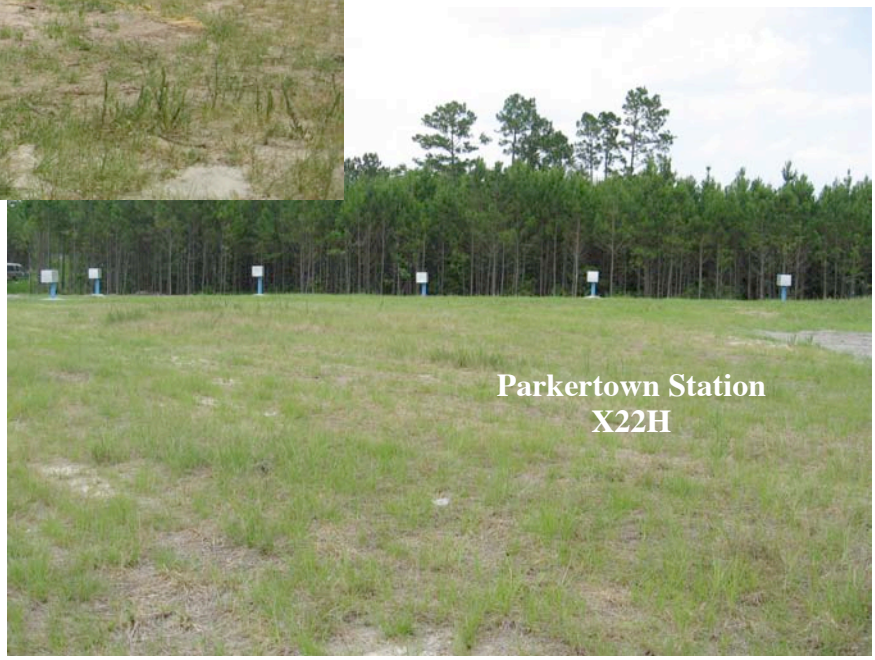
North Carolina
Ground Water Resources
Monitoring Well Network
2008 Annual Report


Folkstone Station
Y25Q


Parkertown Station
X22H


Parkertown Station
X22H

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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 2008 Annual Report summarizes field activities and conclusions that have been derived from activities performed during the July 1, 2007 through June 30, 2008 fiscal year. These activities include water level and water quality data statistics, new and monitoring well 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 548 wells at 182 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 526 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 35 wells within the monitoring well network used to assess drought conditions (Figure 2).

Of the 182 monitoring stations, 59 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 2008 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. The 2007 chloride sampling event is described in Section 5.2.

TABLE 2
Site and Recorder Distribution By Region
North Carolina Ground Water Resources Monitoring Well Network
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Region	Parameter	Number	% of Region	% of Network
1	Wells	108		19.7
	Sites	36		19.8
	Sutrons	3	2.8	0.5
	WL15s	0	0.0	0.0
	WL16s	61	56.5	11.0
	All Recorders	64	59.3	11.7
2	Wells	137		25.0
	Sites	37		20.3
	Sutrons	16	11.7	2.9
	WL15s	47	34.3	8.6
	WL16s	13	9.5	2.4
	All Recorders	76	55.5	13.9
3	Wells	105		19.2
	Sites	27		14.8
	Sutrons	5	4.8	0.9
	WL15s	30	28.6	5.5
	WL16s	40	38.1	7.3
	All Recorders	75	71.4	13.7
4	Wells	127		23.2
	Sites	43		23.6
	Sutrons	7	5.5	1.3
	WL15s	25	19.7	4.6
	WL16s	20	15.7	3.6
	All Recorders	52	40.9	9.5
5	Wells	71		13.0
	Sites	39		21.4
	Sutrons	15	21.1	2.7
	WL15s	13	18.3	2.4
	WL16s	11	15.5	2.0
	All Recorders	39	54.9	7.1

5.0 2007-2008 Well Network Statistics

5.1 Ground Water Data Collection

Depth to ground water was measured in 546 of the 548 wells in the July 1, 2007 through June 30, 2008 fiscal year. Two wells, DD42N2 at Clarendon Station and S49D3 at Viena Vista Station, 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, 2008.

TABLE 3
DWR Monitoring Well Network Statistics (1-1-05 through 6-30-08)
North Carolina Ground Water Resources Monitoring Well Network
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Parameter	2005	2006	2007	2008
Number of monitored wells	539	544	555	548
Manual water levels (tapedowns)	2,535	2,716	2,608	1,228
Daily water levels (automatic recorders)	89,182	92,827	95,170	35,236
Total daily water levels	91,717	95,543	97,778	36,464
Total hourly water levels	2,143,574	2,229,355	2,292,486	843,095
Chloride samples	17	21	172	2
Geophysical & lithologic logs at new stations	2	1	3	1

Figure 3 compares the number of wells monitored to the water level data collected from the network for the years from 1967 to present. Hourly water level data is not included in this graph. Calendar year 2007 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 2008 data was collected through June 2008.

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). Example sampling from these types of wells illustrate these type of issues:

- Chloride concentration 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 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 lies 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 lies near the town of Robersonville in Martin County.

Table 4 summarizes the chlorides analysis to date.

TABLE 4
Chlorides Analysis to Date
Wells Q16G4, Y25Q4 and J22P5
Ground Water Resources Monitoring Well Network
2008 Annual Report

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**

5.3 Well Installation

From April through May 2008, six monitoring wells were installed at Parkertown Station, Onslow County, NC and two wells were installed at Folkstone Station, Onslow 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 interval 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 June 2008 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 2007-2008 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	StationName	Date Installed	Well Diameter	Well Depth (ft bls)	Screened Interval (x to y ft bls)	Well Depth (ft bls)	Aquifer	Static Water Levels (ft bls) (6/19/08)
X22H1	Parkertown	5/08	4-inch	382	372-382	387	Lower Castle Hayne	16.42
X22H2	Parkertown	5/08	4-inch	40	30-40	45	Surficial	12.33
X22H3	Parkertown	5/08	4-inch	290	280-290	295	Lower Castle Hayne	16.92
X22H4	Parkertown	5/08	4-inch	521	511-521	526	Beaufort	19.37
X22H5	Parkertown	5/08	4-inch	787	767-787	792	Pee Dee	22.49
X22H6	Parkertown	5/08	4-inch	1035	1015-1035	1040	Black Creek	72.11
Y25Q7	Folkstone	5/08	4-inch	454	444-454	459	Lower Castle Hayne	45.68
Y25Q8	Folkstone	5/08	4-inch	792	782-792	797	Black Creek	69.71

bls – below land surface

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	46
Global Water Instrumentation, Inc. Model WL15	115
Global Water Instrumentation, Inc. Model WL16	145

*As of June 2008
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 182 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. Eighteen well sites have been installed and surveyed to date. It is anticipated that this work will be completed by Spring 2009.

6.0 Planned Activities for FY 2008-2009

6.1 New Well Installation

Monitoring well network expansion efforts for FY 2008-2009 will be focused on Pitt and Onslow Counties. DWR currently has plans to complete construction of the Grifton Ballfield monitoring station, P240 (Table 7) and add additional wells at Deppe Station (V23X).

TABLE 7
FY 2008-2009 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
Grifton Ballfield P240	Pitt	690-700	Lower Cape Fear		
				20-30	Surficial
				113-123	Beaufort
				253-263	Peedee?
				475-485	Black Creek?
Deppe V23X	Onslow	90-100	Unconfined		
		620-630	PeeDee		
		290-300	Beaufort		
				20-30	Surficial
				210-220	Lower Castle Hayne
				858-868	Black Creek

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 548 monitoring wells at 182 individual stations. From July 2007 through June 2008, ground water level data was collected from 546 wells within the network (two well were dry and eight new wells are not included). These data include manual measurements taken quarterly from 546 wells, plus hourly water levels collected using automatic data recorders from 306 wells.

A total of eight monitor wells have been installed at two different stations in Onslow County. Six monitor wells were installed at Parkertown Station and two monitor wells were installed at Folkstone 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. Two additional samples were 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.

DWR has tentative plans to expand the monitoring well network by installing seven wells at two sites in fiscal year 2008/2009.

FIGURES

Figure 1: North Carolina Division of Water Resources Monitoring Stations July 2008

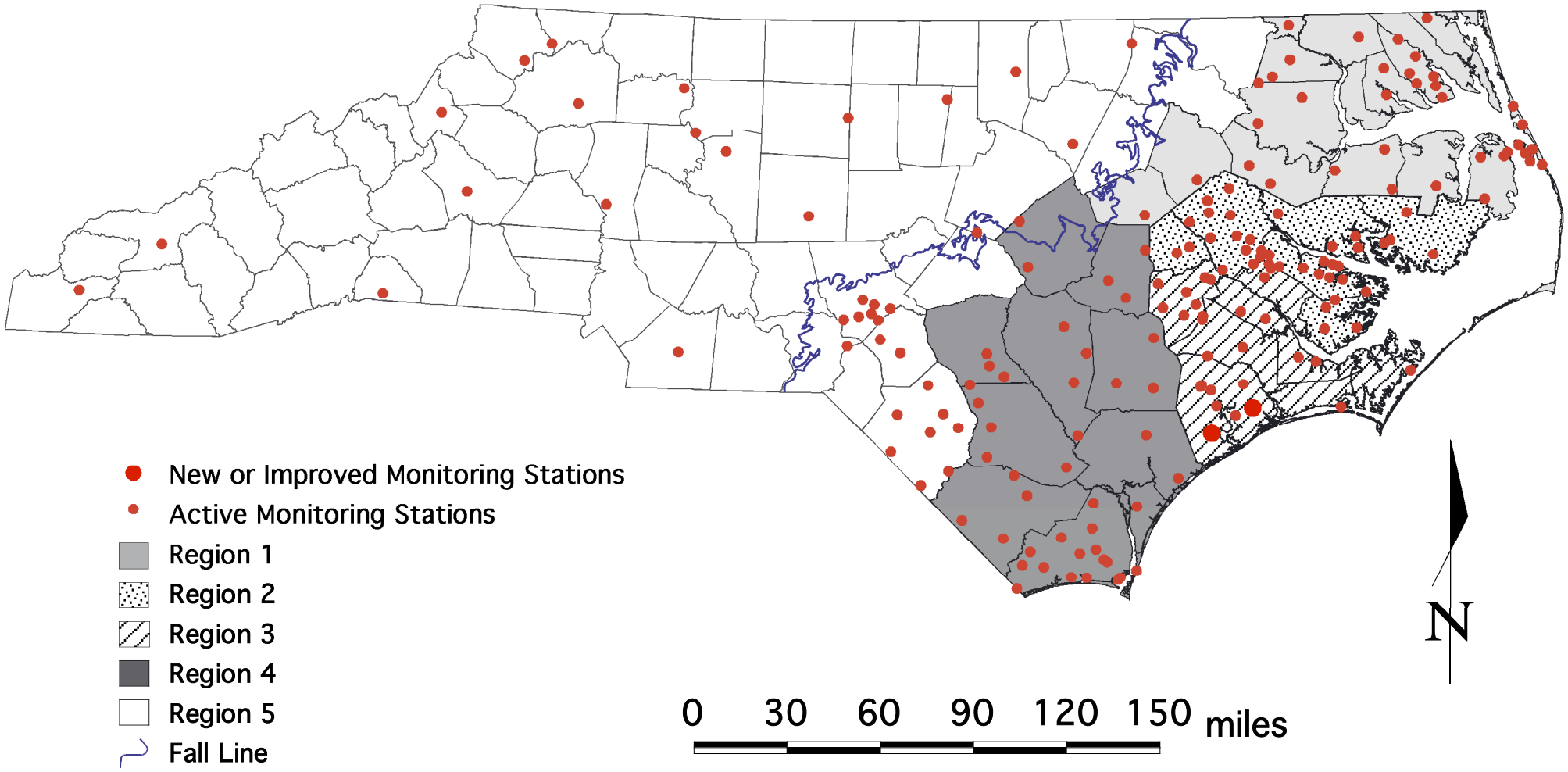


Figure 2: Drought Indicator Wells

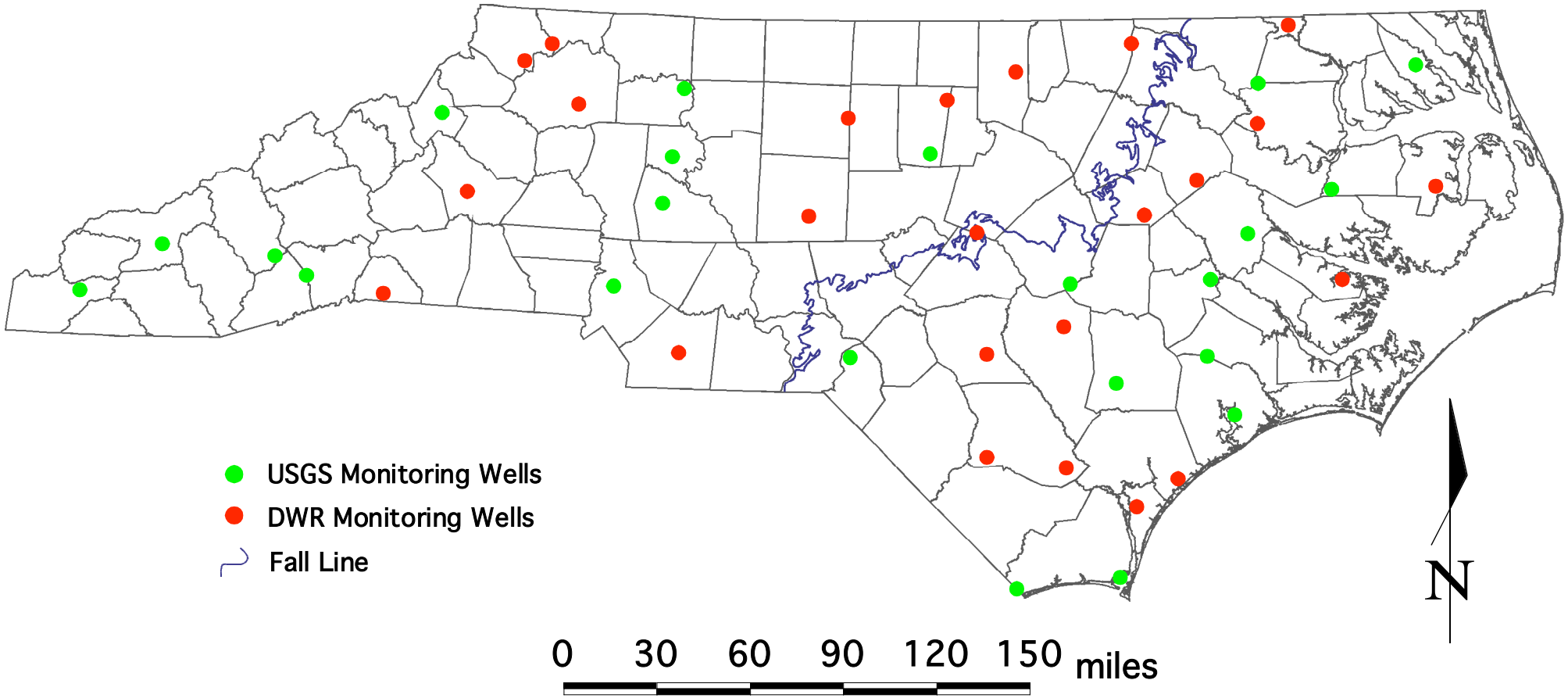
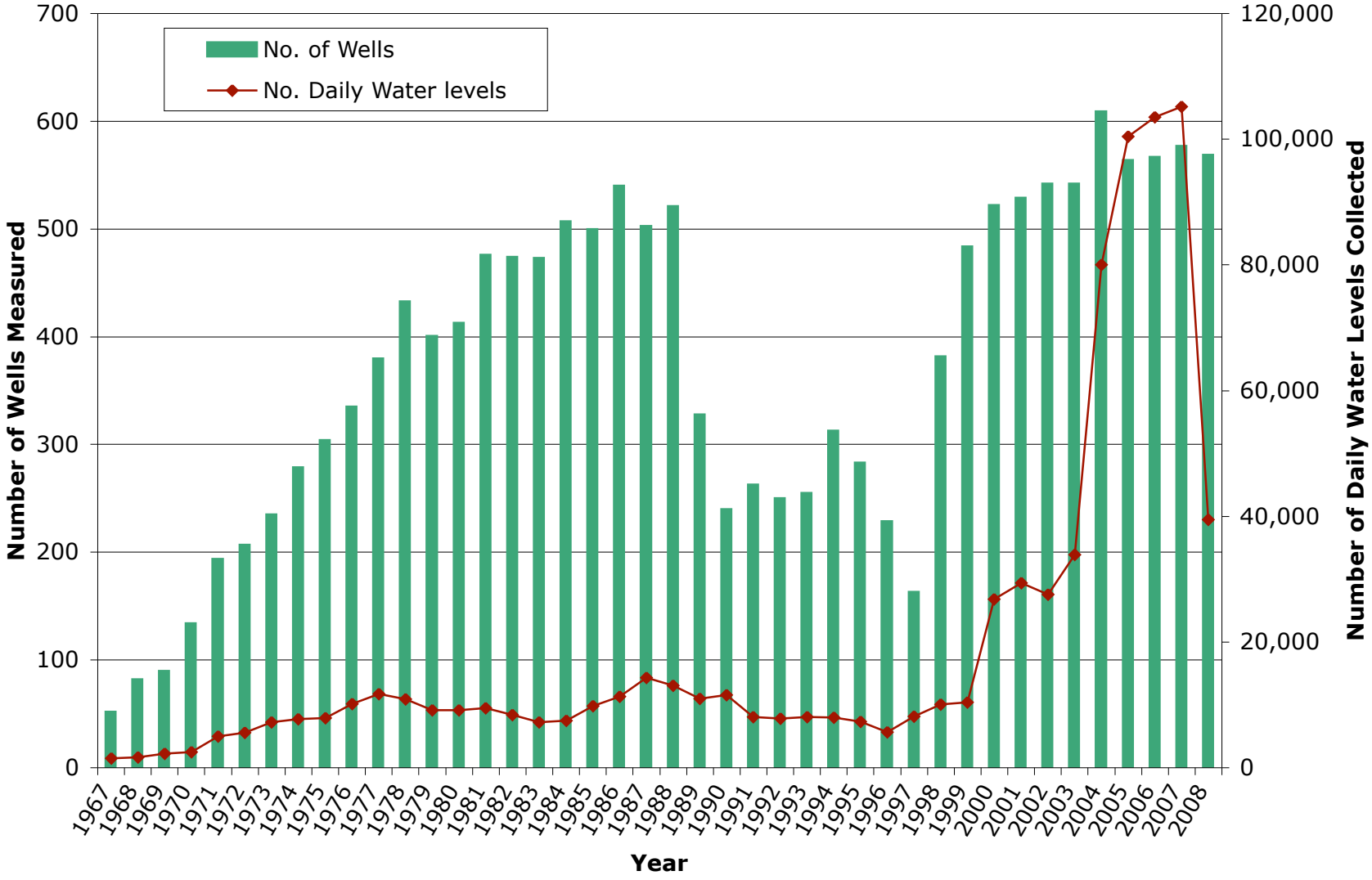


FIGURE 3


No. of Wells
No. Daily Water levels
Number of Wells Measured
Number of Daily Water Levels Collected
Year
0
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