



# A Hydrogeological Modeling Approach to Understand the Fate and Transport of PFAS in the Cape Fear Watershed

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# Overview

*This presentation overviews an approach to model historical PFAS contamination of drinking water in three communities within the Cape Fear Watershed using available data and information.*

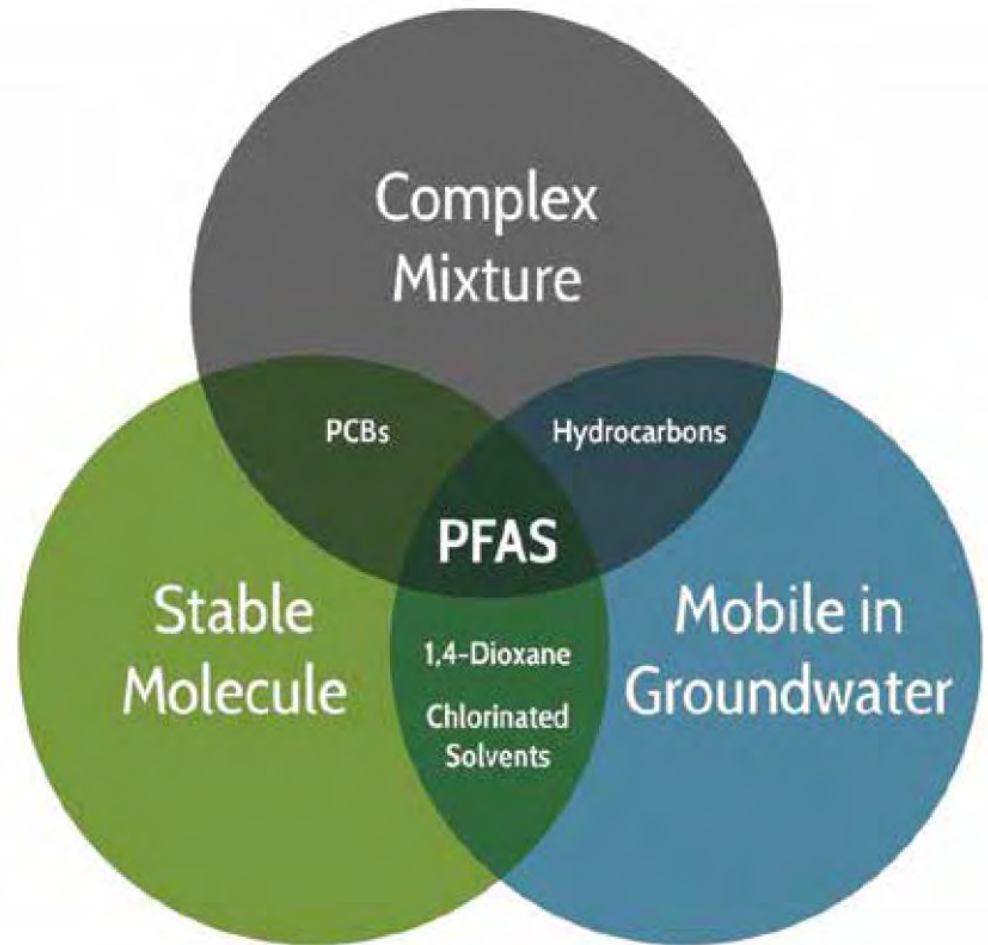
- PFAS Compounds as a Unique Chemical Class
- Hydrogeologic Modeling Overview
- Historical Reconstruction of PFAS in Drinking Water

# PFAS Compounds as a Unique Chemical Class



# What is so special about PFAS?

- ~5,000 PFAS compounds, often found in complex mixtures
- Stable (once transformed)
- Toxic and (possibly) carcinogenic
- Bioaccumulation potential
- Capable of air transport - wet and dry deposition
- Mobile in groundwater

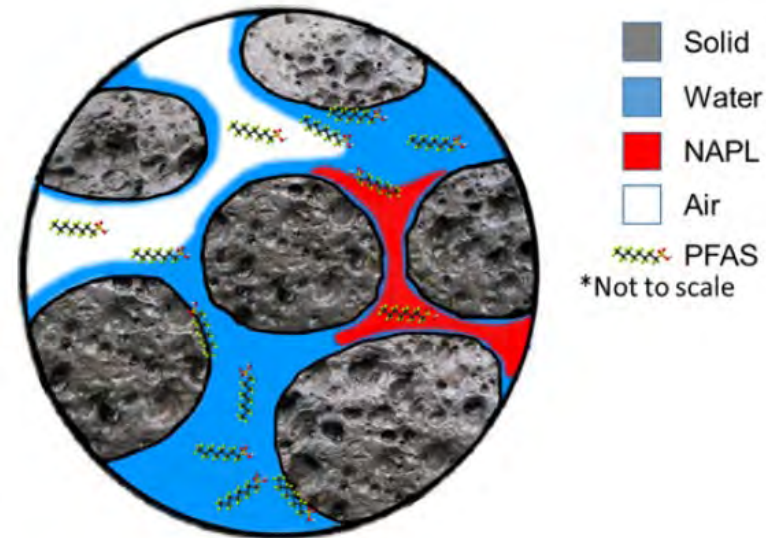


# PFAS Properties, Continued

## Conventional modeling approaches for volatile organic compounds / soluble contaminants **do not capture PFAS lab and field behavior**

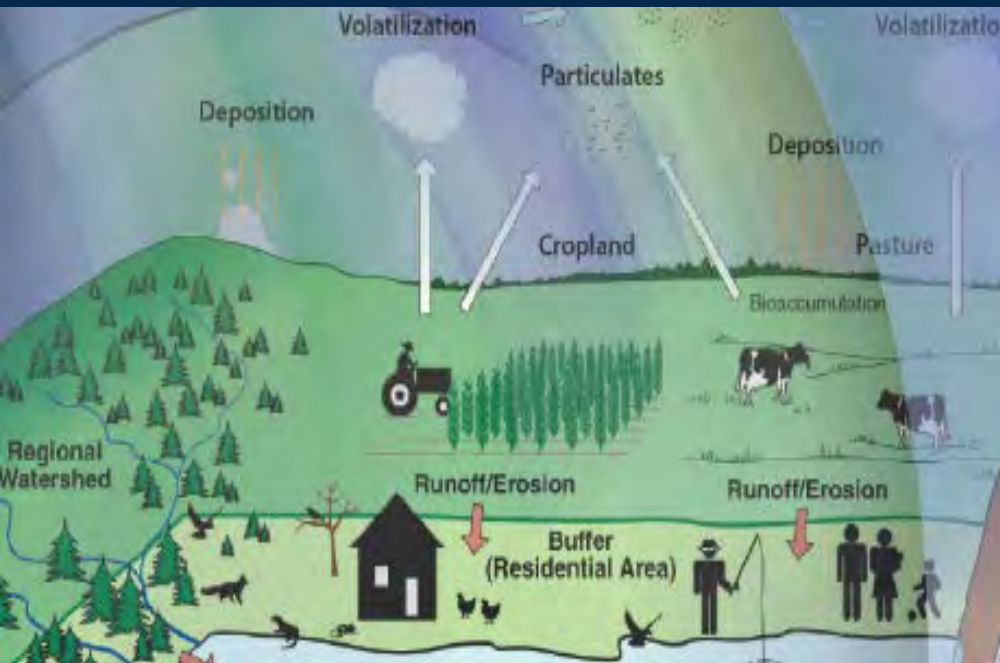
- PFAS change surface tension of water, thereby the way water flows
- Unlike most organic compounds, there is not linear solid phase sorption behavior ( $K_d = K_{oc} * f_{oc}$ )
- Limited data on PFAS other than PFOS and PFOA, pre-cursors and end products

Vadose zone – a subsurface **PFAS reservoir** and **long-term groundwater contaminant source**



PFAS compounds are interface-loving, making unsaturated zone transport behavior more complex

# Hydrogeologic Modeling Overview

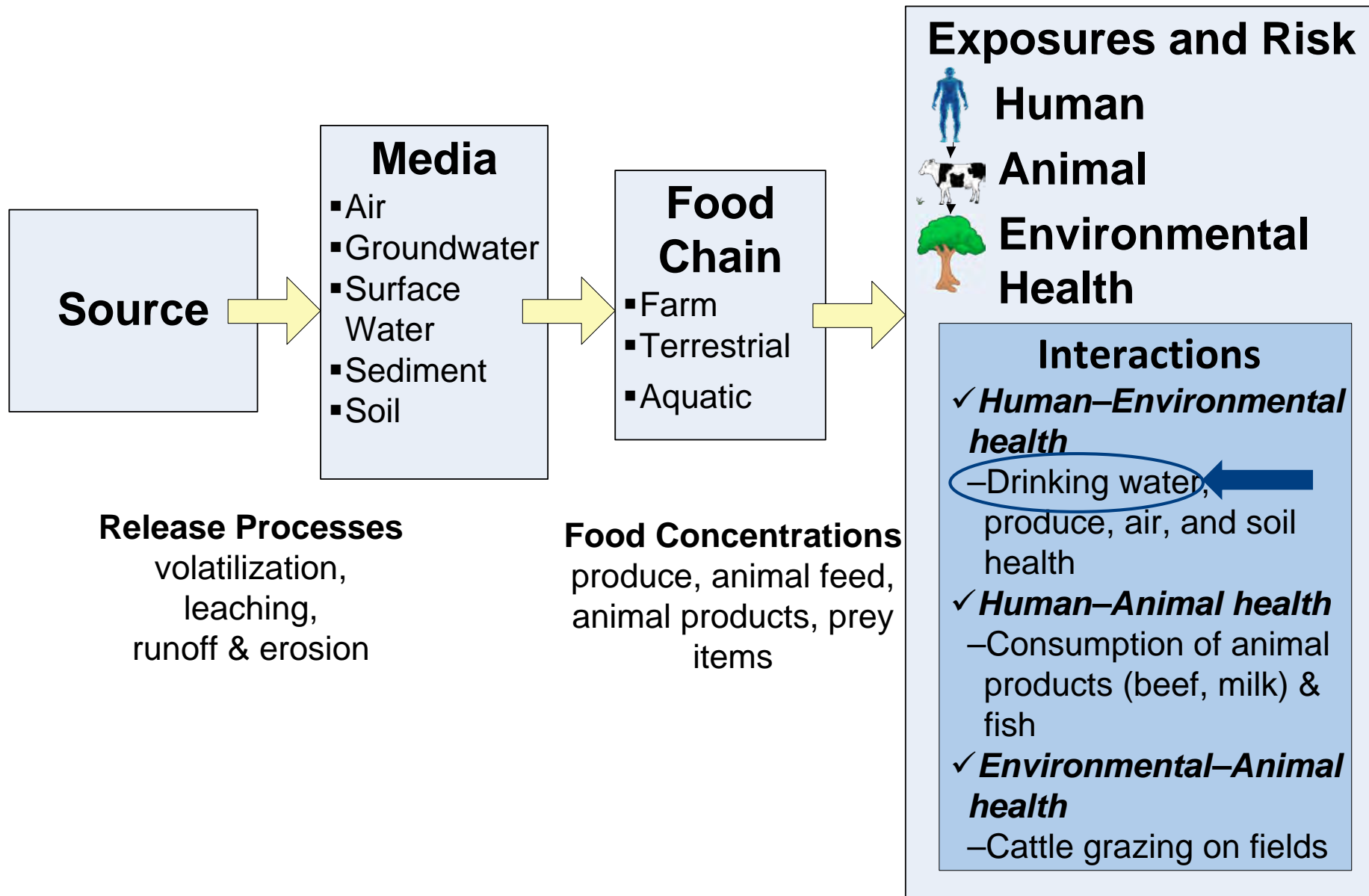


**Hydrogeologic modeling allows us to get a better understanding of the potential fate and transport of PFAS compounds than the use of sampling data alone.**

Modeling is especially useful when we have major gaps in data or knowledge, such as:

- Non-specific information on historic releases
- Limited concentration data and a lack of longitudinal data

# From Source to Risks – A One Health Paradigm





# Historical Reconstruction of PFAS Contamination in Drinking Water

We use available information and data on current or historic releases, develop a conceptual model, and simulate fate and transport under varying conditions to provide probabilistic estimates of PFAS concentrations in drinking water.

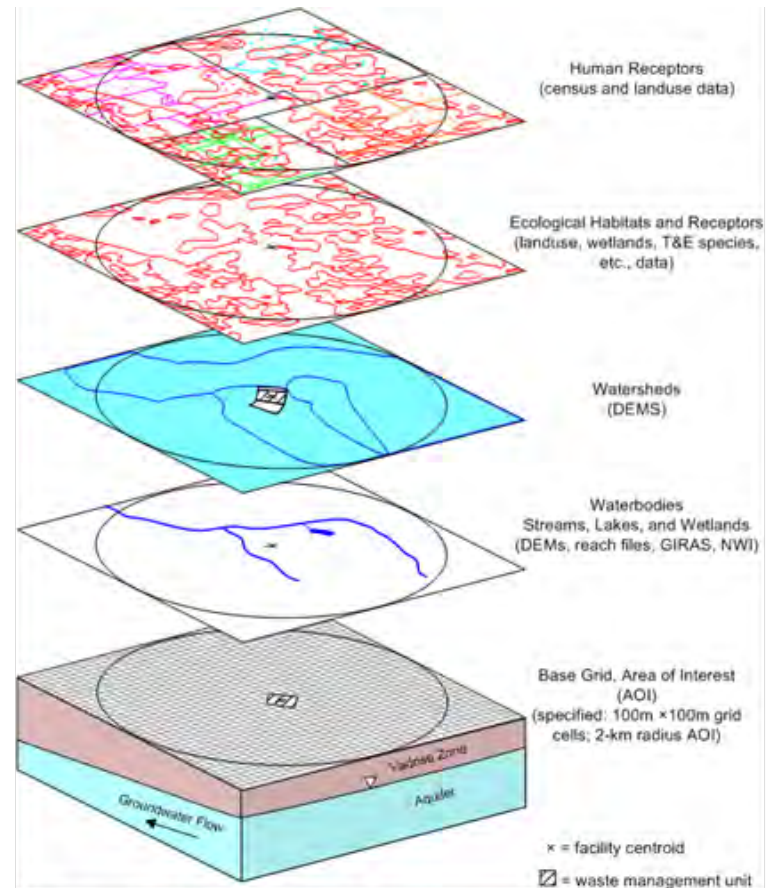


# Conceptual Site Model

The CSM is the **foundation for reconstructing** the most likely historical movement of PFAS through the environment and estimating the **magnitude** and **timing** of PFAS concentrations ingested by receptors in the previous ~20 years.

## The Environmental Setting

- ✓ Historical and current sources
- ✓ Water-intake specific characteristics
- ✓ Concentration data
- ✓ Watershed and surface water characteristics
- ✓ Soil Lithology
- ✓ Meteorological Data



Under 3MRA, RTI pioneered the use of geographic information systems data sources to parameterize environmental models.

# Document Collection and Records Review: Known, Suspected, or Potential PFAS Sources in the Cape Fear Watershed of NC

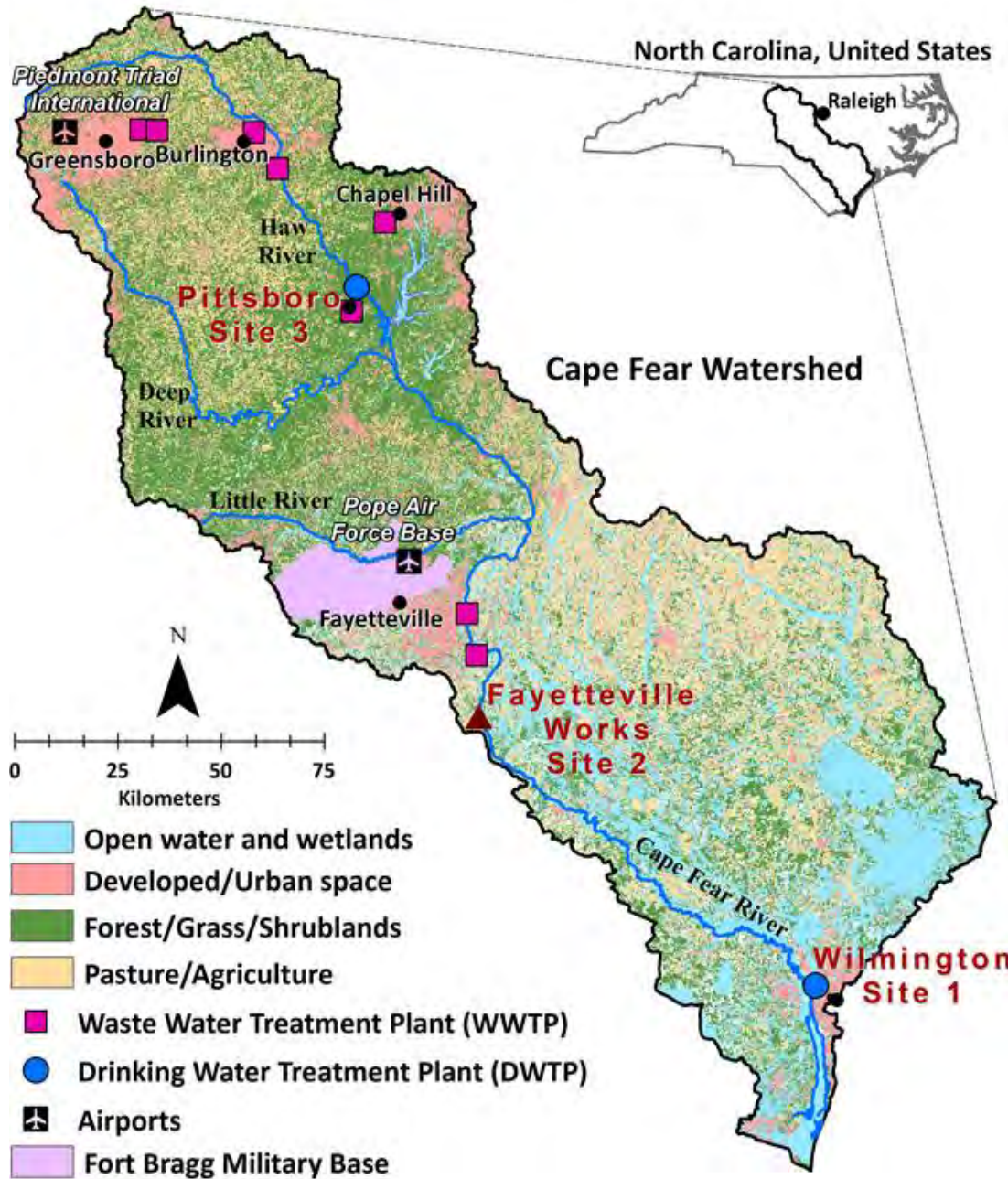
Location	Industrial	Municipal Wastewater Discharge	Aqueous Film Forming Foam (AFFF) Use	Agricultural (Biosolids)
<b>Site 1 - Wilmington</b>	DAK Americas, Smithfield Plant	Yes	Firefighting/ training	Yes
<b>Site 2 - Private Well Community</b>	Fayetteville Works	Yes	1) Greensboro Airport 2) Fort Bragg 3) Pope Air Force Base 4) Firefighting/ training	Yes
<b>Site 3 - Pittsboro</b>	Former/ current textile industry	Yes	Firefighting/ training	Yes

# PFAS Concentration Data in the Cape Fear Watershed

Location	Surface Water	Public Water Supply	Groundwater
<b>Site 1 – Wilmington public water supply users</b>	Cape Fear River Lock and Dam #1*, Sweeney DWTP intake: 2006: 1 EPA sample 6/14/13–10/13/13 (34 samples) 2014: 1 sample; 2015–2016: limited data June 2017-present: frequent data	2014: 1 sample; 2015–2016: limited data June 2017-present: frequent data	Richardson DWTP public water supply wells  2017–present: Limited finished tap water data  2019 data untreated wells
<b>Site 2 – Private Wells surrounding plant</b>	N/A	N/A	2017–present: ~1,000 private wells (DEQ, NC State)
<b>Site 3 – Pittsboro public water supply users</b>	DWTP intake at Haw River Bynum, 2006: 1 EPA sample 6/22/13–11/19/13 (almost daily), 2018/19: limited data	2018-present: limited data	N/A

# Conceptual Watershed Model of the Cape Fear River Basin

Known, suspected, or potential historical or current PFAS sources and communities affected identified

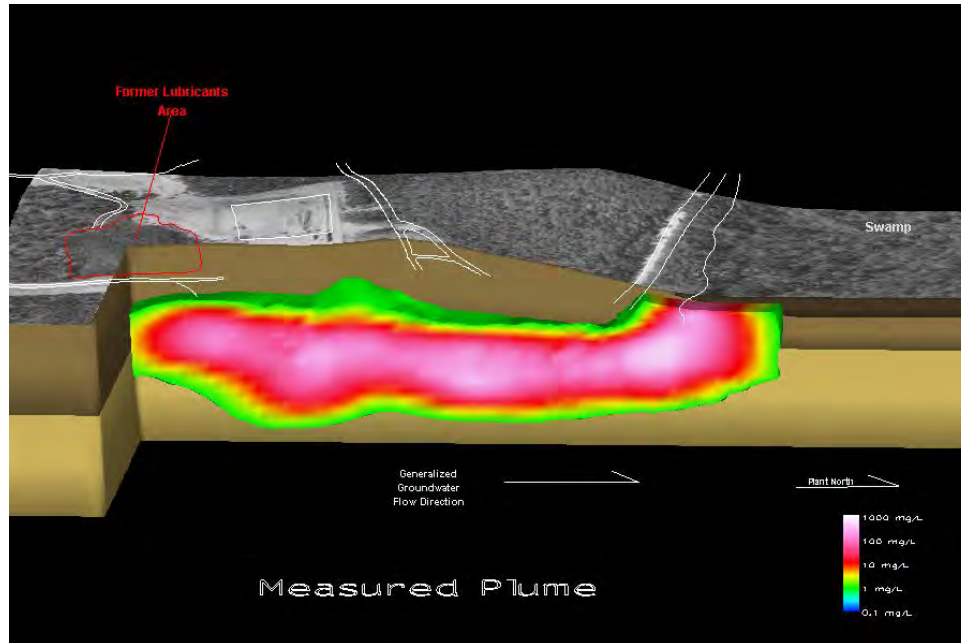


# PFAS-Specific Modeling Approach for NC

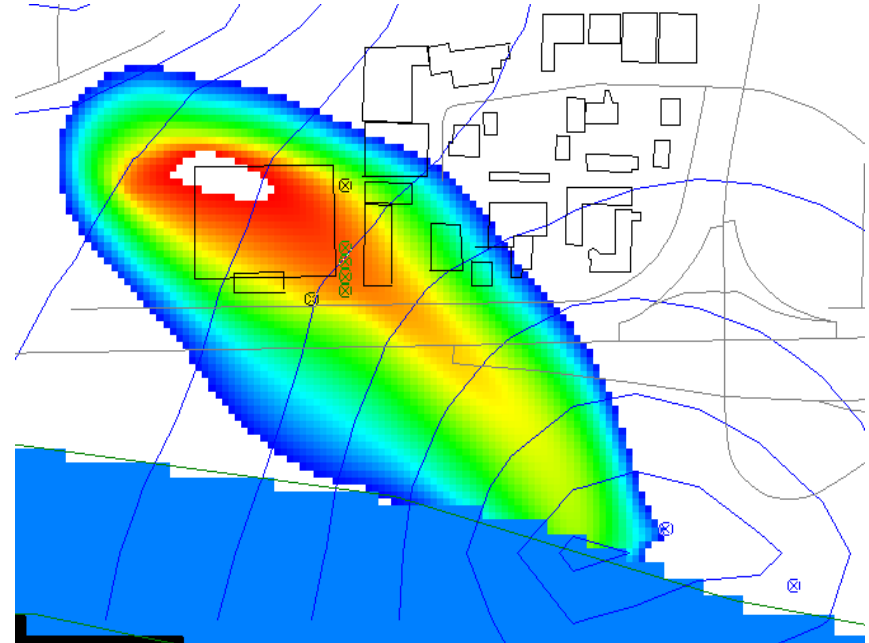
	Modeling Approach				Model Outputs
	Overland Flow	GW-SW Interaction	Air Deposition	Soil to Groundwater	
<b>Pittsboro</b>	Simple Mixing Model	--	--	--	In river concentrations at drinking water intake for Haw River
<b>Fayetteville</b>	Hydrologic modeling for Haw River, Deep River, and Little River confluence into Cape Fear River	Evaluate wells next to Cape Fear River	Air deposition to soil	Soil to groundwater, Groundwater to well	Air deposition mass/concentrations; Vadose zone mass/concentrations; Groundwater mass/concentrations
<b>Wilmington</b>	Use Fayetteville Results and add additional downgradient point and non-point sources	--	--	--	Results of upstream hydrologic modeling plus additional modeling

# Model Outputs

- Probabilistic estimates of drinking water concentrations over time across geographic locations based on varying conditions, data inputs, and assumptions
- This approach makes it possible to isolate and address uncertainty in key model inputs and PFAS sources.



Example of fate and transport of a contaminant plume.



A depiction of hydrogeological modeling predicting historical migration of PFAS in groundwater.

# Where to go from here?

- 1) **How can we use available data and information to most accurately reconstruct the historical fate and transport of PFAS compounds?**
- 2) **What new data, information, or approaches do we need to improve modeling estimates?**
- 3) **What combined role should laboratory studies, field studies, and modeling studies have in characterizing historical PFAS contamination?**
- 4) **What do we need to accurately estimate current and future PFAS fate and transport into drinking water?**





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