

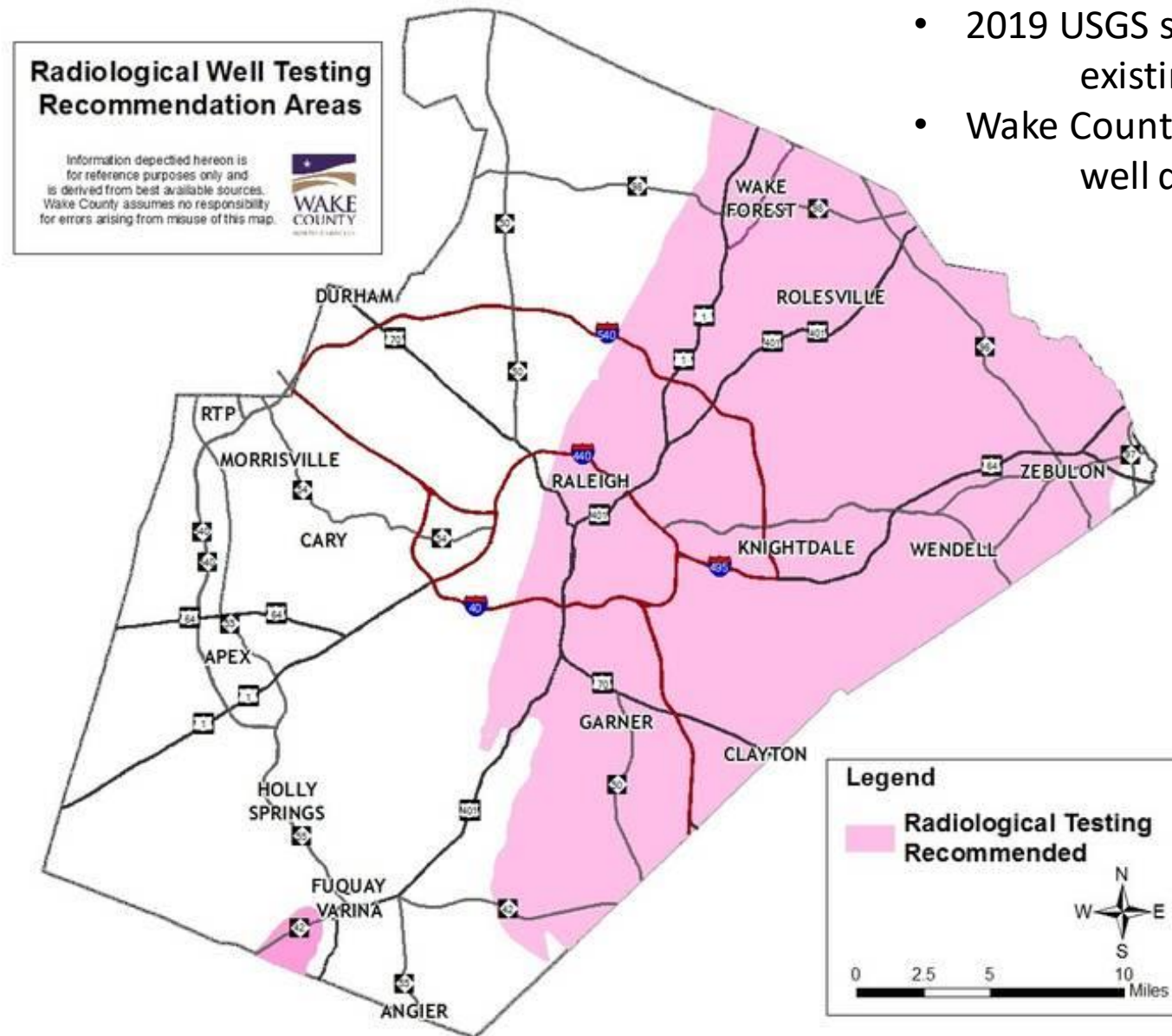


# Geology-Based Radon Potential Map of North Carolina

Jim Chapman

North Carolina Geological Survey (NCGS)

# Groundwater Studies Background (county-level):




- 2019 USGS study, network of 13 existing & 6 new monitoring wells
- Wake County Environmental Services well databases

# Groundwater Studies Background (State-wide):

- NC – State Government studies 2014 study – NCGS/Phil Bradley & DWR/Ted Campbell
- Numerous academic groundwater studies

## Areas of Relative Susceptibility to Elevated Radon in Groundwater in North Carolina

Explanation of overlay symbols:

 Radon susceptibility extrapolated to areas without groundwater data. Extrapolation assumes similar rock types will yield similar Rn concentrations.

Outlier points that exceed predicted susceptibility\*  
n = 144 analyses

- groundwater sample location with Radon 10,000 pCi/L or greater
- groundwater sample location with Radon 4,000 - 9999 pCi/L
- ⊕ groundwater sample location with Radon 300 - 3999 pCi/L

\*Outlier data points that exceed predicted Rn susceptibility may be due to:  
1) mapping limitations (e.g. unmapped felsic intrusive bodies may "infect" low Rn potential rocks; contacts may not be mapped accurately at the scales being investigated); and the subsurface orientation of high-dis-Rn bodies may influence whether or not a well penetrates the unit at depth; and (or) 2) current or historic flowpath geochemistry that can move radium from its original source to distant locations (Ra-226 half life = 1622 y). Inconsistencies also may be due to factors that have not been properly understood or measured (construction details such as depth, casing depth, and yield often are unavailable).

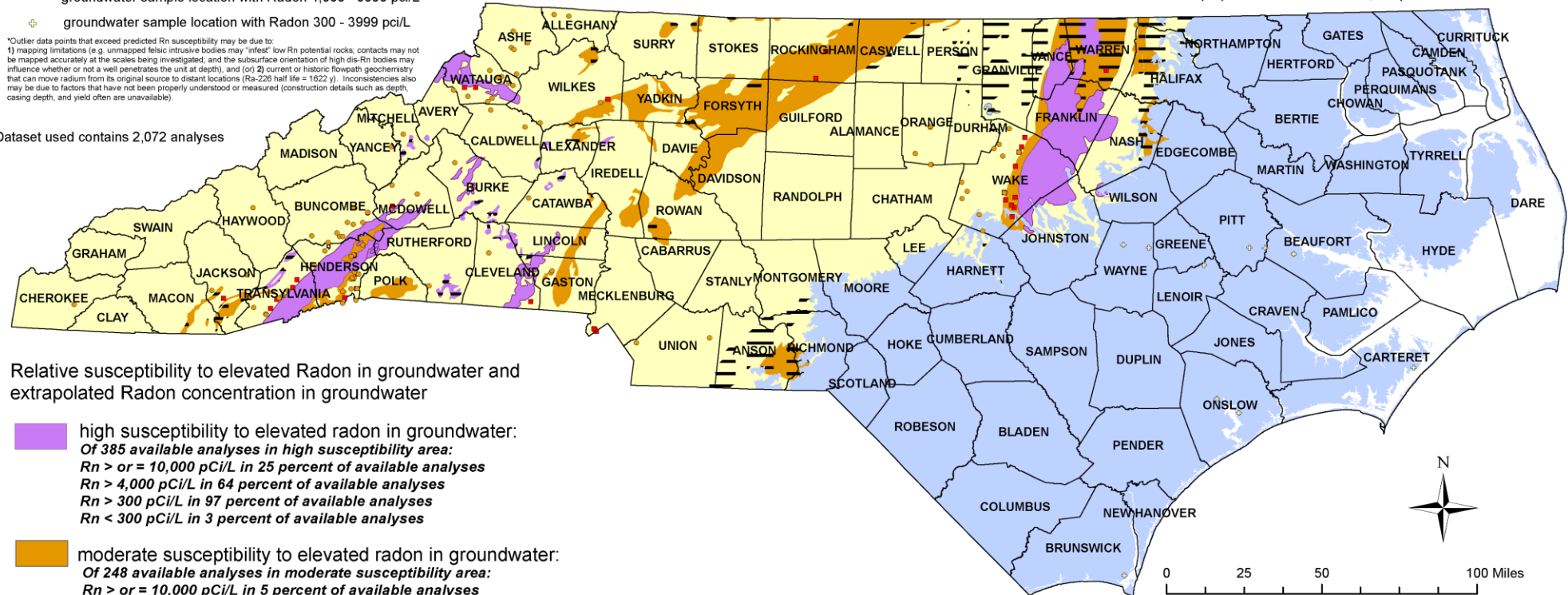
Dataset used contains 2,072 analyses

By  
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Ted Campbell, Division of Water Resources, Water Quality Regional Operations Section


**Preliminary - Draft**


Version 2: 2/3/2015


U.S. EPA proposed MCL for community water supplies = 300 pCi/L  
U.S. EPA proposed alternate MCL = 4,000 pCi/L




Relative susceptibility to elevated Radon in groundwater and extrapolated Radon concentration in groundwater

 high susceptibility to elevated radon in groundwater:  
Of 385 available analyses in high susceptibility area:  
Rn > or = 10,000 pCi/L in 25 percent of available analyses  
Rn > 4,000 pCi/L in 64 percent of available analyses  
Rn > 300 pCi/L in 97 percent of available analyses  
Rn < 300 pCi/L in 3 percent of available analyses

 moderate susceptibility to elevated radon in groundwater:  
Of 248 available analyses in moderate susceptibility area:  
Rn > or = 10,000 pCi/L in 5 percent of available analyses  
Rn > 4,000 pCi/L in 27 percent of available analyses  
Rn > 300 pCi/L in 96 percent of available analyses  
Rn < 300 pCi/L in 4 percent of available analyses

 low to moderate susceptibility to elevated radon in groundwater:  
Of 1,369 available analyses in low to moderate susceptibility area:  
Rn > or = 10,000 pCi/L in 2 percent of available analyses  
Rn > 4,000 pCi/L in 10 percent of available analyses  
Rn > 300 pCi/L in 83 percent of available analyses  
Rn < 300 pCi/L in 17 percent of available analyses

 relatively low susceptibility to elevated radon in groundwater:  
Of 70 available analyses in low susceptibility area:  
Rn > or = 10,000 pCi/L in 1 percent\*\* of available analyses  
Rn > 4,000 pCi/L in 11 percent of available analyses  
Rn > 300 pCi/L in 40 percent of available analyses  
Rn < 300 pCi/L in 60 percent of available analyses

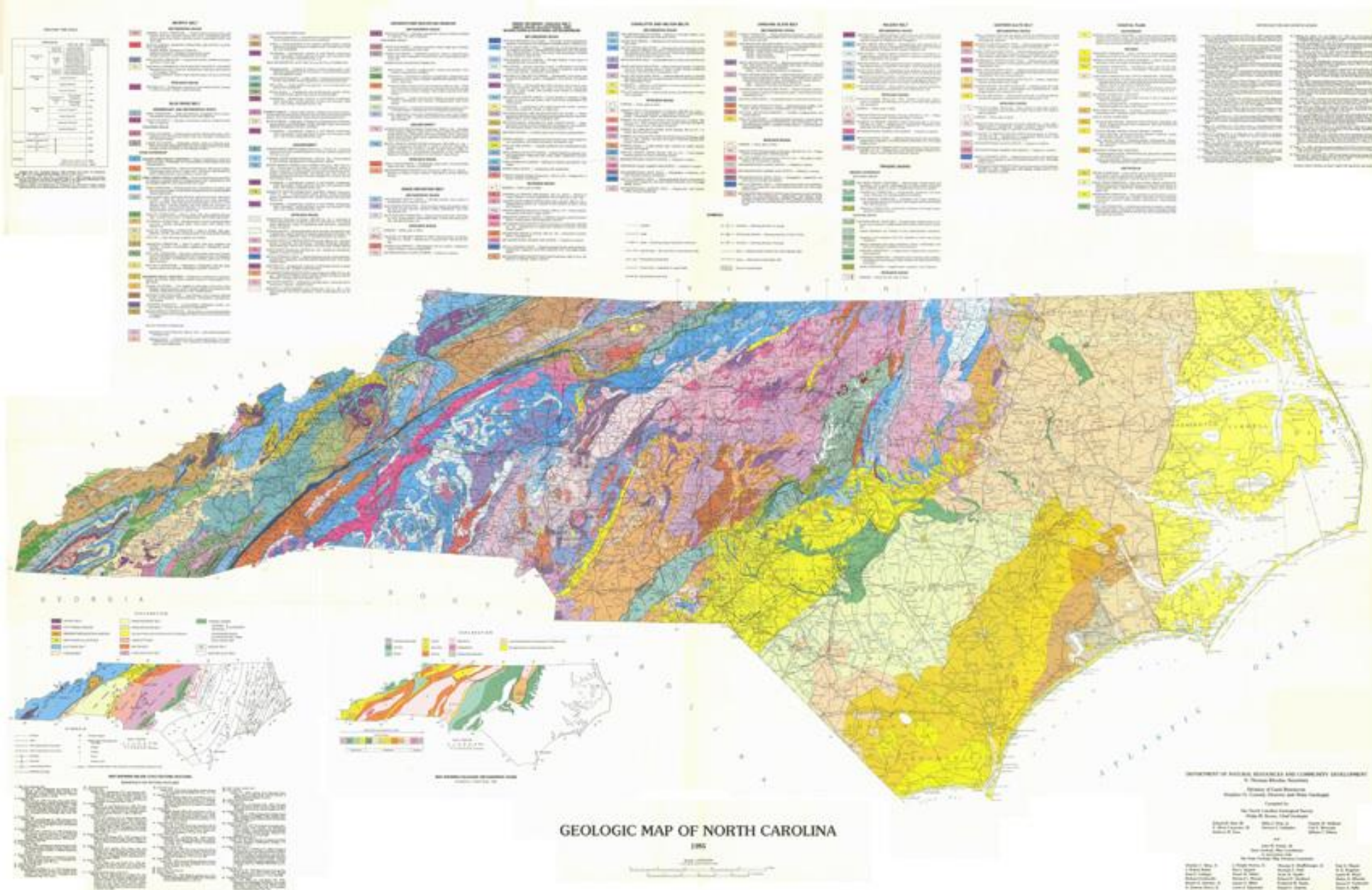
\*\*Location is within extreme up-dip Coastal Plain in southern Wake County. Well likely penetrates Coastal Plain sediments and utilizes groundwater from crystalline rocks.

Radon in Groundwater Data Source: Compiled database from Ted Campbell - DWR  
Additional vendor data was georeferenced and provided by Kyle Messier, PhD candidate, UNC Chapel Hill  
Base Map Data Source: Modified from Hibbard et al., 2006



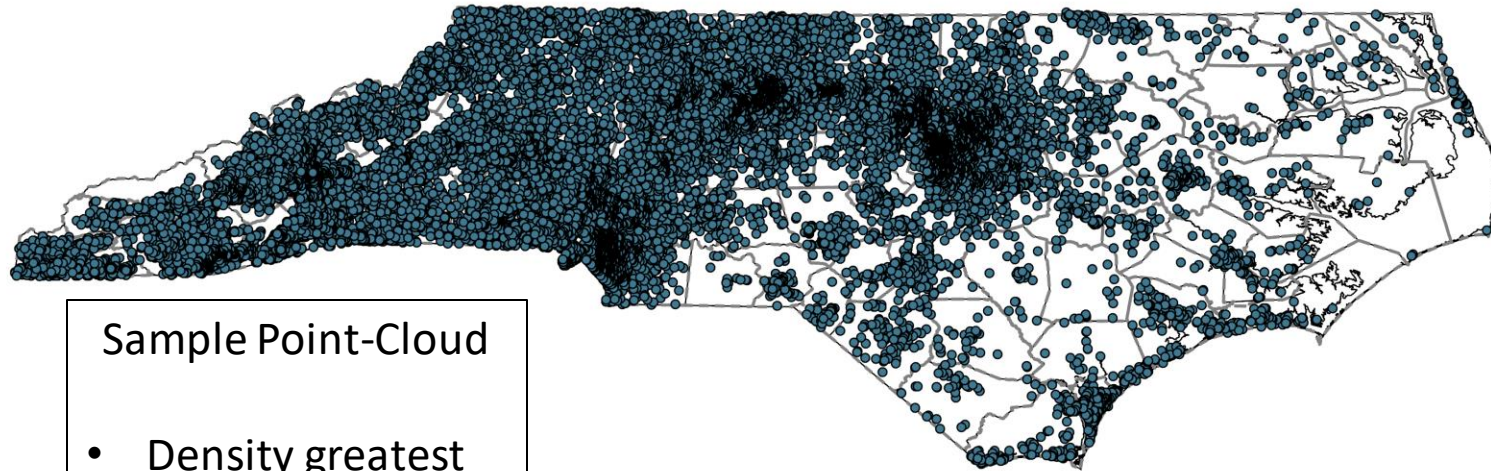


# 1985 North Carolina Geologic Map:



- 203 geologic units
- Scale 1:500,000
- Agency effort to improve unit delineations/descriptions over time

# Building the Radon Potential Map (sample point cloud):



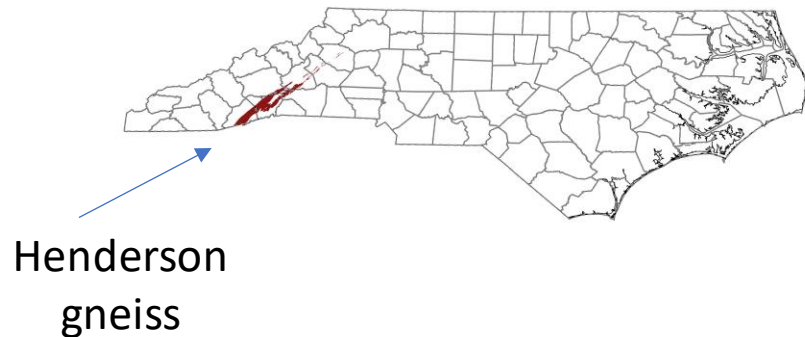
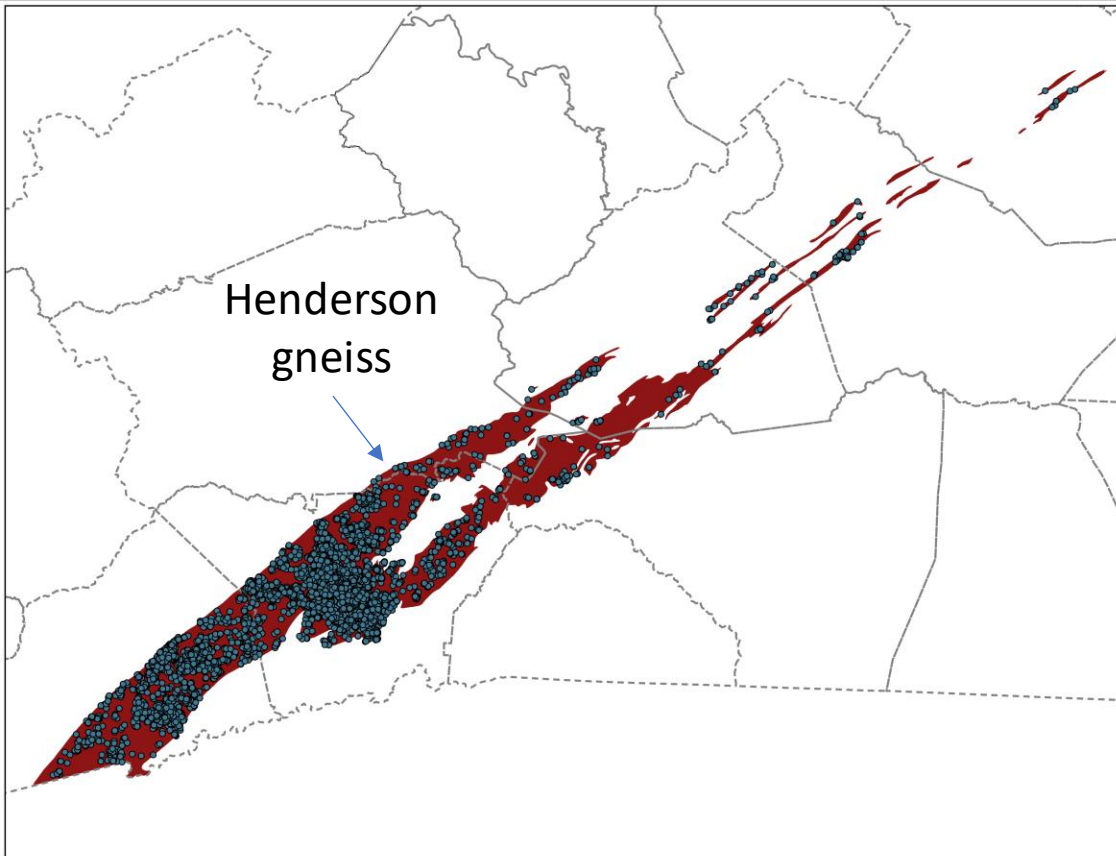
## Sample Point-Cloud

- Density greatest generally in western portion of the State, greatest in the large Piedmont urban centers

- Started with 178,000+ individual sample points over 18 Excel spreadsheets
- Smoothed for: duplicate points; erroneous locations; duplicate x,y but different z, locations; "ERROR" value; <blank> cells for radon value, latitude, or longitude
- Latitude/Longitude reported to 4<sup>th</sup> decimal (approx. 11.1 meters)
- After smoothing sample point database: **154,065** sample points

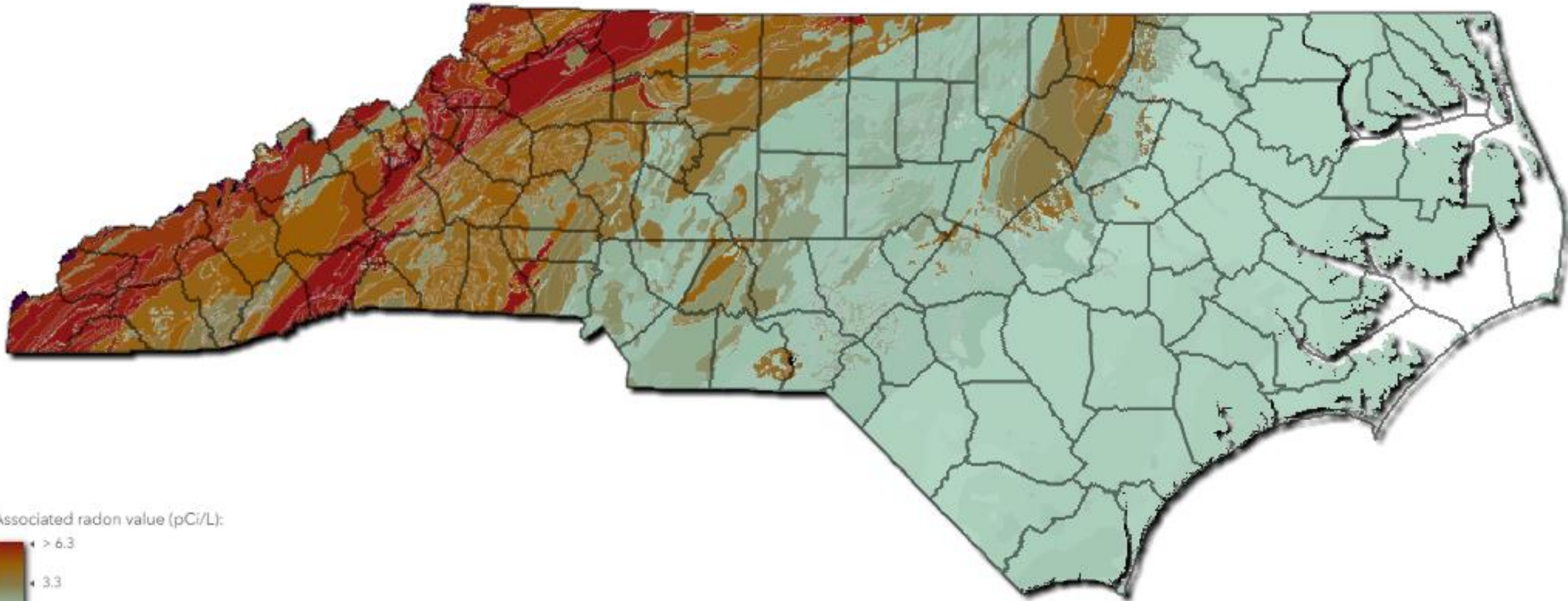


# Building the Radon Potential Map (geologic map units):



- Geologic map unit assigned radon value: 3<sup>rd</sup> quartile (75<sup>th</sup> percentile)
- Additionally: Geologic map unit maximum, minimum, median, and mean values; sample count; & sample density
- 10/203 geologic map units without sample data points
  - Either underlying public lands or small footprint or usually both

# Radon Potential Map of North Carolina – 1985 Geologic Map (basemap):



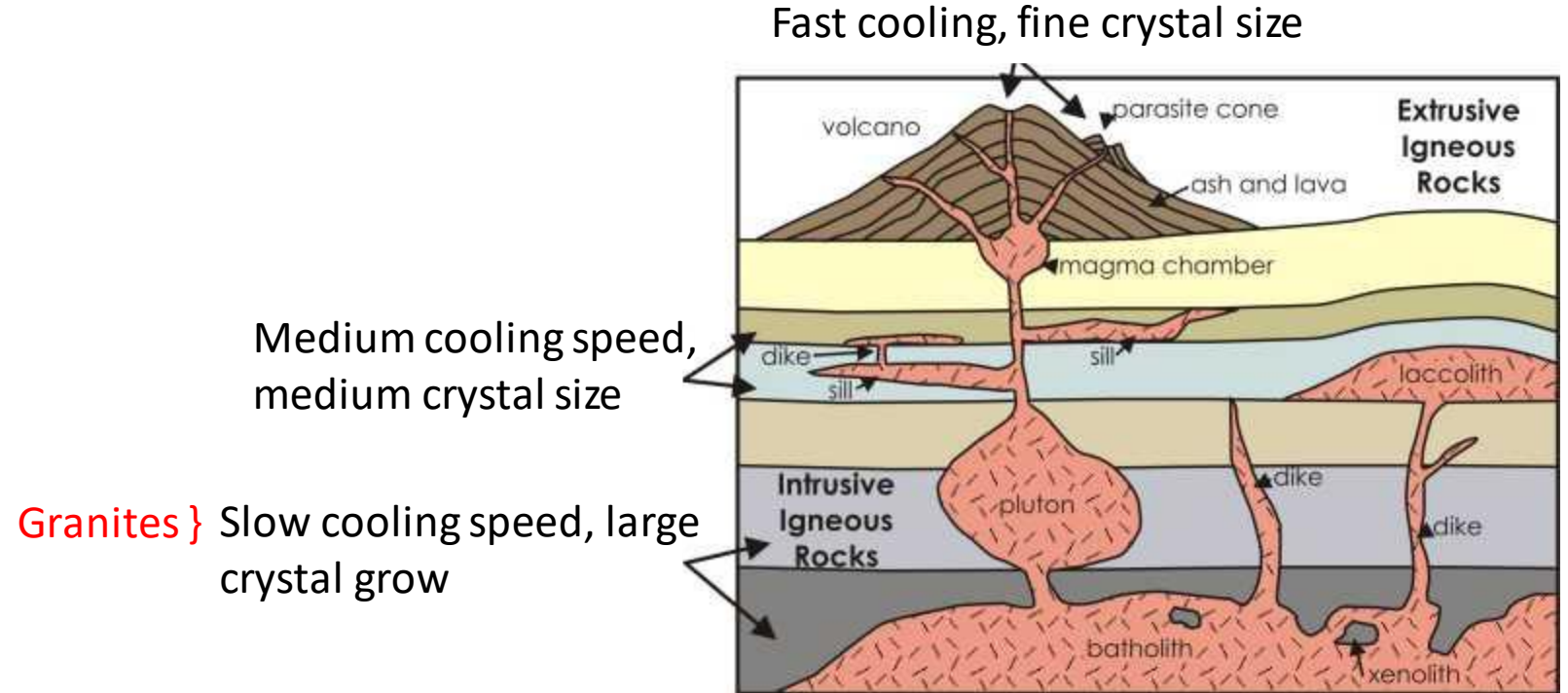
Associated radon value (pCi/L):

- > 6.3
- 3.3
- < 0.3
- no data

# Geologic Sources of Radon:

Rocks with higher radon concentration, generally:

- Granites;
- Some phosphorites (sedimentary rocks);
- Also, some volcanic rocks, with mainly quartz (felsic - ex. Rhyolite) & some dark shales;
- Metamorphic rocks derived from the above.

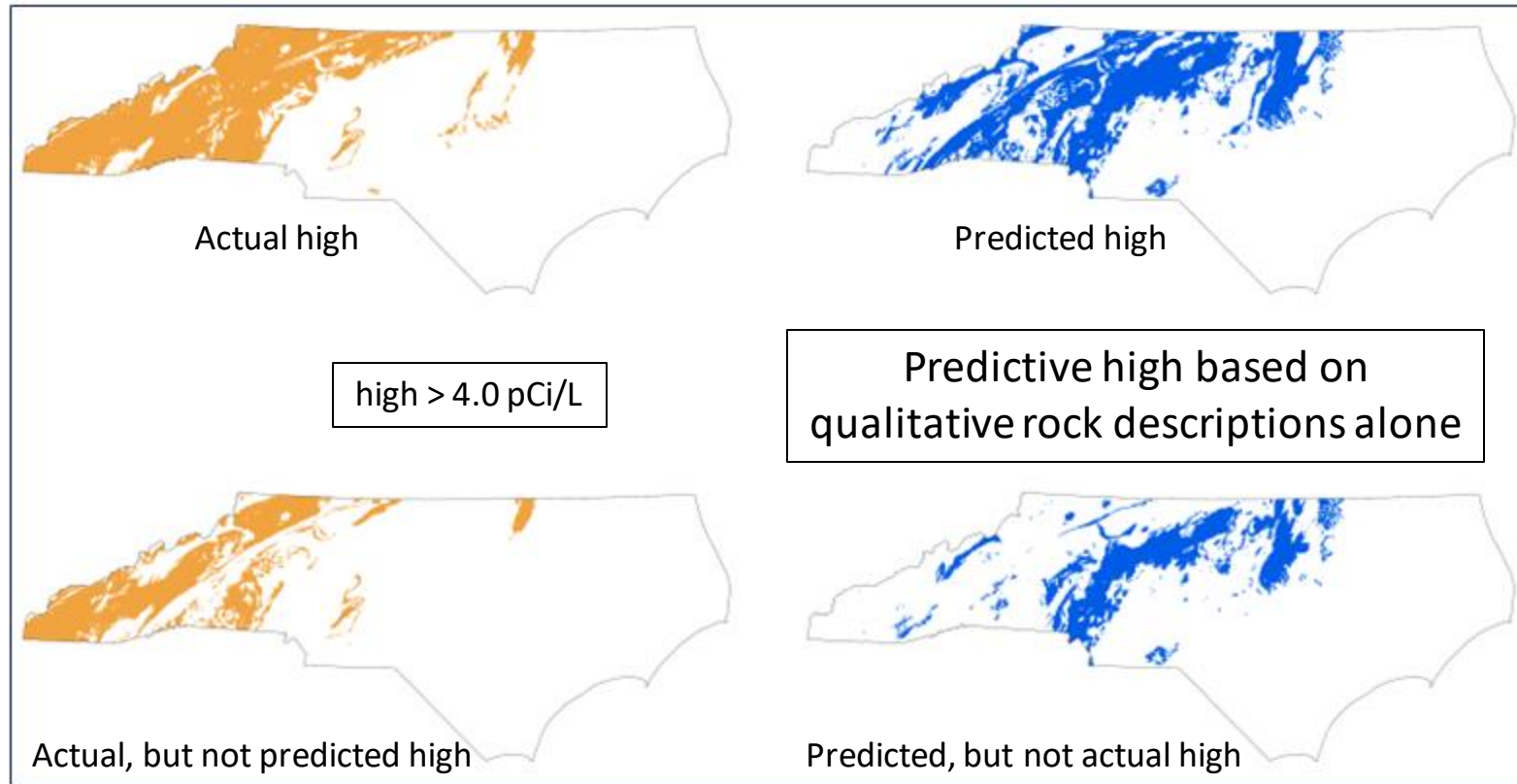


## Phosphorites:

- Made of the mineral apatite,  $\text{Ca}_5(\text{PO}_4)_3(\text{F}, \text{Cl}, \text{OH})$
- Skeletons of marine animals deposited on marine floor as apatite → phosphorites
- $\text{U}^{4+}$  replacing replacing calcium
- Interesting part . . . U in seawater mostly  $\text{U}^{6+}$  (more soluble than  $\text{U}^{4+}$ ) → animal decay → reduces  $\text{U}^{6+}$  to  $\text{U}^{4+}$



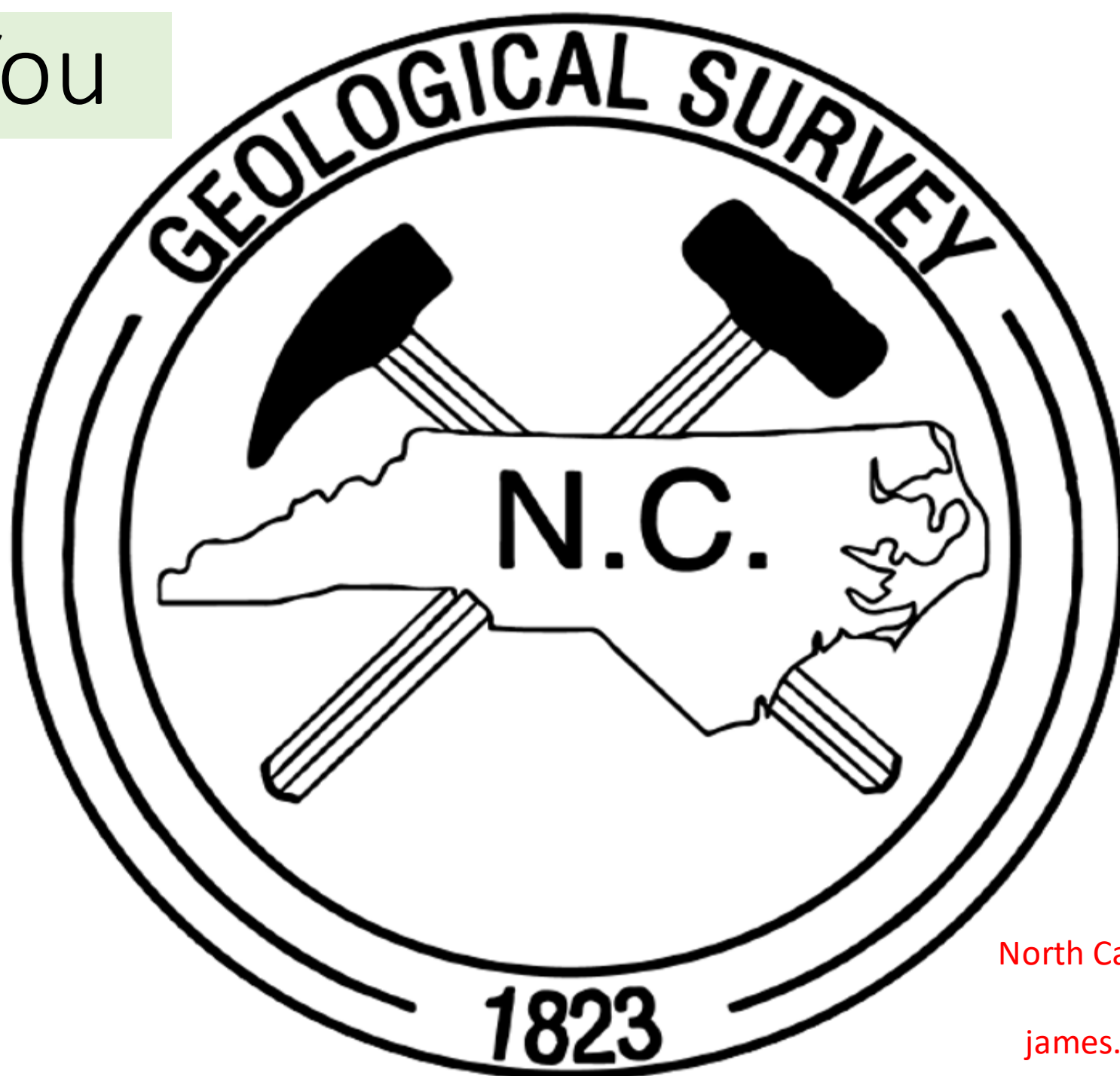
# Graphic Results vs Expectations:



# Going Forward with Radon Prediction Map:

- More detailed rock characterization → Geochemical analysis \$\$\$ → More viable at local mapping scale efforts
- Crustal fracture analysis → Better understanding of natural pathways
- Synthesis of groundwater and air quality studies
- More speciality collaboration

Thank You



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