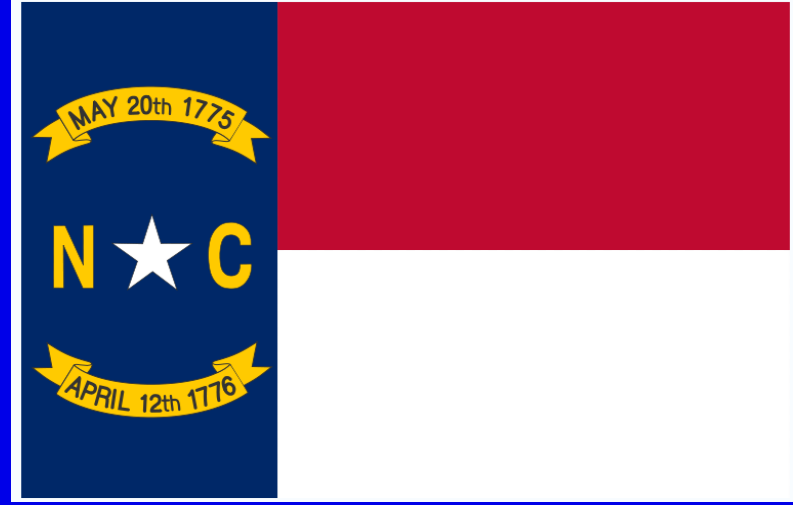
North Carolina Piedmont and Mountains Groundwater Resource Evaluation Program (REP)

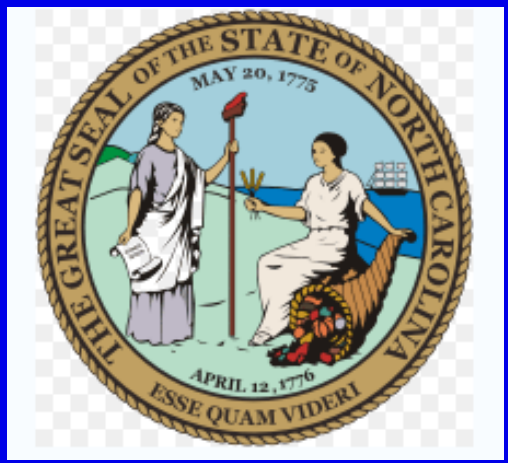
Aquifer Protection Section

Presented by Shuying Wang, May 2008

Capital: Raleigh

Largest City: Charlotte





Total Area: 139,509 Km^2
Ranked 28th in the US
Width: 340 Km
Length: 900 Km
Population: 8,049,313
Ranked 10th in the US
From http://en.wikipedia.org/wiki/North_Carolina

What is the REP ?

- A Groundwater Resource Evaluation Program for the Piedmont and Blue Ridge Mountains Provinces of North Carolina, covering 30,500 sq. miles and 65 Counties
- Funded by NC Legislature in SFY 2000-2001 to ensure the long term availability, sustainability and the quality of groundwater in the state
- A long-term study to improve scientific understanding of North Carolina's crystalline bedrock aquifer hydrogeology
- Joint program between NCDWQ and USGS

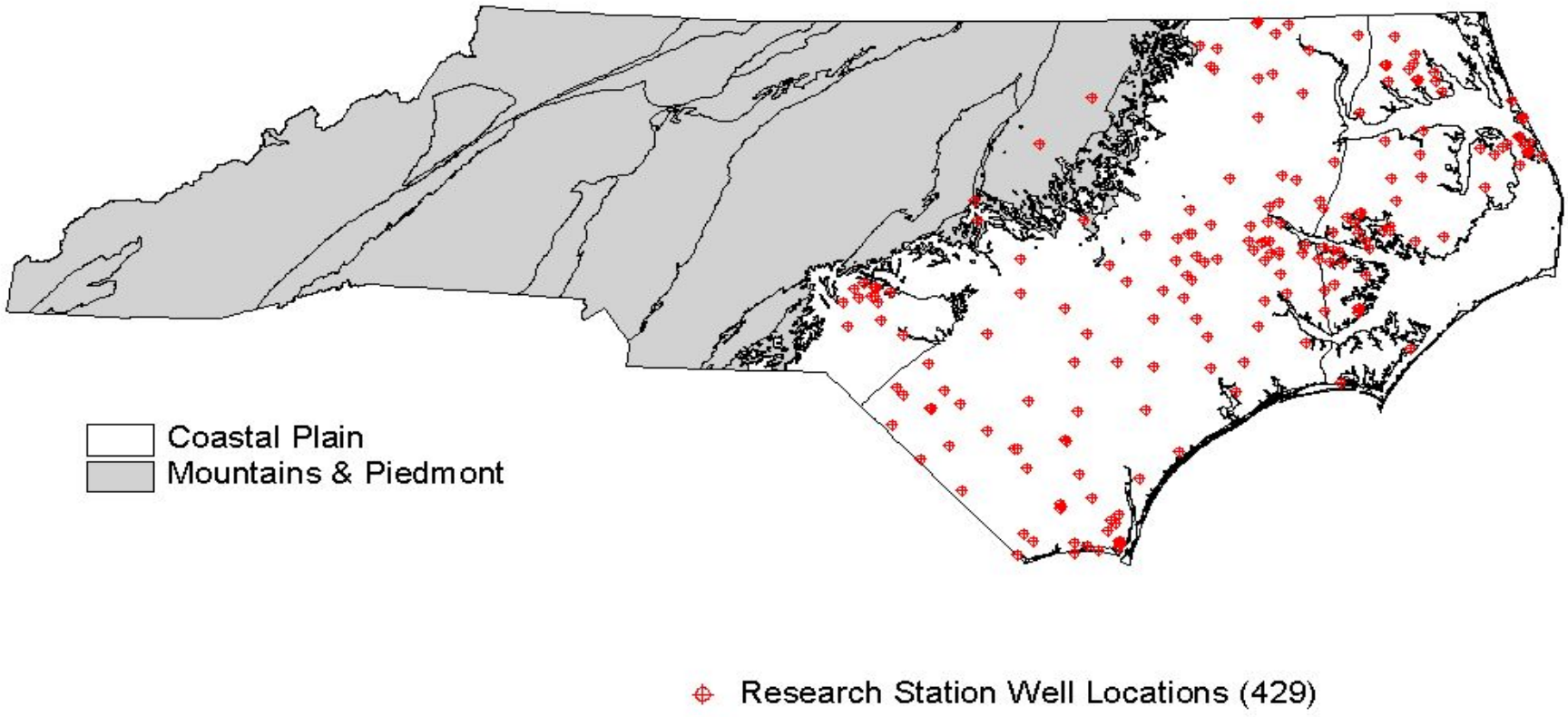
What the REP Does?

- Characterizes regional aquifer properties:
  - Physical hydrogeological characteristics
  - Groundwater quality – hydrochemistry
- Identifies areas vulnerable to contamination
- Understands groundwater-surface water interactions
- Develops groundwater assessment/remediation strategies and supports new policies/regulations
- Performs special studies

Why Do We Need the REP?

- Estimated over 5 million people in the Piedmont and Mountains Region rely on groundwater for potable use
- The hydrogeology of the regolith-fractured bedrock system is very complex and has not been studied intensively
- There is a general lack of detailed studies on groundwater quality (most previous detailed groundwater studies in the Piedmont and Mountains focused on groundwater quantity, not groundwater quality)
- Previous regional hydrogeologic investigations were focused on the Coastal Plain

Previous Groundwater Section Research Station Well Locations (1968 - 1990)



Until 1990

almost all studies were conducted on the Coastal Plain

REP Study Objectives

- Develop a comprehensive groundwater database for the N.C. Piedmont & Mountains Region
  - Existing and project-generated groundwater quantity and quality data
- Establish baseline of groundwater quality characteristics
- Establish a statewide ambient groundwater monitoring program
- Define the hydrogeologic framework for each physiographic province
  - Delineate “hydrogeologic terranes”
  - Develop comprehensive conceptual models
  - Determine relationships between geology and groundwater
    - Chemistry
    - Occurrence

REP Study Objectives cont'd

- Refine present knowledge of recharge and discharge processes
  - Estimate regional water budgets
  - Assess the relationships between groundwater recharge and discharge and their effects on surface water quality
- Amend the state groundwater standards (15A NCAC 2L) in accordance with study results
- Improve NCDENR's (DWQ and DWM) ability to manage pollution incidents, well and permitting programs

REP Study Objectives cont'd

- Provide educational outreach and training opportunities
- Help improve the general public's knowledge of the groundwater resource
  - Technical publications
  - On-site training and demonstrations
  - Educational presentations and displays

REP Study Methodology

- Analyze existing databases
  - Identify trends and data deficiencies
- Develop Standard Operation Procedures (SOP) and Work Plans
  - Ensure data consistency and reliability
- Locate stations with long-term access
  - Government- or University-owned properties
- Consider site access and logistics to locate wells

REP Study Methodology Continued

- Identify potential hydrogeologic research station locations
  - Identify hydrogeologic terranes and drainage basins, considering “transferability” of information
  - Evaluate weak/strong - low angle/vertical foliation affects on the development of the transition zone and fracture system
  - Consider depth of weathering/topographic setting

REP Study Methodology cont'd

- Get access agreements signed
- Devise drill plan and schedule
- Conduct Geologic mapping and surface geophysics
- Install research station borings and wells
  - Continuous wireline coring
    - One core from each well cluster
  - Wells were installed with air rotary and mud rotary techniques
  - Well Clusters along an assumed linear flow path from topographical high to low settings, wells at each cluster in different zones
    - Saprolite
    - Transition Zone
    - Bedrock (open hole)

REP Coring and Drilling Activities











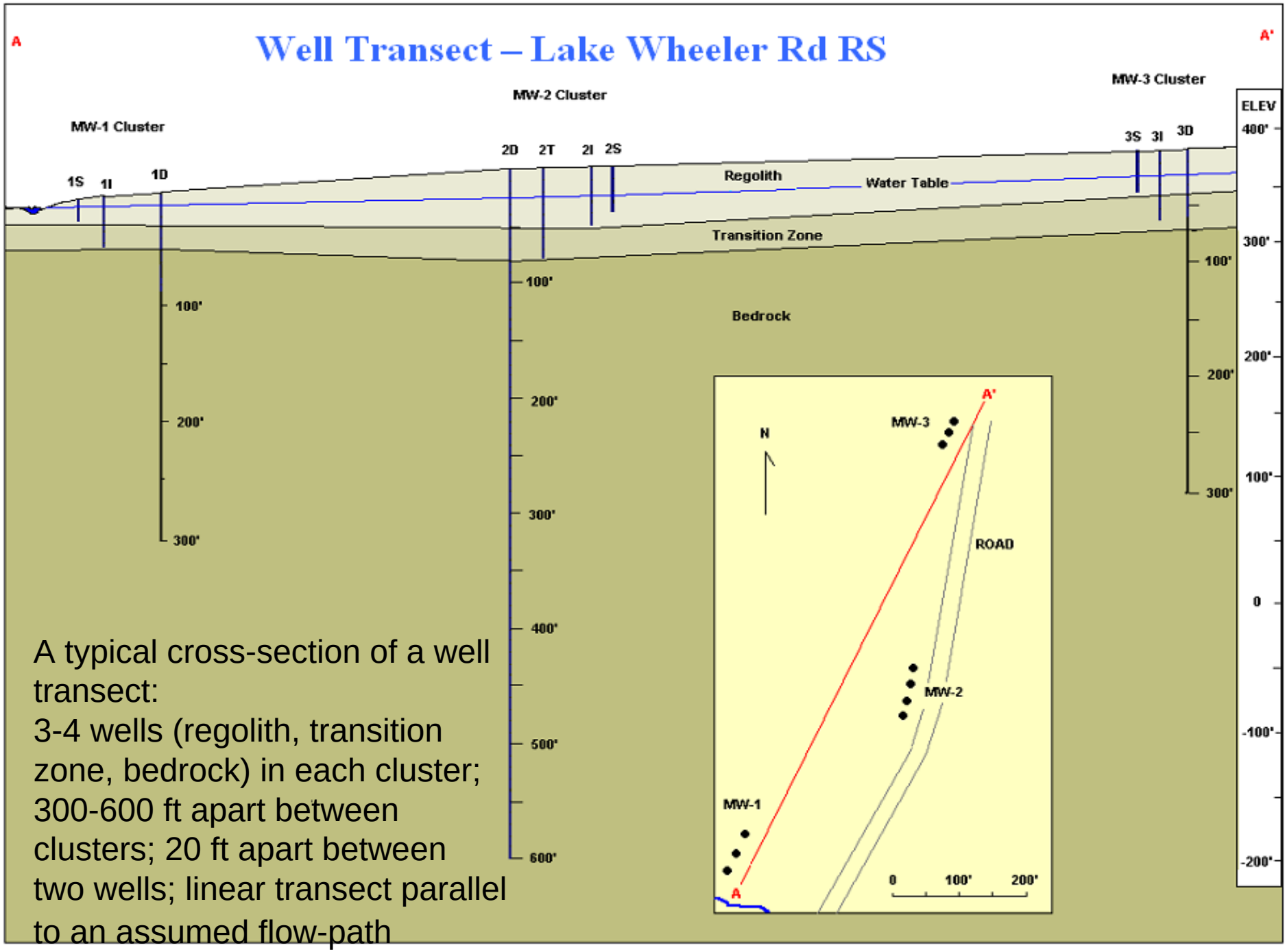
Core Samples

The Zoo, Asheboro

Langtree

Reidsville

Bent Creek



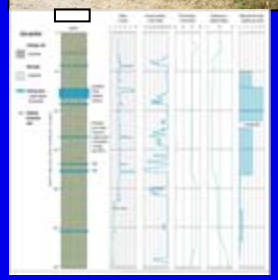
A typical cross-section of a well transect:
3-4 wells (regolith, transition zone, bedrock) in each cluster; 300-600 ft apart between clusters; 20 ft apart between two wells; linear transect parallel to an assumed flow-path

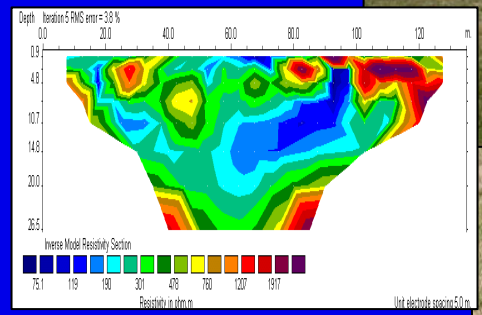
REP Study Methodology cont'd

- On site testing and data collection
  - **Core and well construction logging**
  - **Rock and groundwater sampling (for field and lab analyses)**
  - **Surface geophysical survey and borehole geophysical logging**
  - **Aquifer testing (slug and pumping)**
  - **Tracer studies**
  - **Age dating**
  - **Traditional water level and quality monitoring**
  - **Real-time satellite telemetry for water levels and quality parameters**
- Data analysis
  - **Flow path studies**
  - **Statistical analyses**
  - **Refining conceptual models**

Sampling, Geophysics and Telemetry

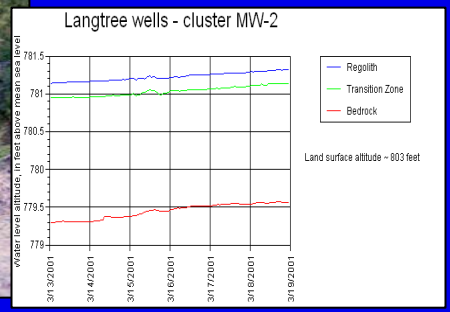
← Borehole geophysics





Surface geophysics

Satellite telemetry



Groundwater sampling

REP Study Methodology cont'd

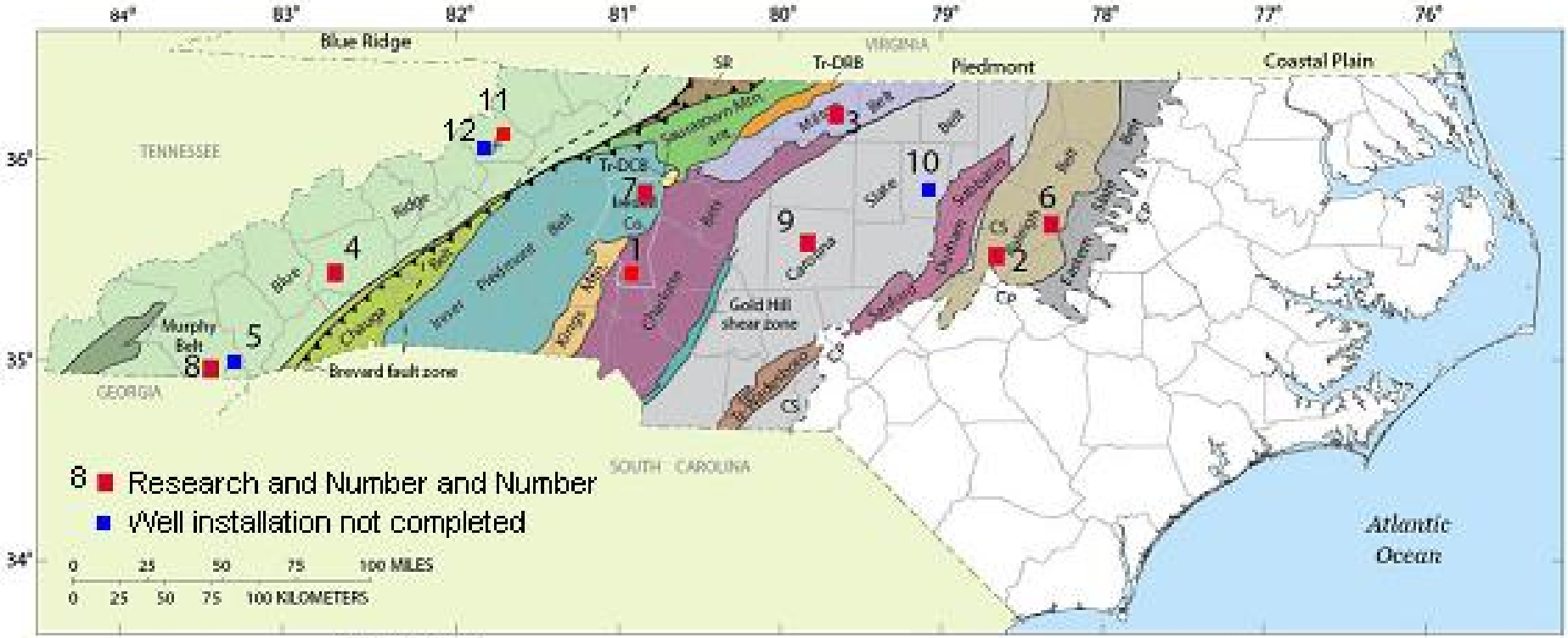
- Publish findings
  - Peer-reviewed journals
  - Professional conferences
  - USGS and NC State publications and open-file reports
  - Web-based documents
- Refine NCDENR guidance documents
  - Contaminant site assessments
  - Well construction
  - Permits

REP Team/Resources

- NCDWQ Aquifer Protection Section hydrogeologists
- USGS hydrogeologists and groundwater specialists
- Aquifer Protection Section drilling crews
  - CME-75; Schramm; Geoprobe
  - Pumps and other equipments
- Local university faculty
- Other investigators interested in “piggy-backing” their experiments

Approximate Locations of Current REP Stations

in Different Geologic Belts of Piedmont and Blue Ridge Provinces of North Carolina



EXPLANATION

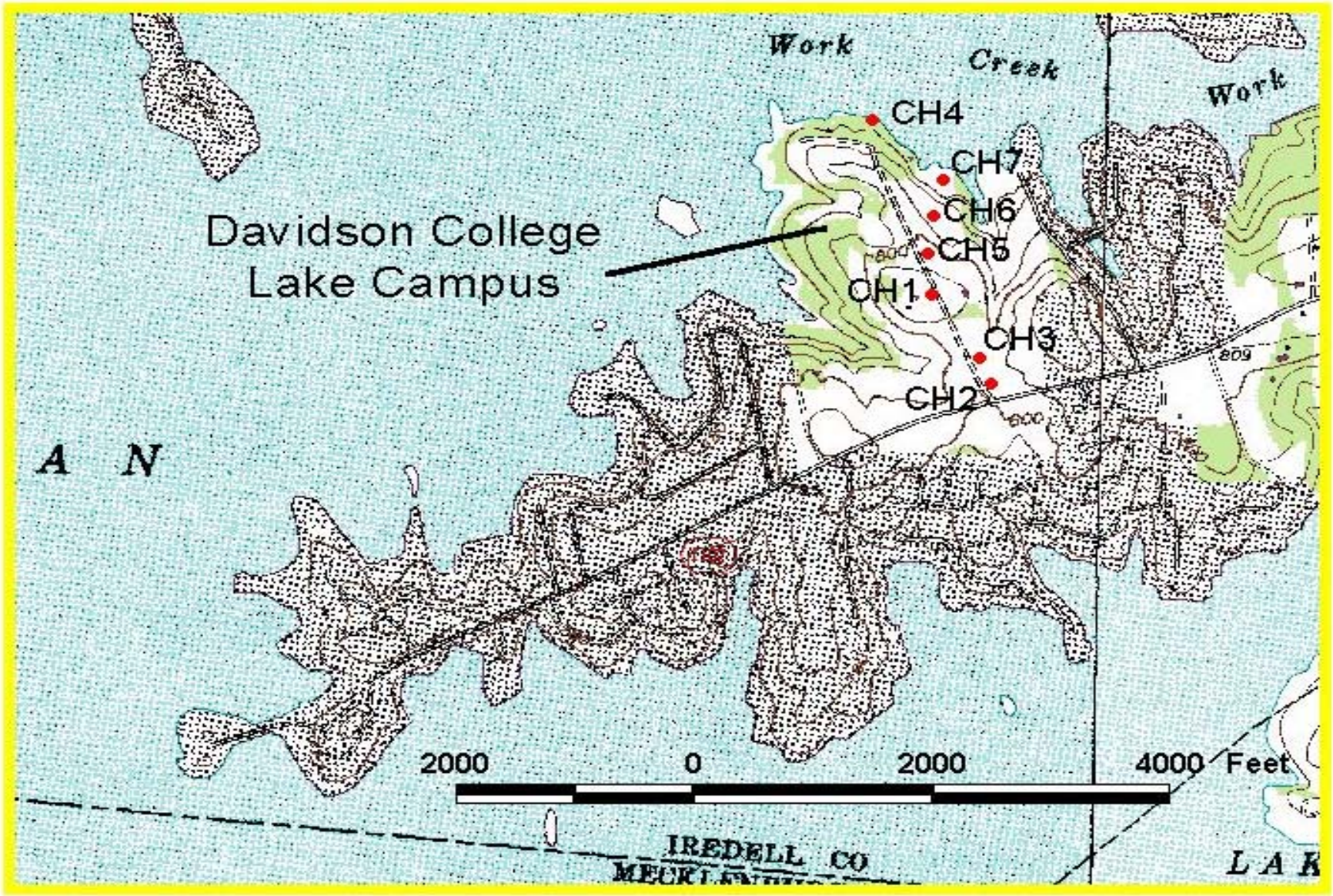
Map number	Research station
1	Langtree Peninsula at Lake Norman (LPRS)
2	North Carolina State University Lake Wheeler Road Field Laboratory (LWRRS)
3	North Carolina State University Upper Piedmont Research Station (UPRS)
4	Bent Creek Experimental Forest (BCRS)
5	City of Highlands; Cullasaja Watershed
6	Raleigh Hydrogeologic Research Station
7	Allison Woods Hydrogeologic Research Station
8	Coweeta Hydrogeologic Research Station
9	North Carolina Zoological Park Research Station
10	Duke Forest Research Station
11	Appalachian State University, Tater Hill
12	Town of Seven Devils

- - - - - Piedmont Crescent

——— Physiographic Province line

(modified from North Carolina Geological Survey, 1985; Daniel and Payne, 1990)

Langtree Peninsula Research Station



20-acre site/2000x750 ft flow scales, 7 CH, 6 cluster/29 wells

NCSU – Lake Wheeler Road Station

3 cluster + 3 add. wells, 1000 ft transect from topo high to low settings, 1 S.W. gage

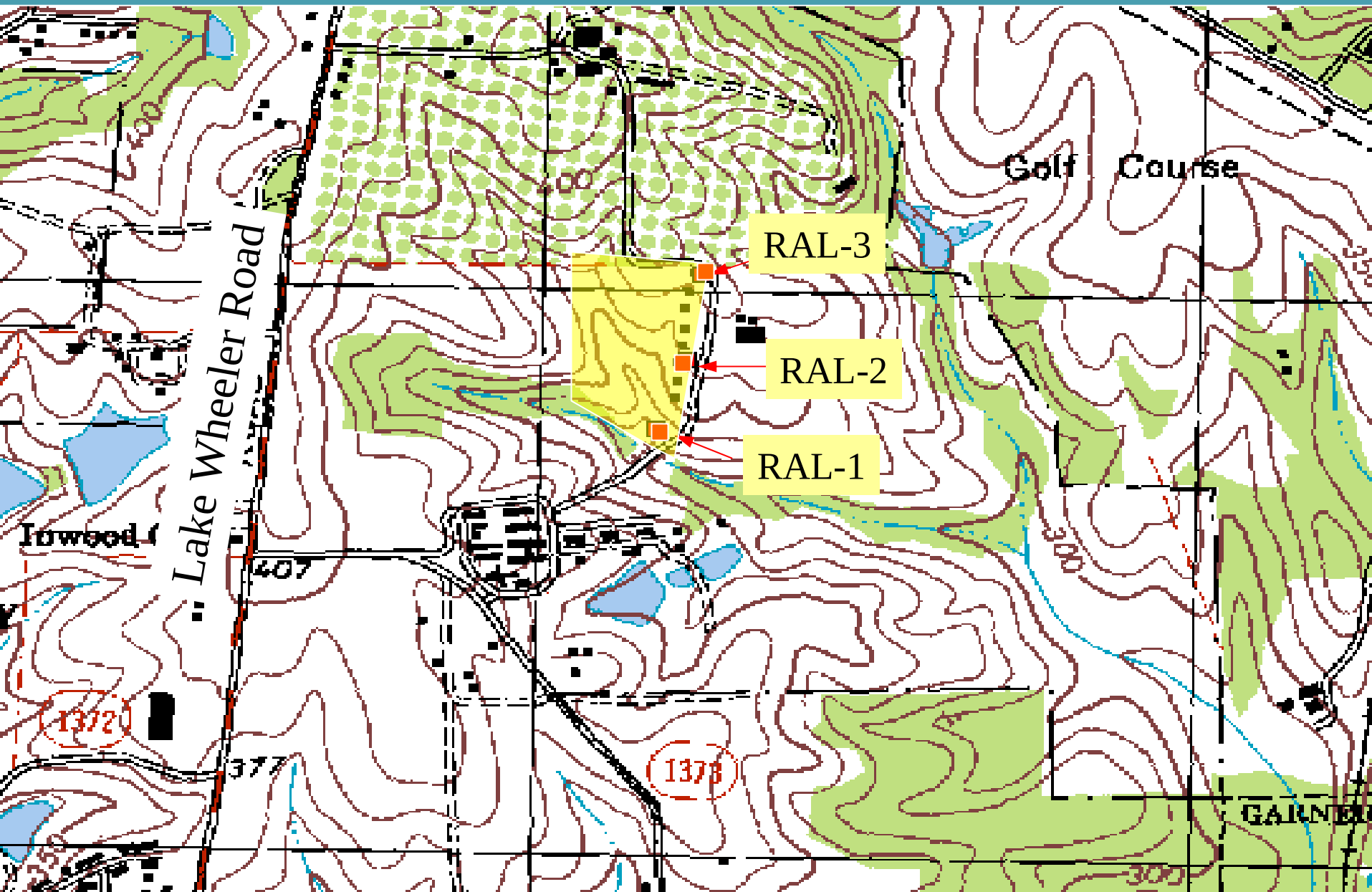
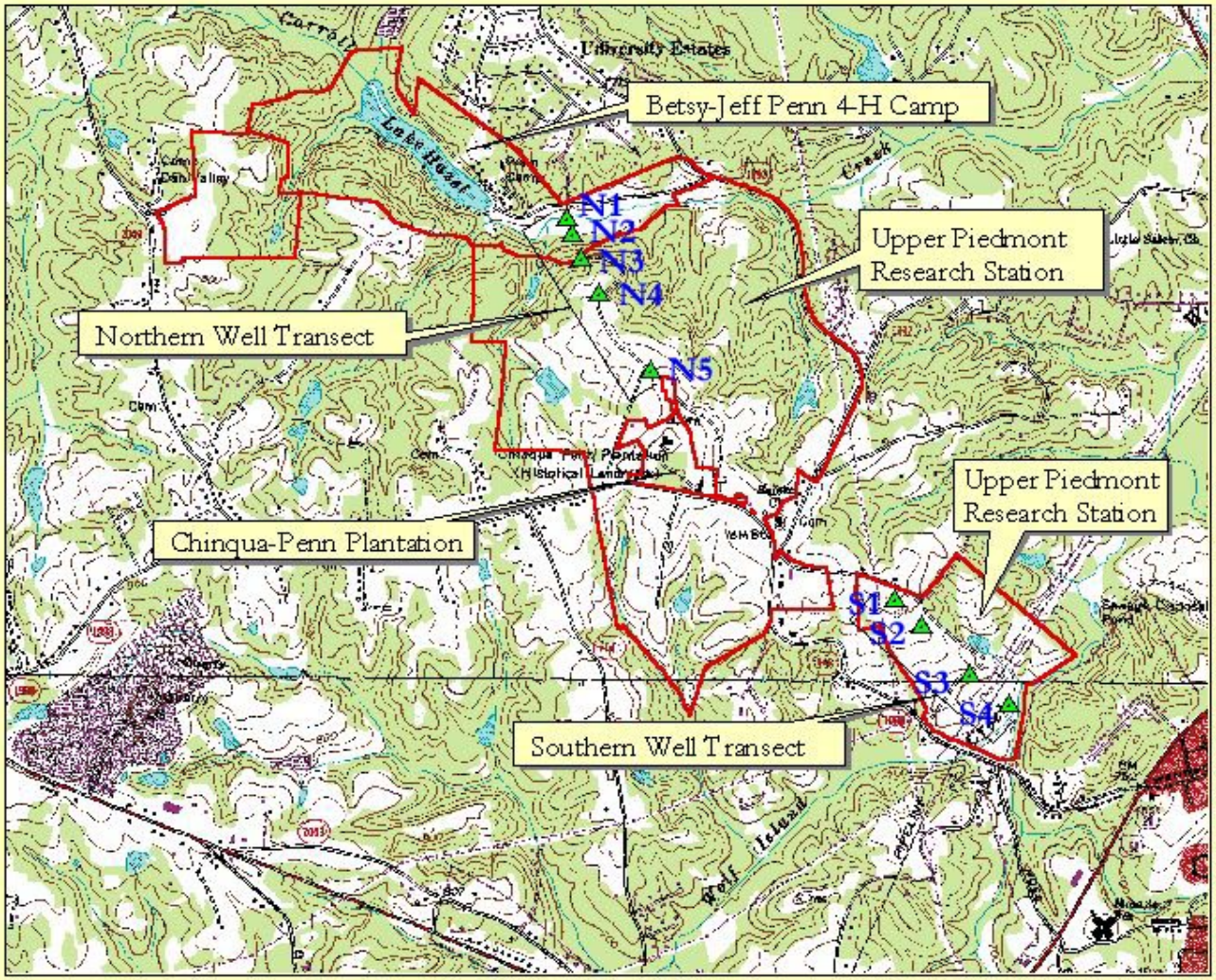


Figure 1:

Upper Piedmont Research Station

Property Boundaries and Proposed Well Cluster Locations



2-2000 ft flow-path well transects, 7 well clusters, 20 MWs, 15 Pzs, 2 SW gages

NC Zoo Groundwater Research Station Site Map, Randolph, NC

About 20 acre site, 1200 ft long flow path transect, 3 clusters, 10 MWs, 5 Pzs

Location Map of Tater Hill Hydrogeological Research Station
Watauga County, NC

Example of a well cluster

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http://h2o.enr.state.nc.us/aps/gpu/documents