Groundwater Vulnerability to Modern Contamination from Floods

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Is NC Groundwater Vulnerable to Flooding?

This question was driven by three main factors:

1. Over 50% of North Carolina (NC) depends on groundwater for its drinking water.
2. As global temperatures rise, the frequency and intensity of rainfall and flood events are increasing.[1]
3. Deep, confined wells are more susceptible to modern water intrusion (water recharged after 1953) than previously understood.[2]

Objectives

- Analyze groundwater samples from NC coastal wells for organic chemicals of emerging concern (CEC) and tritium to evaluate if flooding impacts well water.
- Evaluate if unconfined and confined aquifers are both vulnerable to modern water contamination.

Sampling & Analysis

Groundwater samples were collected from the NC Department of Environmental Quality (NCDEQ) monitoring well network. Between August 2018 and March 2021, we collected and analyzed:

- **112** groundwater samples from **not-flooded** well sites
- **38** groundwater samples from **flooded** well sites

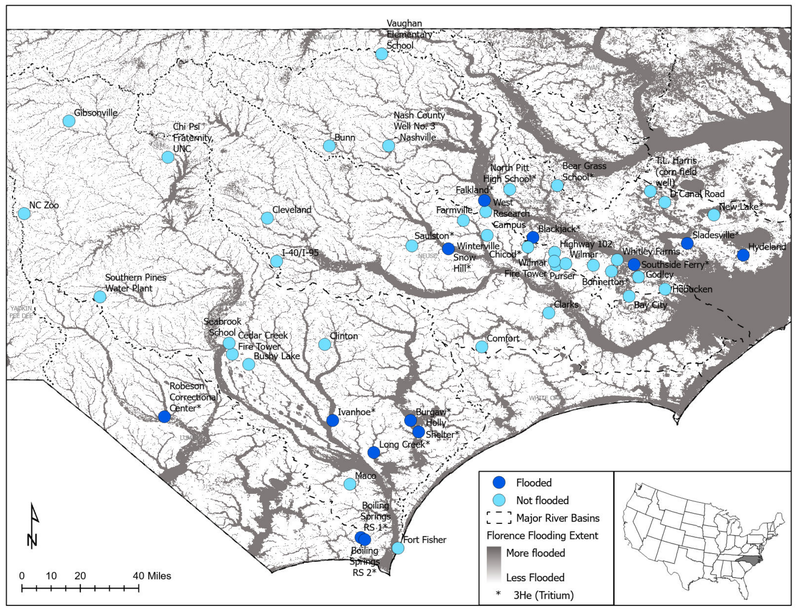

Figure 1. Map of 50 well sites sampled during study with extent of flooding from Hurricane Florence in 2018 shown.

After analysis by non-targeted high resolution mass spectrometry, **organic CECs** were identified using the US EPA ToxCast Phase III List of chemicals of regulatory concern.

Groundwater samples were sent to Utah Noble Gas Laboratory for **tritium analysis**. Tritium results were used to determine the proportion of modern water present in samples.

Modern Water Presence

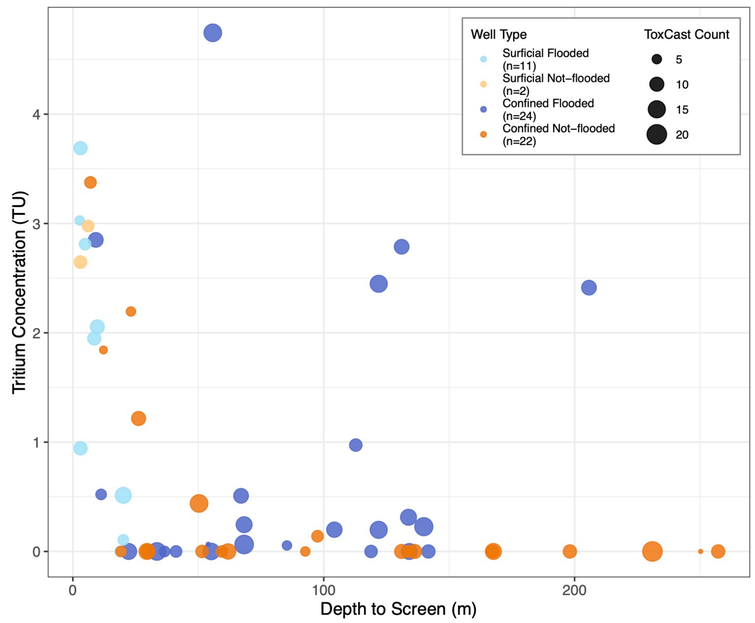

Figure 2. Tritium concentration (TU) versus well screen depth (m) for 59 groundwater samples.

While most samples followed the expected exponential decay pattern between TU and well screen depth, **5 confined flooded wells had higher-than-expected TU values** as well as above average ToxCast chemical counts.[2,3] Overall, flooded wells had significantly higher tritium values than not-flooded wells indicating **greater modern water presence**.

Organic CECs by Aquifer

Table 1. Mean ToxCast chemical count per sample by aquifer and flood status.

Aquifer	Depth Range (m)	Sample Count		ToxCast Chemical Mean Count (± Std Dev.)	
		Not Flooded	Flooded	Not Flooded	Flooded
Surficial	1-32	25	11	8 (±4.5)	8 (±2.5)
Basement Rock	6-60	7	0	9 (±5)	--
Yorktown	7-62	10	3	9 (±4.2)	9 (±2.6)
Basement Saprolite	155	1	0	9	--
Castle Hayne	4-198	22	4	10 (±3.6)	8 (±4.7)
Peedee	20-292	6	5	10 (±5.6)	9 (±5.0)
Upper Black Creek	28-119	5	1	7 (±2.9)	8
Black Creek	22-261	12	5	11 (±4.6)	11 (±2.5)
Beaufort	30-257	7	0	11 (±1.8)	--
Upper Cape Fear	12-315	11	6	10 (±3.3)	15 (±2.7)
Lower Cape Fear	115-250	6	3	12 (±4.6)	14 (±1.2)
Overall	*1-315*	*112*	*38*	*9 (±4.2)*	*10 (±3.9)*

Surprisingly, the only significant count difference between aquifers was **the higher ToxCast count in the deep, confined Lower Cape Fear aquifer** relative to the unconfined, surficial aquifer (Dunn's test, p = 0.034).

Organic CECs and Flooding

Table 2. Detection frequency of at least one ToxCast chemical from the listed use types in flooded and not flooded wells. Use types in orange had **≥10% higher detection frequency in flooded well samples**. Use types in blue were detected in >90% of all samples.

ToxCast Chemical Use Type	Detection Frequency	
	Not Flooded (n=112)	Flooded (n=38)
Chemical manufacturing	93%	97%
Electronics	22%	26%
Flame retardants	60%	61%
Food additives	84%	95%
Fuel products	53%	61%
Personal care products	94%	97%
Pesticides, herbicides, fungicides	85%	89%
Pharmaceuticals	77%	87%
Plastics (plasticizers, surfactants, paints, rubbers)	97%	100%

Conclusion

Flooded wells had:

- A greater presence of modern water *and*
- Higher detection frequencies of certain organic CECs.

Unconfined and confined wells in NC are both susceptible to modern contamination from flood events.

Next Steps

- My KIETS CLP internship with NCDEQ is focused on analyzing relationships between floods, droughts, aquifer overuse, and all groundwater quality parameters monitored by NCDEQ.
- Along with Wake County and US EPA, I am researching if low-cost faucet filters effectively remove organic CECs from private well users' water.

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If you want to learn more, read our article "Vulnerability of wells in unconfined and confined aquifers to modern contamination from flood events." Access with QR code: