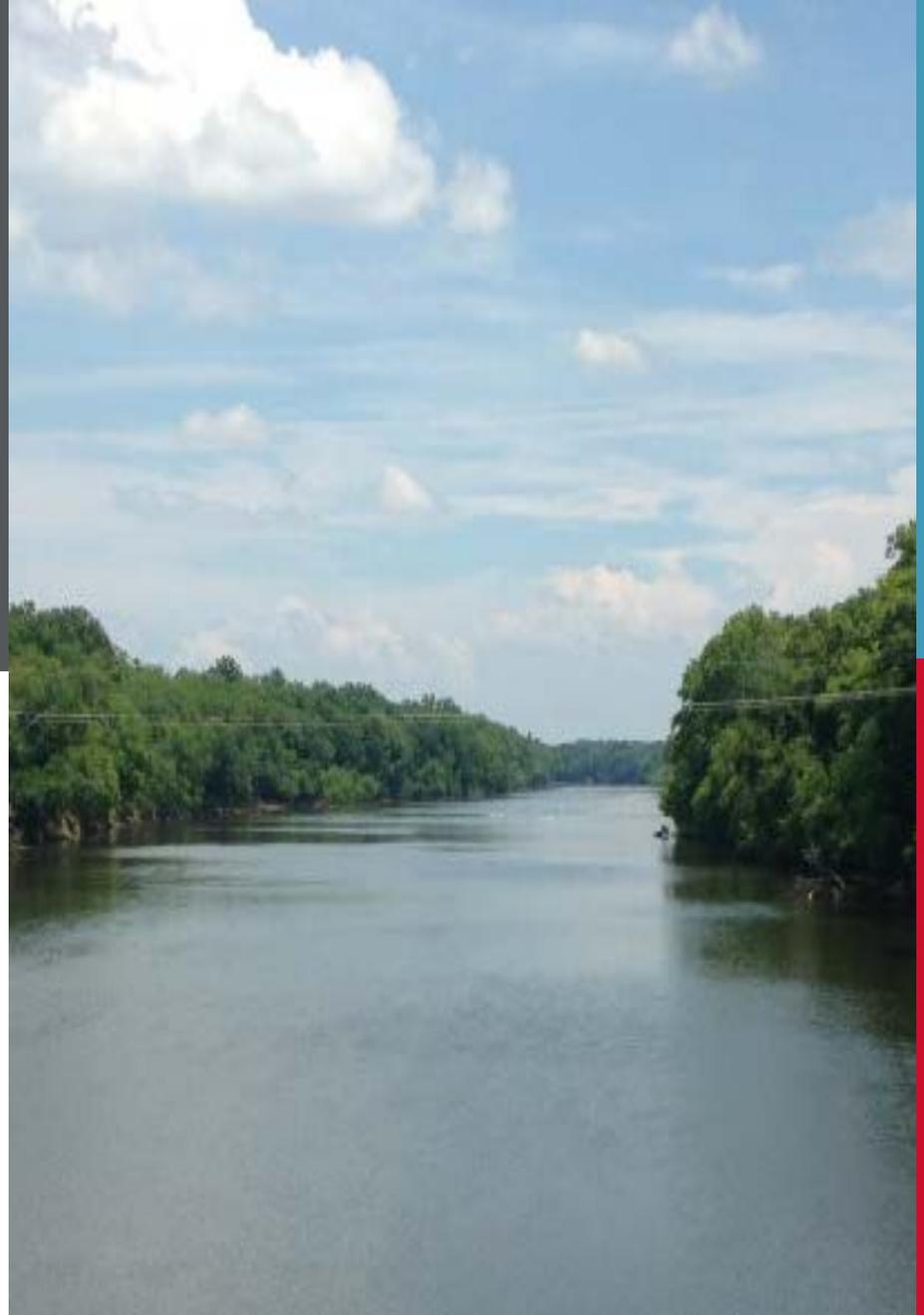


HDR

# Addressing Contaminants of Emerging Concern in the Cape Fear River Basin

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# Introduction

- The Cape Fear River has historically been vulnerable to non-point and point discharges and CECs
  - PFAS
    - GenX
  - 1,4-dioxane
  - Bromide
  - Others
- Many of these contaminants are not federally regulated
- Conventional treatment has limited effectiveness for removing many CECs



# Unregulated Contaminant Monitoring Rule (UCMR)

- Once every 5 years, EPA needs to issue a list of no more than 30 unregulated contaminants to be monitored by public water supply systems
- UCMR provides scientifically valid occurrence data used to
  - Assess exposure
  - Develop regulatory decisions
- Samples are collected at the point-of-entry to the distribution system and maximum residence time

# EPA's Unregulated Contaminant Monitoring Rule 3

## UCMR 3 Contaminant List

### Assessment Monitoring (List 1 Contaminants)

1,2,3-trichloropropane	bromomethane (methyl bromide)	chloromethane (methyl chloride)	bromochloromethane (Halon 1011)
chlorodifluoromethane (HCFC- 22)	1,3-butadiene	1,1-dichloroethane	1,4-dioxane
vanadium	molybdenum	cobalt	strontium
chromium	chromium-6	chlorate	perfluorooctanesulfonic acid (PFOS)
perfluorooctanoic acid (PFOA)	perfluorobutanesulfonic acid (PFBS)	perfluorohexanesulfonic acid (PFHxS)	perfluoroheptanoic acid (PFHpA)
perfluorononanoic acid (PFNA)			

### Screening Survey (List 2 Contaminants)

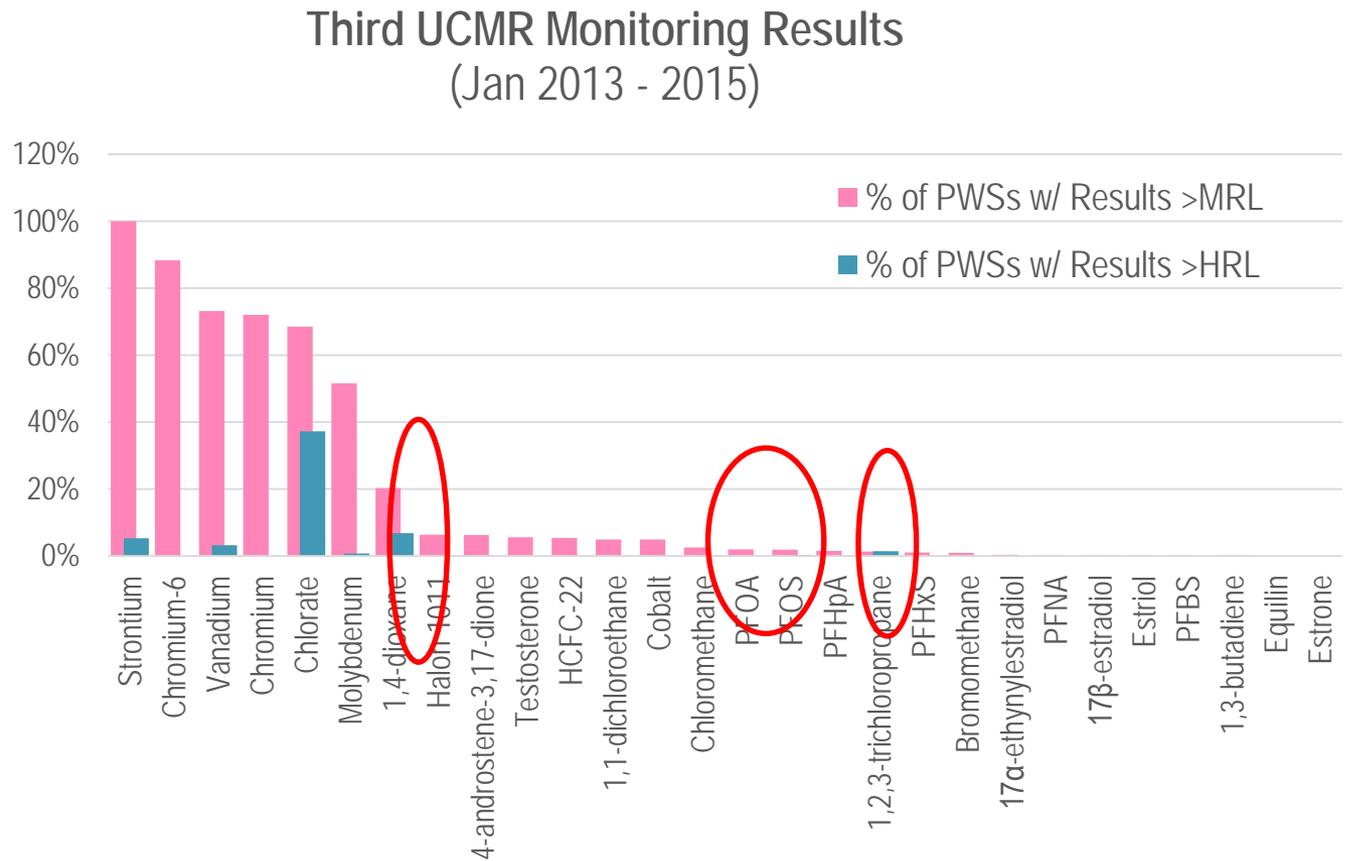
17- $\beta$ -estradiol	estriol	estrone	4-androstene-3,17-dione
17- $\alpha$ -ethynylestradiol	equilin	testosterone	

### Pre-Screen Testing<sup>3</sup> (List 3 Contaminants)

enteroviruses	noroviruses
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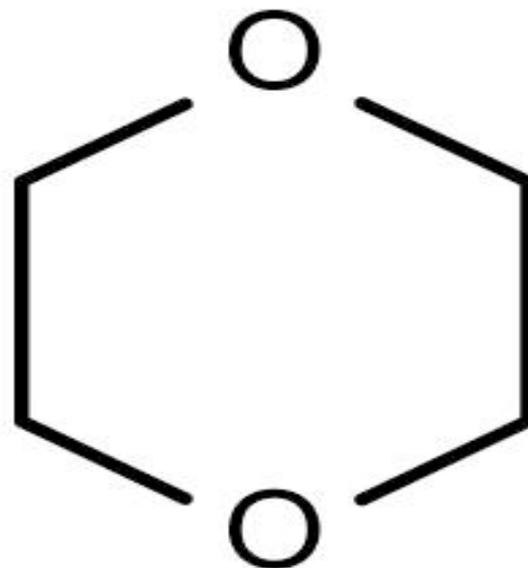
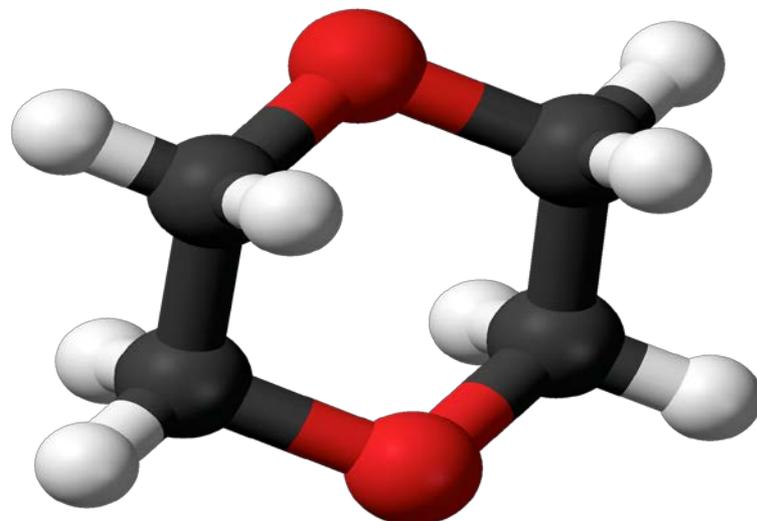
# U.S. Unregulated Contaminant Monitoring

- Lots of low level detections for metals
- Few analytes appear at levels above health reference level



# 1,4-Dioxane

- Primarily used as solvent stabilizer and industrial solvent
- Probable human carcinogen. One in a million cancer risk associated with a 1,4-dioxane concentration of 0.35 mg/L (EPA IRIS database)
- Very stable (soluble and non-volatile)
- Difficult to treat



# 1,4-Dioxane (Graphic from eurofins | Eaton Analytical



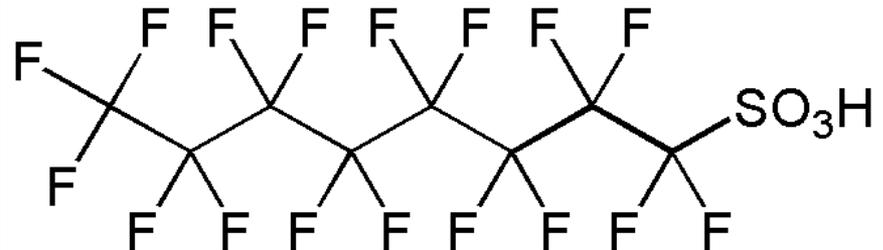
**Detected in 12% of samples nationwide**  
**~3% exceed the 0.35 ug/L HRL**  
**~1% exceed a  $10^{-5}$  risk level of 3.5 ug/L**



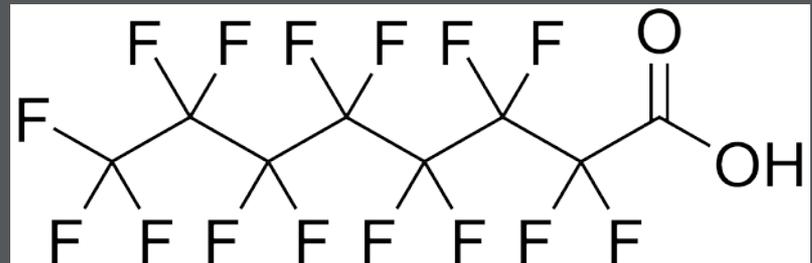
# What are Perfluorinated Compounds (PFCs)?

- Organofluorine compounds
  - C-F bonds
  - C-C bonds
    - More stable than H-C bonds
- Stable, nonreactive, and effective at low concentrations
- Hydrophobic, hydrophilic, and lipophilic all in one – ideal surfactants
- Linked to Reproductive and Developmental Impacts, Cancer, Thyroid Function, Liver Damage

## PFOs

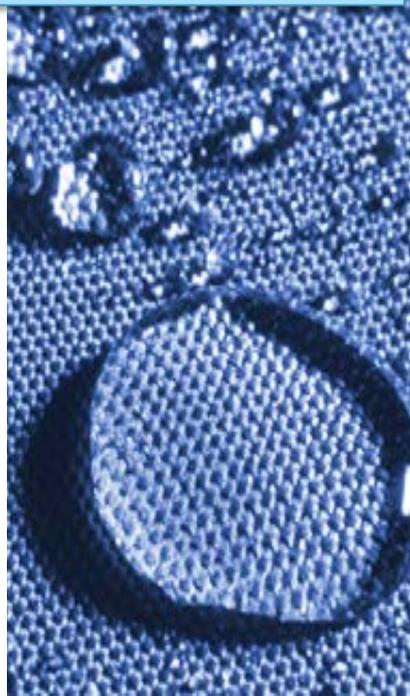


## PFOA





Where are PFCs found?





# Brunswick County UCMR 3 Sampling Results

Constituent	Health Risk Level (HRL) or Health Advisory, mg/L	EPA MCL mg/L	Range Detected (mg/L)	SDWA Violation
Perfluoroheptanoic acid, PFHpA	**	**	0.013-0.022	No
Perfluorohexanesulfonic acid, PFHxS	**	**	0.01	No
Perfluorononanoic acid, PFNA	**	**	0.0068	No
Perfluorooctanesulfonic acid, PFOS	0.07	**	0.0235	No
Perfluorooctanoic acid, PFOA	0.07	**	0.0088-0.0162	No
Chromium, Hexavalent	10	**	0.062-0.33	No
Chromium	100	100	0.121-0.30	No
Molybdenum	40/80	**	0.361-0.903	No
Strontium	4,200	**	38.2-249	No
Vanadium	21	**	0.23-0.53	No
Chlorate	210	**	121-147	No
1,4-Dioxane	0.35	**	3.2	No

# Emerging Fluorinated Alternatives - GenX

- Major manufacturers stopped production of PFOA in 2009/2015
- Perfluoroether carboxylic acid (PFECA) and perfluoroether sulfonic acid (PFESA) used as alternatives
  - PFOA replacement - GenX
- Little is known about their persistence, toxicology and treatability of Gen-X and other PFECAs/PFESAs

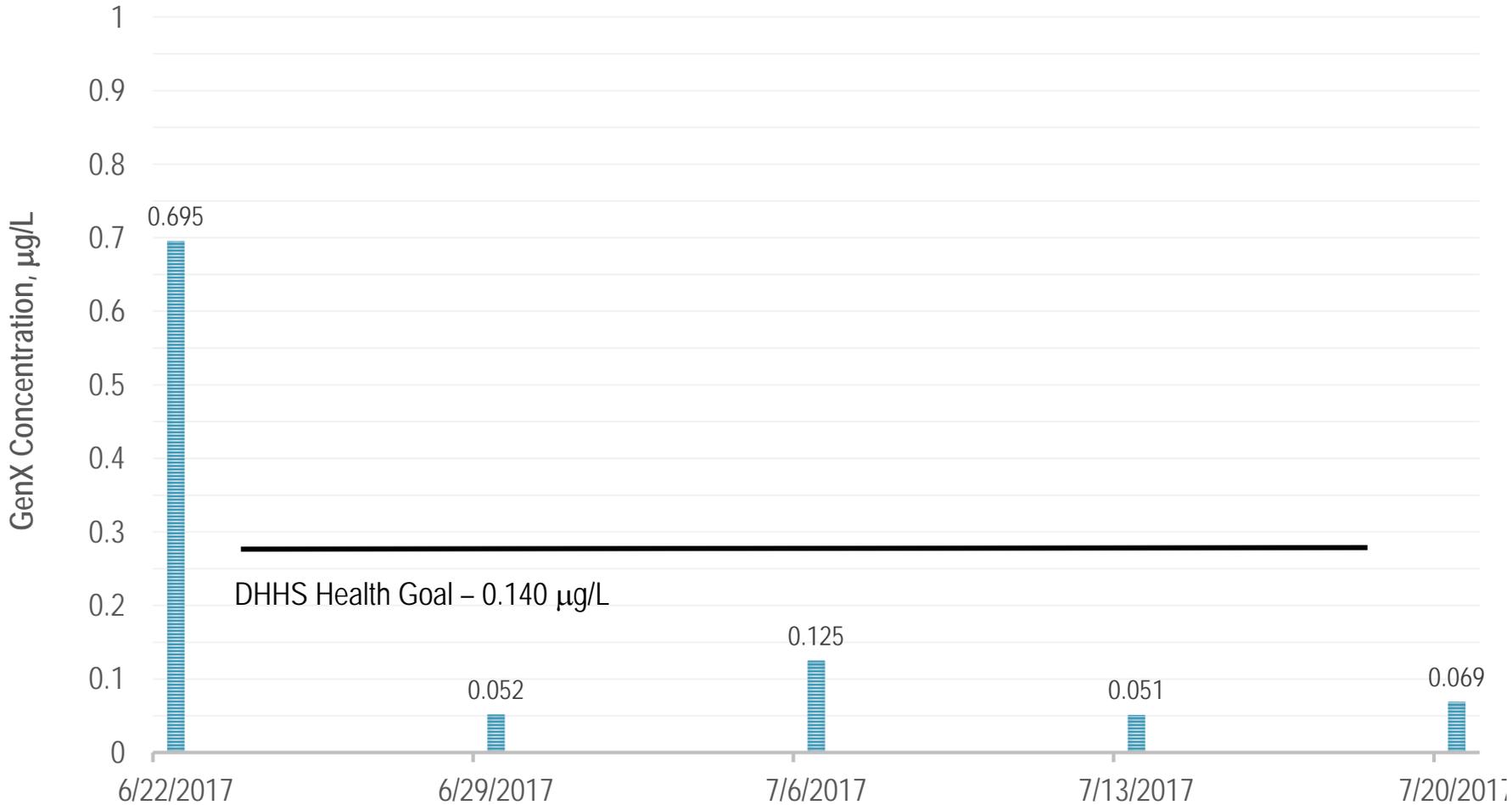
Property	
Nicknames	<u>GenX</u>
Chemical Names	<u>Ammonium perfluoro (2-methyl-3-oxahexanoate)</u>
	<u>Ammonium 2,3,3,3-tetrafluoro-2-(heptafluoropropoxy) Propionate</u>
	<u>Ammonium 2-(heptafluoropropoxy)tetrafluoropropionate</u>
Primary Use	<u>Fluoropolymer resin</u>
CAS Number	62037-80-3
Chemical Formula	C <sub>6</sub> H <sub>4</sub> F <sub>11</sub> NO <sub>3</sub>
Molecular Weight	347.08 <u>g/mol</u>
Chemical Structure	

# PFECAs and PFESAs Toxicological Information

	PFECAs and PFESAs
<b>Persistence</b>	Resistant to photolysis, hydroxyl (OH)-radical-mediated reactions, hydrolysis, and biodegradation, however more research is needed.
<b>Bioaccumulation potential</b>	Uncertain due to lack of information. They might be as bioaccumulative as their predecessors due to similar physicochemical properties, although some research indicates GenX is not as bioaccumulative as PFOA.
<b>(Eco)toxicity</b>	Three PFECAs have been shown to cause liver damage in rats; one PFECA has been suggested by its manufacturer to be classified as "T" under the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH)* regulation. However, GenX appears to be less toxic than PFOA, particularly with respect to reproductive systems.
<b>Long-range transport potential</b>	Suspected to be mobile like their predecessors based on similar physicochemical properties

(Wang et al. 2015; Beekman et al. 2016)

# Raw Water GenX Concentrations for the NWWTP



# Contaminant Treatment Effectiveness

Constituent	Treatability (% Removal Range)							
	Conventional Treatment	Granular Activated Carbon	Powdered Activated Carbon	Ozone	Biofiltration	UV/AOP	Reverse Osmosis	Ion Exchange
Perfluoroheptanoic acid, PFHpA	NE	50 to 90%	0 to >90%	NE	UN	~5%	81 to >98%	38 to >54%
perfluoro-2-propoxypropanoic acid (GenX)	NE	UN	0 to 40%	NE	UN	UN	UN (Likely > 90%)	UN
Perfluorohexanesulfonic acid, PFHxS	NE	50 to >90%	0 to >90%	NE	UN	NE	94 to >96%	97 to >98%
Perfluorononanoic acid, PFNA	NE	>90%	0 to >90%	NE	UN	NE	87 to >98%	>67%
Perfluorooctanesulfonic acid, PFOS	NE	>90%	0 to 50%	NE	UN	~10%	96 to >99%	0 to >94%
Perfluorooctanoic acid, PFOA	NE	>90%	0 to 90%	NE	UN	~10%	47 to >98%	~5 to 76%
1,4-Dioxane	NE	NE	NE	2 to 11%	NE	>90%	~50%	>90%

NE = not effective: UN = Unknown, additional research needed

# Advanced Technology Conceptual Cost Opinions

Conceptual Capital and Operating Cost Opinions			
Technology	Capital Cost (\$M)/MGD	Cost (36 mgd*)	Annual Cost/1,000 gallons
Granular Activated Carbon	\$0.5	\$18M	\$0.15 to \$0.70
Powdered Activated Carbon	\$0.05	\$1.8M	\$0.20 to \$0.50
UV/Advanced Oxidation	\$0.38	\$13.7M	\$0.10 to \$0.30
Reverse Osmosis	\$3.0	\$108M	\$0.5 to \$1.20

\* Potential future Phase 3 capacity of the Northwest WTP

# Conclusions and Recommendations

## ▪ Conclusions:

- The Cape Fear River and Brunswick County's intake has historically been vulnerable to point and non-point discharges of contaminants and will continue to be so in the future given its location in the watershed
- Brunswick County's WTPs provide conventional treatment that is not effective at the removal of many CECs including PFAS, GenX and 1,4-dioxane

## ▪ Brunswick County Recommendations:

- Continue to monitor for PFAS and 1,4-dioxane in the Cape Fear River and confirm that 1,4-dioxane is not a contaminant in the 211 WTP wellfield
- Continue to work at the local, State and Federal levels to eliminate CEC discharges into the Cape Fear River
- In the near term, evaluate performance and cost of providing granular activated carbon (GAC) for removal of PFAS by conducting bench scale studies at the Northwest WTP
- Depending on occurrence data and bench scale test results, conduct a more detailed pilot study to evaluate GAC performance for these compounds
- Evaluate the need for additional treatment as part of the next NW WTP expansion