



Lessons Learned in Full-Scale PFAS Residuals Disposal

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02 Residuals management

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Lakewood Water District, WA

Piedmont Triad, NC

04 Summary



PFAS Treatment and Residuals

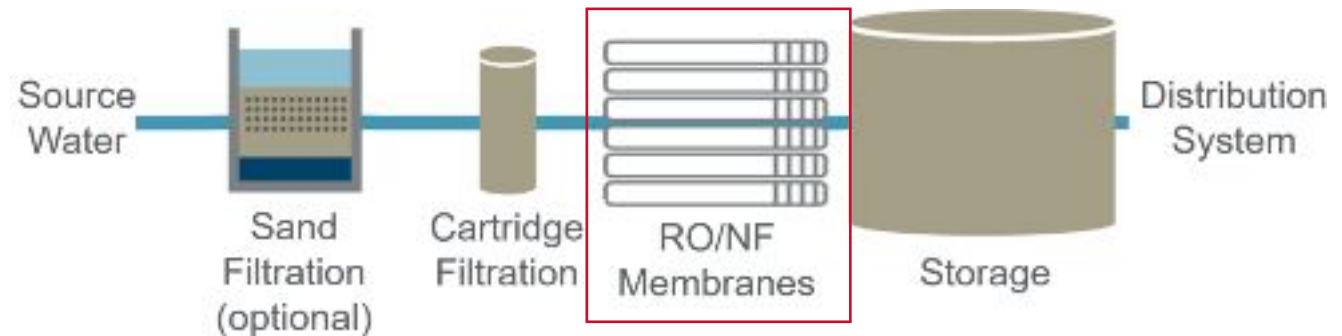
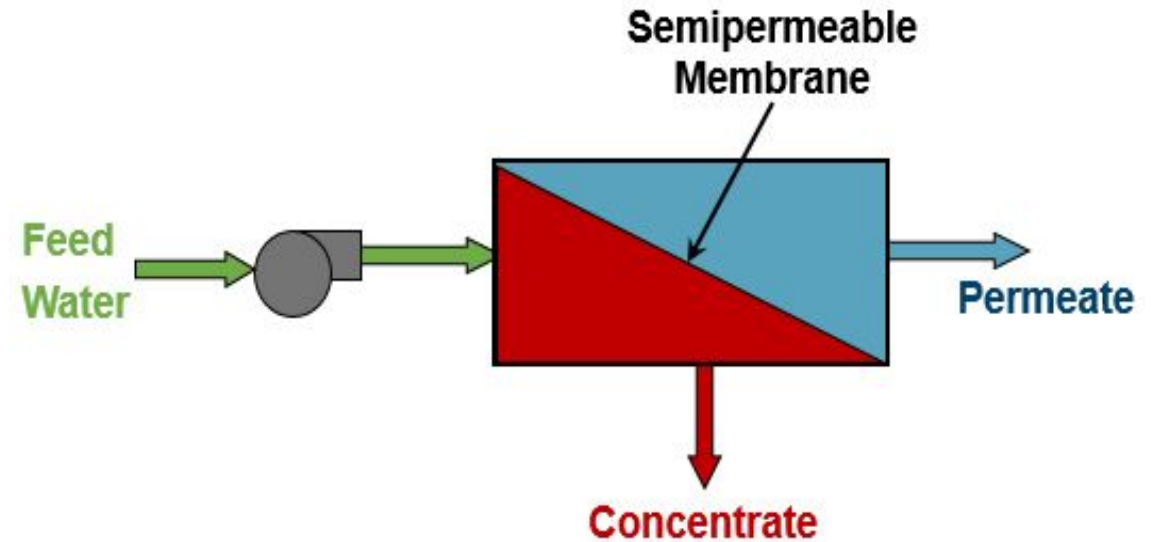


Absorption Processes

- Draws PFAS in the water to a solid phase material
- Material has a finite capacity (“bed life”) – must be replaced when treated water PFAS exceeds goals
- Spent (exhausted) media has high PFAS concentrations along with other contaminants

High-Pressure Membranes

- Physically separates PFAS from water
- Also removes other ions – sodium, potassium, chloride, sulfate
- Concentrate has high salinity – very difficult to discharge in Northwest waters
- Will often contain other contaminants – arsenic, iron, manganese, nitrate





Residuals Management

Many Residuals Handling Options Are Problematic





Lakewood, Wash.



**Piedmont Triad
Regional Water Authority**

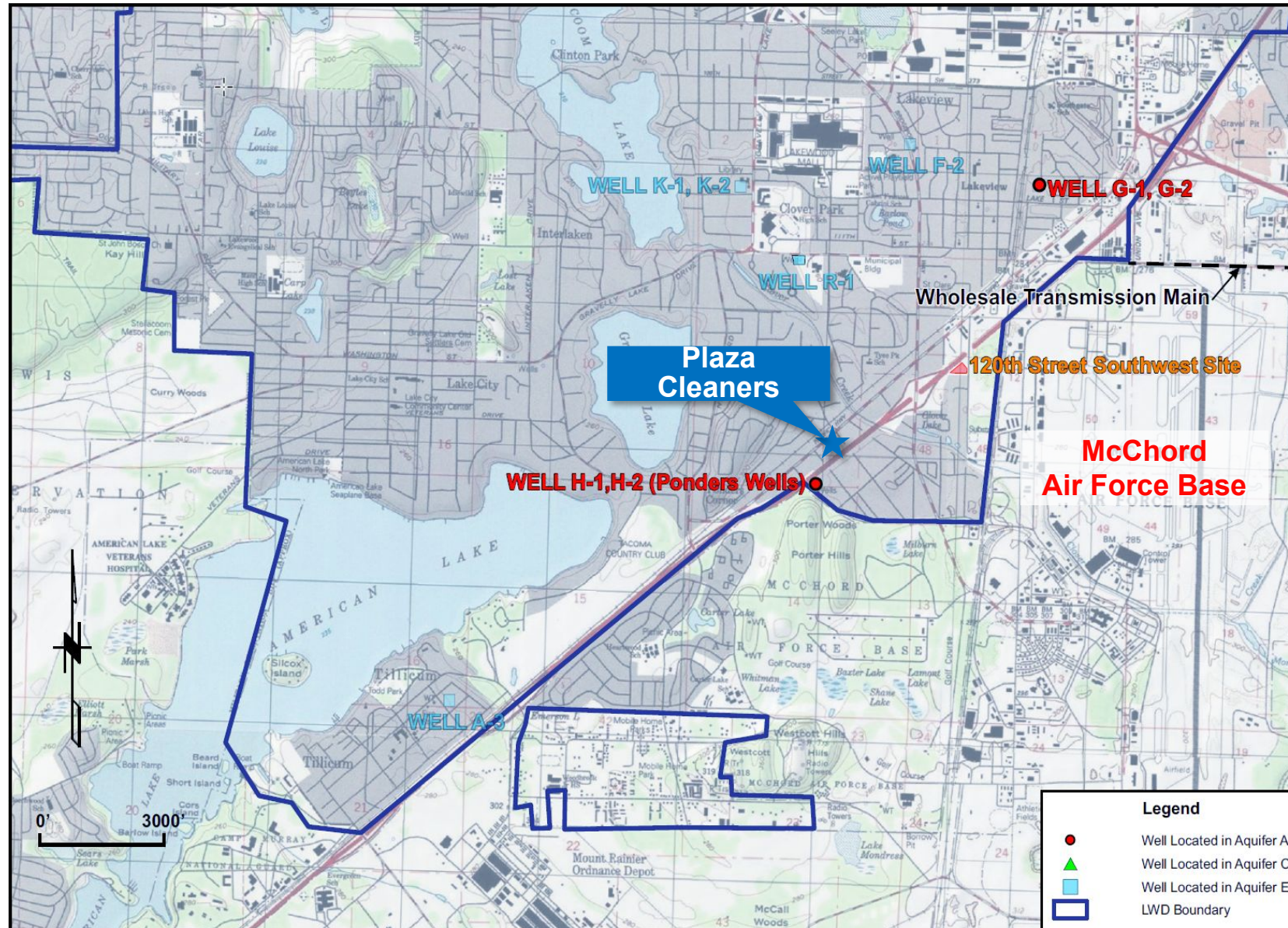
Randleman, N. Carolina

Case Studies

Lakewood Water District

- Serves:
 - Over 60,000 retail customers
 - 55,000 wholesale customers (Town of Steilacoom, Summit Water & Supply Co, Spanaway Water Co., Rainier View Water Co., Firgrove Mutual Water Co.)
- Groundwater supply
- 30 active wells

Lakewood Water District's Ponders Wells



Lakewood Water District Ponders Wells

- Ponders Wells
 - H-1 1,200 gpm
 - H-2 800 gpm
 - Water rights 2,800 gpm
 - Annual production 250 MG
- 1980-81 DOH VOC investigation of Chambers Creek-Clover Creek Basin
 - PCE 18 $\mu\text{g/L}$
 - TCE < 10 $\mu\text{g/L}$
 - 1,2 (trans) dichloroethylene 61 $\mu\text{g/L}$



Ponders Wells

- Wells shutdown for 3 years
 - Limited pressure
 - Inadequate fire flow protection
- Declared a Superfund Site
- EPA had air stripping towers designed & installed 1984
- 2015 Alternatives Evaluation to replace failing air stripping towers.



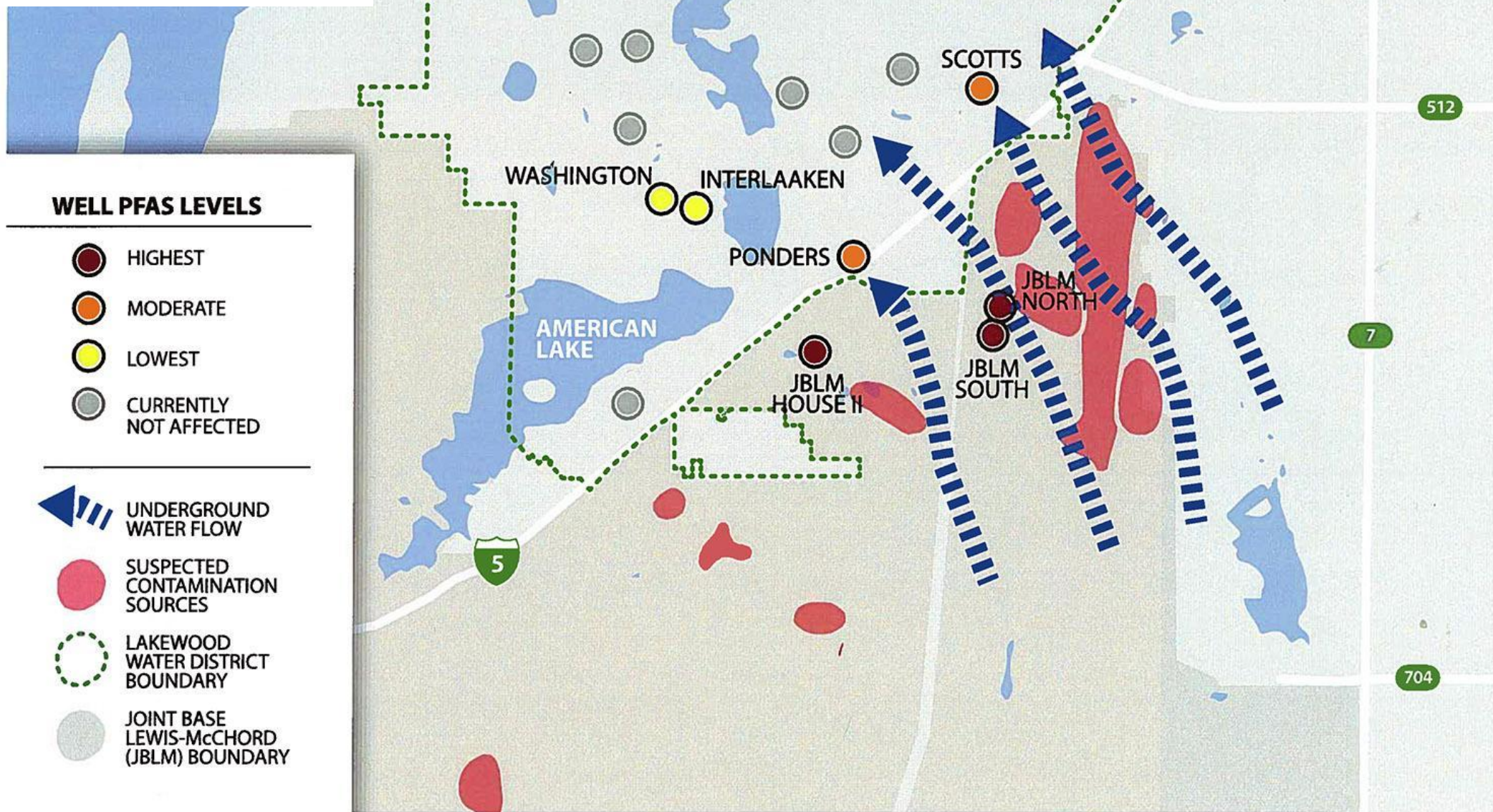
PFAS

- Unregulated Contaminant Monitoring Rule 3 – 2013
 - District sampled
 - Shallow, Sea Level & Deep Aquifers
 - All Non Detect for PFAS
 - Fort Lewis
 - PFOA 51 ppt at one well
- 2016 EPA set Lifetime Health Advisory Levels (LHAL) at PFOS + PFOA at 70 ppt
- McChord Field
 - Nov 2016 - 3 wells exceeded LHAL (PFOS + PFOA 250, 204, & 71 ppt)
 - Shut down the wells
- District sampled Ponders 2016

Lakewood Ponders PFAS Data

Date	PFBS	PFHpA	PFHxS	PFNA	PFOS	PFOA	PFOS+PFOA
	(ppt)	(ppt)	(ppt)	(ppt)	(ppt)	(ppt)	(ppt)
Aug 2016	ND	ND	22	ND	46.5	ND	46.5
Oct 2016	ND	ND	19.2	ND	50.5	ND	50.5
June 2017	7.5	3.9	21	ND	38	8	46
May 2018	11	6	26	ND	52	11	63
Oct 2018	6.9	3.4	24	ND	42	5.6	47.6
Feb 2020	11/12	5.4/6.6	30/22	ND	62/63	11/17	73/80
HAL							70
SAL	345		65	9	15	10	
MCL			10	10	4	4	

PFAS Migration (2018)



PFAS

- H-1 and H-2 shutdown in Fall 2018 for construction
- District decided to add GAC for PFAS treatment
- Intent to have Ponders on-line for peak 2019 season
- Used Rapid Small-Scale Column Test data from another facility given short time frame
- Plan to reactivate GAC

Ponders Water Quality

Constituent	Units	Value
TOC	mg/L	0.2
Turbidity	NTU	< 0.1
Hardness	mg/L as CaCO ₃	63
Iron	mg/L	< 0.1
Manganese	mg/L	< 0.01
Mercury	mg/L	< 0.0002



Completed Ponders Facility

Jan. 2020 Startup

- 4 - 40,000 lbs. GAC vessels with F400 GAC
- Packed bed stripping towers removed PCE to ND
- Operated for 4+ years (approximately 100K bed volumes) without an operational backwash



GAC Acceptance for Reactivation

- Gila Bend, Arizona is nearest custom reactivation facility
- Acceptance Criteria
 - VOC
 - Semi VOC
 - Metals
 - Lead
 - Mercury



Mercury

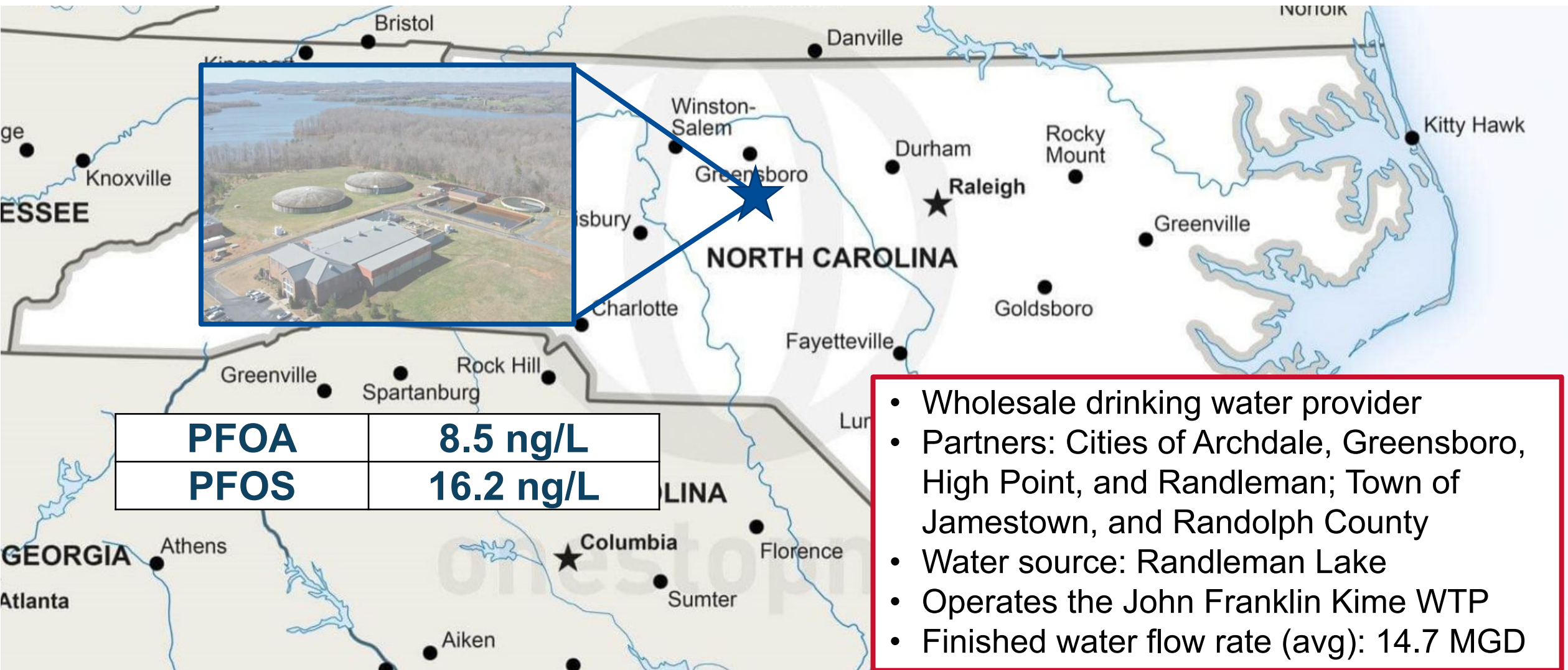
- Municipal Limit 0.1 mg/kg
- Industrial Limit 1.3 mg/kg
- Ponders 2.5 mg/kg
- Landfill disposal \$93,000
- Ponders lag vessels now lead vessels
- Scott lead vessels
 - Changed out 2025
 - GAC accepted for custom reactivation

Well Mercury Testing Method 1631E

Well	Mercury (ppt)
Ponders H-1	0.79, 0.98
Ponders H-2	9.5, 10.0
Scott G-1	1.4
Scott G-2	<0.50
88th and Pine J-1	0.75
88th and Pine J-2	8.5
88th and Pine J-3	<0.50

- State Reporting Limit: 200 ppt

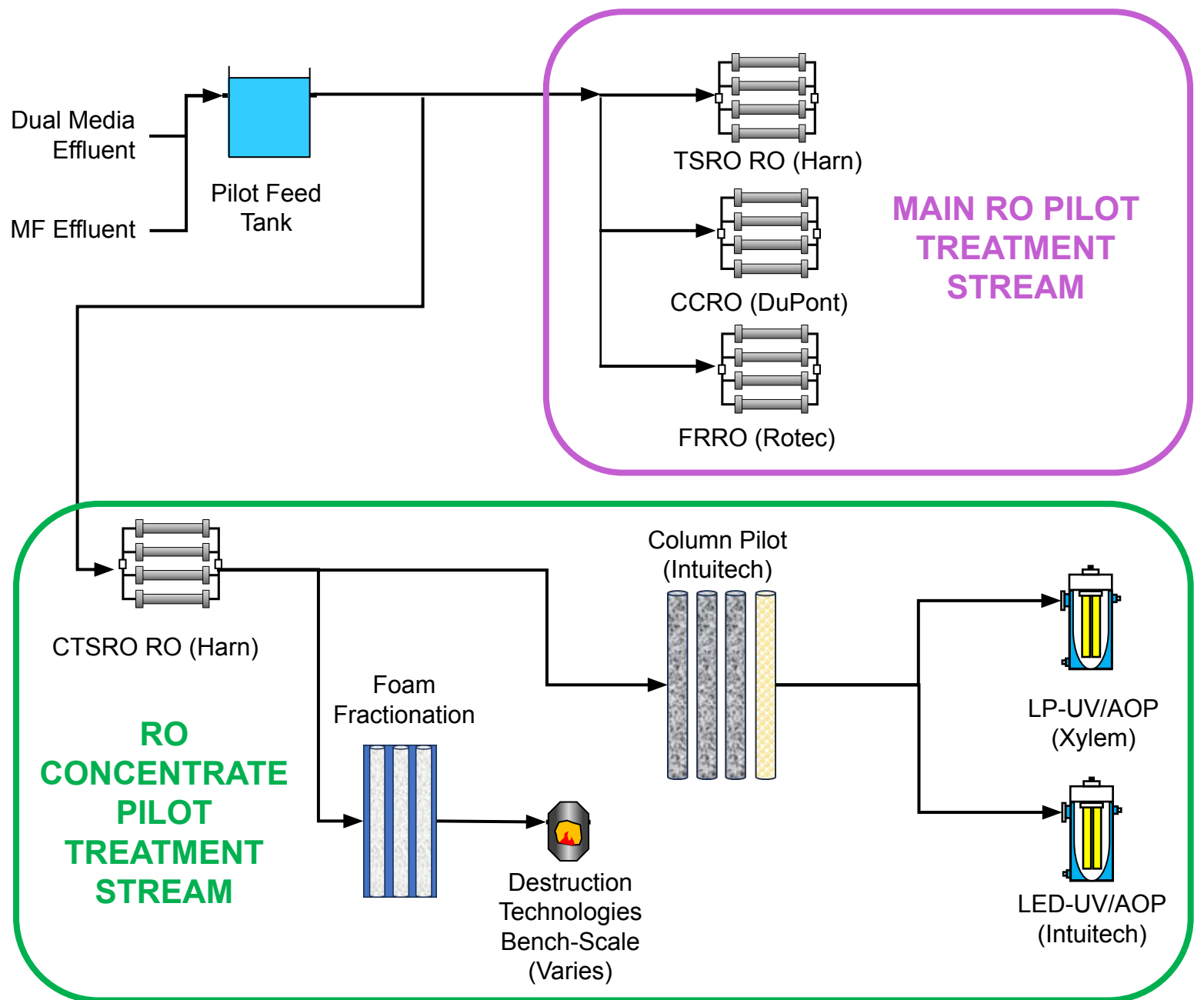
Piedmont Triad Regional Water Authority



Overall Pilot Process

LEGEND:

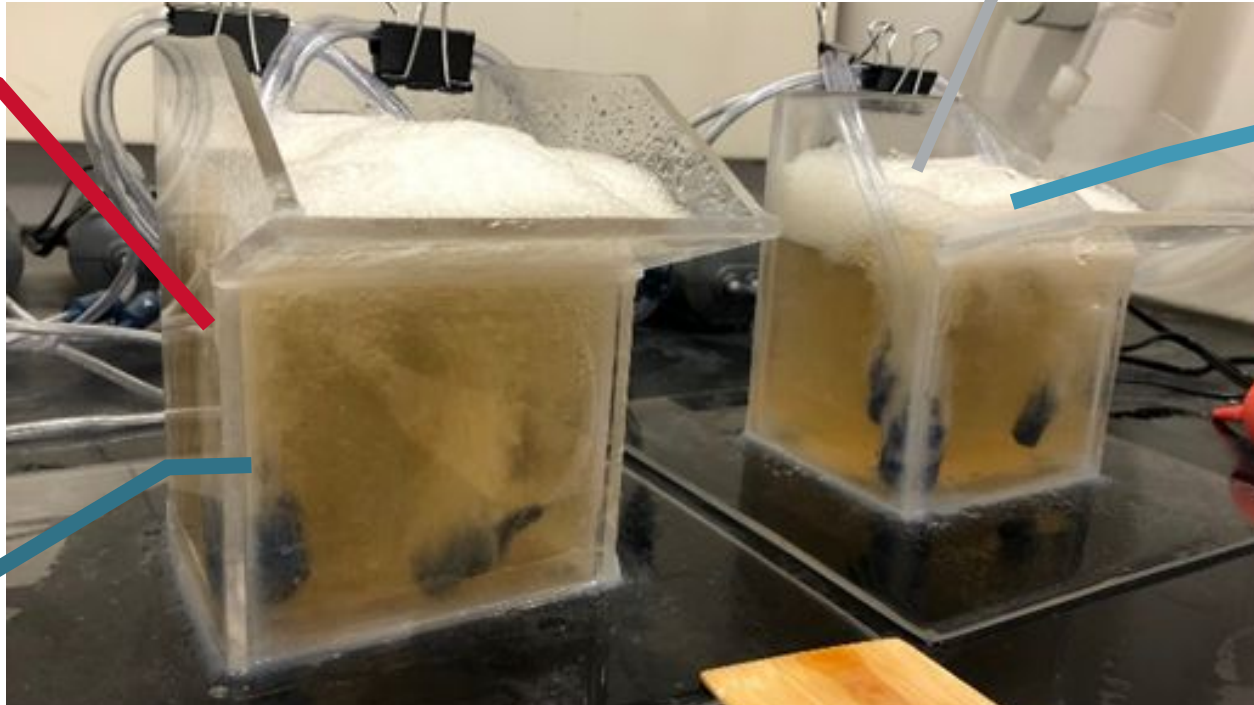
- TSRO – Three-Stage RO
- CCRO – Closed Circuit RO
- FRRO – Flow Reversal RO
- CTSRO – Concentrate Three-Stage RO
- LP-UV/AOP – Low Pressure UV / Advanced Oxidation
- LED-UV/AOP – Light-Emitting Diode UV / Advanced Oxidation



Foam Fractionation

Flotation reagent aids PFAS to attach to the air bubble surface

Hydrophobic portion of PFAS is drawn to air in the bubble



Air must be treated using another process

Foam must be disposed of using another process

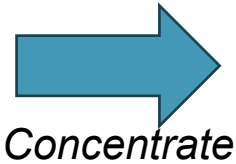


How These Technologies Work Together



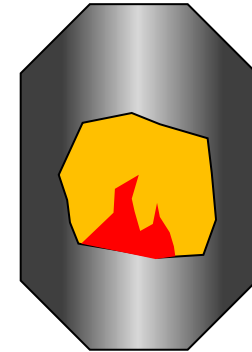
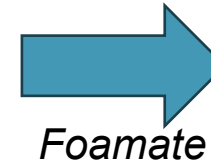
RO Membranes
(90% Recovery, 10% Brine)

**8 ng/L
PFOS**

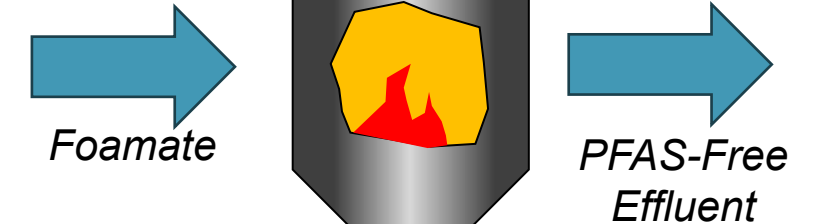


Foam Fractionation
(200x PFAS concentration)

**62 ng/L
PFOS**



**Destruction
Technology**



**12,400 ng/L
PFOS**

Tested Destruction Technologies

Technology	Vendor
UV Photocatalysis	Enspire
UV Photocatalysis	Invicta
Electro-oxidation	Aclarity
Electro-oxidation	E2Metrix
Supercritical Water Oxidation	Revive
Supercritical Water Oxidation	374Water
Plasma	Onvector

- Requires >1,000 to 5,000 ng/L PFAS to work
- 95 to 99% percent effective
- **But 1% of 12,400 ng/L PFOS is 124 ng/L (31x MCL)**

Summary

- PFAS residuals are much harder to dispose of than other water residuals
- Landfill facilities have stringent PFAS acceptance limits and may not accept your residuals
- PFAS residuals also contain many other contaminants that complicates disposal
- PFAS destruction technologies are still a few years away from municipal-scale implementation



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