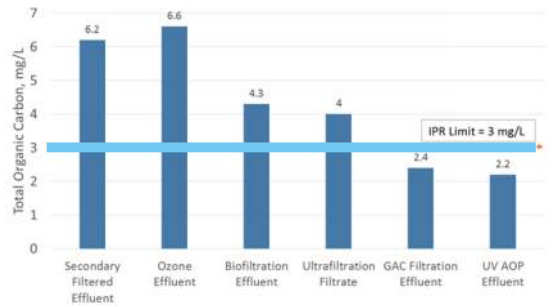


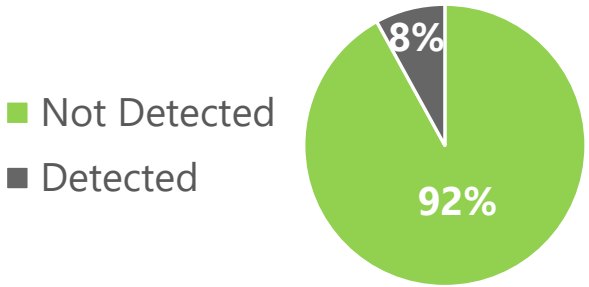
We've Demonstrated Everything RO Does! *(Except Desalinate)*

1. ***Pathogen removal:***
   Meet goals with margin of safety from ~5-log to >6-log

2. ***TOC removal:***
   Meets Florida Regulations!

3. ***CECs (and more!):***
   Removed!





pureALTA Finished Water

I did promise you it was “International-Award Winning”

2017
WateReuse
“Innovative Project of the Year” Award

2018
International Water Association Innovation Awards Silver

See https://www.altamonte.org/754/pureALTA for details.

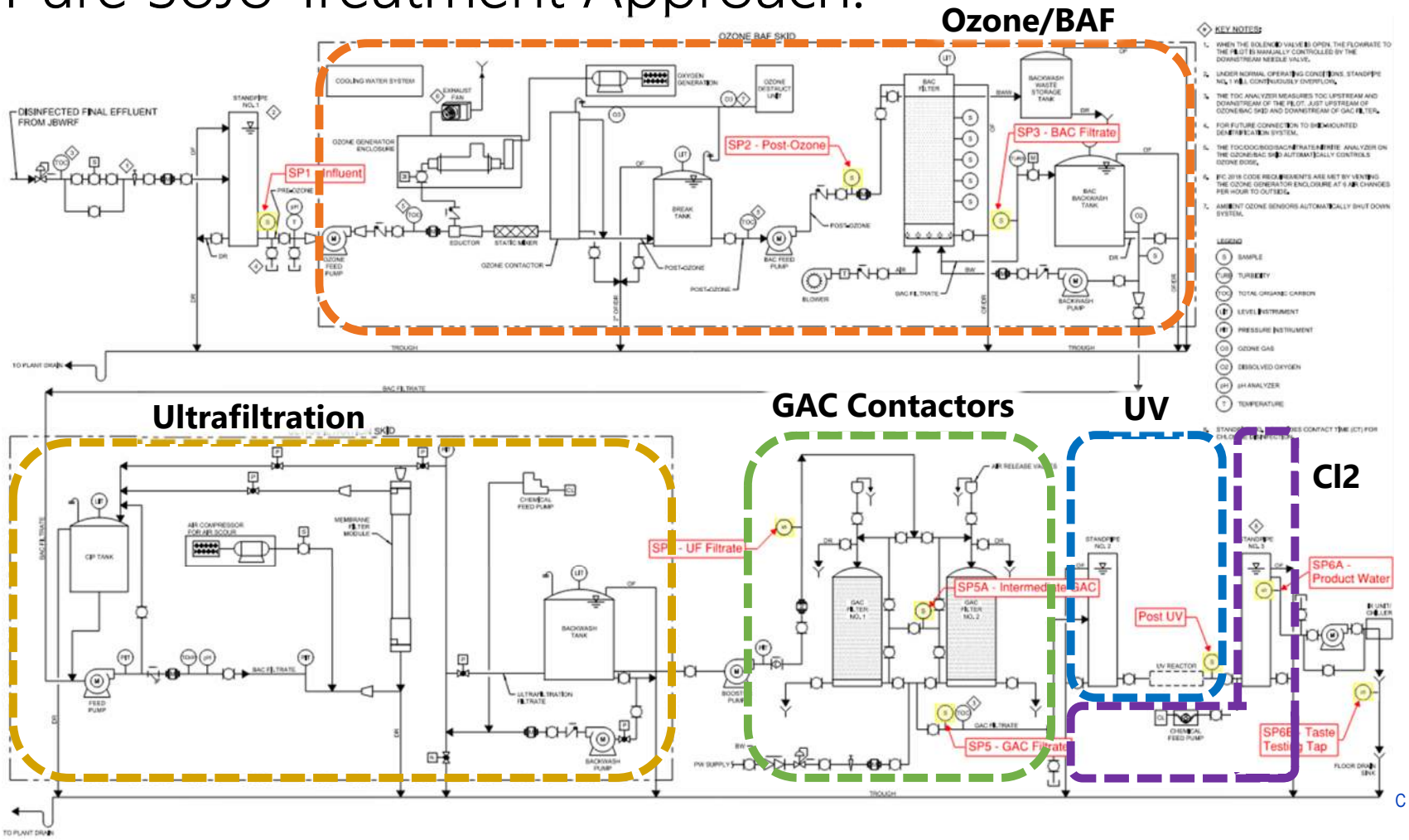
City of South Jordan, UT

More Carbon-Based Advanced Treatment for DPR

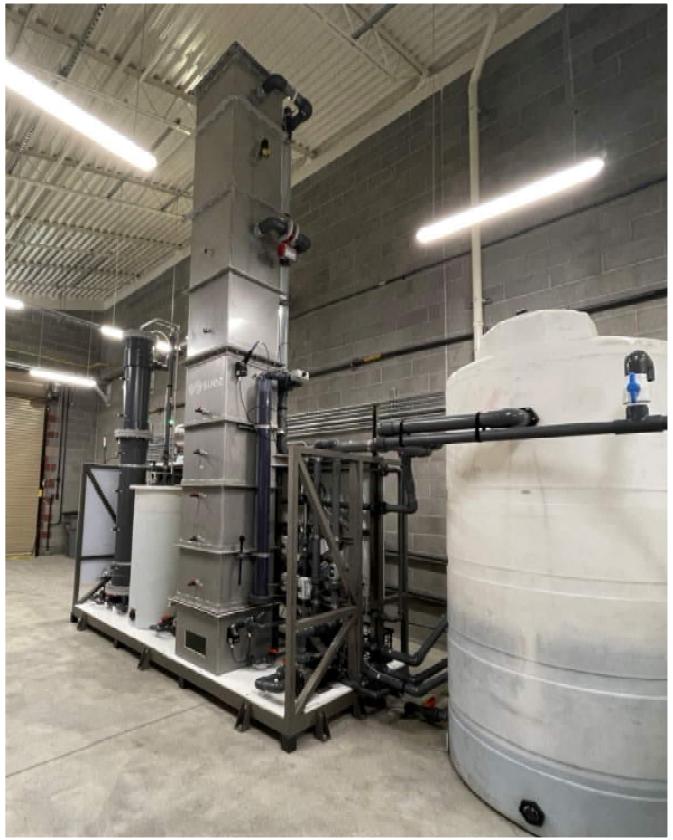
South Jordan City – Alternative Water Supplies?

- **Groundwater – the only potential local supply – is contaminated by mine tailings**

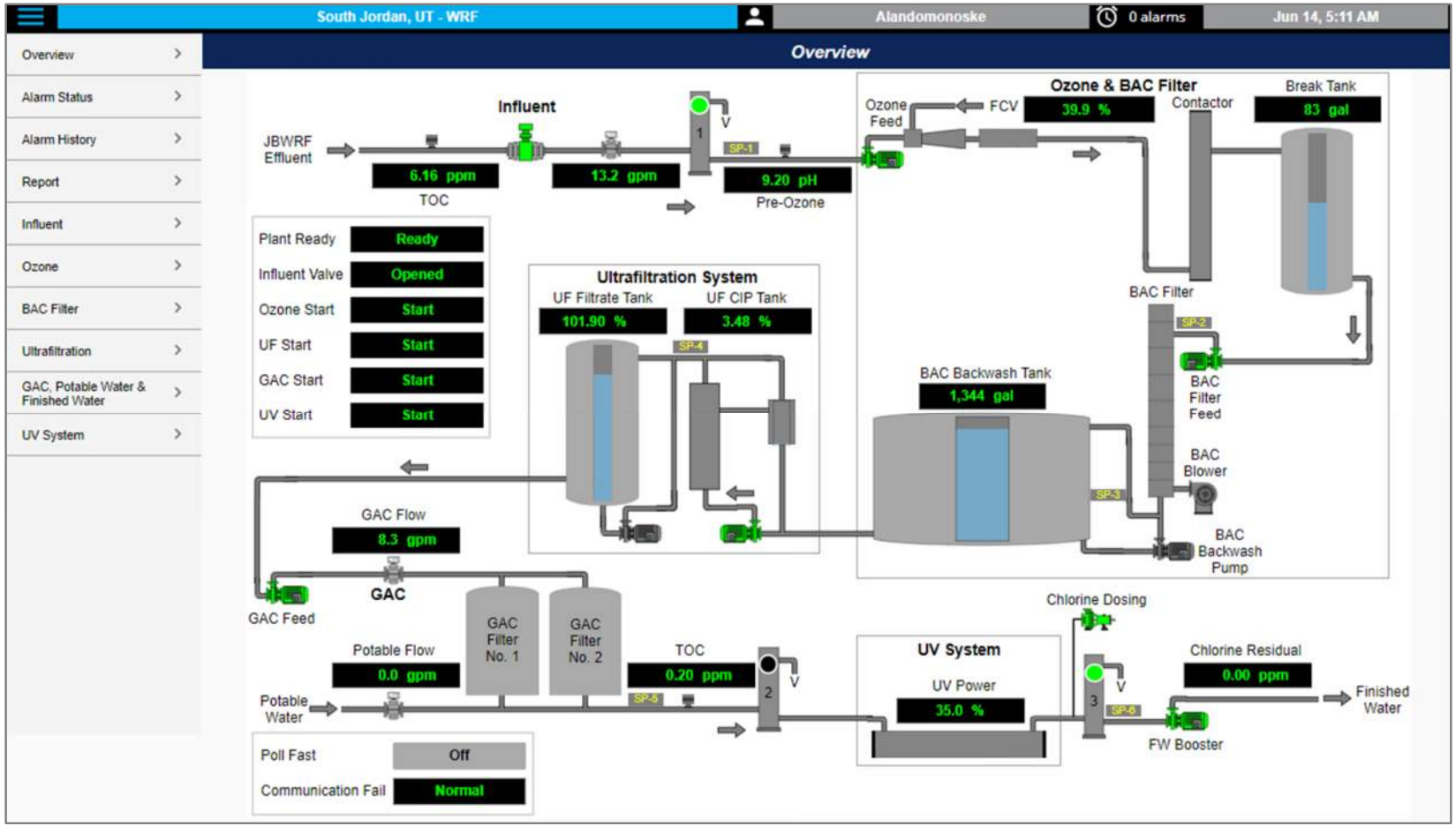
Pure SoJo Treatment Approach:



Pure SoJo Demo has been operating since April 2022



The system is fully automated, including remote SCADA



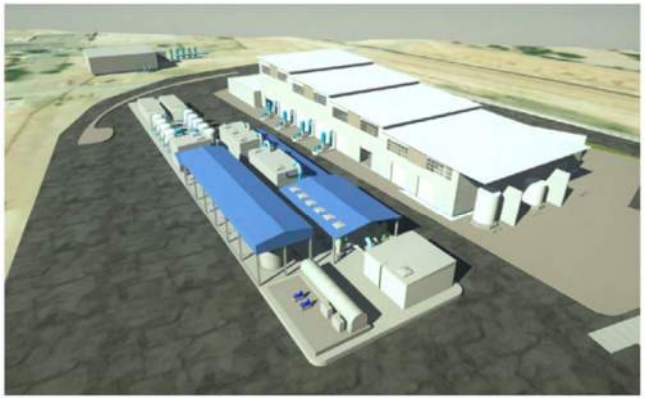
Pure SoJo Demo is generating quite some interest!!

- Visit from Governor in 2022
- Grand Award for 2024 ACEC
  - » Utah Engineering Excellence Award
  - » National Engineering Excellence Award May 2024 in Washington D.C.

Full-Scale IPR/DPR Projects

(And a few cool demo projects and studies at the end)

Selections from "The Carollo Maps"



Advanced Water Purification Facility (DPR)

El Paso Water, TX

ADVANCED TREATMENT DESIGN/PERMITTING

Carollo is currently designing the first direct-to-distribution direct potable reuse (DPR) facility in the U.S., the Advanced Water Purification Facility (AWPF) in El Paso, Texas. The AWPF will provide a new, drought-proof, and completely renewable source of drinking water for this Chihuahuan Desert community by producing up to 12 mgd of blended drinking water at build-out. In 2017, El Paso Water selected Carollo to guide this project through major permitting and pre-design milestones, and ultimately through final design using the Construction Manager at Risk (CMAR) project delivery method.

Key project tasks include:

- Preliminary and final design for AWPF, including microfiltration, reverse osmosis, UV advanced oxidation, granular activated carbon, free chlorine disinfection, and chemical stabilization processes.
- Ongoing dialogue and written coordination with Texas regulators (TCEQ) to permit this first-of-its-kind facility, including continued source water characterization sampling to address regulatory questions.
- Follow-up pilot testing to establish operating conditions for membrane processes.
- Incorporating brackish groundwater to increase overall AWPF production and reduce chemicals needed for stabilization.
- Providing procurement support for the selection of a CMAR contractor.
- Development of a critical control point approach to facility operation.
- Supporting El Paso Water's successful applications for grant funding totaling $23.5 million.

The design was completed in 2023 and a construction manager-at-risk (CMAR) was selected. Construction is expected to begin mid-2024.

PROJECT HIGHLIGHTS

- *Design of first direct-to-distribution DPR project in the US.*
- *Ongoing regulatory coordination and characterization sampling.*
- *Coordination with upstream improvements at RBWWTP.*
- *Incorporating brackish groundwater to increase supply and reduce chemical costs.*
- *CMAR project delivery and CMAR procurement support.*
- *$23.5M in grant funding.*

Groundwater Replenishment System Final Expansion

Orange County Water District and
Orange County Sanitation District

CONSTRUCTION MANAGEMENT

The $310 million Groundwater Replenishment System Final Expansion (GWRSFE) project will increase the system treatment capacity from 100 to 130 million gallons per day (MGD). In order to produce 130 MGD of purified water through the GWRS, additional secondary effluent from the Orange County Sanitation District (OCSD) is required for source water. This additional secondary effluent source water must be received from OCSD's Treatment Plant Number 2 (OCSD P2) which is located in the city of Huntington Beach approximately 3.5 miles south of the GWRS facility. The GWRSFE project includes:

- Addition of 30 MGD of additional capacity.
- Constructing Plant No 2 Secondary Effluent Conveyance Facilities
- Rehabilitating an existing pipeline between Plant No. 2 and Plant No 1 to bring secondary effluent to the GWRS

The project is being financed in part with a low interest rate U.S. EPA WIFIA loan of $135 million. Construction on the final expansion began in 2019 and will be completed by 2023.

Carollo provided construction management and engineering services during construction.

PROJECT HIGHLIGHTS

- *Modify major pipeline tie-ins to reduce GWRS downtime by providing isolation valve additions, line stops and fit-up spools.*
- *New MF system quality assurance testing and coordination to reduce risk of membranes system failure.*
- *Pipeline rehabilitation fabrication quality assurance to minimize rework.*
- *The 130 MGD facility provides enough water to serve 1 million people annually.*

Terminal Island Water Reclamation Plant

City of Los Angeles Bureau of Sanitation (LASAN)

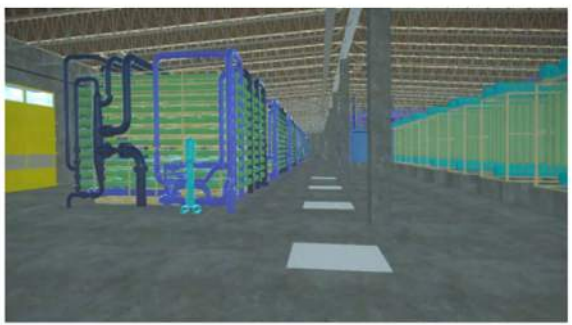
PILOT TESTING, DESIGN-BUILD

Carollo worked closely with Los Angeles Bureau of Sanitation (LASAN) on its Terminal Island Water Reclamation Plant, from pilot testing to design-build and startup. Carollo's services included an MF/RO evaluation, the analysis and piloting of potable reuse technologies, and, most recently, serving as design lead for the plant's expansion from 6 mgd to 12 mgd.

The $41.5 million design-build expansion features an upstream 2 million gallon tertiary effluent equalization tank, additional MF and RO systems, an Advanced Oxidation Processes (AOP) system that includes a combination of UV and sodium hypochlorite (NaOCl) for disinfection, pump upgrades, a chemical system addition, auxiliary systems, and utilities. The design optimizes reuse and more than doubles prior recycled water production levels by allowing 100 percent of the plant's flow to receive advanced treatment. Carollo was able to achieve cost-effective purification solutions for the client without compromising performance through the use of extensive pilot testing of the first UV/NaOCl system for potable reuse.

PROJECT HIGHLIGHTS

- *As one of the world's most technologically advanced water treatment systems, the project was awarded the "California's 2017 Best Projects" by ENR.*
- *Held a number of partnering and value engineering workshops to identify additional cost and time saving solutions.*
- *Worked closely with City Engineering, Plant staff, and two different consultant owner's advisors through pilot-scale demonstration, design, and construction.*



Pure Water Program

City of San Diego

DESIGN

The Pure Water San Diego Program will generate one third of San Diego's potable water supply using recycled water by 2035. Carollo has completed the design of the first potable water reuse advanced water treatment plant (AWTP) in the program, the $345-million North City Pure Water Facility (NCPWF).

The Pure Water Program's premier project and the first project of its kind in California, the NCPWF will purify tertiary effluent from the North City Water Reclamation Plant to meet Title 22 California Code of Regulations for surface water augmentation indirect potable reuse (IPR) to discharge to Miramar Reservoir. While groundwater recharge IPR facilities have been in operation in California for decades, NCPWF will be the first that augments surface water for potable reuse.

The new NCPWF will produce safe, high-quality drinking water using a proven five-step water purification process of ozonation, biologically active carbon filters, membrane filtration, reverse osmosis, and ultraviolet disinfection with sodium hypochlorite advanced oxidation. San Diego's Miramar Water Treatment Plant will provide final purification of water from Miramar Reservoir prior to distribution into the potable supply.

Designed to produce 34 mgd, NCPWF will send 30 mgd to the Miramar Reservoir and 4 mgd back to NCWRP to reduce the total dissolved solids (TDS) concentration in the chlorine contact tank effluent for downstream non-potable water reuse (irrigation). Carollo completed the fast-paced, 11-month final design of the NCPWF in May 2018.

Carollo is now overseeing construction, which is expected to be complete in 2025.

PROJECT HIGHLIGHTS

- *First California surface water augmentation project.*
- *Focus on process performance, reliability, and safety.*
- *Use of CFD modeling to maximize ozone transfer efficiency and optimize hypochlorite dose point location.*
- *Complex and innovative design completed in 11 months.*

Padre Dam MWD/ East County IPR Program

Padre Dam MWD

PROGRAM MANAGEMENT

The East County Advanced Water Purification (AWP) Project is a collaborative effort among Padre Dam Municipal Water District (Padre Dam), the County of San Diego (County), City of El Cajon (El Cajon), and Helix Water District (Helix). The Joint Powers Authority (JPA) governs the AWP Project and consists of the three East County wastewater agencies (i.e., Padre Dam, the County, and El Cajon). The AWP Project will treat East County's wastewater locally and implement potable reuse by producing advanced treated water from an AWP facility, which will be pumped to Lake Jennings Reservoir for surface water augmentation (SWA), where it will be mixed with other water owned by Helix. After SWA, the water will be sent to Helix's R. M. Levy Water Treatment Plant for treatment to become potable water. The AWP Project will treat the combined 16 mgd wastewater flow at the Water Recycling Facility, producing 11.5 mgd of purified water at the AWP Facility. 10.3 mgd will be delivered to Lake Jennings Reservoir for SWA IPR and 1.2 mgd will be distributed to Padre Dam Title 22 recycled water customers. Retrofits/expansions of lift stations and a regional brine line will also be constructed for residuals (brine and centrate) management. The AWP Project is expected to come online in 2025.

Carollo is providing Owner's Advisor services to the JPA, working with Padre Dam as the administrator, to provide the necessary management and administrative support, procurement support, professional engineering and technical assistance, information and data management planning, and future construction, start-up, and commissioning support services.

PROJECT HIGHLIGHTS

- *Designed to produced 11.5 MGD of purified recycled water, representing ~30% of East County's water demand.*
- *Requires extensive coordination and outreach among stakeholders, public, regulators, and subcontractors to implement this regional reuse program.*
- *Will significantly reduce East County water imports from Northern CA the and Colorado River.*

Regional Recycled Water Advanced Purification Center Design and Testing

Metropolitan Water District of Southern California

PLANNING, DEMONSTRATION DESIGN AND TESTING

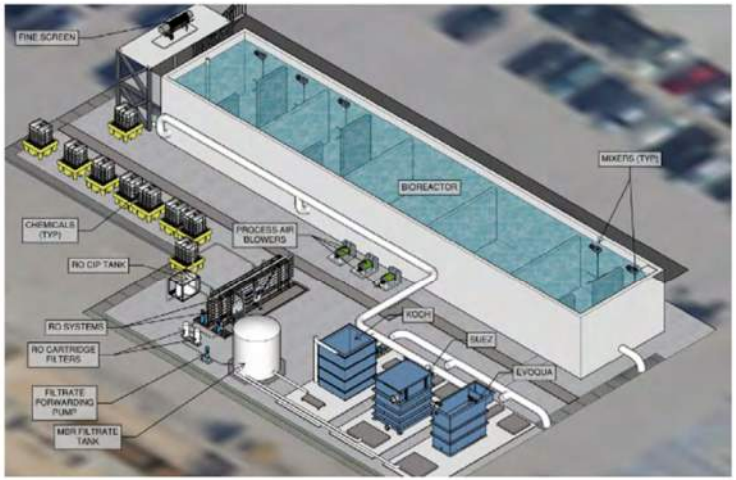
Metropolitan Water District of Southern California (MWDSC) and the County Sanitation Districts of Los Angeles County (LACSD) formed a partnership to assess the potential for augmenting potable supplies with highly purified effluent from LACSD's Joint Water Pollution Control Plant (JWPCP) in Carson through indirect potable reuse (IPR). The scope of this effort included a detailed examination of the Southern California groundwater basins; groundwater pumping, recharge, institutional constraints, extraction capacities, and storage capacities; and other factors to quantify the potential demand for a new supply. The study looked at basic IPR concepts using the JWPCP and the San Jose Creek WRPs as potential water sources for purification, either for conventional groundwater replenishment, groundwater recharge and export, or reservoir augmentation.

As part of the Recycled Water Program, Carollo, partnering with another firm, worked as part of a design team to design and operate an Advanced Water Treatment (AWT) Demonstration Facility and assist in regulatory approval for the full-scale AWT Facility process train. The AWT Demonstration Facility treated non-nitrified secondary effluent from the JWPCP. The treatment train included MBR, RO, UV/AOP with the flexibility to include a separate MF step as further pretreatment for RO if needed. The AWT Demonstration Facility design was completed in May 2017. The facility operated for one year to collect data needed for the possible design and construction of a full-scale facility (up to 150 mgd).

The project has evolved into evaluating Direct Potable Reuse (DPR), and Carollo is currently pursuing the Environmental permitting steps (EIR).

PROJECT HIGHLIGHTS

- *Required important public education and outreach to provide a high degree of public acceptance of this regional groundwater replenishment program.*
- *Coordinated with MWDSC, LACSD, state regulators and advisory panels.*
- *Developed the design criteria for the 150 mgd MBR/RO/AOP full-scale AWT facility for planned future DPR.*



Hyperion 100% Water Recycling Implementation

City of Los Angeles Bureau of Sanitation (LASAN)

PLANNING, DESIGN, TESTING, OPERATIONS, CONSTRUCTION MANAGEMENT

Carollo is assisting LASAN with implementation of the City of Los Angeles' (City's) Hyperion Water Reclamation Plant (HWRP) 100% Water Recycling Program to source 70% of the City's water supply locally by 2035. Carollo is currently helping LASAN with three separate projects in this ambitious endeavor, including:

The **Hyperion Advanced Water Purification Facility (HAWPF)** project will produce 1.5 mgd of purified water for potable reuse by the Los Angeles World Airport and for internal uses at HWRP. HAWPF is considered a "Proof of Concept" project for 100% recycling at HWRP. Treatment processes include MBR, RO, GAC, and UV AOP. The project is being delivered using the progressive design-build method. Carollo's owner's advisor services include preparation of a conceptual design report and services during progressive design-build delivery, including design and guaranteed maximum price (GMP) cost model review.

The **1 mgd Hyperion MBR Pilot Facility** will demonstrate the effectiveness of an MBR-based potable reuse treatment train that could be used to convert the 250 mgd HWRP to a 100% water recycling facility. Project goals include gaining regulatory approval, assessing MBR as a pre-treatment to RO, and evaluating equipment from three membrane suppliers. Carollo's services include design, construction management, pilot testing, and operations assistance.

The **100% Water Recycling Spatial Feasibility Study** assessed the spatial requirements to convert for a 250 mgd full reuse conversion at Hyperion. Carollo provided planning and cost estimating services. Current cost estimates for the 250 mgd 100% recycling conversion at Hyperion are $3.65 billion without O3 and BAC, and $4.55 billion with O3 and BAC.

PROJECT HIGHLIGHTS

- *Design, construction management, testing, and operations of a 1 mgd MBR-based pilot facility.*
- *Feasibility and cost assessment of 250 mgd water recycling facility.*
- *Owners advisor for progressive design-build of a 1.5 mgd advanced treatment facility for potable reuse.*

Mobile Demonstration of Carbon-based Advanced Treatment DPR Process Train

Colorado Springs Utilities, CO

DEMONSTRATION TESTING

Colorado Springs Utilities (Utilities) anticipates integrating DPR into its water supply portfolio in the future. DPR is expected to provide a new water supply source while reducing the need to invest in treatment for increasingly stringent discharge limits at its water resource recovery facilities. To initiate public engagement toward future implementation of DPR, Utilities commissioned Carollo to design a 5 gallon per minute DPR demonstration facility. Tours of the demonstration, and production of beer and soda with the purified water are vehicles for public education and engagement. The facility uses a carbon-based advanced treatment train (CBAT) consisting of ozone, biologically active filtration, microfiltration/ultrafiltration, granular activated carbon, and ultraviolet (UV) disinfection – intentionally avoiding the use of reverse osmosis (RO) because of the challenges of RO brine disposal in inland mountain communities.

Carollo fostered a unique partnership between Utilities, the Colorado Water Conservation Board (CWCB), and the Colorado School of Mines (Mines) to design, construct, and deploy the mobile demonstration unit. CWCB provided grant funds in support of implementing key facets of Colorado's statewide Water Plan, and Mines constructed the mobile facility in a 28-foot trailer. Utilities specifically chose a mobile unit to extend its value beyond its initial operation at the JD Phillips Water Resource Recovery Facility, serving an ongoing educational and research role for Mines students and for other communities' future use. Direct coordination with the Colorado Department of Public Health and Environment provided additional design guidance. The facility's design provides flexibility for a range of future uses and water qualities, with options for microfiltration vs. ultrafiltration, space for future installation of nanofiltration/RO, and use of advanced oxidation processes (AOP) in conjunction with UV when needed.

PROJECT HIGHLIGHTS

- *CBAT process demonstrates effective purification without needing brine disposal.*
- *Public engagement avenues include onsite tours and purified water beverage production.*
- *First-of-its-kind mobile demonstration of CBAT purification process train.*

One Water Polk

Polk County Utilities

PRELIMINARY DESIGN, OPERATION

To meet anticipated future water supply needs, Polk County Utilities (PCU) is investigating the feasibility of implementing DPR as a potential cost-effective alternative water supply through pilot testing at their Cherry Hill Water Production Facility (WPF). Reclaimed water from the Northwest Regional Wastewater Treatment Facility (NWRWWTF) is treated to drinking water standards using ozone, biologically activated carbon filtration, ultrafiltration, granular activated carbon, and UV disinfection. The facility is set up to provide pre-treatment using enhanced coagulation ahead of ozone to maximize TOC removal. The goal of the feasibility study is to develop a site-specific potable water supply solution of up to 1.5 mgd to supplement the PCU's groundwater supplies. Carollo provided preliminary design, review of public outreach material, and startup services of the DPR facility. Carollo is currently leading operations of the facility with PCU staff and project partners and using Microsoft Azure and Power BI for data visualization on a daily basis. Carollo is also providing technical assistance during public tours of the pilot facility.

PROJECT HIGHLIGHTS

- *Preliminary design, and pilot equipment procurement of a DPR demonstration facility.*
- *Test plan development for regulatory approval.*
- *Stakeholder engagement and public outreach tours.*
- *Permanent facility for regulatory approval, operator training, and public outreach.*
- *Working with the Florida Department of Environmental Protection on providing data on carbon-based advanced treatment during rulemaking.*

pureALTA Potable Reuse Pilot Study and Demonstration Facility

City of Altamonte Springs

DESIGN, OPERATION

The City of Altamonte Springs is developing an alternative water supply to maximize the use of existing resources and improve the robustness and resilience of their high quality water supply. However, the City is located in Central Florida with no easy way to manage brine produced by membrane based treatment. Carollo worked with the City to select a non-RO purification process for potable reuse that meets all regulated standards and unregulated water quality goals. The process included ozone followed by biologically activated carbon filtration, ultrafiltration, granular activated carbon, and UV disinfection.

The 12-month demonstration effort included treatment process design, equipment procurement, installation, operation, and testing. After a year of continuous operation, the treatment train was shown to provide high purity water at a fraction of the cost of RO-based systems and without the waste products (RO concentrate). Completed in October 2017, the project demonstrated the safety of a carbon-based (i.e., non- RO) process train for direct potable reuse. The multiple barrier performance for removal of pathogens, regulated chemicals, and constituents of emerging concern was proven through online monitoring systems and advanced analytical monitoring.

pureALTA continues to operate on a daily basis producing safe water and hosting educational tours for the public, building confidence in their water supply for a sustainable future.

PROJECT HIGHLIGHTS

- *Awarded the 2017 Innovative Project of the Year award from the WateReuse Association and the 2018 Market Changing Water Technology from the International Water Association.*
- *Proved the ability to meet potable water quality requirements at a reduced cost and without the generation of a concentrate waste or brine stream as is the case in RO-based projects.*
- *Provided support to the City in their public education efforts.*

PureSoJo Non-RO DPR Demonstration Facility

South Jordan City, UT

PURE WATER DEMONSTRATION DESIGN AND TESTING

South Jordan City, Utah, has no drinking water rights of its owns and currently obtains all of its drinking water from its regional wholesaler Jordan Valley Water Conservancy District. The City has been on a decade-long mission to develop a drought-tolerant, year-round, local supplemental supply to help meet their rapidly expanding population.

Carollo worked with the City to complete a predesign study for a Direct Potable Reuse Demonstration Facility using a non-RO based process train that relies on ozone, biological filtration, ultrafiltration, granular activated carbon and UV. This project is the first step in a long journey to introduce DPR to Utah. The demonstration facility, and a potential future DPR facility, will treat high quality, membrane bioreactor-treated and UV-disinfected wastewater from the Jordan Basin Water Reclamation Facility. The purified water from the demonstration facility will meet all drinking water regulations and be available for tasting (pending permit), but will be discharged back to the front of the plant.

The demonstration project will educate state officials, water managers, and the public on DPR, and generate critical information to help forge a regulatory path for DPR in Utah. Carollo completed the design and pre-purchase equipment packages and City staff installed, wired, and plumbed in the equipment forthis critical pilot project. Carollo is providing piloting assistance for the first year of operations.

Carollo is now supporting the City in obtaining a permit from the Utah Division of Drinking water to allow the City to serve water for tasting as part of facility tours in preparation for a future full-scale facility.

PROJECT HIGHLIGHTS

- *Non-RO DPR demonstration facility.*
- *First step towards introducing DPR to regulators and the public in Utah.*
- *MBR-based potable reuse treatment train.*

Advanced Purification Project

City of Spring Hill, TN

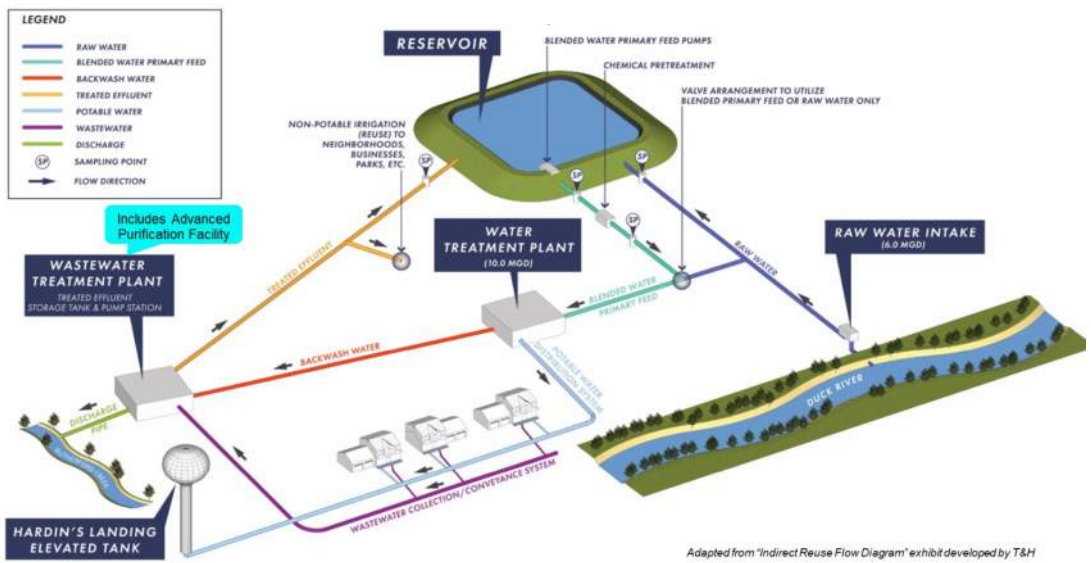
PURIFICATION PILOT CONCEPTUAL DESIGN, TEST PLAN

Carollo was sole-sourced by the City of Spring Hill to complete a conceptual design and develop a test plan for an advanced purification pilot facility. A regional plan for drought mitigation limits the City's ability to draw more source water for their drinking water plant from the Duck River. Coupled with population growth and increasing demand, the City is investigating alternative water supply solutions, which include partnering with a local water purveyor and an advanced purification project. The Tennessee Department of Environment and Conservation (TDEC) has required a pilot-scale demonstration project to provide design criteria and define operational requirements for full-scale concept implementation. The pilot will serve as the first step in the City's fast-track plan to augment a surface water reservoir upstream of their drinking water plant.

Carollo evaluated the City's wastewater treatment plant operation and water quality to assess the feasibility of advanced treatment and identify additional treatment to meet required chemical and pathogen removals. Based on this evaluation, a conceptual design was delivered to the City to treat wastewater effluent using ozone, biologically activated carbon (BAC) filtration, ultrafiltration (UF), granular activated carbon (GAC) adsorption, and UV disinfection. Free chlorine disinfection was included in the pilot design to allow for water tasting during public tours. The pilot will be located at the wastewater treatment plant site and is expected to be operated for nine (9) months, including the time required for media acclimation in the BAC filter. In the absence of potable reuse rules in Tennessee, the sampling plan includes several regulated and unregulated contaminants. Carollo's experience in rule and policy development in other states, like Colorado, Arizona, Texas, and Florida, will serve as a helpful and timely resource to the City as their program continues toward the full-scale execution of the project.

PROJECT HIGHLIGHTS

- *Developed a conceptual design of an advanced purification pilot facility.*
- *Assisted the City in discussing the project with stakeholders.*



Adapted from "Indirect Reuse Flow Diagram" exhibit developed by T&H

Phoenix Advanced Purified Water Plan

City of Phoenix

PLANNING

The City of Phoenix is proactively working to secure a safe, reliable, and long-term drinking water supply for their customers. In addition to long-term drought conditions in the area, reductions are expected to continue for water allocations from the Colorado River, which is a major source of water for the City. The City is now acting to further diversify their water portfolio and improve their ability to reliably meet water demands through the use of highly purified recycled water.

Carollo completed a feasibility study of several potential direct potable reuse (DPR) alternatives for the City. The alternatives use an advanced water treatment (AWT) system to provide highly purified recycled water that can be added into the potable water distribution system. Carollo developed an Advanced Purified Water Alternatives Evaluation and Implementation Plan that includes planning-level cost opinions and an implementation plan for several viable DPR alternatives. The Plan identifies optimal AWT processes and locations and describes other potential infrastructure needed to convey and store source and/or purified water.

The proposed AWT train uses reverse osmosis (RO) membranes, which generate a high-TDS waste stream requiring disposal. Three concentrate management options were considered for implementation:

1. Evaporation ponds (EPs).
2. Multi-effect vapor recompression (MVRE) + EPs.
3. Lime softening (LS) + UF + RO + MVRE + EPs.

While EPs are the simplest method of concentrate management and disposal, they require extensive amounts of land, which made this option infeasible. Options 2 and 3 incorporate treatment processes that reduce the volume of concentrate prior to disposal, thus reducing the total acreage of the EPs. Option 3 was found to be more cost-effective than Option 2 and was selected for inclusion in the DPR alternatives.

PROJECT HIGHLIGHTS

- *Selected alternatives to maximize the use of the City's existing and planned water and wastewater infrastructure.*
- *Developed different advanced water treatment trains for different source waters (i.e., raw wastewater or conventional wastewater effluent).*
- *Identified likely treated water quality goals for DPR within both current regulatory structure and anticipated revisions to existing regulations.*
- *Developed a concentrate management approach that allows these facilities to be located on available land near the AWT facility.*