

North Carolina Ground Water Resources Monitoring Well Network 2011 Annual Report



Susan Laughinghouse, L.G.
North Carolina Department of
Environment and Natural Resources
Division of Water Resources
September 2011

**WINDSOR
STATION
H20T**

1.0 Introduction

The state of North Carolina (the state) relies on ground water for approximately 50 percent of its drinking (potable) water. In addition, the state has thousands of agricultural and industrial ground water users. Since 1998, the N.C. 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 is used to:

- 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 website at www.ncwater.org. These data includes 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 2011 Annual Report summarizes field activities and conclusions derived from activities performed during the July 1, 2010 through June 30, 2011 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 Division of Water Quality (DWQ) and its predecessor agencies initially operated the statewide Ground Water Resource Monitoring Program. DWQ installed the original network wells in the 1960s and is responsible for installation of approximately 67 percent of the current monitoring well network. DWQ actively monitored the network through the early 1990s, collecting a portion of the ground water data 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 North Carolina and the federal government. The cooperative well network consists of 13 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 consists of 588 wells at 197 monitoring stations (sites), divided into five regions, comprising 60 counties ([Figure 1](#)). There are 28 wells in the Piedmont and Mountain physiographic provinces (Piedmont and Mountain) and 560 wells in the Coastal Plain physiographic province (Coastal Plain). The Coastal Plain relies more heavily on ground water supplies than either the Piedmont or Mountains. 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 39 wells within the monitoring well network used to assess drought conditions ([Figure 2](#)).

Of the 197 monitoring stations, 60 are on state or federal property, 50 are on property owned by local governments, 82 are on private property through agreements with landowners and five stations are on properties where the landowner has indicated that the property ownership may change. 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 and 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.

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 each region. Staff member responsibilities include visiting the wells quarterly to collect water level data, performing routine site maintenance, keeping automatic data recorders in working order and keeping sites accessible and aesthetically 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, vented and unvented). 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 next chloride sampling will occur September 2013. Section 5.2 summarizes the 2010 chloride sampling event.

TABLE 2 Site and Recorder Distribution by Region through 6/30/11 North Carolina Division of Ground Water Resources Monitoring Well Network 2011 Annual Report				
Region	Parameter	Number	% of Region	% of Network
	Wells	122		20.7
	Sites	41		20.8
	Sutrons	1	0.8	0.2
1	WL15s	0	0.0	0.0
	WL16s	59	48.4	10.0
	Hobos	16	13.1	2.7
	All Recorders	76	62.3	12.9
	Wells	148		25.2
	Sites	41		20.8
	Sutrons	10	6.8	1.7
2	WL15s	30	20.3	5.1
	WL16s	52	35.1	8.8
	Hobos	27	18.2	4.6
	All Recorders	119	80.4	20.2
	Wells	111		18.9
	Sites	27		13.7
	Sutrons	3	2.7	0.5
3	WL15s	7	6.3	1.2
	WL16s	62	55.9	10.5
	Hobos	12	10.8	2.0
	All Recorders	84	75.7	14.3
	Wells	131		22.3
	Sites	43		21.8
	Sutrons	2	1.5	0.3
4	WL15s	11	8.4	1.9
	WL16s	30	22.9	5.1
	Hobos	27	20.6	4.6
	All Recorders	70	53.4	11.9
	Wells	76		12.9
	Sites	45		22.8
	Sutrons	9	11.8	1.5
5	WL15s	10	13.2	1.7
	WL16s	23	30.3	3.9
	Hobos	10	13.2	1.7
	All Recorders	52	68.4	8.8

5.0 2010-2011 Well Network Statistics

5.1 Ground Water Data Collection

Depth to ground water was measured in 579 of the 588 wells in the July 1, 2010 through June 30, 2011 fiscal year. One well, P17E4 (Whitley Farms was dry for four consecutive quarters, therefore, depth to ground water could not be measured in this well) and eight new wells at Windsor (H20T1, H20T2, H20T3, H20T4, H20T5, H20T6, H20T7 and H20T8) were not measured. Table 3 contains DWR monitoring well network statistics from January 1, 2005 through June 30, 2011.

Parameter	2005	2006	2007	2008	2009	2010	2011
Number of monitored wells	542	544	555	565	575	578	580
Manual water levels (tapedowns)	2,617	2,729	2,620	2,468	2,555	2,909	1333
Daily water levels (automatic recorders)	89,088	92,827	95,333	107,883	122,969	131,325	67,818
Total hourly water levels	2,141,368	2,229,355	2,294,909	2,591,483	2,961,371	3,163,229	1,638,347
Chloride Samples	17	22	173	12	17	251	13
Geophysical & lithologic logs at new stations	2	1	3	1	1	0	2

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 2010 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 2011 data was collected through June 2011.

Archived water level recorder charts obtained from DWQ with records dating from the 1960s through the 1980s continue to be digitized and data is recorded into DWR's online database. Additional digitized information recorded in the database includes well construction records, well development, chloride sampling events and field notes.

5.2 Triennial Chloride Sampling

The triennial chloride sampling was performed in September 2010 and October 2010. Ground water from 245 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. Two hundred-fifty parts per million (ppm) of chloride is considered salt water. The September 2010 chloride field sampling results associated with wells near larger pumping centers illustrate these types of issues:

- Chloride concentrations from October 2010 in the lower Castle Hayne aquifer well Q16G4 at the Godley Station continue to indicate salt water intrusion with levels of 531 ppm which exceed the 250 ppm threshold for salt water. This station is located near PCS Phosphate Inc. in Aurora in Beaufort County.
- Chloride concentrations from the Peedee aquifer well Y25Q4 at the Folkstone Station show a large decrease in chlorides from 252 ppm on September 2007 to BDL (below detection limit of 33 ppm) in September 25, 2010. This station is located near the ONWASA Dixon well field in Onslow County.
- Chloride concentrations from the Upper Cape Fear aquifer well J22P5 at the Gold Point Station decreased from 162 ppm on September 2007 to 54 ppm in September 2010. This station is located near the town of Robersonville in Martin County.
- Chloride concentrations from the Upper Cape Fear aquifer well R23X9 at the Cove City station increased from 352 ppm in October 2007 to 463 ppm in September 2010. This well is located near the town of Cove City in Craven County.

Table 4 summarizes the chloride field analysis to date.

TABLE 4 Chloride Field Analysis to Date Wells Q16G4, Y25Q4, J22P5 and R23X9 Ground Water Resources Monitoring Well Network 2011 Annual Report		
Station	Date	Chlorides (ppm)
	10/04/2010	531
	10/01/2007	564
Godley	09/15/2004	137
Station	10/07/1999	91
Q16G4	07/14/1998	174
	02/23/1981	No Reading Available
	09/22/2010	BDL of 33
	09/25/2007	252
Folkstone	09/14/2004	266
Station	10/12/1999	35
Y25Q4	08/06/1998	11
	09/25/1982	No Reading Available
	10/04/2010	54
Gold Point	09/24/2007	162
Station	09/30/2004	BDL of 28 **
J22P5	09/15/2004	BDL of 28
	06/10/2002	10
	09/20/2010	463
Cove City	10/05/2007	352
Station	09/13/2004	309
R23X9	10/04/2000	30
Chloride Level for Salt Water		250

**Collected after well development

The triennial chloride sampling will take place again in September 2013 and October 2013.

5.3 Well Installation

From February through May 2011, the following monitoring wells were installed:

- Rose Hill Station, Trenton, Duplin County, three monitoring wells installed;
- Pink Hill Station in Duplin County, two monitoring wells installed;
- Caledonia Prison Farm in Halifax County, three wells installed; and
- Windsor Station in Bertie County, eight wells installed.

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 10 feet, above the screen. A minimum of 10 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.

A pilot hole was not advanced prior to installing the wells at the Rose Hill and Pink Hill stations, since both stations had pilot holes advanced in previous years and geophysical logging was conducted. Pilot holes were advanced and geophysical logging conducted at both the Caledonia Prison Farm and the Windsor Stations prior to well installation. 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 well development and chloride measurement collection.

The wells were developed June through August 2011 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 to stop well development.

5.4 Well Maintenance

The well network requires continual maintenance to keep existing monitoring stations usable. Many of the wells are more than 30 years old and constructed of materials 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 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 2010-2011 fiscal year. The new wells are included on [Figure 1](#).

5.5 Addition of Monitoring Network Wells

Eight wells were acquired from municipalities, schools and private residences and were included in the Monitoring Well Network. The wells are located in the following counties: three wells in Warren County, two wells in Granville County, two wells in Northampton County and one well in Nash County. Some of these wells may be monitored for several months prior to inclusion on the active well network to ensure they are properly constructed and that the water levels are consistent with water table conditions.

TABLE 5
Well Construction Information*
Rose Hill, Pink Hill, Duplin County, Caledonia Prison Farm, Halifax County, Windsor, Bertie County, North Carolina
Ground Water Resources Monitoring Well Network
2011 Annual Report

Well ID	Station Name	Date Installed	Well Diameter (inches)	Well Depth (ft bls)	Screened Interval (x to y ft bls)	Measuring Pt (MP) (ft)	Aquifer	Water Level (from MP) (ft)
								Not Measured
T29G10	Pink Hill	03/09/11	4	592	560-580		Klcf	95.71
T29G11	Pink Hill	03/09/11	4	25	150-20		S	8.38
T29G12	Pink Hill	03/18/11	4	474	456-466		Kucf	94.24
								Measured - 06/08/11
V32V10	Rose Hill	02/17/11	4	495	480-490	2.18	Klcf	36.31
V32V11	Rose Hill	02/24/11	4	413	398-408	2.35	Kucf	37.21
								Measured - 06-29-11
E25L1	Caledonia Prison Farm	04/11/11	4	278	210-220	3.79	Klcf	72.62
E25L2	Caledonia Prison Farm	04/12/11	4	85	70-80	3.68	Kucf	21.41
E25L3	Caledonia Prison Farm	04/11/11	4	35	20-30	3.64	To Be Determined	18.89
								Measured April/May 2011
H20T1	Windsor	04/25/11	4	1,001	875-885		To Be Determined	106.10
H20T2	Windsor	05/09/11	4	560	545-555		To Be Determined	77.06
H20T3	Windsor	05/11/11	4	335	320-330		To Be Determined	49.48
H20T4	Windsor	05/16/11	4	280	265-275		To Be Determined	50.92
H20T6	Windsor	05/18/11	4	105	90-100		To Be Determined	9.75
H20T7	Windsor	05/19/11	4	60	45-55		To Be Determined	7.43
H20T8	Windsor	05/19/11	4	35	20-30		To Be Determined	7.76
H20T9	Windsor	05/18/11	4	185	170-180		To Be Determined	-

*Wells had not been developed at the time this data was collected. (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 remote well stations. Three primary recorders are used (Table 6).

TABLE 6	
Automatic Water Level Recorders	
North Carolina Ground Water Resources Monitoring Well Network	
2011 Annual Report	
Recorder Type	Number in Service*
Sutron Corporation Model 8400A	25
Global Water Instrumentation, Inc. Model WL15	58
Global Water Instrumentation, Inc. Model WL16	226
HOBO U20 Water Level Logger (including separate barometer per station installed)	112 (20 barometers)

***As of June 30, 2011**

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 197 monitoring well 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. One hundred seventy-four monuments have been to installed date. It is anticipated that this work will be completed by the winter of 2011/2012. Surveying the monuments will take place once the monument installation at each well station is complete.

6.0 Planned Activities for FY 2011-2012

6.1 New Well Installation

Monitoring well network expansion efforts for fiscal 2011-12 will be focused on Bladen, Carteret, Chowan, Columbus, Duplin, New Hanover, Pender, Pitt, Sampson, Scotland, Washington and Wayne counties. In addition, some wells in the network that cannot be used due to bad construction or screening in multiple aquifers may be abandoned during this upcoming fiscal year. Table 7 summarizes the possible upcoming expansion of the network in 2011-12.

6.2 Well Abandonment

The following wells were abandoned during fiscal 2010-11: Southern Pines 1, Moore County R48Y3; Vienna Vista, Moore County, S49D3; and Weymouth Woods, Moore County, S48H1.

**TABLE 7
 FY 2011-2012 Network Expansion
 North Carolina Ground Water Resources Monitoring Well Network
 2011 Annual Report**

Station Name/Quad	County	Proposed New Well Screens (ft bls)	Aquifer
		20-30	Surficial
		60-70	Yorktown
		120-130	Upper Black Creek
Farmville	Pitt	170-180	Lower Black Creek
		300-310	Upper Cape Fear
		438-448	Lower Cape Fear
		475	Pilot Hole
		20-30	Surficial
Vicinity of Walnut Creek	Wayne	45-55	Black Creek?
		100-110	Black Creek
		220-230	Upper Cape Fear
		350	Pilot Hole
		20-30	Surficial
		100-110	Yorktown
Pocosin Lake Area	Washington	200-210	Castle Hayne (upper)
		350-360	Castle Hayne (lower saltwater)
		500-510	Beaufort
		600	Pilot Hole

TABLE 7 (continued) FY 2011-2012 Network Expansion North Carolina Ground Water Resources Monitoring Well Network 2011 Annual Report			
Station Name/Quad	County	Proposed New Well Screens (ft bls)	Aquifer
		20-30	Surficial
		80-90	Yorktown
		220-230	Castle Hayne
Valhalla	Chowan County	320-330	Beaufort
		450-460	Upper Cape Fear
		850-860	Lower Cape Fear
		1200-1210	Lower Cretaceous
		1300	Pilot Hole
		20-30	Surficial
		124-134	Yorktown
		244-254	Castle Hayne (upper)
Belhaven	Beaufort	312-322	Castle Hayne (lower)
		388-398	Beaufort
		540-550	PeeDee
		720-730	Black Creek
		900	Pilot

7.0 Summary and Conclusions

The 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 website at www.ncwater.org. These data include 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 588 monitoring wells at 197 individual stations. From July 2010 through June 2011, ground water level data were collected from 579 wells within the network (one well was dry and eight new wells are not included). These data include manual measurements taken quarterly from wells, plus hourly water levels collected using automatic data recorders from 418 wells.

A total of 16 monitor wells have been installed at four different stations. Three monitor wells were installed at Pink Hill in Duplin County. Two monitor wells were installed at Rose Hill in Duplin County. Three wells were installed at the Caledonia Prison Farm in Halifax County, and eight wells were installed near Windsor in Bertie County. Borehole advancement and well installation included well development and collection of chloride measurements.

A total of three wells were abandoned at three different stations. One well was abandoned from Southern Pines. One well from Vienna Vista and another well from Weymouth Woods were also abandoned. All three stations are in Moore County.

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 a global positioning system (GPS).

The triennial chloride sampling was performed on 245 wells in September 2010 and October 2010. Thirteen additional samples were collected from the new well installations between in December and May 2011. 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 September 2013 and October 2013.

DWR has tentative plans to expand the monitoring well network by installing between 13 and 26 wells at four sites in fiscal 2011-12. 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 August 2011

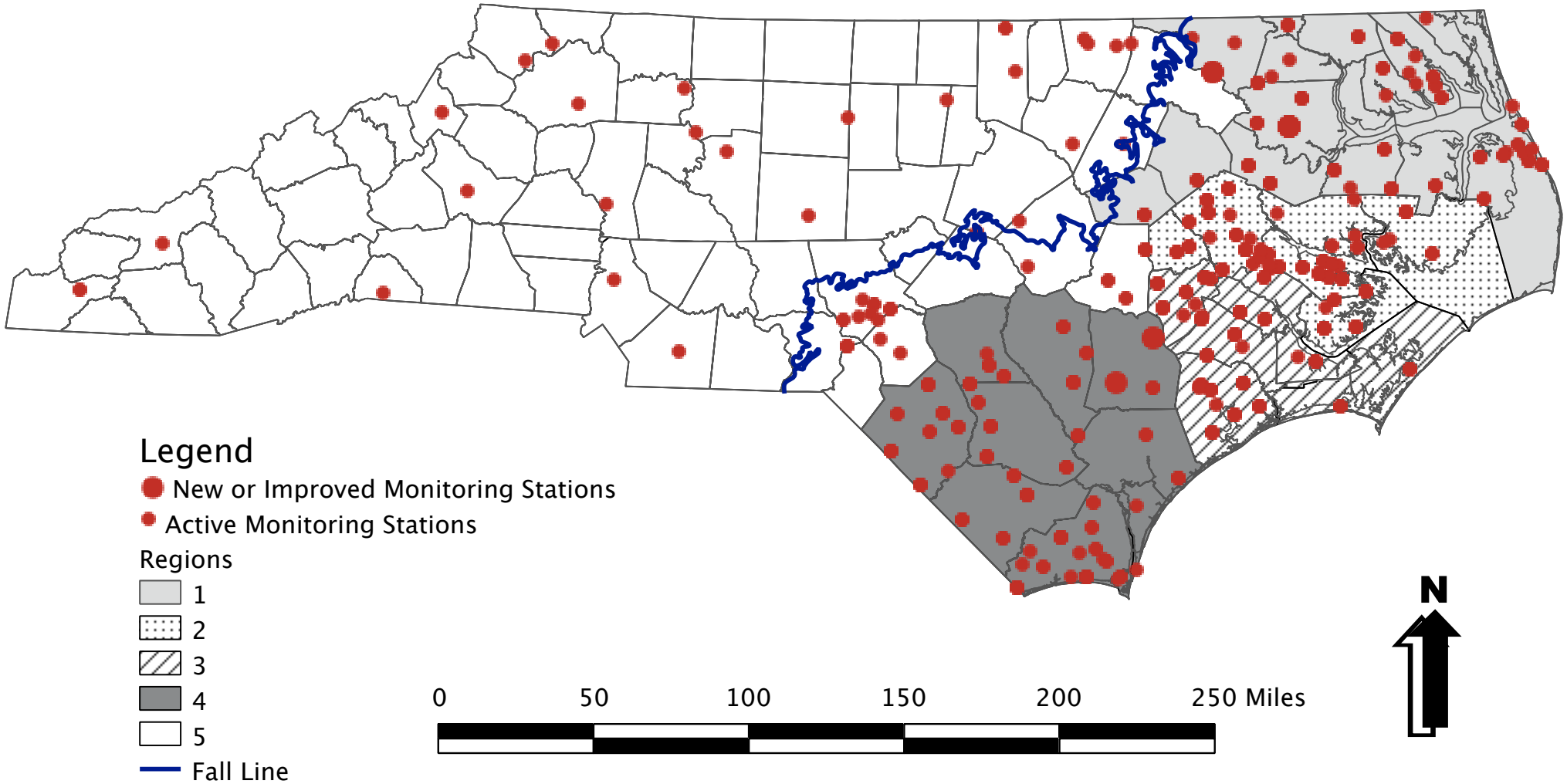


Figure 2: Drought Indicator Wells

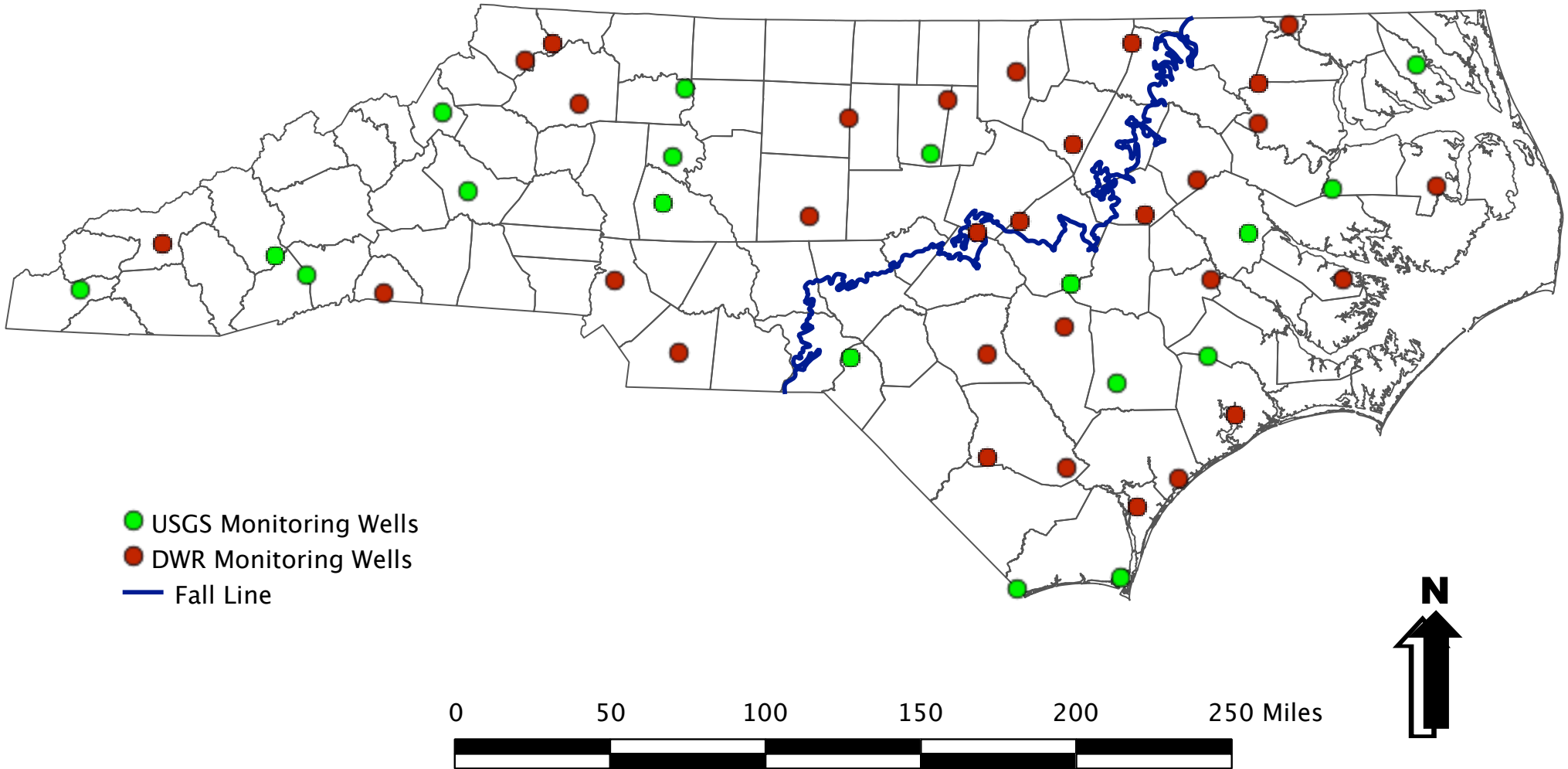


FIGURE 3
Water Level Data Collected from 1967-2011
 (Plot includes both DWR and USGS Data)

