North Carolina Ground Water Resources Monitoring Well Network 2009 Annual Report


Grifton Ball Field Station
P24O


Deppe Station
V23X


Trenton Station
T24J

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Environment and Natural Resources
Division of Water Resources
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1.0 Introduction

The State of North Carolina (the State) relies on ground water for approximately 50 percent of its drinking (potable) water use. The State has thousands of agricultural and industrial ground water users. Since 1998, the North Carolina Department of Environment and Natural Resources (DENR), Division of Water Resources (DWR) has monitored and maintained a statewide network of monitoring wells to assess North Carolina's ground water supply. The operation of this monitoring well network is an integral part of DWR's mission to ensure that the State has an adequate water supply for its citizens. Information (data) collected quarterly from this well network include the following:

- Evaluate climatic influences on the State's ground water supply, including effects of drought and recharge-discharge relationships;
- Monitor human-induced effects on the State's ground water supply, particularly in the regional aquifer systems of the Coastal Plain physiographic province. These effects include local and regional water level declines as well as migration of the fresh water-salt water interface within various aquifers;
- Provide supporting data for enforcement and creation of current and future ground water usage regulations, such as the Central Coastal Plain Capacity Use Area rules; and
- Provide high quality ground water data to local governments, ground water professionals, and the general public to use in making informed decisions in ground water related issues.

Data collected from the network are available to the public through DWR's internet website, *www.ncwater.org*. These data include ground water levels, chloride measurements, well construction information, borehole log construction (lithological and geophysical), ground water monitoring station locations, and geophysical/lithological data collection from non-DWR well sites.

2.0 Purpose and Scope

The 2009 Annual Report summarizes field activities and conclusions derived from activities performed during the July 1, 2008 through June 30, 2009 fiscal year. These activities include water level and water quality data statistics, monitoring well installations including new installations, monitoring equipment usage, and evaluations and site surveys.

3.0 Background

The statewide Ground Water Resource Monitoring Program was initially operated by the DWQ and its predecessor agencies. DWQ installed the original network wells in the 1960s and is responsible for installation of approximately 75 per cent of the monitoring well network. DWQ actively monitored the network through the early 1990s, collecting a portion of the ground water

data currently contained within the network database. The program was transferred to DWR in 1998.

The U.S. Geological Survey (USGS) has also contributed to the monitoring of the State's ground water resources under a cooperative agreement between the State of North Carolina and the Federal government. The cooperative well network consists of 21 monitoring wells, many of which are also part of the DWR statewide network.

4.0 DWR Statewide Monitoring Well Network-Overview

4.1 Description

The monitoring well network currently consists of 555 wells at 183 monitoring stations (sites), divided into five regions, comprising 56 counties (Figure 1). There are 22 wells located in the Piedmont and Mountain physiographic provinces (Piedmont and Mountain) and 533 wells located in the Coastal Plain physiographic province (Coastal Plain). The Coastal Plain relies more heavily on ground water supplies than either the Piedmont or Mountain. As a result, ground water monitoring and research has been more concentrated in the Coastal Plain. Recently, more resources have been invested in monitoring the Piedmont and Mountain ground water conditions to better understand the impact of drought cycles on ground water supplies and their contribution to surface water flow. There are 37 wells within the monitoring well network used to assess drought conditions (Figure 2).

Of the 183 monitoring stations, 60 are on State or Federal property and 43 are located on property owned by local governments. The remaining 79 stations are located on private property through agreements with landowners. In the past, some wells have been abandoned at the landowner's request due to changes in land use or ownership. Due to the high cost of well construction combined with the fact that the wells are most valuable when they are monitored continuously over a period of decades, every attempt is made to put new stations in secure, stable locations. A scale has been developed to rank new and existing wellsites for potential well abandonment due to land-use issues in the future (Table 1). It is preferred that new wells be installed at sites with a susceptibility rating of 1 or 2.

TABLE 1 Site Susceptibility Rating North Carolina Ground Water Resources Monitoring Well Network 2009 Annual Report	
Susceptibility Rating	**Description**
1	**Secure**—station is located on State or Federal government property
2	**Secure**—station is located on local government or school property
3	**Moderately secure**—station is located on private property, but landowner does not give any indication that land use or property ownership may change
4	**Tenuous**—station is located on public or private property and landowner is giving indications that land use or property ownership may change
5	**Imminent threat**—station is on public or private property and landowner desires abandonment of well station.

4.2 Monitoring

The statewide monitoring network is divided into five regions (Figure 1). Table 2 summarizes site and recorder distribution by region. One staff member is responsible for managing each region. Staff member responsibilities include visiting the wells quarterly to collect water level data, performing routine site maintenance, and keeping automatic data recorders in working condition. Site maintenance includes clearing vegetation and ensuring that sites are easily accessible and esthetically pleasing. Additional site activities (i.e. recorder removal/replacement, weed/grass maintenance, etc.) are conducted on an as needed basis.

Depth to ground water level measurements are collected from the network in two different ways. Manual water levels are measured using electronic water level indicators. Hourly water level measurements are collected using one of two types of automatic water level recorders (shaft encoders or submersible pressure transducers). Hourly water level data are extremely valuable in assessing aquifer recharge, impacts of large storms on ground water conditions, and delineation of aquifer boundaries. DWR typically publishes only the manual water level readings and daily water level data from recorders on the website. Hourly data is available upon request for specific wells.

Triennial chloride samples are collected from select wells in the Coastal Plain. The samples are analyzed using the Quantab field method. Field results are used to monitor the migration of the fresh water-salt water interface in the Coastal Plain aquifers. Additional chloride samples are collected for field analysis when new monitoring wells are installed and as needed for special projects. Chloride sampling will occur in 2010. Section 5.2. summarizes the 2007 chloride sampling event.

TABLE 2
Site and Recorder Distribution By Region through 6/30/09
North Carolina Ground Water Resources Monitoring Well Network
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Region	Parameter	Number	% of Region	% of Network
1	Wells	108		19.3
	Sites	36		19.7
	Sutrons	4	3.7	0.7
	WL15s	0	0.0	0.0
	WL16s	71	65.7	12.7
	All Recorders	75	69.4	13.4
2	Wells	139		24.8
	Sites	37		20.2
	Sutrons	16	11.5	2.9
	WL15s	35	25.2	6.3
	WL16s	52	37.4	9.3
	All Recorders	103	74.1	18.4
3	Wells	120		21.4
	Sites	29		15.8
	Sutrons	6	5.0	1.1
	WL15s	10	8.3	1.8
	WL16s	65	54.2	11.6
	All Recorders	81	67.5	14.5
4	Wells	126		22.5
	Sites	43		23.5
	Sutrons	5	4.0	0.9
	WL15s	19	15.1	3.4
	WL16s	44	34.9	7.9
	All Recorders	68	54.0	12.1
5	Wells	67		12.0
	Sites	38		20.8
	Sutrons	14	20.9	2.5
	WL15s	10	14.9	1.8
	WL16s	23	34.3	4.1
	All Recorders	47	70.1	8.4

5.0 2008-2009 Well Network Statistics

5.1 Ground Water Data Collection

Depth to ground water was measured in 555 of the 560 wells in the July 1, 2008 through June 30, 2009 fiscal year. Five wells, P17E4 (Whitley Farms), S48H1 (Weymouth Woods), S49D3 (Vienna Vista), Z47R8 (Rowland), DD42N2 (Clarendon) were dry, therefore, depth to ground

water could not be measured in these wells. Table 3 contains DWR monitoring well network statistics from January 1, 2005 through June 30, 2009.

TABLE 3
DWR Monitoring Well Network Statistics (1-1-05 through 6-30-09)
North Carolina Ground Water Resources Monitoring Well Network
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Parameter	2005	2006	2007	2008	2009
Number of monitored wells	539	544	555	564	555
Manual water levels (tapedowns)	2,535	2,716	2,608	2,447	1,267
Daily water levels (automatic recorders)	89,182	92,827	95,333	107,006	56,080
Total daily water levels	91,717	95,543	97,941	109,453	57,347
Total hourly water levels	2,143,574	2,229,355	2,294,909	2,570,228	1,352,582
Chloride samples	17	22	173	14	3
Geophysical & lithologic logs at new stations	2	1	3	1	1

Figure 3 compares the number of wells monitored to the water level data collected from the network from 1967 to present. Hourly water level data is not included in this graph. Calendar year 2008 represents the most water level data collected in any single year since starting the monitoring well network operation. This is due to the gradual increase in the number of wells monitored and the increased use of automatic data recorders. The 2009 data was collected through June 2009.

Archived water level recorder charts obtained from DWQ with records dating from the 1960s through 1980s continue to be digitized and data recorded into DWR online database.

5.2 Triennial Chloride Sampling

The triennial chloride sampling was performed in September 2007. Ground water from 174 wells within the network was sampled for chlorides using Quantab® chloride titrators. Field data were collected for pH, conductivity and salinity using YSI® portable probes. The intention of the triennial chloride sampling is to assess the position of the fresh-salt water interface within each of the major coastal plain aquifers. Current results are compared to results of previous sampling events to evaluate potential landward migration of the fresh-salt water interface due to aquifer overuse. Chloride sampling results are posted in the database and the DWR website.

Sampling results indicate that there continues to be concern for salt water encroachment, especially near larger pumping centers located near the fresh-salt water interface (250 parts per

million (ppm) chloride is considered salt water). The September 2007 chloride field sampling results associated with wells near larger pumping centers illustrate these type of issues:

- Chloride concentrations in the Castle Hayne aquifer well at the Godley Station increased from 137 ppm on September 15, 2004 to 564 ppm on October 11, 2007. This station is located near PCS Phosphate Inc. at Aurora, NC in Beaufort County.
- Chloride concentrations from the Peedee aquifer well at the Folkstone Station increased from 35 ppm on October 12, 1999 to 266 ppm on September 14, 2004 and measured 252 ppm on September 25, 2007. This station is located near the ONWASA Dixon well field in Onslow County.
- Chloride concentrations from the Upper Cape Fear aquifer well at the Gold Point Station increased from <28 ppm on September 30, 2004 to 162 ppm on September 24, 2007. This station is located near the town of Robersonville in Martin County.

Table 4 summarizes the chloride field analysis to date.

TABLE 4
Chloride Field Analysis to Date
Wells Q16G4, Y25Q4 and J22P5
Ground Water Resources Monitoring Well Network
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Station	Date	Chlorides (ppm)
Godley Station Q16G4	2/23/1981	No Reading Available
	7/14/1998	174
	10/7/1999	91
	9/15/2004	137
	10/11/2007	**564**
Folkstone Station Y25Q4	9/25/1982	No Reading Available
	8/6/1998	11
	10/12/1999	35
	9/14/2004	**266**
	9/25/2007	**252**
Gold Point Station J22P5	6/10/2002	10
	9/15/2004	<28
	9/30/2004	<28
	9/24/2007	162
Chloride Level for Salt Water		**250**

The triennial chloride sampling will take place again in 2010.

5.3 Well Installation

From January through May 2009, four monitoring wells were installed at the Trenton Station, Jones County, four monitoring wells were installed at the Deppe Station, Onslow County and four wells were installed at the Grifton Ball Field Station, Pitt County, NC. The wells were installed using 4-inch PVC riser and 10 or 20 feet of 4 to 4.5-inch stainless steel continuous wire wrap V-slot screen. The wells were constructed of a gravel pack extending from the bottom of the screen to a minimum of five feet, but no more than ten feet, above the screen. A minimum of

ten feet of bentonite overlay the top of the gravel pack in order to provide a sufficient bentonite seal in the well. Table 5 summarizes the monitoring well construction information.

Prior to well installation, a pilot hole was advanced in order to conduct geophysical logging. Geophysical and lithologic log interpretation enabled the DWR staff to assess well screen intervals and the number of wells to be installed. Borehole advancement and well installation included conducting Time Domain Electromagnetic (TDEM) surveys, constructing lithologic and geophysical well logs, developing wells and collecting chloride measurements.

The wells were developed in September 2009 by pumping. Development removes fine-grained sediments from the vicinity of the well screen and ensures proper hydraulic connection with the aquifer. In addition, field data were collected for pH, conductivity, salinity, and temperature in thirty minute or hourly intervals. Field data exhibiting overall consistency was used to assist in the decision for well development completion.

5.4 Well Maintenance

The well network requires continual maintenance to keep existing monitoring stations usable. Many of the wells are over 30 years old and are constructed of materials that are susceptible to corrosion, especially in acidic or saline ground water conditions. Some older wells were constructed with outdated, less than desirable construction practices including backfilling boreholes with cuttings instead of neat cement or bentonite grout. Boreholes backfilled with cuttings form an inadequate seal and allow other aquifers to influence the water level and water quality in that well. Another outdated practice included well construction using telescoped casing. Telescoped casing uses a reducer to trim the well to a smaller diameter casing at depth apparently to save money during well construction. Telescoped wells are very susceptible to blockage at the depth of the reducer. Approximately 154 wells in the network were constructed with reducers. DWR has implemented a long-term program for replacing damaged or unsuitably constructed wells with new properly constructed wells.

Installation of new and replacement monitoring wells occupies a large portion of DWR's resources. Table 5 lists the new wells installed during the 2008-2009 fiscal year. The new wells are included on Figure 1.

TABLE 5
Well Construction Information*
Parkertown/Folkstone, Onslow County, North Carolina
Ground Water Resources Monitoring Well Network
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Well ID	Station Name	Date Installed	Well Diameter (inches)	Well Depth (ft bls)	Screened Interval (x to y ft bls)	Measuring Point (MP) (ft)	Aquifer	Water Level (from MP)
								Measured 6/27/09
T24J1	Trenton	5-13-09	4.5	1005	990-1000	2.67	Lower Cape Fear	89.86
T24J2	Trenton	5-19-09	4.5	175	160-170	2.63	Castle Hayne	11.77
T24J3	Trenton	5-19-09	4.5	95	80-90	2.85	Upper Castle Hayne	10.10
T24J4	Trenton	5-21-09	4.5	35	20-30	2.90	Surficial	9.75
								Measured 3-31-09
V23X4	Deppe	1-23-09	4.5	35	20-30	3.10	Surficial	6.88
V23X5	Deppe	1-28-09	4.5	225	210-220	3.25	Castle Hayne	7.25
V23X6	Deppe	2-12-09	4.5	85	70-80	3.00	Castle Hayne	6.82
V23X7	Deppe	3-13-09	4.5	873	858-868	-	Black Creek	-
								Measured 3-30-09
P24O2	Grifton	2-9-09	4.5	490	475-485	2.90	Upper Cape Fear	126.46
P24O3	Grifton	2-11-09	4.5	268	253-263	2.75	Black Creek	124.87
P24O4	Grifton	3-19-09	4.5	128	113-123	3.20	Peedee	16.08
P24O5	Grifton	3-20-09	4.5	35	20-30	3.32	Surficial	6.23

bls – below land surface
*Wells had not been developed at the time this data was collected.

5.5 Automatic Water Level Recorders

Automatic water level recorders play an integral role in the DWR monitoring program. They allow for economical collection of near-continuous data at the remotest of well stations. Three primary recorders are utilized (Table 6).

TABLE 6
Automatic Water Level Recorders
North Carolina Ground Water Resources Monitoring Well Network
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Recorder Type	Number in Service*
Sutron Corporation Model 8400A	45
Global Water Instrumentation, Inc. Model WL15	74
Global Water Instrumentation, Inc. Model WL16	255

*As of June 2009
Note: Due to the large number of recorders employed by DWR, there are, at any given time, a number of units that are being serviced or refurbished. These units are not reflected in the above totals.

5.6 Site Surveys

Concrete survey monuments continue to be installed at each of the 183 stations within the network. Once installation is complete, the monuments will be surveyed using the Global Positioning System (GPS) to calculate the most accurate horizontal and vertical location data possible. Eighty-four monuments have been installed date. It is anticipated that this work will be completed by Spring 2010. Surveying of the monuments will take place once monument installation at each well station is complete.

6.0 Planned Activities for FY 2009-2010

6.1 New Well Installation

Monitoring well network expansion efforts for FY 2009-2010 will be focused on Pitt, Lenoir and Jones Counties. DWR currently has plans to complete construction of the Trenton Station (T24J) in Jones County and possibly drill a new station in Farmville, Pitt County and /or Lenoir County north of Moss Hill. In addition, some wells throughout the network that cannot be used due to bad construction, screening in multiple aquifers, etc., may be abandoned during this upcoming fiscal year. Table 7 summarizes the possible upcoming expansion of the network in 2009-2010.

TABLE 7
FY 2009-2010 Network Expansion
North Carolina Ground Water Resources Monitoring Well Network
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Station Name/Quad	County	Existing Well Screens	Aquifer	Proposed New Well Screens	Aquifer
Trenton T 24J	Jones	990-1000	Lower Cape Fear		
		160-170	Castle Hayne		
		80-90	Castle Hayne		
		20-30	Surficial		
				340-350	Peedee
				515-525	Black Creek
				795-805	Upper Cape Fear

7.0 Summary and Conclusions

The NCDENR, DWR has maintained and monitored a statewide network of ground water monitoring wells used to assess North Carolina's ground water supply since 1998.

Data collected from the network are available to the public through DWR's Internet website, www.ncwater.org. These data include, but are not limited to, ground water levels, chloride measurements, well construction information, borehole log construction (lithological and geophysical), ground water monitoring station location, and geophysical/lithological data collected from other (non-DWR) well sites.

The well network consists of 555 monitoring wells at 183 individual stations. From July 2009 through June 2010, ground water level data was collected from 555 wells within the network (six wells were dry and twelve new wells are not included). These data include manual measurements taken quarterly from 555 wells, plus hourly water levels collected using automatic data recorders from 374 wells.

A total of twelve monitor wells have been installed at three different stations. One station is located in each of the following counties: Onslow, Jones, and Pitt. Four monitor wells were installed at the Trenton Station, four wells were installed at the Deppe Station, and four wells were installed at the Grifton Station. Borehole advancement and well installation included, but was not limited to, conducting TDEM surveys, constructing lithologic and geophysical well logs, developing wells and collecting chloride measurements.

Archived water level recorder charts obtained from the DWQ with records dating from the 1960s through 1980s continue to be digitized and data recorded into the DWR online database. Survey monuments continue to be installed at each of the well stations with plans to survey each monument using global positioning system (GPS).

The triennial chloride sampling was performed on 172 wells in September 2007. One additional sample was collected from the new well installation in April/May 2008. Sampling results indicated that there continues to be concern for saltwater encroachment especially near larger pumping centers located near the fresh-salt water interface. The triennial sampling will occur again in 2010.

DWR has tentative plans to expand the monitoring well network by installing two to six wells at two sites in fiscal year 2009/2010. In addition several wells in the network may be scheduled for abandonment or replacement.

FIGURES

Figure 1: North Carolina Division of Water Resources Monitoring Stations July 2009

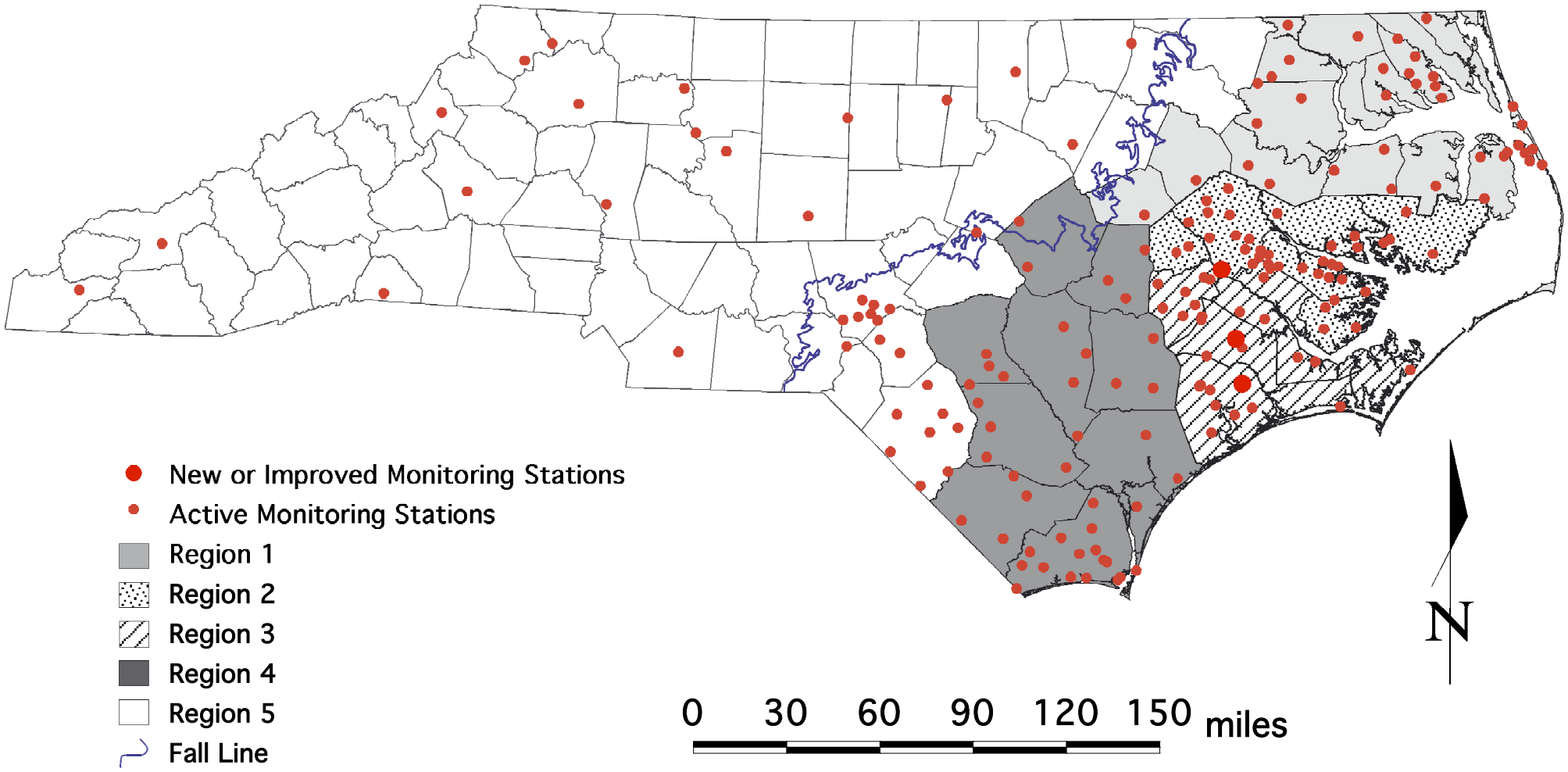

Figure 2: Drought Indicator Wells

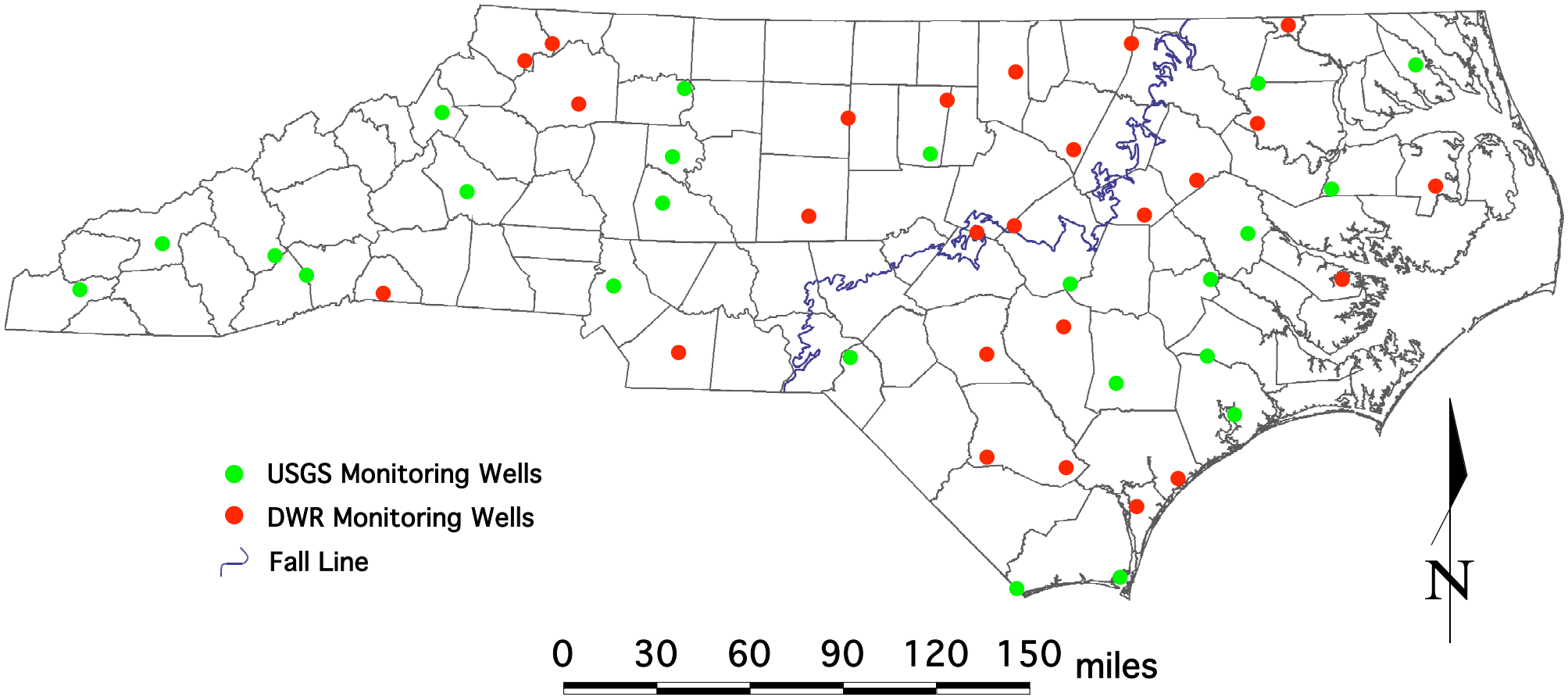

FIGURE 3
Water Level Data Collected from 1967-2009
(Plot includes both DWR and USGS Data)