North Carolina
Division of Water Resources
Groundwater Management Branch
Monitoring Well Network
2023 Annual Report

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Jones Middle School Monitoring Station, T24J
Jones County, NC

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1.0 Introduction

The State of North Carolina (the State) relies on groundwater for approximately 50 percent of its drinking (potable) water use. In addition, the State has thousands of agricultural and industrial groundwater users. The North Carolina Department of Environmental Quality (DEQ), Division of Water Resources (DWR), Groundwater Management Branch (GWMB) and preceding agencies have operated, installed, and monitored a statewide monitoring well network (MWN) from the 1960s to the present. The operation of this MWN is an essential part of DWR's mission to ensure that the State has an adequate water supply for its citizens. Information collected quarterly from this well network include the following:

- Understanding groundwater use and availability;
- Sampling and analysis of groundwater to understand the impacts of contaminants or saltwater encroachment;
- Evaluating climatic influences on the State's groundwater supply, including effects of drought, flooding, and seasonal change;
- Monitoring human-induced impacts on the State's groundwater 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 freshwater-saltwater interface within various aquifers;
- Periodic sampling of the monitoring well network to establish background levels for constituents (e.g., nitrates, metals, etc.);
- Providing high quality groundwater data to local governments, groundwater professionals, educational institutions, and the public to use in making informed decisions in groundwater related issues; and
- Understanding how climatic conditions affect base flow to streams and rivers, which can affect the surface water supplies of dozens of North Carolina communities.

Data collected from the MWN are available to the public through DWR's internet website https://www.ncwater.org/GWMB. These data include, but are not limited to, groundwater levels, water quality measurements, well construction information, borehole log construction (lithological and geophysical), groundwater monitoring station locations, and geophysical/lithological data collection from non-DWR well sites.

The Monitoring Well Network 2023 Annual Report summarizes activities performed or associated with the MWN during the July 1, 2022 through June 30, 2023 fiscal year (FY2023). These activities include, but are not limited to, the following items:

- MWN groundwater quantity and groundwater quality data statistics;
- Monitoring well installations, both new installations and acquired wells;
- Monitoring well abandonments;
- Monitoring well repairs;
- Monitoring well equipment usage and evaluations; and
- Central Coastal Plain Capacity Use Area FY2023 activities.

2.0 Groundwater Resource

2.1 Overview

Groundwater in the State can be broadly divided into two classes divided by the Fall Line which separates the Piedmont from the Coastal Plain (Figure 1). Groundwater to the west of the Fall Line occurs in the bedrock aquifers of the Blue Ridge and Piedmont regions. Groundwater to the east of the Fall Line occurs in a series of distinct hydrogeological units that thicken from west to east.

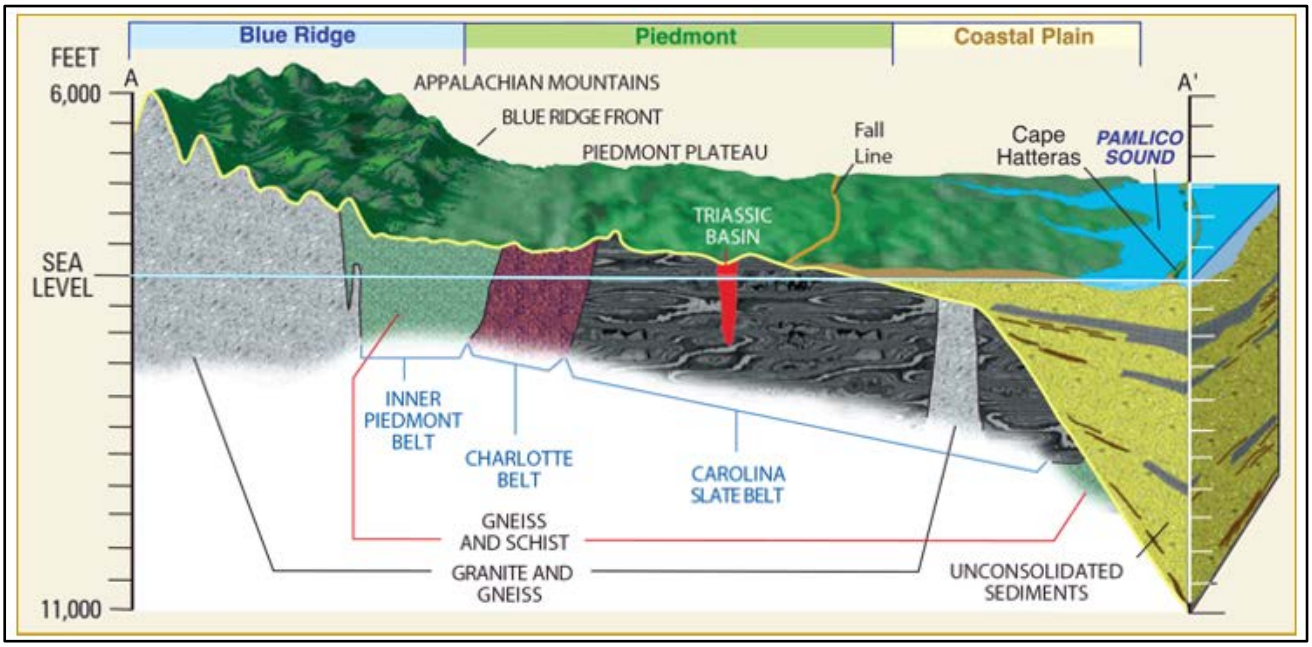


Figure 1. Diagrammatic Cross-Section of North Carolina. Modified from "Map if North Carolina and Diagrammatic Geologic Section of North Carolina." U.S. Geological Survey, pubs.usgs.gov/fs/FS-033-96/. Accessed 27 July 2023.

2.2 Blue Ridge and Piedmont Aquifer System

The Blue Ridge and Piedmont aquifers are part of a complex regolith-fractured bedrock system that underlies approximately 2/3 of the State. Historically, groundwater has not been a source for large water supply needs, and its primary use is domestic supply. Drought and surface water withdrawals have placed increasing demand on groundwater supplies in this region.

2.3 Coastal Plain Aquifer System

The Coastal Plain Aquifer System of the State is composed of a series of sediment layers deposited over crystalline bedrock, forming a wedge that begins at the Fall Line and thickens eastward. Deposits of highly transmissive sand, gravel, and limestone are commonly separated by poorly transmissive units of clay, resulting in a sequence of distinct hydrogeologic units or aquifers (Figure 2). Groundwater provides the base flow to coastal plain streams and serves as an important source of fresh water for public supply, agriculture, and industry. The aquifers of the Coastal Plain are highly productive and are available in sufficient amounts to provide adequate water supplies for most municipal, industrial, agricultural, and domestic issues. Groundwater pumping issues have arisen in multiple areas. Groundwater pumping lowers water levels in the aquifer which can divert base flow from surface water, cause the aquifer skeleton to collapse (land subsidence), or lead to saltwater intrusion of the aquifers.

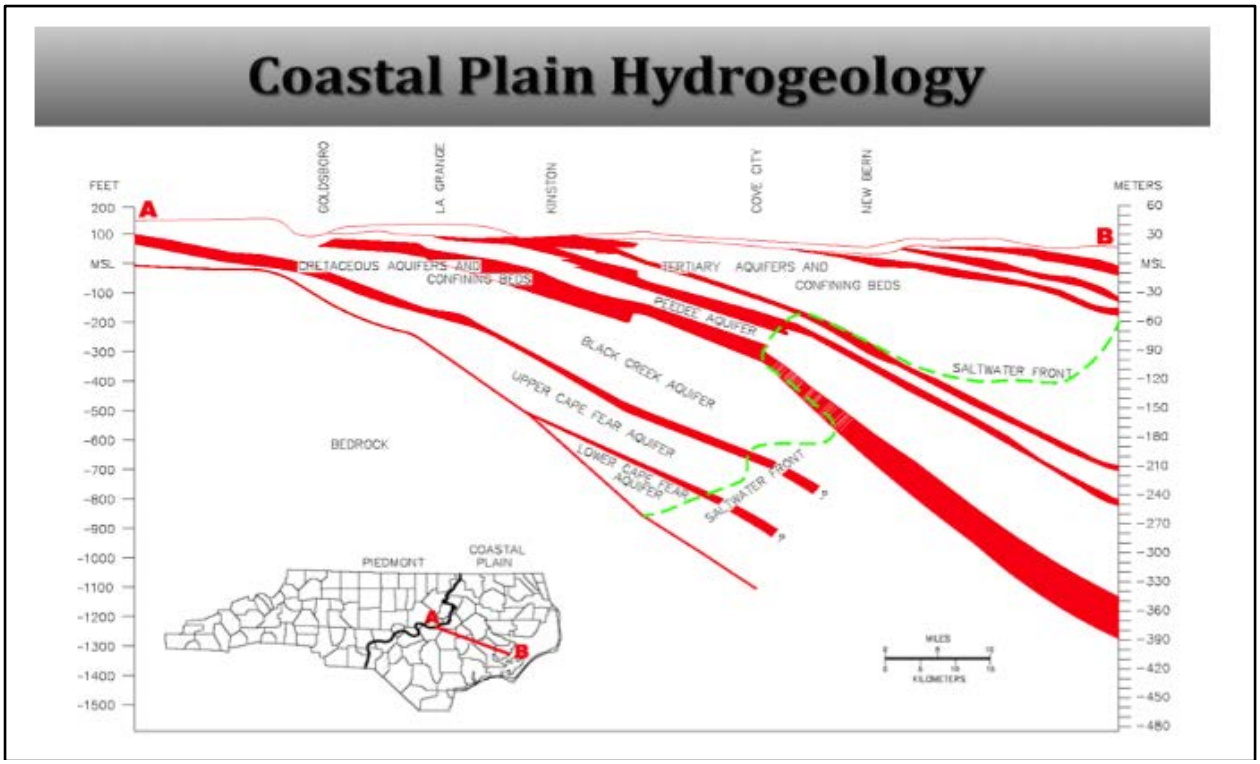


Figure 2. Hydrogeologic section through the central Coastal Plain showing the Cretaceous aquifers and confining beds and the position of the saltwater front. (Adopted from Winner and Coble, 1996, Plate 6)

3.0 Monitoring Well Network

3.1 DWR Statewide Monitoring Well Network

As of June 30, 2023, the MWN included six regions comprised of 699 monitoring wells (Figure 3). There are 235 monitoring stations located in 67 counties. Fifty-six (56) of these wells are located in the Piedmont and Mountain physiographic provinces and 643 wells are located in the Coastal Plain physiographic province. The Coastal Plain relies more heavily on groundwater supplies than either the Piedmont or Mountains.

Consequently, groundwater monitoring and research have been more concentrated in the Coastal Plain. Of the 699 monitoring wells, 656 wells are included in the National Ground-Water Management Network (NGWMN).

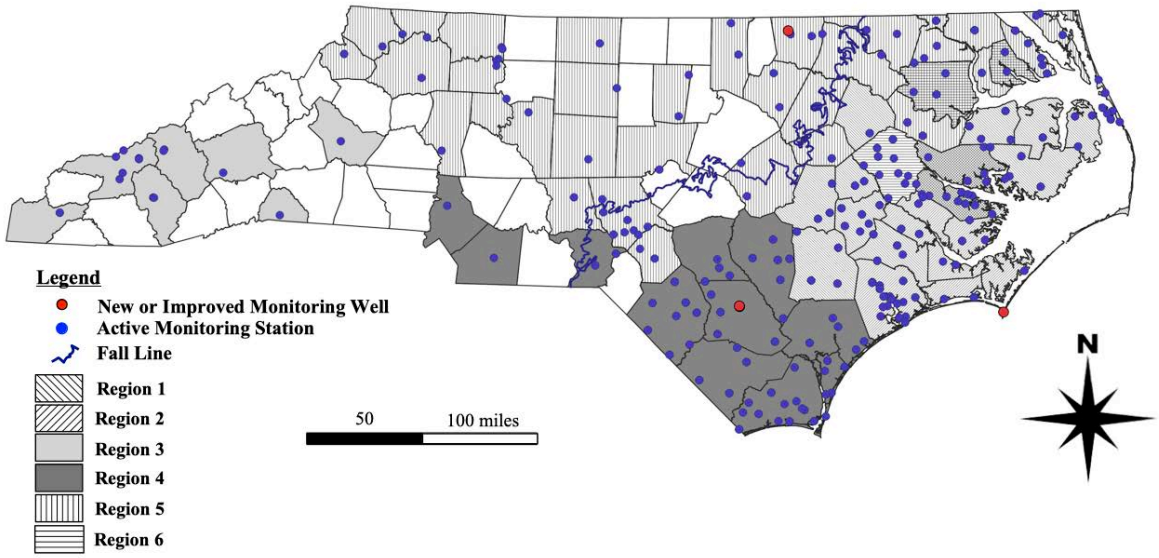


Figure 3. NC Statewide Monitoring Well Network Station and Region Locations FY2023

The United States Geological Survey (USGS) has also contributed to the monitoring of the State's groundwater resources under a cooperative agreement between the State of North Carolina and the Federal government. The USGS cooperative well network consists of 14 monitoring wells, six of which are also part of the DWR statewide network.

Three local cooperative networks whose water level data are currently being uploaded to the DWR database and contribute to both the MWN and the drought indicator well network are the Orange Well Network (OWN) in Orange County, the Guilford County network, and the Western Carolina Hydrological Research Station (WCHRS) in Jackson County. The MWN includes two wells, CC Old Well (Q94I1) and Stillwell Building (Q94J1) from the WCHRS cooperative network.

Of the 235 monitoring stations, 88 are on State or Federal property, 65 are located on property owned by local governments, 80 are located on private property through agreements with landowners, and 2 stations are located on properties where the landowner indicates that the land 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, 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 well sites for potential well abandonment due to land-use issues in the future. This scale is referred to as the Site Susceptibility Rating (Table 1). It is preferred that new wells be installed at sites with a susceptibility rating of 1 or 2.

Table 1. Site Susceptibility Ratings for MWN FY2023			
Susceptibility Rating	**Description**	**# Stations**	**# Wells**
1	Secure: station is located on State or Federal government property	88	249
2	Secure: station is located on local government or school property	65	210
3	Moderately secure: station is located on private property, but landowner does not give any indication that land use or property ownership may change	80	233
4	Tenuous: station is located on public or private property and landowner is giving indications that land use or property ownership may change	2	7
5	Imminent threat: station is on public or private property and landowner desires abandonment of well station.	0	0

3.2 NC Drought Indicator Well Network

The NC Drought Indicator Well Network includes 57 active monitoring wells in the statewide network (Figure 4). Of these, 6 wells are monitored by the USGS for drought conditions, and 51 wells are monitored by the GWMB, 15 of which are equipped with telemetry systems. Table 2 summarizes the NC Drought Indicator Network Wells. More information on the drought statistics can be found on the Drought Management Advisory Council website https://www.ncdrought.org.

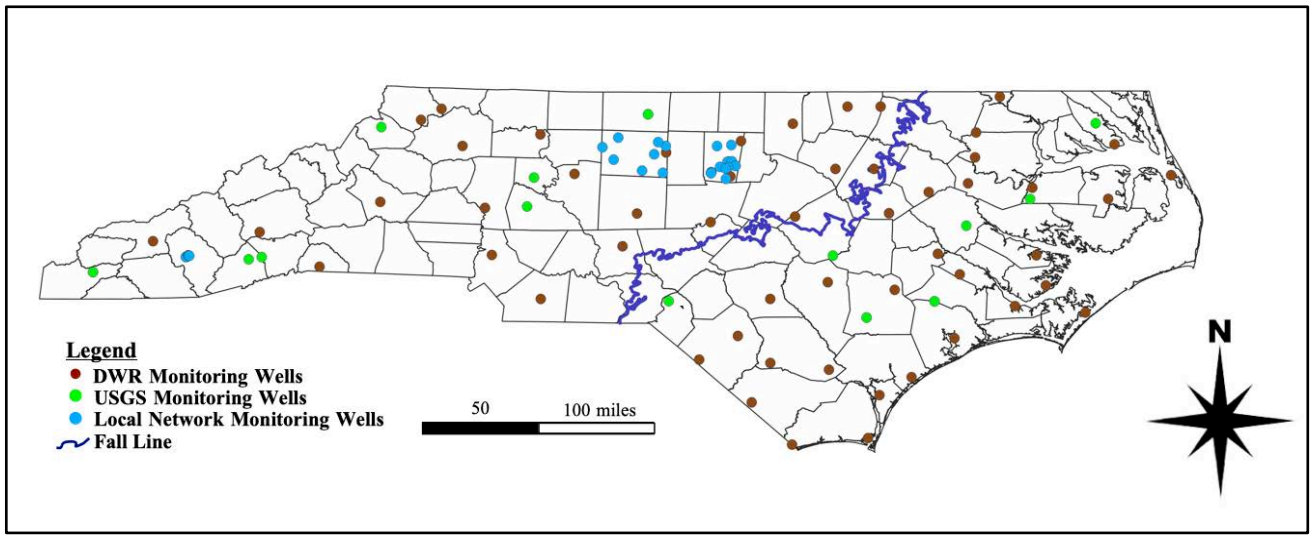


Figure 4. NC Drought Indicator Well Network FY2023

Table 2. NC Drought Indicator Network Wells FY2023			
Station Name	**Well Number**	**Aquifer**	**STS or USGS**
Atlantic	V 12I5	Surficial (S)	
Beaver Creek	D 72Y1	Basement rock (Br)	
Bent Creek	O 87D1	Basement saprolite (Bs)	
Big Flatty Creek	G 9C6	Surficial (S)	
Bladenboro	Z 41U1	Surficial (S)	
Bryson City	O 97W2	Basement rock (Br)	STS
Bunn	I 35K2	Basement rock (Br)	STS
Calabash	HH39J8	Surficial (S)	USGS
Caldwell	F 43X1	Basement rock (Br)	
Caledonia Prison Farm	E 25L3	Surficial (S)	
Cherry Point	U 18Q6	Surficial (S)	
Chi Psi Fraternity (UNC Campus)	J 44D1	Basement saprolite (Bs)	
Clarendon	DD 42N1	Surficial (S)	STS
Cleveland	M 38Q1	Basement rock (Br)	
Columbus	R 82I1	Basement rock (Br)	
Comfort	U26J8	Surficial (S)	USGS
Como	B 20U8	Surficial (S)	STS
Cove City	R 23X5	Surficial (S)	
Densons Creek Park	P 54H1	Basement rock (Br)	
East Bend VFD	F 62J1	Basement rock (Br)	
General Timber	N 46H1	Basement rock (Br)	
Gibsonville	G 50W2	Basement rock (Br)	STS
Glen Alpine	L76G2	Basement rock (Br)	USGS
Godley	Q 16G6	Surficial (S)	
Gold Point	J 22P3	Basement rock (Br)	
Graingers	Q 25D11	Basement saprolite (Bs)	
Gum Neck	L 10A2	Surficial (S)	
Hadnot Point (Camp Lejeune)	X 24S7	Surficial (S)	
Halls	S 35Q5	Surficial (S)	
Hornets Nest Park	Q 66C1	Basement saprolite (Bs)	STS
Kelly	AA 35N1	Surficial (S)	
Laurel Springs	C 71U1	Basement rock (Br)	STS
Lewiston	H 22I3	Surficial (S)	
Littleton	C 30P1	Basement rock (Br)	
Magnolia School	X 44K4	Surficial (S)	
Manteo Airport	I 4W5	Surficial (S)	STS
Monroe	U 62A1	Basement rock (Br)	STS
Nash County Well No. 3 - Nashville	I 31M1	Basement rock (Br)	
NC Zoo	M 53L1	Basement rock (Br)	STS
New Hanover Correctional Institute	CC 31U1	Surficial (S)	
Old Sparta	K 26M3	Surficial (S)	
Oxford	E 38F1	Basement rock (Br)	
Pink Hill	T 29G11	Surficial (S)	
Plymouth	K 17A9	Surficial (S)	

Table 2. NC Drought Indicator Network Wells (Continued)			
Station Name	**Well Number**	**Aquifer**	**STS or USGS**
Rose Hill	V32V9	Surficial (S)	USGS
Roxobel	F 22B7	Surficial (S)	
Seabrook School	U 41A1	Surficial (S)	
Southport	GG 32T6	Surficial (S)	USGS
Stantonsburg	M 30L1	Surficial (S)	
Topsail Beach	BB 28J5	Surficial (S)	STS
Troutman	L 67U2	Basement rock (Br)	STS
Upper Piedmont RS	D 52L1	Basement saprolite (Bs)	USGS
Warren County High School	C 33Y1	Basement saprolite (Bs)	
Welcome	I 58Y2	Basement rock (Br)	
Whortonsville	S 15Y7	Surficial (S)	
Wilkesboro	G 69J1	Basement rock (Br)	STS

3.3 Local Monitoring Well Networks

There are three local cooperative networks whose water level data are currently being uploaded to the DWR database and contribute to both the MWN and the drought indicator well network. The following sections briefly describe each cooperative network.

3.3.1 Orange County Cooperative Well Network

The creation of the Orange County Groundwater Observation Well Network, referred to as Orange Well Net (OWN), was proposed in May 2005. It was decided to utilize existing bedrock wells in lieu of installing new wells for monetary reasons. In March 2010, the OWN included six inactive bedrock wells for groundwater data collection. In 2011, three regolith wells were added to the OWN as a result of a cooperative arrangement. In 2012, two bedrock wells (Ray Road and Rocky Ridge) were removed from the network. These wells were replaced with two bedrock wells (4D in Duke Forest and a well at the former Orange County 911 Center). The wells that were most recently added to the network are the Brumley East well, as the result of an agreement with the Triangle Land Conservancy, and the Duke Forest 4S and 4I wells, with the agreement (informal) of DWR and Duke Forest. Table 3 summarizes the OWN well information. Figure 5 is a map of the OWN well locations.

Table 3. Orange County Cooperative Well Network						
Quad	**Well Name**	**Total Depth (ft bgs)**	**Casing Depth (ft bgs)**	**Land Surface (ft)**	**Aquifer**	**Geology**
G 44G1	Northeast Park NES	45	15	622	Bs	Epiclastics
G 45F1	Eno Confluence Property	192	37	611	Br	Felsic Tuff
H 44P1	Blackwood Farm Bedrock	302	100	556	Br	Felsic Lavas and Tuffs (Dacite)
H 44P2	Former 911 Center	400	85	581	Br	Altered Tuff
H 44P3	Blackwood Farm Regolith	45	15	556	Bs	Felsic Lavas and Tuffs (Dacite)
H 44R1	Brumley East	605	108	562.39	Br	Mafic Lavas and Tuffs
I 44B1	Duke Forest DF-4D	397.09	82.1	424.91	Br	Felsic Plutonics
I 44B2	Duke Forest DF-4S	25	15	428.81	Bs	Felsic Plutonics
I 44B3	Duke Forest DF-4I	41	26	426.77	Br	Felsic Plutonics
I 44F1	Millhouse Road	166	67	517	Br	Epiclastics
I 45G1	Rocky Ridge	Removed from network in 2012				
I 45J1	Eubanks Road	141	33	525		
I 46R1	Andrews Rd. (COL-1)	30	10	514	Bs	Felsic Tuff
I 46R2	Hwy 54 (COL-3)	40.5	25	516	Bs	Epiclastics
I 46W1	Orange Grove Rd (COL-4)	32	17	502	Bs	Epiclastics
J 45J1	Ray Road	Removed from network in 2012				

bgs – below ground surface
** Estimated Elevation

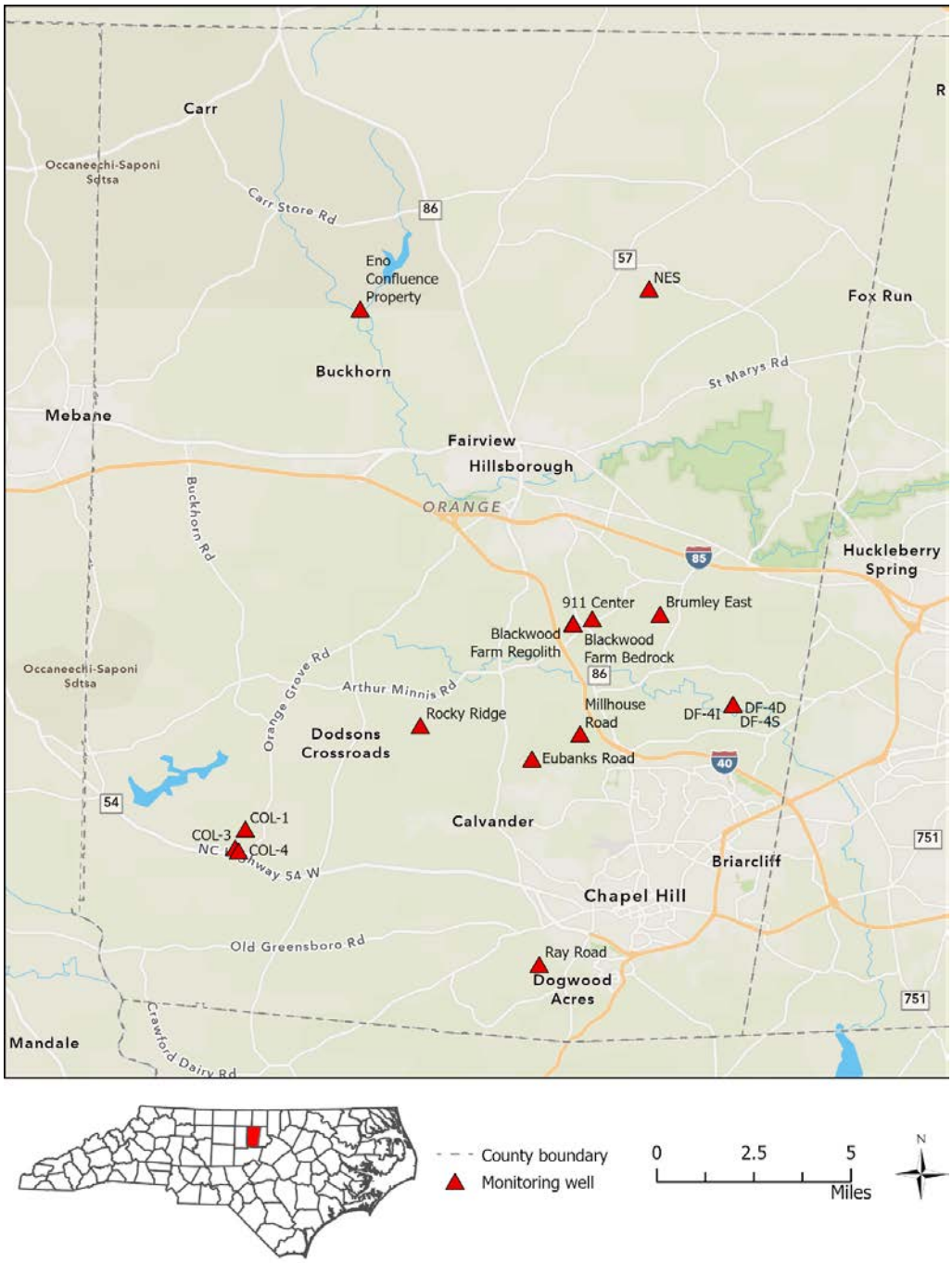


Figure 5. Orange County Cooperative Well Network

3.3.2 Guilford County Cooperative Well Network

The Guilford County groundwater monitoring network was established in 2002 and includes eight monitoring well stations located on public properties owned by Guilford County or the City of Greensboro (Figure 6). Each well site was selected to represent an area of the county and to minimize the influence of any existing water supply wells nearby. In addition, NC A&T State University uses the Knox Road Station for their hydrology class and the students use the data from this station for their course project. Table 4 summarizes the Guilford County Cooperative Well Network.

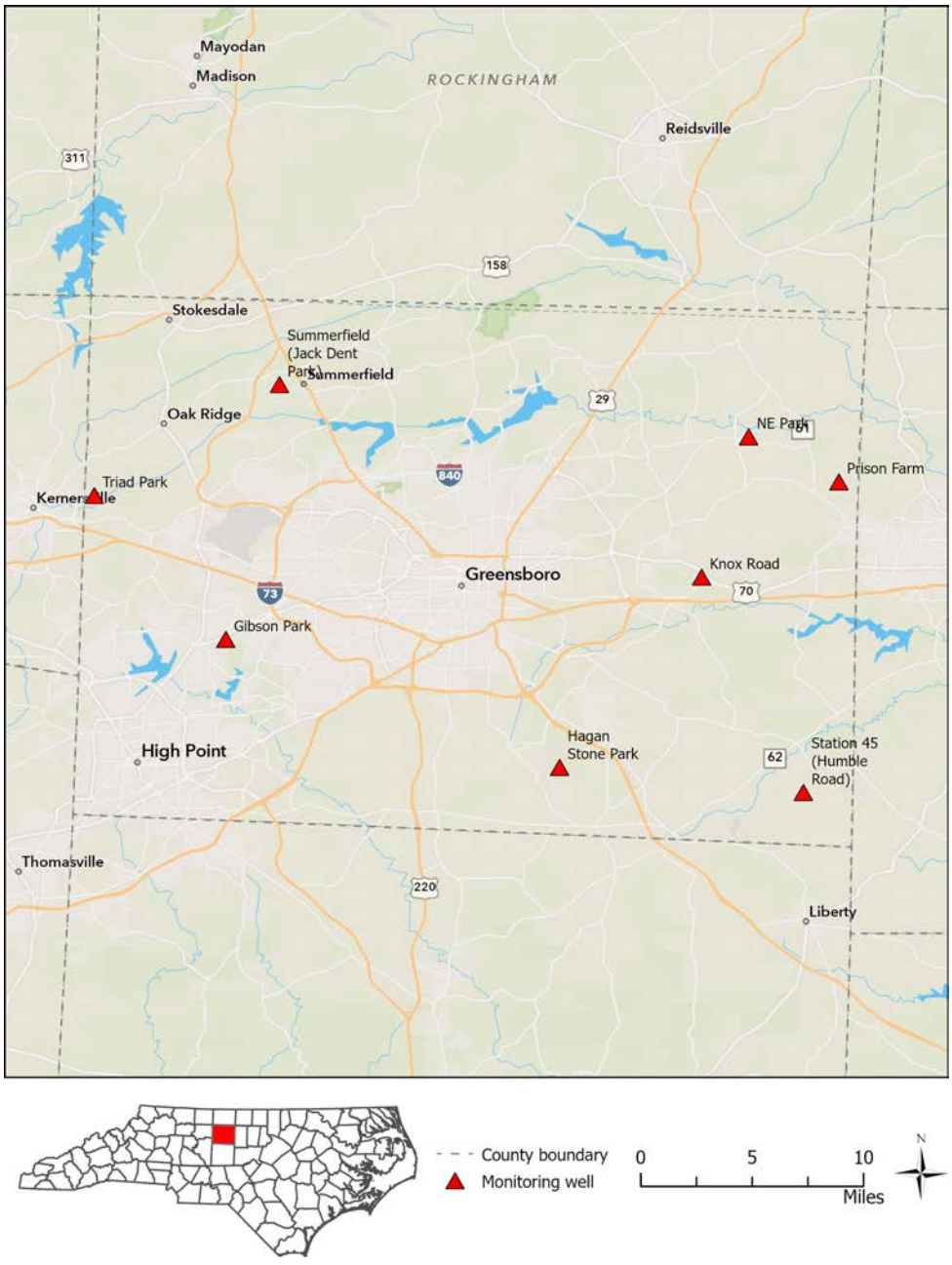


Figure 6. Guilford County Cooperative Well Network

Table 4. Guilford County Cooperative Well Network								
Quad	**Station Name**	**Date Installed**	**Well Diameter (inches)**	**Well Depth (ft)**	**Casing Depth (ft)**	**Land Surface (ft)**	**Aquifer**	**City**
F 54O1	Summerfield (Jack Dent Park)	10/2/02	6.25	103	81	858.5	Br	Summerfield
G 50H1	Prison Farm	5/14/04	6.25	120	45	685	Br	Gibsonville
G 51B1	Northeast Park	6/24/15	6.125	100	77	683	Br	Gibsonville
G 56L1	Triad Park	10/9/02	6.25	140	0	925	Br	Colfax
H 51D1	Knox Road	10/9/02	-	-	39	715	Br	McLeansville
H 55L1	Gibson Park	4/15/03	6.25	205	79	813	Br	Jamestown
I 50P1	Station 45 (Humble Road)	12/15/04	6.25	180	124	679.5	Br	Liberty
I 52N1	Hagan Stone Park	05/17/03	6.125	100	52	755	Br	Pleasant Garden

3.3.3 Western Carolina Hydrological Research Station Cooperative Network

The Western Carolina Hydrological Research Station, (WCHRS), was established in 2010 in a partnership between Western Carolina University (WCU) and DEQ. The WCHRS is comprised of over 40 monitoring wells and is located within the Cullowhee Creek watershed. The well network was designed to study groundwater interaction with streams in a headwaters region typical of the southern Appalachians. The hydrologic station is unique in that is serves four distinct, but mutually supportive roles:

1. hydrologic monitoring and research
2. research-based education for undergraduates
3. real-world training of future hydrology and geoscience professionals
4. incubator for doing and advancing models for course-based undergraduate research experiences.

The WCHRS cooperative well network is comprised of about 40 wells, including two wells acquired by DWR, Stillwell Building Station (Q 94J1) and the CC Old Well Station (Q 94I1), both active wells in the statewide monitoring well network (Figure 7). Table 5 summarizes the WCHRS cooperative network well information. Groundwater data is collected periodically, mostly by students, from the WCHRS. Data from select wells are formatted and uploaded to the DWR groundwater database and is available to the public.

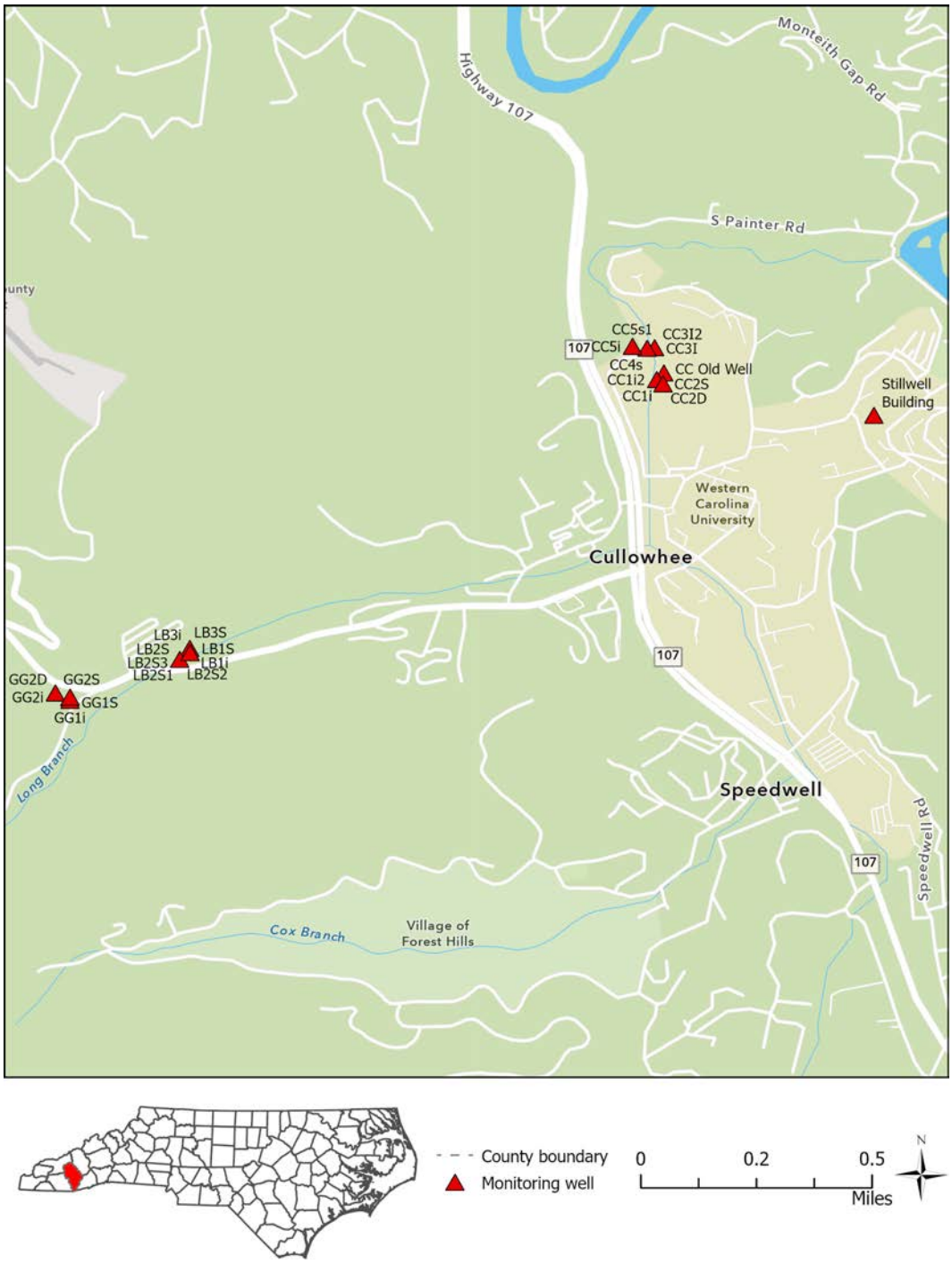


Figure 7. Western Carolina Hydrological research Station Cooperative Well Network

Table 5. Western Carolina Hydrological Research Station Cooperative Well Network									
Quad	**Station Name**	**Date Installed**	**Well Depth (meters)**	**Casing Depth (meters)**	**Screen (meters)**	**MP (meters above land surface)**	**Land Surface (NED Elevation) (meters)**	**Geology**	**Aquifer**
Q 94H1	GG1S	11/30/09	2.41	0.88	0.88-2.4	1.02	682.99	colluvium/saprolite	Bs
Q 94H2	GG1i	11/30/09	4.42	3.81	3.81-4.42	0.99	683.00	Saprolite	Bs
Q 94H3	GG1D	11/30/09	7.56	6.95	6.95-7.56	0.97	682.99	Saprolite	Bs
Q 94H4	GG1D-long	11/30/09	7.25	3.90	3.9-7.25	0.93	682.98	Saprolite	Bs
Q 94H6	GG2i	11/30/09	4.27	3.66	3.66-4.27	0.98	684.23	Saprolite	Bs
Q 94H7	GG2D	11/30/09	6.34	4.82	4.82-6.34	0.97	684.23	Saprolite	Bs
Q 94H8	GG3S	11/30/09	3.11	1.58	1.58-3.1	0.96	682.52	colluvium/saprolite	Bs
Q 94H9	GG3i	11/30/09	4.42	3.81	3.81-4.42	0.96	682.52	Saprolite	Bs
Q 94H10	GG3D	11/30/09	7.62	7.01	7.01-7.62	0.94	682.52	Saprolite	Bs
Q 94H11	GG4S	11/30/09	2.83	1.31	1.31-2.83	0.89	684.39	colluvium/saprolite	Bs
Q 94H12	GG4i	11/30/09	5.18	4.57	4.57-5.18	0.96	684.42	Saprolite	Bs
Q 94H13	GG4D	11/30/09	7.80	7.19	7.19-7.8	1.01	684.42	Saprolite	Bs
Q 94H14	LB3S	11/30/09	2.65	1.13	1.13-2.65	1.02	668.32	colluvium/saprolite	Bs
Q 94H15	LB3i	11/30/09	3.87	3.41	3.41-3.87	1.05	667.82	Saprolite	Bs
Q 94H16	LB3D	11/30/09	5.43	4.82	4.82-5.43	1.05	667.77	Saprolite	Bs
Q 94H17	LB2S	11/30/09	3.66	3.35	3.35-3.65	1.02	672.28	colluvium/saprolite	Bs
Q 94H18	LB2i	11/30/09	3.75	2.23	2.23-3.75	1.03	672.28	Saprolite	Bs
Q 94H19	LB2S1	11/30/09	3.35	1.83	1.83-3.35	1.00	672.42	colluvium/saprolite	Bs
Q 94H20	LB2S2	11/30/09	3.08	1.55	1.55-3.07	1.06	672.28	colluvium/saprolite	Bs
Q 94H21	LB2S3	11/30/09	2.90	1.37	1.37-2.89	1.02	672.18	colluvium/saprolite	Bs
Q 94H22	LB1S	11/30/09	2.47	0.94	0.94-2.46	1.00	667.85	colluvium/saprolite	Bs
Q 94H23	LB1i	11/30/09	3.87	3.26	3.26-3.87	1.00	667.82	Saprolite	Bs
Q 94H24	LB1D	11/30/09	5.67	5.06	5.06-5.67	0.96	667.85	Saprolite	Bs

Table 5. Western Carolina Hydrological Research Station Cooperative Well Network (Continued)									
Quad	**Station Name**	**Date Installed**	**Well Depth (meters)**	**Casing Depth (meters)**	**Screen (meters)**	**MP (meters above land surface)**	**Land Surface (NED Elevation) (meters)**	**Geology**	**Aquifer**
Q 94I2	CC1S	11/30/09	2.53	1.01	1.01-2.53	1.01	634.18	alluvium/saprolite	Bs
Q 94I3	CC1i	11/30/09	3.29	2.99	2.99-3.29	1.05	634.18	Saprolite	Bs
Q 94I4	CC1i2	11/30/09	4.82	4.21	4.21-4.82	0.98	634.20	Saprolite	Bs
Q 94I5	CC1D	11/30/09	5.64	5.33	5.33-5.63	1.02	634.19	Saprolite	Bs
Q 94I6	CC1D2	11/30/09	6.95	6.34	6.34-6.95	1.00	634.21	Saprolite	Bs
Q 94I7	CC2S	11/30/09	2.68	1.16	1.16-2.68	0.98	635.42	alluvium/saprolite	Bs
Q 94I8	CC2i	11/30/09	4.36	3.75	3.75-4.36	0.93	635.43	Saprolite	Bs
Q 94I9	CC2D	11/30/09	6.31	5.70	5.7-6.31	0.99	635.42	Saprolite	Bs
Q 94I10	CC3I2	11/30/09	3.47	3.17	3.17-3.47	1.00	634.11	Saprolite	Bs
Q 94I11	CC3I	11/30/09	3.41	3.11	3.11-3.41	1.00	634.10	Saprolite	Bs
Q 94I12	CC4s	11/30/09	2.29	1.98	1.98-2.28	-0.08	634.60	Saprolite	Bs
Q 94I13	CC4i	11/30/09	4.45	3.84	3.84-4.45	-0.03	634.59	Saprolite	Bs
Q 94I14	CC5s1	11/30/09	2.99	2.68	2.68-2.98	-0.04	635.51	Saprolite	Bs
Q 94I15	CC5s2	11/30/09	4.27	2.74	2.74-4.26	-0.07	635.53	Saprolite	Bs
Q 94I16	CC5i	11/30/09	4.05	3.75	3.75-4.05	-0.04	635.55	Saprolite	Bs
Q 94I17	CC5D	11/30/09	4.85	4.54	4.54-4.84	-0.06	635.51	Saprolite	Bs
Q 94I1	CC Old Well	11/22/04	6.28	0.31	0.31-6.40	0.82	633.84	alluvium/saprolite	Bs
Q 94J1	Stillwell Building	2000	61.26	25.91	25.91-61.27	0.66	656.64	Bedrock	Br

Note: All monitoring wells are located in Jackson County, NC

Research at the WCHRS focuses on four broad questions:

1) How does the interaction of groundwater and stream water vary with their landscape setting?
2) Where and when does recharge of groundwater occur in the watershed?
3) What is the influence of historic land uses and ongoing changes in land cover on water resources and quality?
4) How does the sensitivity of groundwater to climate/weather changes vary in different settings?

Many WCU students use the Research Station for labs and research. Courses such as Hydrogeology, Wetlands, Soils and Hydrology used the DWR database extensively. Outside of classes, students (mostly volunteers) help run the station. Key students this past year were Katherine Davis and Lily Glass. An ongoing research project seeks to determine locations and sources of fecal coliform. Sampling has focused on WCHRS wells and nearby streams.

Mark Lord and David Kinner, Professors of Geology with the Department of Geosciences and Natural Resources, WCU in Cullowhee, NC, the http://wchrs.wcu.edu/ website, and information provided by the DWR database are the sources for the WCHRS information provided herein.

4.0 Groundwater Quantity

4.1 Groundwater Monitoring Overview

Groundwater levels are measured using two different methods. Manual measurements are collected on a quarterly basis (February, May, August, November), or more frequently, using electronic water level indicators. Automated measurements are collected hourly using ONSET Hobo U20 series pressure transducers, or similar equipment, installed in most wells. After Quality Analysis and Quality Control (QA/QC) review, water level data are published on the DWR website https://www.ncwater.org/GWMB. Due to the large volume of water level data collected, a 0600 AM daily groundwater level measurement is published for public access in lieu of all hourly data. Hourly data is available upon request for specific wells.

At the end of FY2023, there were 591 Hobo data loggers collecting hourly water levels and 230 Hobo data loggers collecting barometric data installed on the MWN. Due to the large number of Hobo data loggers deployed on the DWR MWN, there are, at any given time, a number of units being serviced or replaced. These units are not reflected in the aforementioned totals.

One staff member is responsible for each region. Tasks include, but are not limited to:

- Collecting quarterly water level quantity data;
- Maintaining, downloading, and replacing data loggers and telemetry equipment;
- Collecting water level data from drought wells monthly, if needed;
- Performing routine site maintenance;
- Keeping sites accessible and aesthetically pleasing;
- Collecting chloride samples every two to three years;
- Installing monuments;
- Conducting site leveling and surveying; and
- Video logging wells (conducted on an as needed basis).

By plotting continuous water level data versus time on a hydrograph, groundwater level fluctuations and trends can be observed in unconfined water table aquifers and underlying confined aquifers. These observations range in duration from multi-year trends to instantaneous events and include:

- Local and regional decline from over pumping (years to decades);
- Rebound from managed groundwater use (years to decades);
- Seasonal recharge and discharge from the hydrologic cycle (annual);
- Rise from precipitation, hurricanes, and flood events (days to months);
- Decline from drought (days to months);
- Tidal-like fluctuation from lunar gravity (daily); and
- Response to earthquakes and other seismic events (seconds to days).

Solinst Telemetry System (STS) data logger units were previously installed in sixteen wells that are included in the Drought Indicator Well Network. They are used to collect and send real-time data. The STS units consist of one pressure transducer, one barometer (corrects for air pressure), and are powered by a twelve-volt battery. Data is collected by a controller unit that stores hourly readings. The readings are sent to the home station (DWR web page server) every reporting interval (currently 3 hours) via a cell phone modem. DWR uses the STS system on the Drought Indicator Well Network to take the place of monthly visits. They are serviced every quarter or semi-annually depending on battery life. The STS data is especially helpful in keeping the Drought Indicator Well Network water levels up to date https://www.ncwater.org/droughtwells.

The majority of STS sites were upgraded from March through May 2023. Solinst STS Edge hardware replaced the old Solinst STS Gold systems. The upgrades included new controllers and transducers, as well as wiring.

Table 6 summarizes STS system information. Fourteen of the STS data logger units did not collect data due to equipment failure at some point in the FY2023. Lewiston, (H22I3), was removed from the STS network due to lack of 4G wireless availability in the area. Table 7 summarizes the site and data logger distribution by region.

Table 6. Solinst Telemetry System Distribution by Region

Region	Station Name	Well Number	Date Installed	Date Upgraded
6	Bryson City	O97W2	02/18/2014	FY2024 Upgrade
5	Bunn	I58K2	10/20/2016	01/08/2023
4	Clarendon	DD42N1	04/24/2014	04/17/2023
6	Columbus	R82I1	02/19/2014	04/10/2023
5	Como	B20U8	10/14/2014	03/16/2023
5	Gibsonville	G50W2	09/26/2016	04/05/2023
4	Hornets Nest	Q66C1	10/07/2014	04/10/2023
5	Laurel Springs	C71U1	06/20/2013	04/04/2023
5	Lewiston	H22I3	06/04/2014	FY2023 Removed
1	Manteo	I4W5	06/04/2014	FY2024 upgrade
4	Monroe	U62A1	07/02/2014	03/27/2023
5	NC Zoo	M53L1	06/19/2014	03/30/2023
4	Rowland	Z47R5	04/24/2014	04/12/2023
4	Topsail Beach	BB28J5	06/12/2014	04/19/2023
5	Troutman	L67U2	08/27/2014	04/12/2023
5	Wilkesboro	G69J2	11/22/2016	04/04/2023

Table 7. Site and Data Logger Distribution by Region FY2023.				
Region	**Parameter**	**Number**	**% of Region**	**% of Network**
	Wells	151		21.6
1	Sites	45		19.1
	Hobo	129	85.4	18.5
	Solinst	1		
	Wells	176		25.2
2	Sites	40		16.9
	Hobo	159	90.3	22.7
	Solinst	0		
	Wells	15		2.1
3	Sites	15		6.4
	Hobo	12	80.0	1.7
	Solinst	2		
	Wells	182		26.0
4	Sites	56		23.7
	Hobo	144	79.1	20.6
	Solinst	5		
	Wells	126		18.3
5	Sites	67		28.4
	Hobo	113	89.7	16.2
	Solinst	8		
	Wells	49		7.0
6	Sites	13		5.5
	Hobo	48	98.0	6.9
	Solinst	0		
These are counts of the number of wells which have at least one recorder of the stated variety. These numbers do not indicate the total number of recorders deployed. For example, there are always two Solinst recorders on a well and only one is counted per well. In addition, Solinst recorders are always installed on wells with Hobos, so the number of Solinst recorders does not increase the total number of wells with recorders.				

In FY2024, we plan to upgrade the remaining units in addition to adding 4 new telemetry sites to the STS network. The specific sites are waiting to be determined. An energy audit will be conducted to assess the performance of the solar panels which are used to keep the 12 volt batteries charged. Due to the age of the solar panels, (7-10 years old), we plan to replace all site solar panels in FY2024. The energy audit will be used to purchase the correct sized solar panel based on sunlight and tree cover for each well.

4.2 Monitoring Well Network Groundwater Statistics

Depth to groundwater was measured in 705 wells in the FY2023. It is not uncommon for this number to differ from the total number of wells currently in the network (e.g., well abandonment, well removal, etc.). Statistics may vary in comparison to previous years due to additional data entry in the DWR database as older field books are scanned and unrecorded data entered.

Data obtained from DWR and its predecessor agencies, including records dating from the 1960s through 1980s, continue to be recorded into the DWR online database. These data include, but are not limited to, water level data, well construction records, well development information, chloride sampling events, memorandums of agreement, and field notes.

Table 8 summarizes the MWN statistics from January 1, 2005 through June 30, 2023.

Table 8. DWR Monitoring Well Network Statistics (01/01/2005 through 06/30/2023)				
Year	**Number of Monitored Wells**	**Manual Water Levels (Tapedowns)**	**Daily Water Levels (Data Loggers)**	**Total Hourly Water Levels**
2005	537	2,606	89,088	2,141,368
2006	538	2,719	92,038	2,229,355
2007	550	2,599	93,145	2,294,909
2008	559	2,463	105,708	2,593,630
2009	568	2,556	120,694	2,961,371
2010	579	2,906	131,317	3,163,188
2011	591	2,624	136,208	3,276,496
2012	605	2,953	150,912	3,622,891
2013	626	3,265	172,111	4,128,993
2014	637	2,703	176,111	4,225,684
2015	651	3,140	182,907	4,389,822
2016	655	2,996	189,302	4,542,068
2017	667	3,477	186,558	4,447,347
2018	671	3,890	192,646	4,618,783
2019	702	4,085	200,395	4,712,493
2020	705	3,662	211,823	4,995,091
2021	708	4,211	214,121	5,037,298
2022	713	3,835	216,906	5,113,309
2023	705	1,859	109,685	2,587,922

A water level data plot (Figure 8) compares the number of wells monitored to the water level data collected from the network from 1967 through FY2023. Hourly water level data is not included in this graph. Calendar year 2022 represents the most water level data collected in any single year since starting the monitoring well network operation. The FY2023 data was collected from January 1 through June 30, 2023.

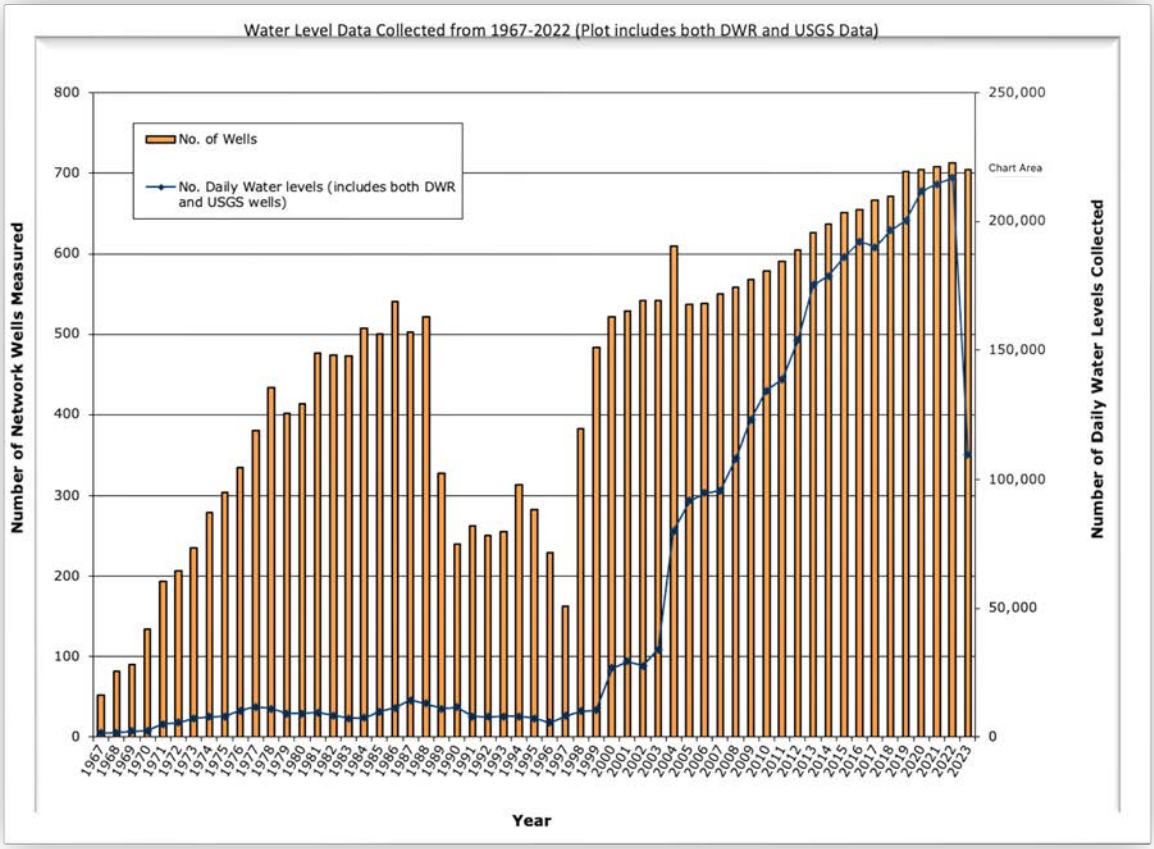


Figure 8. Water Level Data Plot FY2023

4.3 Local Cooperative Network Groundwater Monitoring Statistics

4.3.1 Orange County Well Network Statistics

Groundwater data is collected periodically from the OWN. This data is collected to assess groundwater availability and concerns locally in Orange County. The data is formatted and uploaded to the DWR groundwater database and is available to the public. Table 9 is a summary of the OWN statistics from March 2010 through June 30, 2023. The 2011, 2012, and 2013 OWN Annual Reports are available on the DWR website. Wesley Poole (Water Resources Coordinator for the Orange County Department of Environment, Agriculture, Parks and Recreation), the OWN Annual Reports, and information provided by the DWR database, are the sources for the Orange County Monitoring Well Network information provided herein.

Table 9. Orange Well Network Statistics (2008 through 06/30/2023)			
Year	**Manual Water Levels (Tapedowns)**	**Daily Water Levels (Data Loggers)**	**Total Hourly Water Levels**
2008	3	-	-
2009	18	-	-
2010	49	1,612	38,802
2011	68	2,783	66,689
2012	59	3,095	74,065
2013	54	3,281	78,636
2014	52	3,468	83,090
2015	75	4,286	102,643
2016	71	5,096	121,985
2017	80	4,865	116,515
2018	65	4,744	113,565
2019	54	4,721	114,948
2020	72	4,616	109,219
2021	91	4,617	110,816
2022	65	4,676	112,212
2023	39	2,353	56,459

4.3.2 Guilford County Well Network Statistics

Water levels are collected manually on the same day of each month. Hourly data is collected using Global Water WL16 submersible transducers and are downloaded at the time of manual collection of depth to groundwater levels. The data is formatted and uploaded to the DWR groundwater database which is available to the public.

Table 10 summarizes the Guilford County monitoring well statistics from 2008 through June 30, 2023. . Gene Mao (Guilford County Department of Health and Human Services, Division of Environmental Health, Health, Environment, & Risk Assessment Unit), and information obtained from the DWR database, are the sources for the Guilford County Monitoring Well Network information provided herein.

Table 10. Guilford County Well Network Statistics (2008 through 06/30/2023)			
Year	**Manual Water Levels (Tapedowns)**	**Daily Water Levels (Data Loggers)**	**Total Hourly Water Levels**
2005	-	2,106	-
2006	28	1,884	-
2007	14	1,922	-
2008	28	1,892	-
2009	35	2,000	-
2010	77	2,592	3
2011	77	2,561	-
2012	56	2,474	-
2013	63	2,585	-
2014	49	2,562	-
2015	69	2,592	36,415
2016	71	941	22,636
2017	72	432	10,379
2018	55	134	3,216
2019	79	1,258	37,281
2020	62	2,572	62,634
2021	65	2,571	62,963
2022	70	2,545	62,811
2023	24	1,156	28,730

4.3.3 Western Carolina Hydrological Research Station Well Network Statistics

Groundwater data is collected periodically, mostly by students, from the WCHRS. Data from select wells are formatted and uploaded to the DWR groundwater database and is available to the public. Table 11 is a summary of the WCHRS statistics from 2011 through June 30, 2023.

Table 11. WCHRS Network Statistics (2011 through 06/30/023)	
Year	**Manual Water Levels (Tapedowns)**
2011	619
2012	1,628
2013	1,728
2014	1,199
2015	1,181
2016	1,547
2017	1,760
2018	1,352
2019	428
2020	464
2021	346
2022	467
2023	551

5.0 Groundwater Quality

5.1 Chloride Sampling Events

During a chloride sampling event, groundwater is analyzed using Quantab® chloride test strips and field parameters for conductivity, salinity, temperature, and pH are measured using a YSI ProDSS meter, or similar instrument. The purpose of the chloride sampling is to monitor salinity levels and trends at the freshwater-saltwater interface within each of the major coastal plain aquifers. Salinity levels and the location of the interface can change as a result of sea level rise, storm surges during hurricanes, groundwater pumping, and mine-dewatering. Chloride levels are used to determine if groundwater is fresh, less than 250 parts per million (ppm) chloride, or salty which is greater than or equal to 250 ppm chloride. Chloride sampling is used to identify the transition zone between the fresh and salty zones within the aquifer. This transition zone is characterized by a vertical salinity gradient within the aquifer in which salinity increases with depth, from fresh to salty (Figure 9).

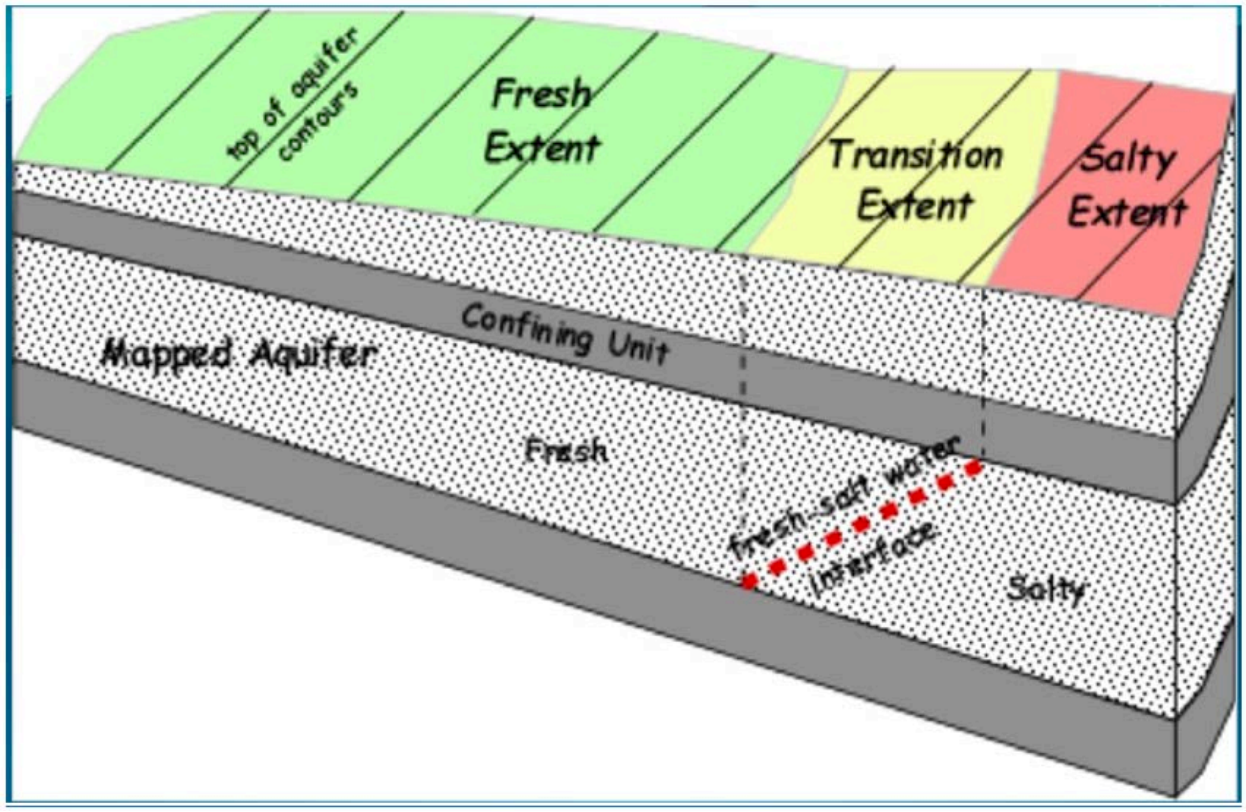
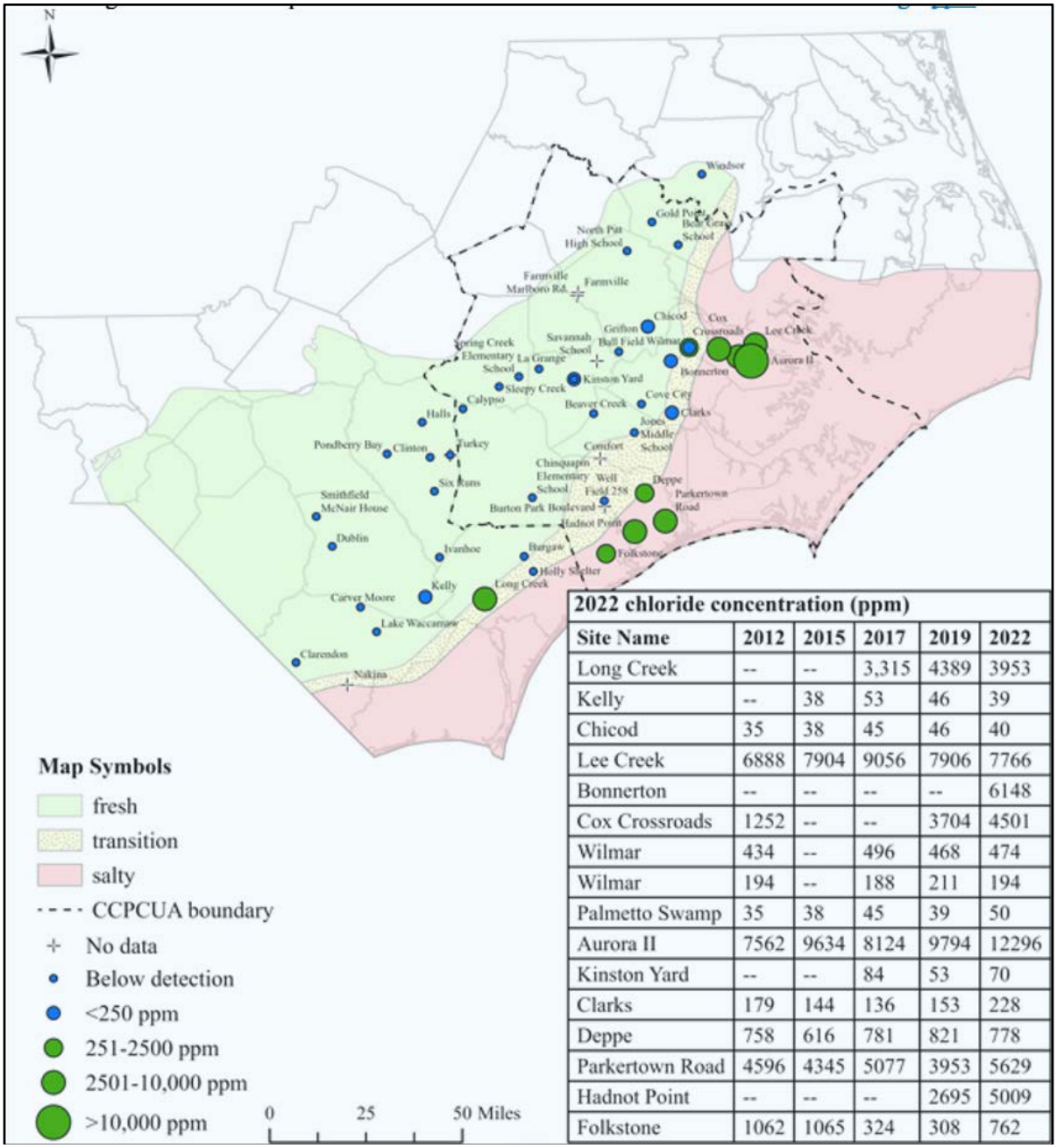


Figure 9. Transition Zone

The 2022 chloride sampling event was conducted from March 15 through May 15, 2022. Samples were collected at 413 wells in the MWN to identify salinity zones and chloride results for three of the state's major Cretaceous aquifers: the Black Creek Aquifer (Kbc) Figure 10; the Upper Cape Fear Aquifer (Kucf) Figure 11; and the Lower Cape Fear Aquifer (Klcf) Figure 12. Included in the figures are analytical results from chloride sampling events in 2012, 2015, 2017, 2019, and 2022 for wells that detected chlorides. The number of samples in 2022 collected from the Black Creek, Upper Cape Fear, and Lower Cape Fear aquifers were 48, 45, and 23, respectively.

Figure 10 shows chloride sample results for selected Black Creek aquifer wells located along the aquifer's freshwater-saltwater interface. For 2022, chloride levels range from below detection limits to as high as 12,296 ppm. Between 2019 and 2022, salinity increases were observed at Aurora II, Clarks, Cox Crossroads, Folkstone, Hadnot Point, Palmetto Swamp, Parkertown Road, and Wilmar (P21K5) stations. During this same period, decreases in salinity were observed at Bear Grass School, Chicod, Deppe, Kelly, Lee Creek, Long Creek, and Wilmar (P21K9) stations. Notable fluctuations in chloride levels have occurred over the years at the Lee Creek and Aurora II wells, both of which are located near open-pit mines where large-scale pumping and dewatering contribute to frequent fluctuation in chloride levels. Ten wells exceeded 250 ppm.

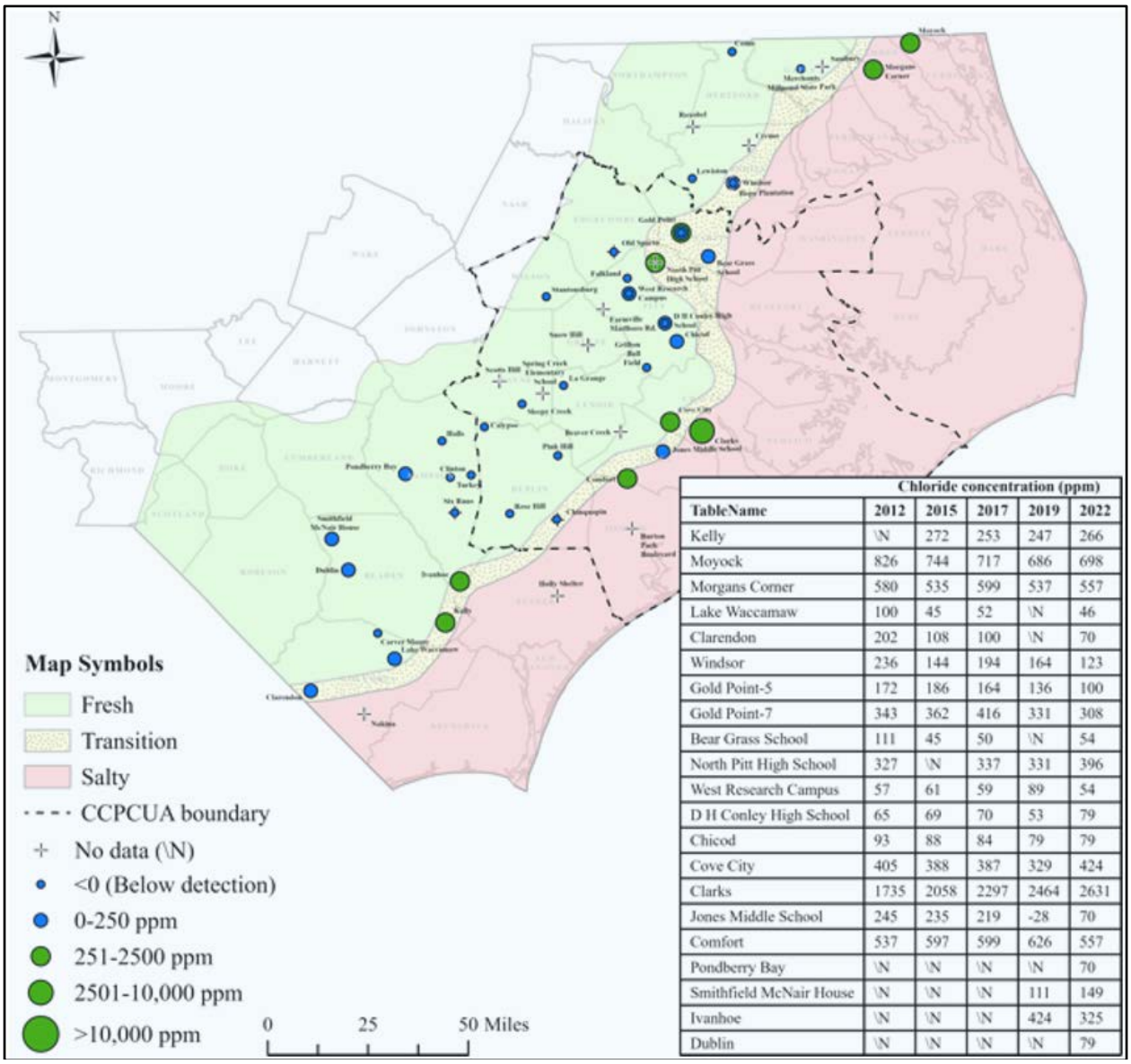


2022 chloride concentration (ppm)

Site Name	2012	2015	2017	2019	2022
Long Creek	--	--	3,315	4389	3953
Kelly	--	38	53	46	39
Chicod	35	38	45	46	40
Lee Creek	6888	7904	9056	7906	7766
Bonnerton	--	--	--	--	6148
Cox Crossroads	1252	--	--	3704	4501
Wilmar	434	--	496	468	474
Wilmar	194	--	188	211	194
Palmetto Swamp	35	38	45	39	50
Aurora II	7562	9634	8124	9794	12296
Kinston Yard	--	--	84	53	70
Clarks	179	144	136	153	228
Deppe	758	616	781	821	778
Parkertown Road	4596	4345	5077	3953	5629
Hadnot Point	--	--	--	2695	5009
Folkstone	1062	1065	324	308	762

Figure 10. Chloride Levels in Black Creek Aquifer

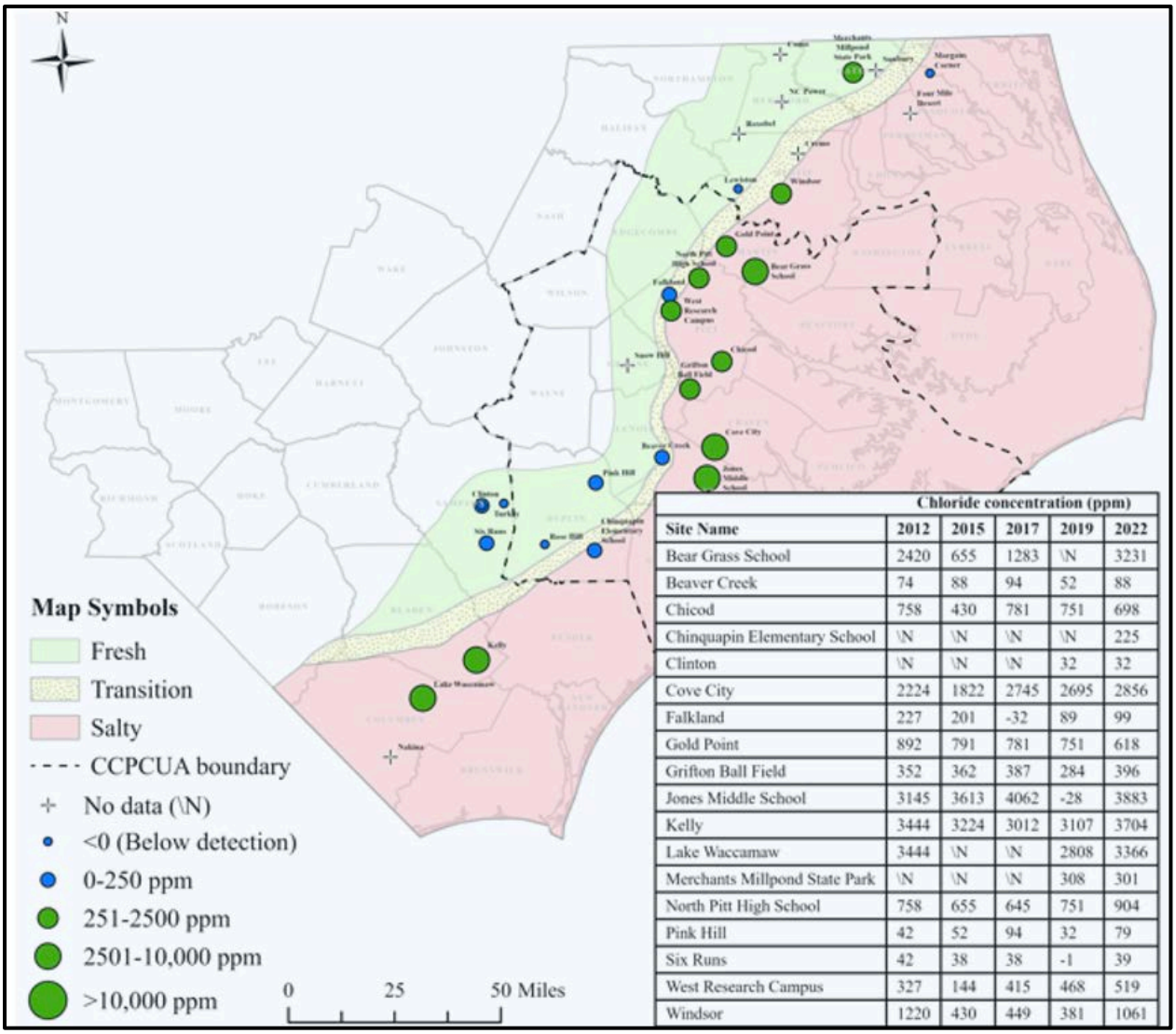
Figure 11 shows chloride sample results for selected Upper Cape Fear aquifer wells located along the aquifer's freshwater-saltwater interface. For 2022, chloride levels range from below detection limits to as high as 2,631 ppm. Between 2019 and 2022, salinity increases were observed at Bear Grass School, Chicod, Clarks, Cove City, DH Conley High School, Jones Middle School, Kelly, Moyock, Morgans Corner, and North Pitt High School monitoring stations. During the same period, decreases in salinity were observed at Comfort, Gold Point, Ivanhoe, LaGrange, Merchants Millpond, West Research Campus, and Windsor monitoring stations. Nine wells exceeded 250 ppm.



	Chloride concentration (ppm)				
TableName	2012	2015	2017	2019	2022
Kelly	\N	272	253	247	266
Moyock	826	744	717	686	698
Morgans Corner	580	535	599	537	557
Lake Waccamaw	100	45	52	\N	46
Clarendon	202	108	100	\N	70
Windsor	236	144	194	164	123
Gold Point-5	172	186	164	136	100
Gold Point-7	343	362	416	331	308
Bear Grass School	111	45	50	\N	54
North Pitt High School	327	\N	337	331	396
West Research Campus	57	61	59	89	54
D H Conley High School	65	69	70	53	79
Chicod	93	88	84	79	79
Cove City	405	388	387	329	424
Clarks	1735	2058	2297	2464	2631
Jones Middle School	245	235	219	-28	70
Comfort	537	597	599	626	557
Pondberry Bay	\N	\N	\N	\N	70
Smithfield McNair House	\N	\N	\N	111	149
Ivanhoe	\N	\N	\N	424	325
Dublin	\N	\N	\N	\N	79

Figure 11. Chloride Levels in Upper Cape Fear Aquifer

Figure 12 shows chloride sample results for selected Lower Cape Fear aquifer wells located along the aquifer's freshwater-saltwater interface. For 2022, chloride levels range from below detection limits to as high as 3,883 ppm. Between 2019 and 2022, salinity increases were observed at Beaver Creek, Cove City, Falkland, Grifton Ball Field, Jones Middle School, Kelly, Lake Waccamaw, North Pitt High School, Pink Hill, Six Runs, West Research Campus, and Windsor monitoring stations. During the same period, decreases in salinity were observed at Chicod, Gold Point, and Merchants Millpond State Park monitoring stations. Twelve wells exceeded 250 ppm.



	Chloride concentration (ppm)				
Site Name	**2012**	**2015**	**2017**	**2019**	**2022**
Bear Grass School	2420	655	1283	\N	3231
Beaver Creek	74	88	94	52	88
Chicod	758	430	781	751	698
Chinquapin Elementary School	\N	\N	\N	\N	225
Clinton	\N	\N	\N	32	32
Cove City	2224	1822	2745	2695	2856
Falkland	227	201	-32	89	99
Gold Point	892	791	781	751	618
Grifton Ball Field	352	362	387	284	396
Jones Middle School	3145	3613	4062	-28	3883
Kelly	3444	3224	3012	3107	3704
Lake Waccamaw	3444	\N	\N	2808	3366
Merchants Millpond State Park	\N	\N	\N	308	301
North Pitt High School	758	655	645	751	904
Pink Hill	42	52	94	32	79
Six Runs	42	38	38	-1	39
West Research Campus	327	144	415	468	519
Windsor	1220	430	449	381	1061

Figure 12. Chloride Levels in Lower Cape Fear Aquifer

Figure 13 illustrates the freshwater, transition, and salty zones for the 7 major NC Coastal Plain aquifers.

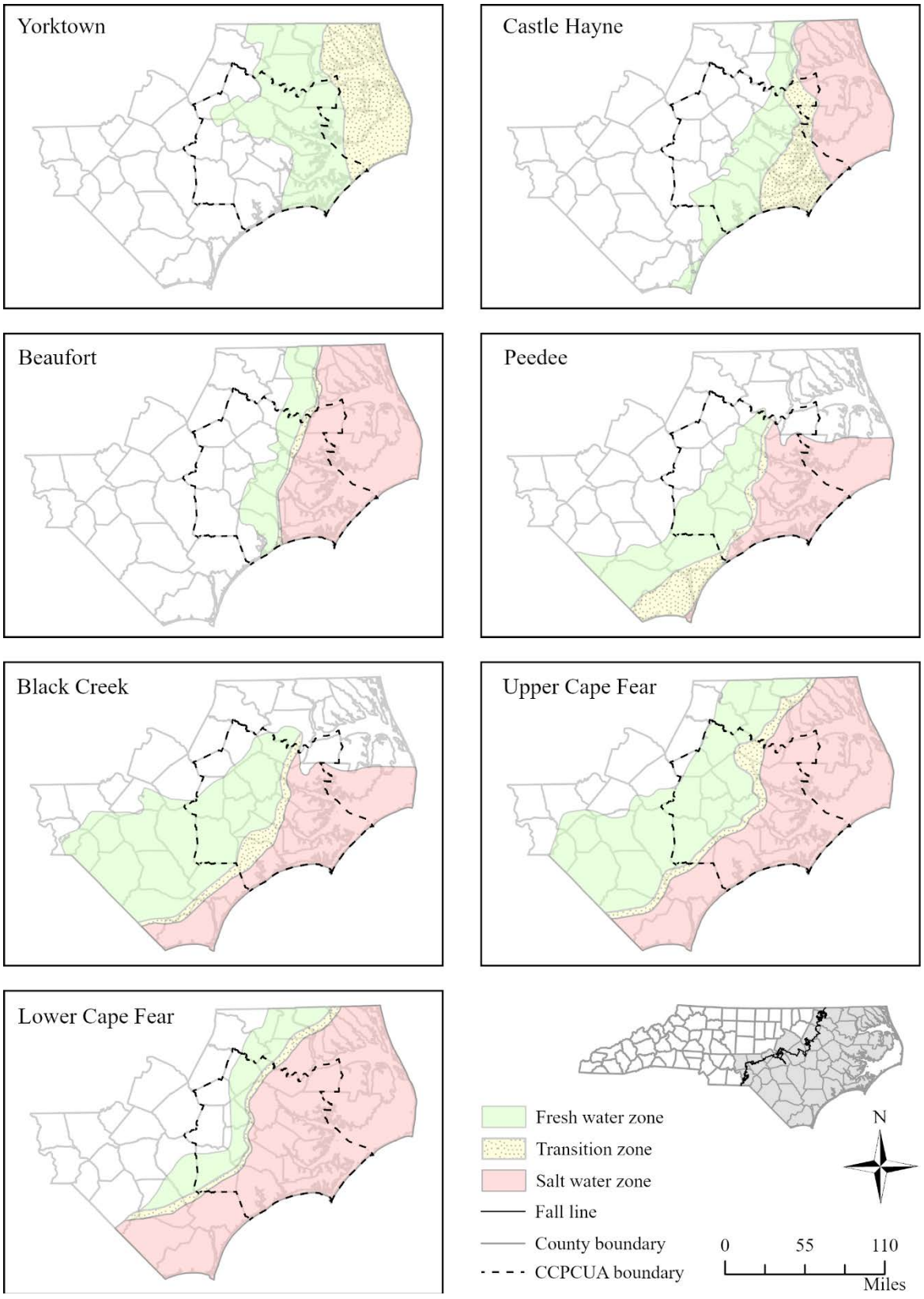


*Figure 13. Freshwater, Transition, and Salty Zones for Seven Major Coastal Plain Aquif*ers

5.2 Groundwater Quality Sampling Events

The DWR's groundwater monitoring program advances the DWR mission by improving DWR's knowledge in the following areas:

1. Impacts of land-applied wastes, artificial infiltration practices, or other human activities, including:
   - Potential impacts of these activities on the surficial aquifer and the secondary impacts to the deeper aquifers or surface waters;
   - The occurrence of "emerging contaminants" related to these activities; and
   - Effectiveness of regulations and permits for these activities.
2. Threats to groundwater quality, including:
   - The existence, nature, and scope of emerging or existing threats;
   - Assessment of the causes and factors affecting naturally occurring contamination, agricultural contamination, or contamination resulting from activities permitted by DWR; and
   - Tracking the status of groundwater quality across the state.

GWMB staff collect groundwater quality data throughout the state. Most of the groundwater quality data being collected is from the MWN. The MWN consists of wells ranging in age from 50+ years to less than a year old. A typical well site in the Coastal Plain may have several wells, each screened in one of the different aquifers at that particular location, while most well sites in the Piedmont and Mountain regions of the state have only one well in the basement rock/saprolite aquifer system.

These wells are, in most cases, located in areas where influence by industry or other land-use practices on groundwater quality is unlikely. This, along with the MWN's broad geographic and geologic coverage, provides prime conditions and an excellent opportunity to conduct a detailed characterization of ambient, or background, groundwater quality from both deep and shallow aquifer systems throughout the state. Currently, a long-term sampling project is underway to collect water quality data from all wells in the network.

Goals of the DWR groundwater quality monitoring program are to:

- Collect chemical data that describes the overall condition of groundwater quality across the state based on the geologic environment, identifying areas where groundwater quality does not meet the 15A NCAC 02L Standards;
- Characterize groundwater quality in the different aquifers present in the NC Coastal Plain using the MWN;
- Monitor water quality trends and characterization of ambient groundwater quality within defined geologic environments;
- Collect samples from all MWN wells initially, then re-sample on a regular basis. Surficial and first confined aquifer wells will be sampled every 1 to 3 years, and deeper aquifer wells will be sampled every 5 to 10 years; and
- Make all GWMB-collected groundwater quality data publicly available for viewing and downloading in a user-friendly mapping application and various other formats.

The State uses comprehensive water quality monitoring and assessment information on environmental conditions and changes over time to support water quality management decisions. This information helps to set levels of protection in water quality standards and to identify problem areas that are emerging or that need additional regulatory and non-regulatory actions. Results from this project yield valuable groundwater quality data throughout the state and inform decision making regarding the relationship of groundwater quality to environmental quality and public health. Data from this project supports multiple programmatic areas such as nutrient management, coal ash management, agricultural influences on

drinking water in the Coastal Plain, groundwater as a source of surface water parameters of concern, and saltwater intrusion. Data is available for viewing and downloading from our groundwater quality webpage or through our groundwater quality mapping interface.

Specific parameters and analytical methods used by the DWR Chemistry Lab for all wells sampled by the DWR/GWMB are provided in Table 12.

Table 12. Specific Parameters and Analytical Methods

Analyte Names	Method Reference
Alkalinity, Bicarbonate, Carbonate	SM 2320 B-1997
Total Organic Carbon (TOC)	SM 5310 B-2000
Turbidity	SM 2130 B-2001
Ammonia (NH_3 as N)	EPA 350.1 REV2
Nitrite (NO_2) + Nitrate (NO_3) as Nitrogen (N)	EPA 353.2 REV 2
Total Phosphorus	EPA 365.1 REV 2
Total Kjeldahl Nitrogen as N (TKN)	EPA 351.2 REV 2
Bromide, Chloride, Fluoride, Sulfate	EPA 300.0 REV 2.1
Silica	SM 4500-SiO2-C-1997
Sulfide	SM 4500-S2-D-2000
Total Dissolved Solids (TDS)	SM 2540 C-1997
Mercury (Hg) 245.1	EPA 245.1 REV 3
Chlorinated Pesticides	EPA 608 / SW8081B
Nitrogen-based Pesticides	EPA 619
Phosphorus-based Pesticides	EPA 641
Semivolatile Organic Compounds (SVOCs)	EPA 625/8270D
Volatile Organic Compounds (VOCs)	EPA 624/8260C
Metals by ICPMS - Silver (Ag), Antimony (Sb), Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Molybdenum (Mo), Nickel (Ni), Lead (Pb), Selenium (Se), Tin (Sn), Strontium (Sr), Thallium (Tl), Zinc (Zn)	EPA 200.8 REV 5.4
Metals by ICP - Aluminum (Al), Boron (B), Barium (Ba), Beryllium (Be), Calcium (Ca), Cobalt (Co), Iron (Fe), Potassium (K), Lithium (Li), Magnesium (Mg), Manganese (Mn), Sodium (Na), Titanium (Ti), Vanadium (V)	EPA 200.7 REV 4.4
Per- and polyfluoroalkyl substances (PFAS)	In-house Isotope Dilution Method (w/ solid phase extraction)

GWMB staff sampled a total of 116 wells located in 44 monitoring station in FY2023. Groundwater Quality Statistics for FY2023 are as follows:

- Forty two (42) sites were sampled for PFAS only;
- One (1) site was sampled for all analytes listed in Table 12;
- Forty three (43) sites were sampled for at least one or more analytes listed in Table 12 plus PFAS; and
- Fifteen (15) sites were resampled for PFAS.

6.0 Well Installation, Abandonment, Repair and Associated Activities

The following sections describe the activities associated with monitoring well installation, abandonment, repair, and other associated activities conducted in the FY2023.

6.1 Monitoring Well Installation

No monitoring wells or monitoring stations were installed in the FY2023.

6.2 Acquired Wells

Three (3) wells were acquired by the MWN in FY2023. Pertinent monitoring well details are included in Table 13.

Table 13. Pertinent Details for Monitoring Wells Acquired in FY2023

Well ID	Station Name/County	Date Constructed	Well Diameter (inches)	Well Depth (ft bls)	Screened Interval (x to y ft bls)	Measuring Point (MP)	Aquifer
Y 14L	Keepers Quarters Well/Carteret	No Record	4	375	Unknown	1.40	Castle Hayne (Tch)
X 38Y2	Turnbull State Forest/Brunswick	11/20/2001	2	269	215-235	-0.27	Black Creek (Kbc)
X 39T6	Turnbull State Forest/Brunswick	01/11/2011	4	27	12-27	2.70	Surficial (S)

6.3 Wells Moved to Inactive Status

Three (3) wells were moved to inactive status in FY2023 and are summarized in Table 14.

Table 14. Wells Moved to Inactive Status FY 2023

Well ID	Station Name/County	Date Inactive	Comment
B 39X2	Wallace Vaughan/Granville	10/24/2022	Open bore well directly connected to pond.
K 40M1	Powell Drive/Wake	April 2023	Property sold. Owner requested we remove hobos.
EE 36K4	Bear Pen/Brunswick	February 2023	Well casing corroded 20+ feet below surface and affecting water levels and hydrographs.

6.4 Well Abandonment

Eleven (11) wells were abandoned in FY2023. Table 15 summarizes the monitoring well abandonment information.

Table 15. Monitoring Well Abandonments FY2023			
Well ID	**Station Name/County**	**Date Abandoned**	**Comment**
V35T4	Six Runs/Sampson	10/11/2022	Poor well construction
V35T5	Six Runs/Sampson	10/11/2022	Poor well construction
R48G1	Southern Pines Water Plant/Moore	02/01/2023	Well integrity compromises during earthwork
R48G2	Southern Pines Water Plan/Moore	02/01/2023	Well integrity compromises during earthwork
P22F6	Calico/Pitt	05/01/2023	Dangerous Location
P22F7	Calico/Pitt	05/01/2023	Dangerous Location
O22V6	Creeping Swamp/Pitt	05/01/2023	Dangerous Location
O22V7	Creeping Swamp/Pitt	05/01/2023	Dangerous Location
O21Q1	Highway 102/Beaufort	05/01/2023	Dangerous Location
O21Q2	Highway 102/Beaufort	05/01/2023	Dangerous Location
O21Q3	Highway 102/Beaufort	05/01/2023	Dangerous Location

6.5 Well Repair

Northside Elementary (C34L1) in Warren County was repaired in FY2023. The casing was extended and a new concrete pad poured. The well was damaged by a fallen tree.

7.0 Additional Tasks Associated with the Monitoring Well Network

7.1 Site Maintenance

Continual maintenance is required to keep monitoring active wells. Maintenance is performed by GWMB staff and includes routine vegetative control, such as mowing, pruning, and sapling removal from around each well in a station. Specific maintenance of all installed MWN equipment is completed as needed. Routine painting of exposed well casing to retard oxidative corrosion and repair of deteriorated well casings is completed as needed.

7.2 Well Development

Periodically, well development is necessary prior to initiating monitoring. Development is typically performed using a submersible pump to remove fine-grained sediments from the vicinity of the well screen to ensure sufficient hydraulic connection with the aquifer. Prior to initiating development, and at thirty-minute to hourly intervals during development, groundwater samples are collected. Groundwater samples are tested for field parameters such as pH, specific conductivity, DO, and temperature using a YSI ProDSS meter, or similar instrument. Field data exhibiting overall consistency are used to assess if well development has been completed prior to monitoring.

7.3 Sites Surveys and Leveling

Accurately measured positioning data of the monitoring wells is crucial for acquiring reliable water level data. To assure this, concrete survey monuments are installed at each of the monitoring stations. Monuments are installed such that the brass top is below ground surface (bgs) so it does not interfere with mowing grass or activities involving equipment that does not need to encounter obstacles above ground. The monuments are approximately three feet long. They are installed using gas-powered augers and /or

hole diggers. Once they are advanced and seated in the ground, they are cemented in place. Subsequent to monument installation, DWR uses the Global Positioning Satellite (GPS) unit to determine the coordinates of the monitoring well station. GPS works by triangulating locations on the earth using satellites. DWR typically attains accuracy within 10 to 15 feet using standard grade GPS units. The Trimble R10/Trimble R12 survey grade GPS units allow DWR to collect location data within 0.0328 feet horizontally and within 0.0833 feet vertically. Leveling between the site monument and the individual wells using a laser level maintains a high level of accuracy.

7.4 Video Logging

Prior to adding or acquiring an existing well to the MWN, GWMB staff typically video log the well to assess well construction and source of groundwater. The GWMB's downhole video camera can capture real time video images of the well at depths exceeding one thousand feet. This tool has proven itself to be invaluable in assisting with well maintenance and rehabilitation. Blockages and extraneous items staff occasionally finds in wells include, but are not limited to, logs, sticks, leaves and other organic debris, dead animals, rocks, pens and pencils. The ability to visually assess casing collapses, clogged screens, and collapsed holes in bedrock allow staff the opportunity of repairing damaged wells in lieu of replacement, placing the well in inactive status, or well abandonment.

8.0 Central Coastal Plain Capacity Use Area

8.1 Groundwater Withdrawal Permitting Program

The DEQ is authorized under North Carolina Statute §143-215.13 to regulate ground and/or surface water withdrawals. A water withdrawal permit program was established in 2002 to promote sustainable groundwater use in the Central Coastal Plain. The DWR uses water level data to evaluate groundwater recovery in the permit region and to document any notable changes in non-permitted areas. Effective March 2007, administrative rule Title 15A North Carolina Administrative Code, Subchapter 2E, Section .0600 (15A NCAC 02E.0600), also require all groundwater users in the state who withdraw more than 100,000 gallons per day (gpd), (1,000,000 gpd for agricultural users) to register with the DWR/GWMB and report the water use annually.

8.2 Central Coastal Plain Capacity Use Area Permit Program

The Central Coastal Plain Capacity Use Area (CCPCUA) has established groundwater withdrawal limits for fifteen counties in the coastal plain due to unsustainable groundwater overuse. The 15 counties in the CCPCUA are Beaufort, Carteret, Craven, Duplin, Edgecombe, Greene, Jones, Lenoir, Martin, Onslow, Pamlico, Pitt, Washington, Wayne, and Wilson.

On August 1, 2002, the Environmental Management Commission granted the DWR additional authority to establish withdrawal limits in the CCPCUA. These limits were established to address severely declining water levels, including dewatering in some aquifers, and salt-water encroachment. "The intent is to protect the long-term productivity of aquifers within the designated area and to allow the use of groundwater for uses at rates which do not exceed to threaten to exceed the recharge rate of the aquifers…," (15A NCAC 2E .0501). in accordance with this rule, a valid CCPCUA permit is required for all groundwater users in the 15 CCPCUA counties wishing to withdraw more than 100,000 gpd. Groundwater users who withdraw 10,000-100,000 gpd are required to register and report their groundwater use. Surface water users must register and report their water use if the water withdrawals are more than 100,000 gpd. For many years, water was withdrawn from the deep confined aquifers, which are a primary source of water in the CCPCUA, at a rate that was greater than they were naturally recharged.

If this situation had been allowed to continue indefinitely, the aquifers could have been permanently damaged, impairing their ability to function as a water supply. Figure 14 illustrates the CCPCUA delineated by zone.

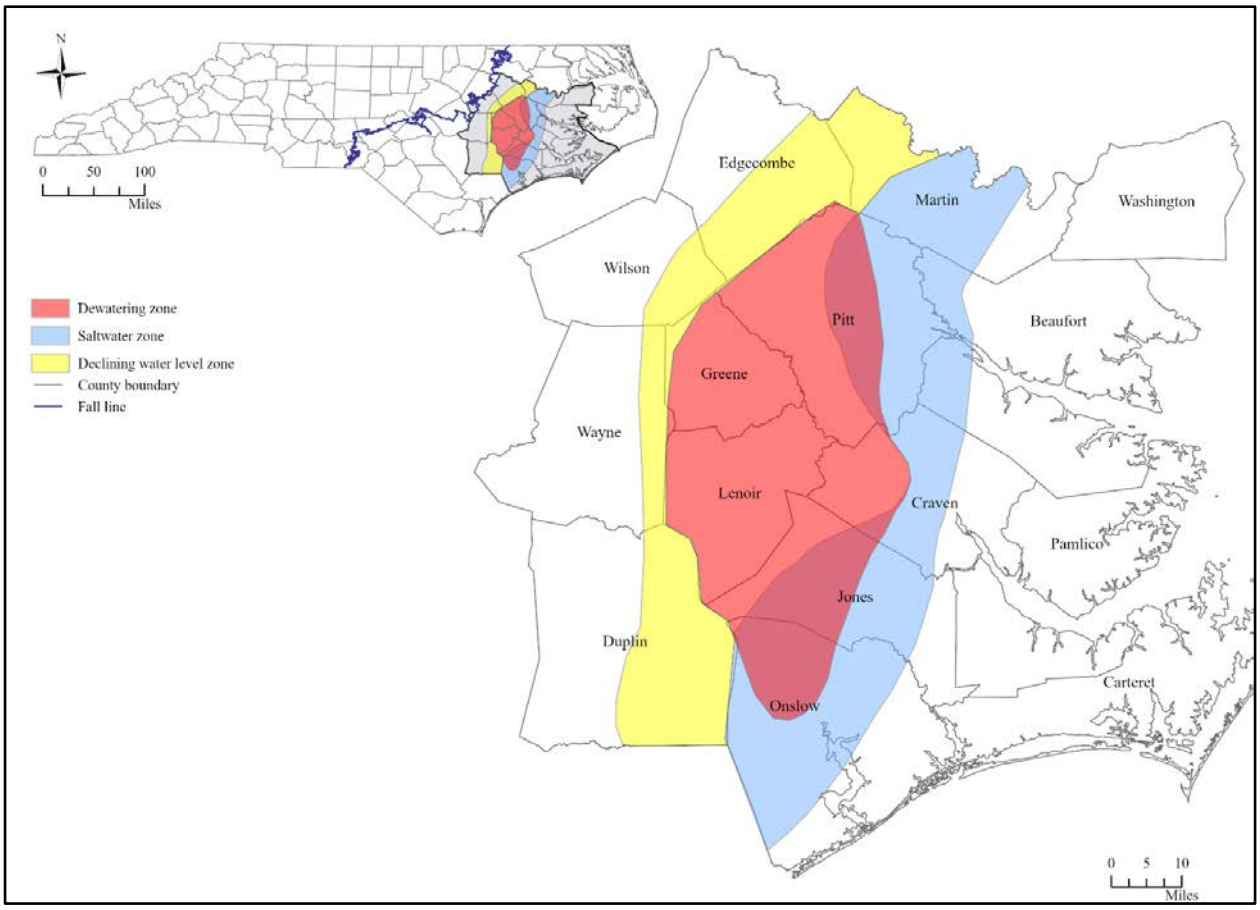


Figure 14. Central Coastal Plain Capacity Use Area Delineated by Zone

8.3 Water Supply and Usage

Most registered and permitted groundwater withdrawals in the CCPCUA are used for public water supply, mining, industry, and irrigation. Figure 15 illustrates the percentage of registered users by purpose of use.

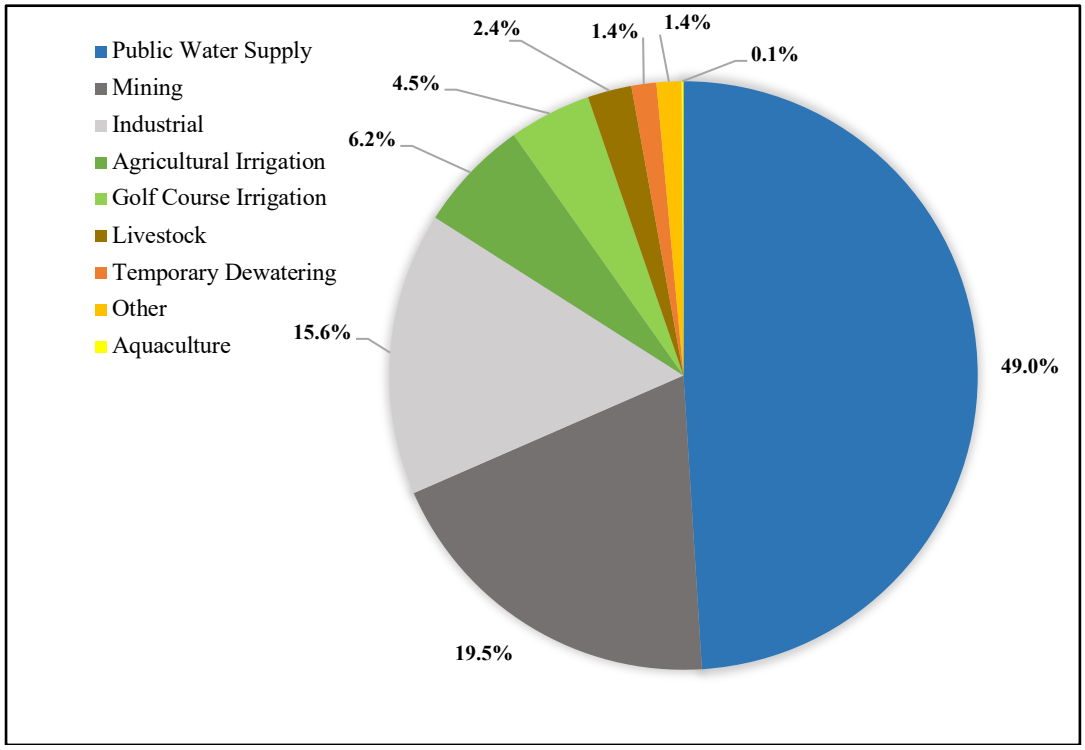


Figure 15. Percentage of Registered and Permitted Users by Purpose of Use

8.4 CCPCUA Monitoring and Recovery

The DWR MWN, cooperative monitoring well networks, and water levels reported by CCPCUA permittees, provide hourly and monthly data used to assess aquifer conditions within the 15 designated CCPCUA counties.

Figure 16 compares the mean water level of the Black Creek aquifer in 2023 to the mean water level in 2007. Figure 17 compares the mean water level of the Upper Cape Fear aquifer in 2023 to the mean water level in 2007. Positive changes to water levels in these aquifers measure the magnitude of recovery that has occurred since the CCPCUA rules were adopted. These figures are used by DWR to assess the success of the CCPCUA program and guide rule modification during the 10-year review period.

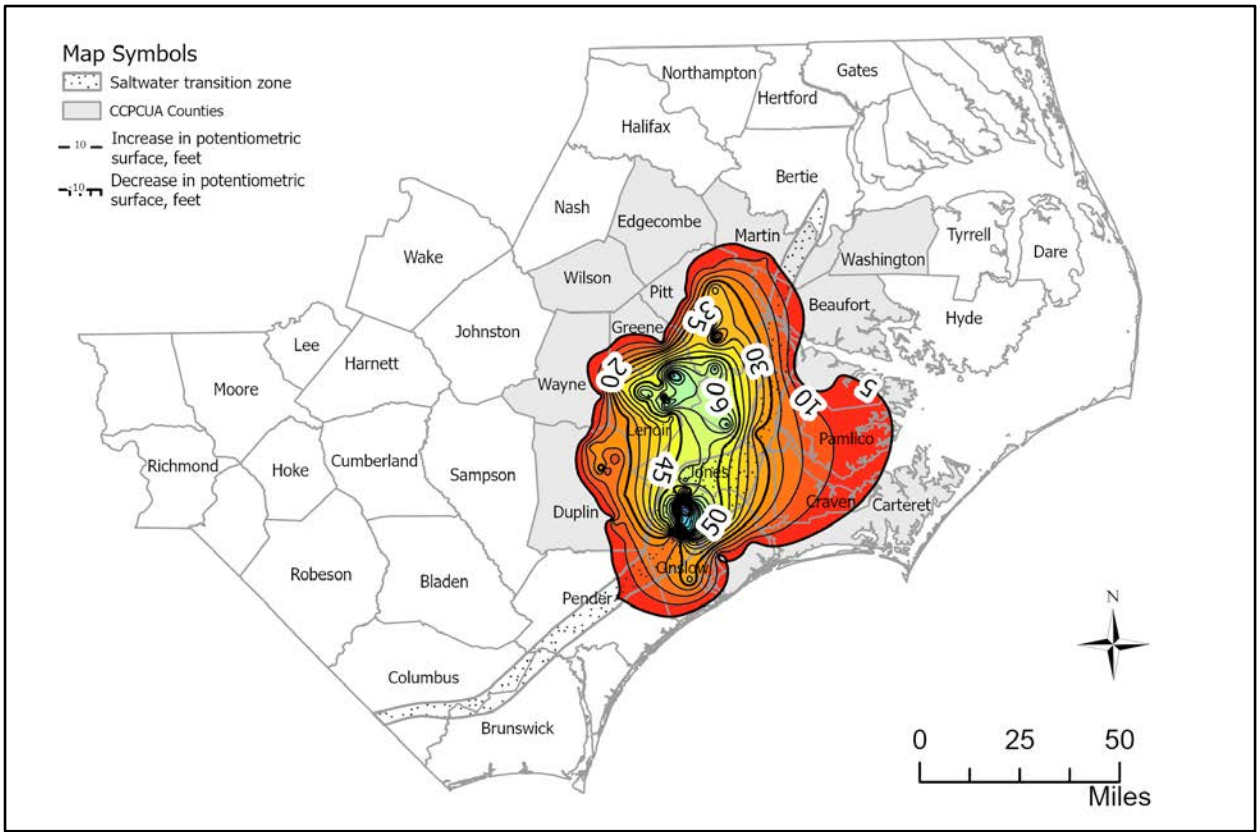


Figure 16. Black Creek Aquifer Recovery in CCPCUA Counties Between 2007 and 2023

The Black Creek Aquifer Recovery map (Figure 16) shows the areas where groundwater levels have risen between 5 feet to more than 55 feet from between 2007 through 2023. The largest recovery is observed in the Onslow County area where water users have made large investments in developing the Castle Hayne aquifer as an alternate water source.

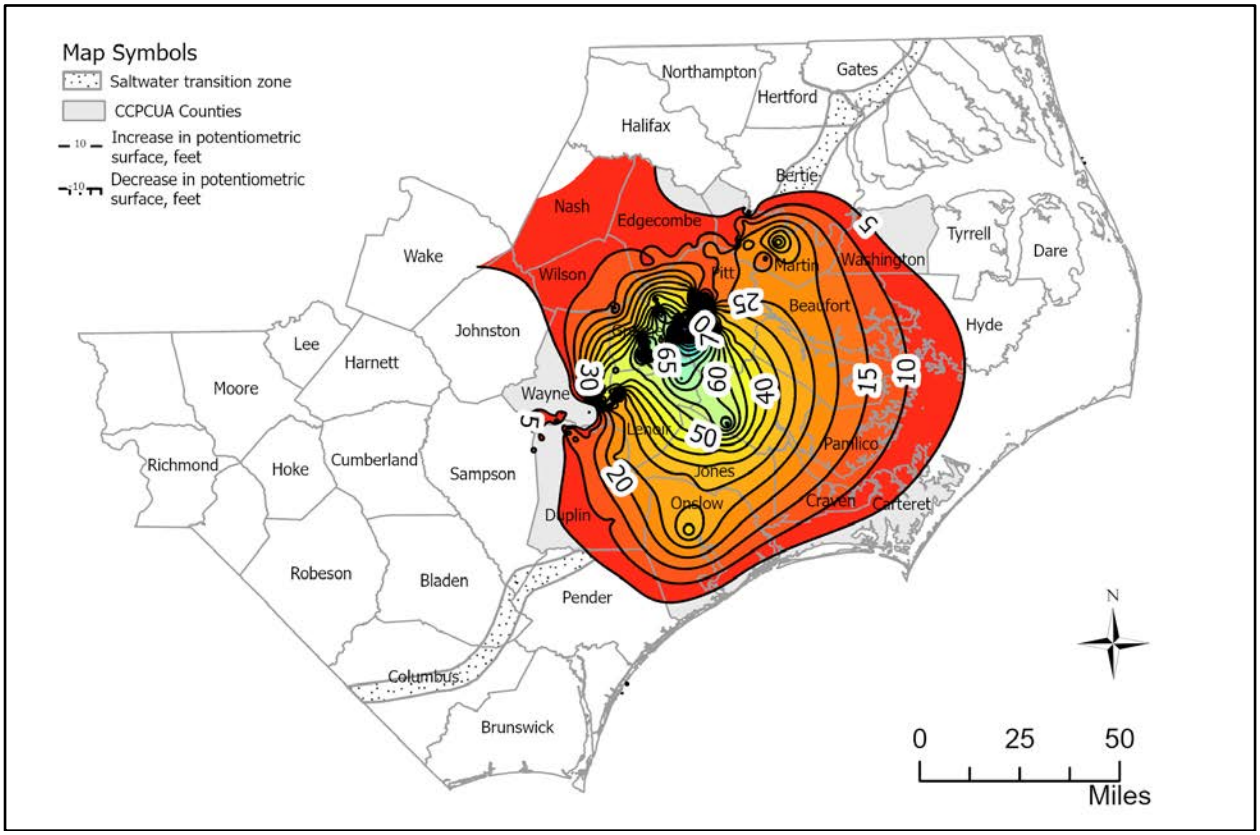


Figure 17. Upper Cape Fear Aquifer Recovery in CCPCUA Counties Between 2007 and 2023

The Upper Cape Fear Aquifer Recovery map (Figure 17) shows the areas where groundwater levels have risen between 5 feet to more than 65 feet between 2007 and 2023. The largest recovery is observed in the Lenoir County area due to the development of a surface water treatment plant on the Neuse River in 2008, and the Craven County area which developed wells in the Castle Hayne aquifer as an alternate water source.

Although the CCPCUA rules require assessments to be produced in 2008, 2013, and 2018, the DWR staff will continue to constantly track aquifer conditions to best serve the permit holders in the region and to provide awareness of potential groundwater supply issues. The 2018 assessment concluded with the EMC's approval of the report on October 10, 2018. The assessment report reviewed aquifer data in a similar fashion to previous efforts in 2008 and 2013. Water levels in the Black Creek and Upper Cape Fear aquifers were found to be equilibrating to the lower rate of aquifer use as water systems continue to shift demand to other sources which include surface water and shallower aquifers. While water level data are consistent with sustainable use of the aquifer system, chloride concentrations are somewhat inconsistent. Smaller and static cones of depression have developed in the Peedee and Castle Hayne aquifers in response to new well fields and are only visible using the combined DWR and permit holder water level data. Figures 18 through 24 depict the average potentiometric surface elevation for the seven major Coastal Plain aquifers from July 1, 2022 through June 30, 2023 per water levels provided by the CCPCUA permit holders and DWR's groundwater monitoring stations:

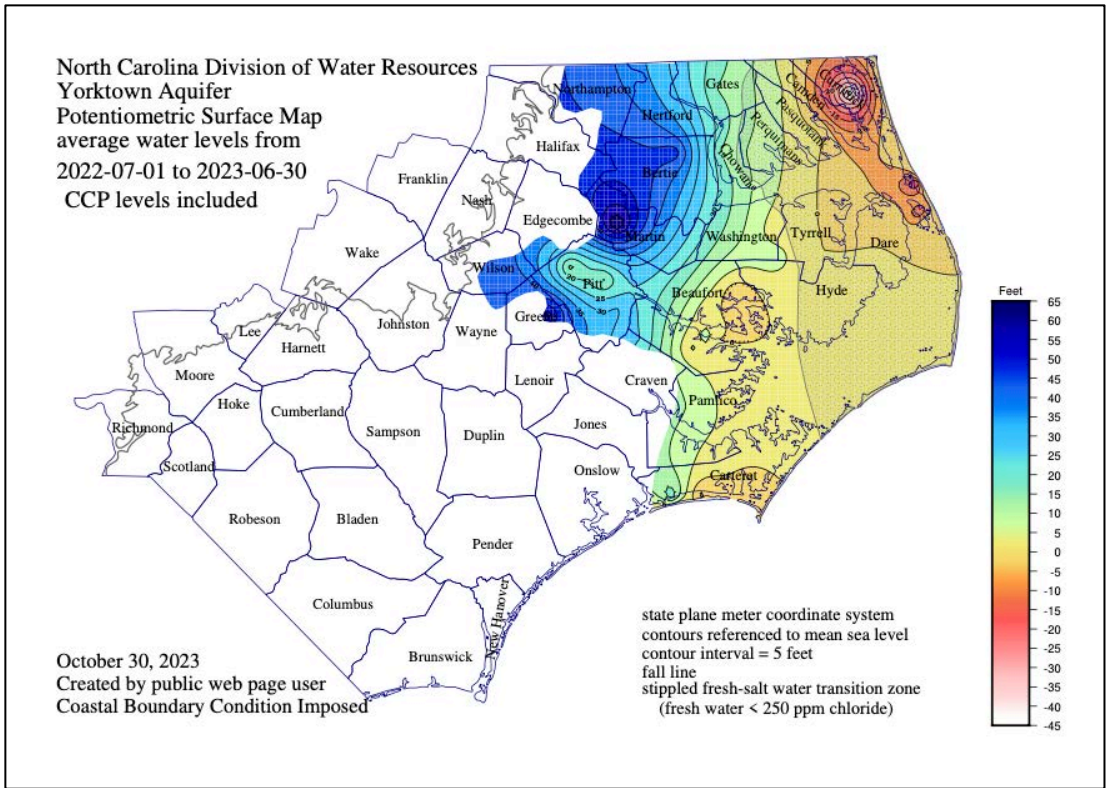


Figure 18. Yorktown Aquifer Average Potentiometric Surface Elevation (7/1/22-6/30/23) Elevation is relative to mean sea level (msl).

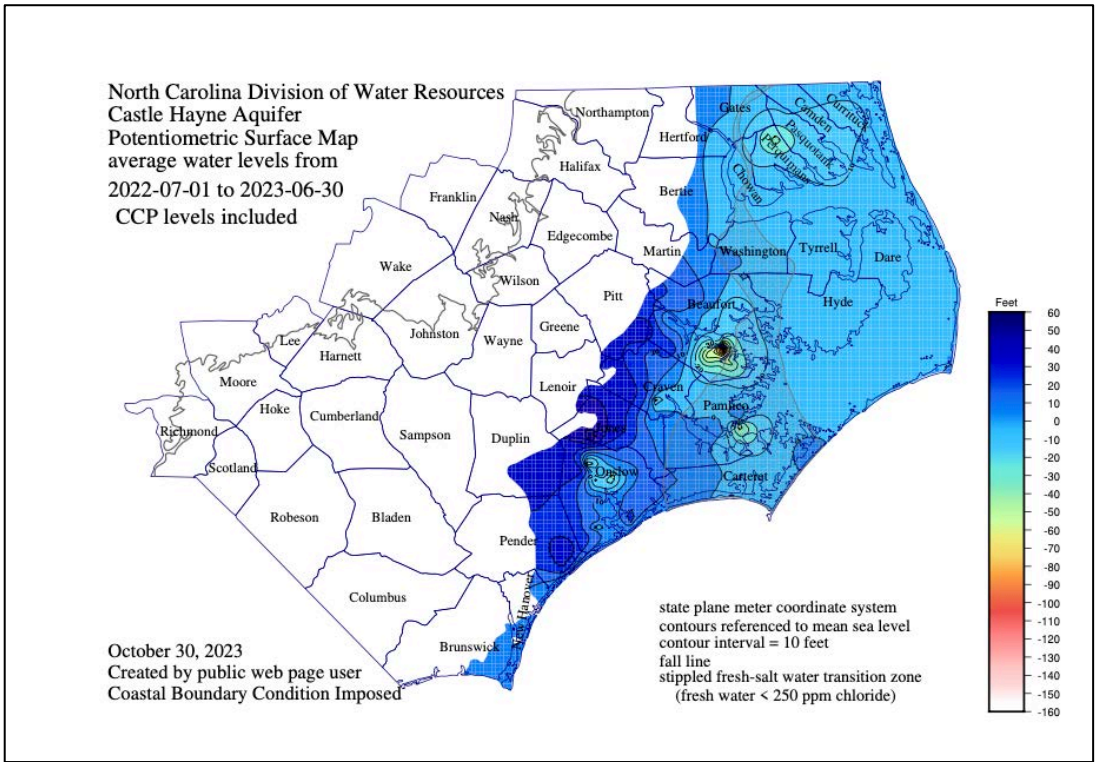


Figure 19. Castle Hayne Aquifer Average Potentiometric Surface Elevation (7/1/22-6/30/23) Elevation is relative to mean sea level (msl).

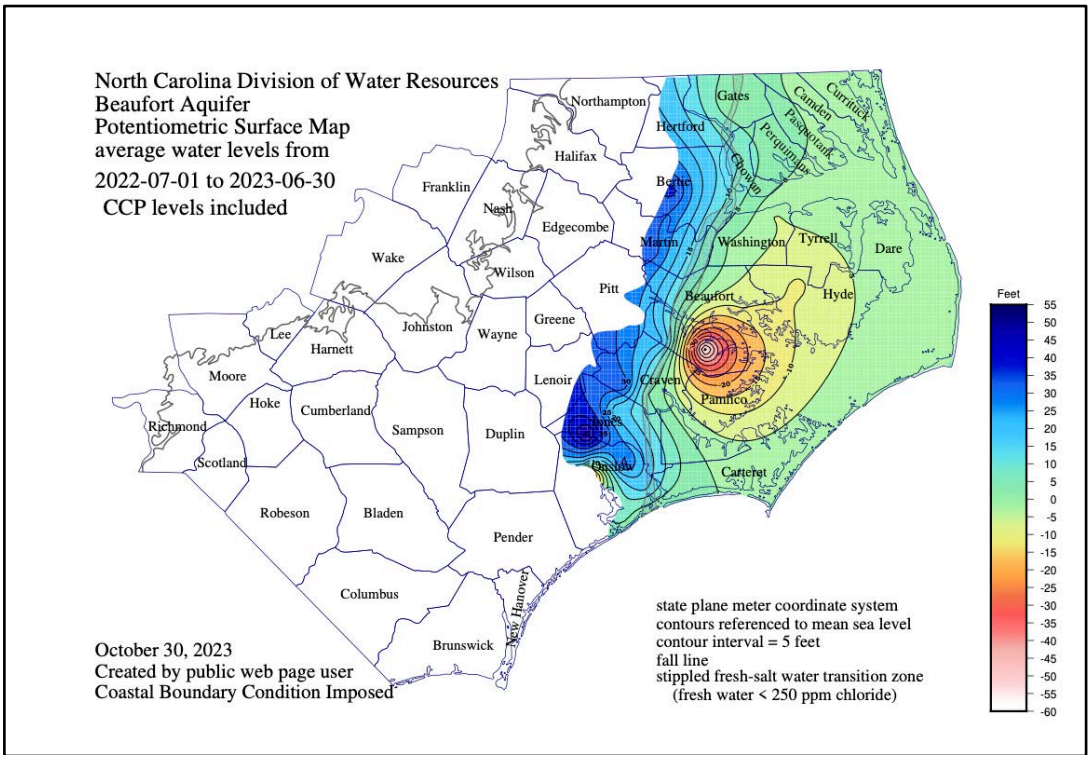


Figure 20. Beaufort Aquifer Average Potentiometric Surface Elevation (7/1/22-6/30/23) Elevation is relative to mean sea level (msl).

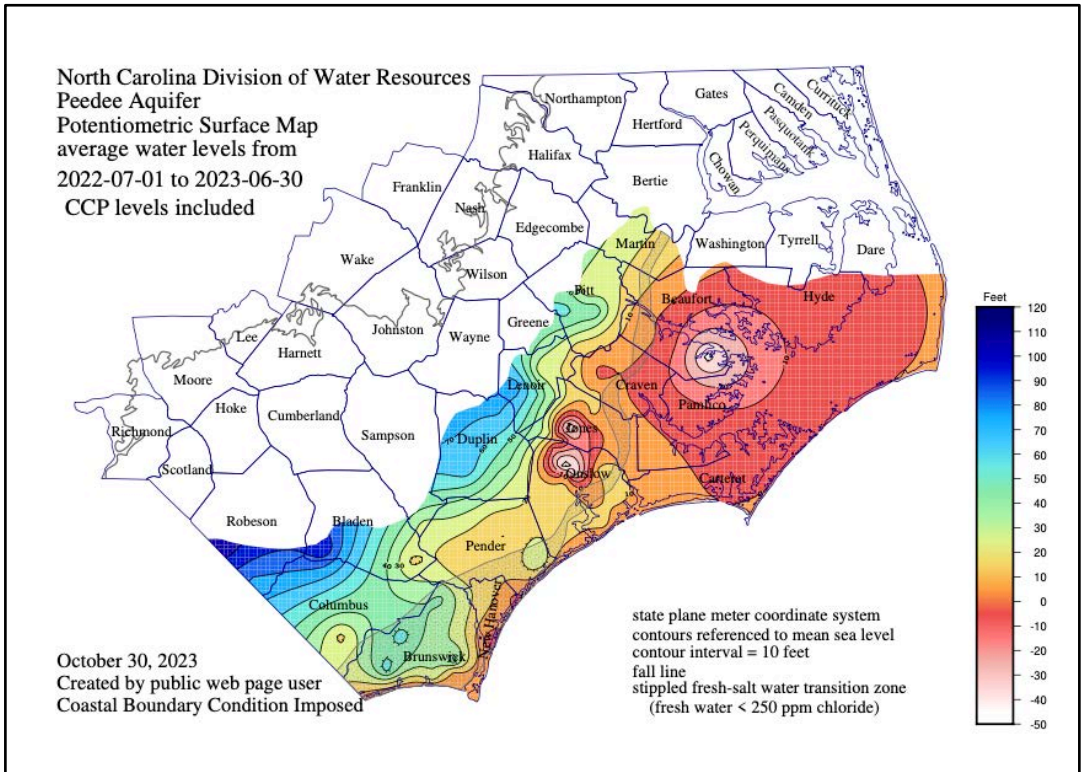


Figure 21. Peedee Aquifer Average Potentiometric Surface Elevation (7/1/22-6/30/23) Elevation is relative to mean sea level (msl).

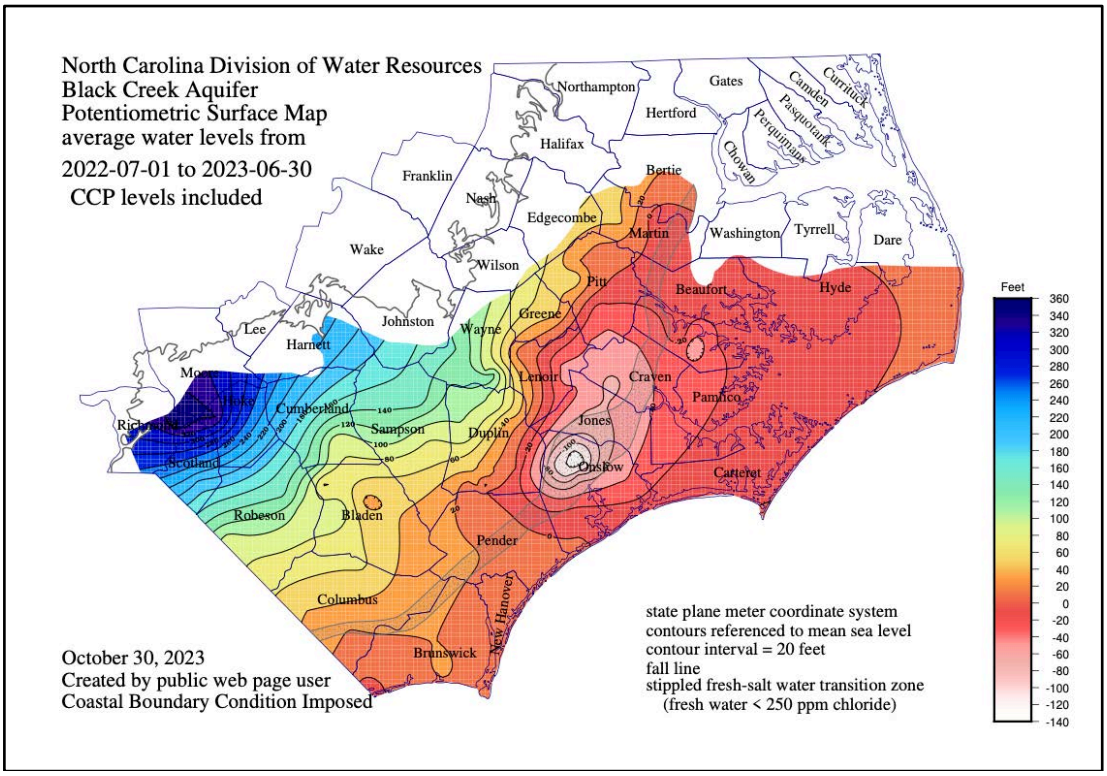


Figure 22. Black Creek Aquifer Average Potentiometric Surface Elevation (7/1/22-6/30/23) Elevation is relative to mean sea level (msl).

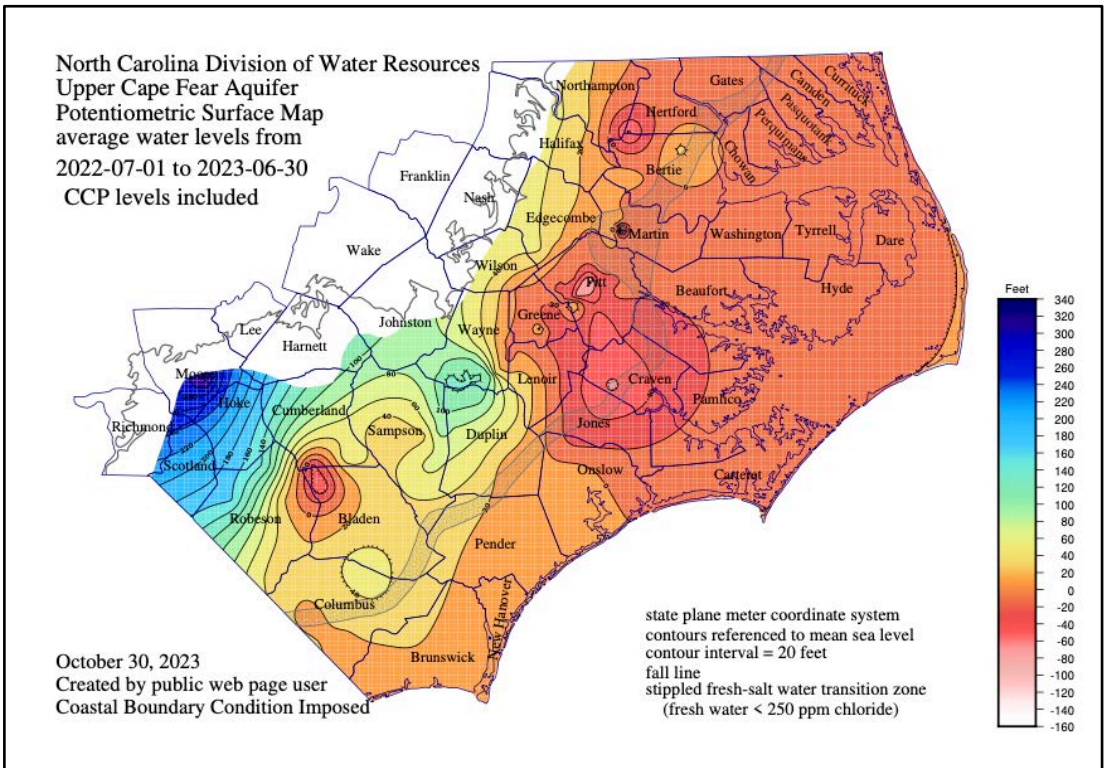


Figure 23. Upper Cape Fear Aquifer Average Potentiometric Surface Elevation (7/1/22-6/30/23) Elevation is relative to mean sea level (msl).

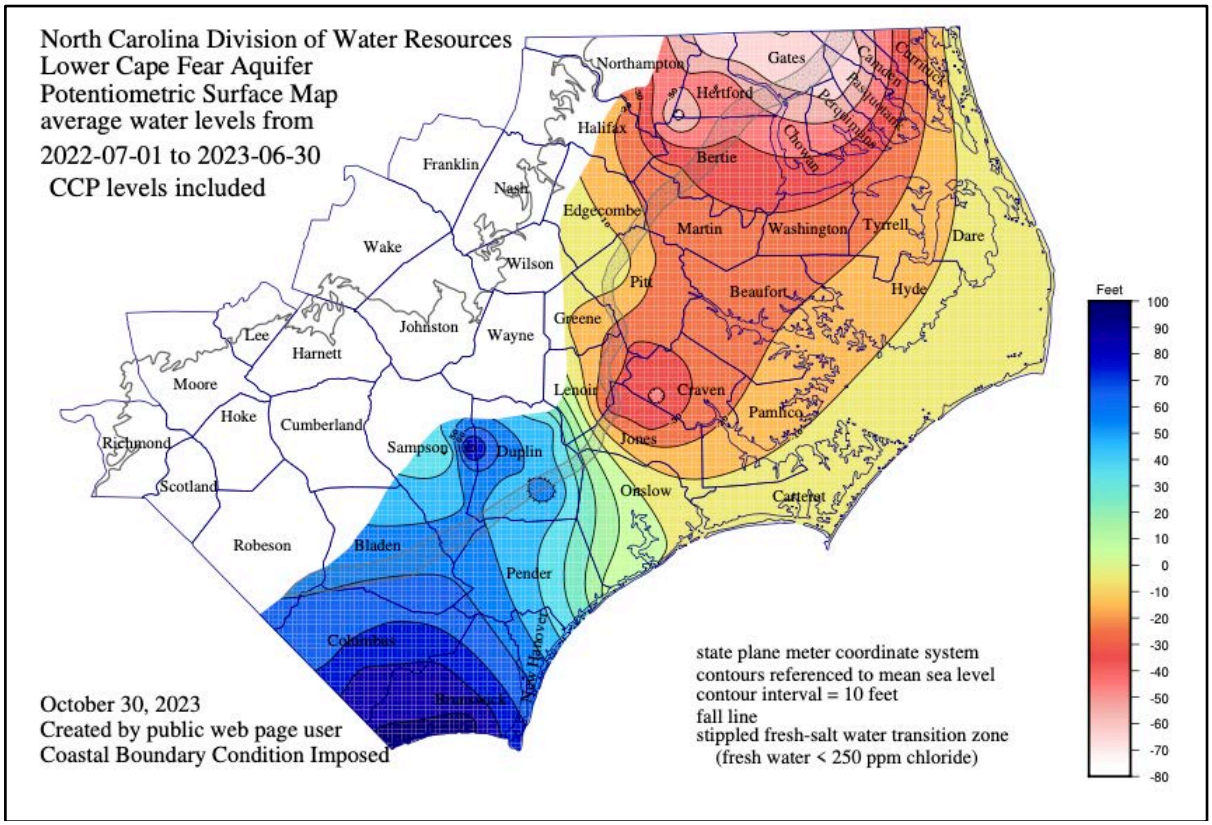


Figure 24. Lower Cape Fear Aquifer Average Potentiometric Surface Elevation (7/1/22-6/30/23) Elevation is relative to mean sea level (msl).

8.5 CCPCUA Rule Revisions

N.C. General Statute150B-21.3A requires state agencies to review existing rules every 10 years, determine which rules are necessary, and either re-adopt or repeal each rule as appropriate. 15A NCAC 2E .0506 required DWR to assess aquifer conditions in 2008, 2013, and 2018 to determine if CCPCUA rule changes were necessary.

Based on analysis of water level and water quality concentration data gathered through January 2013 in the CCPCUA, and a thorough review of aquifer conditions, DWR concluded that no action needed to be taken by the EMC to alter either the reduction zone boundaries or rule language in 15A NCAC 2E .0503 but recommended the use of temporary permits under rule .0502. This may give certain permit holders a stable withdrawal rate which is higher than indicated by their reduction schedule and reduction zone, provided that all well construction and reporting criteria are met as specified in the 2013 CCPCUA Assessment Report. As of June 30, 2022, the following twelve permit holders acquired temporary permits: Greene County Regional Water System, Craven County Water, Jones County Regional Water, City of New Bern, Town of La Grange, Town of Snow Hill, Town of Winterville, Belfast-Patetown Sanitary District, Northwestern Wayne Sanitary District, Southeastern Wayne Sanitary District, Fork Township Sanitary District, and Chinquapin Water Association, Inc.

The CCPCUA rules were re-adopted and became effective on January 1, 2022 with minor changes. A summary of the CCPCUA rule revisions are included in Table 16. Reports referencing the CCPCUA rules along with water use and permit holder information may be viewed by visiting the DWR's CCPCUA website, https:/www.ncwater.org/CCPCUA.

Table 16. Summary of CCPCUA Rule Revisions

Rule	Proposed Change
15A NCAC 02E .0501 Declaration and Delineation of Central Coastal Plain Capacity Use Area	Format changes and removed language deemed unnecessary.
15A NCAC 02E .0502 Withdrawal Permits	Format changes and removed language deemed unnecessary. Updated language for clarification.
15A NCAC 02E.0503 Prescribed Water Use reductions in Cretaceous Aquifer Zones	Repeal rule. Removed language deemed unnecessary.
15A NCAC 02E .0504 Requirements for Entry and Inspection	Updated language for clarification.
15A NCAC 02E .0505 Acceptable Withdrawal Methods that Do Not Require a Permit	Format changes and removed language deemed unnecessary.
15A NCAC 02E .0506 Central Coastal Plain Capacity Use Area Status Report	Repeal rule. Removed language deemed unnecessary.
15A NCAC 02E .0507 Definitions	Updated language for clarification. Added 3 definitions (aquifer recharge, cretaceous aquifer system zones, and recharge rate).

N.C General Statute 150B-21.3A requires state agencies to review existing rules every 10 years, determine which rules are still necessary, and either re-adopt or repeal each rule as appropriate. In May of 2021, a public hearing was held for the Rules Re-adoption of 15A NCAC O2E (Water Use Registration and Allocation). The public comment period ended July 2, 2021. DWR staff submitted the Hearing Officers report to the Environmental Management Commission on November 18, 2021, which the EMC approved. The re-adopted rules became effective on January 1, 202, which can be reviewed at https://www.ncwater.org/CCPCUA under the Laws and Rules link.

Figure 25 is a summary of water withdrawals reported by permit holders and registrants within the CCPCUA for the calendar year 2022. Water withdrawal summaries of historical years may be found on the CCPCUA website https://www.ncwater.org/CCPCUA.

Central Coastal Plain Capacity Use Area 2022 Water Withdrawal Summary Tables

Tables compiled 07-26-2023, units are gallons per day

Permitted				Reported for 2022					
Current Permit Limits				Ground Water					Surface Water
County	max daily	yearly (ABRs)	yearly (2018)	by all permits	# of permits	% reported	by yearly permits	by registrations	by registrations
Beaufort	180,564,400			47,552,534	40	70			
Carteret	33,656,080			8,574,661	25	84		246,770	38,137
Craven	73,683,200	6,956,526	1,814,132	17,209,037	31	71	1,907,943	58,639	15,548,969
Duplin	68,765,925	2,805,747	2,297,255	7,449,641	67	61	1,935,942	141,676	
Edgecombe	13,536,000	527,697	429,388	1,519,592	12	92	237,003		359,589
Greene	1,055,000	3,058,197	914,551	1,032,679	5	80	961,077	40,020	
Jones	48,641,600	679,282	169,821	15,254,925	9	56	154,310		
Lenoir	4,765,320	14,256,285	3,706,446	3,832,413	15	87	3,202,578		7,822,044
Martin	4,440,000	4,895,506	2,226,326	1,065,429	13	100	604,979	30,993	23,697,436
Onslow	62,496,600	9,845,143	2,461,286	22,668,677	18	72	4,047,107	194,223	
Pamlico	37,192,000			1,229,731	14	64		148	
Pitt	8,078,080	8,651,572	2,521,003	1,816,882	22	82	1,362,661	72,114	15,467,255
Washington	1,000,000				31	55			
Washington	50,448,000			957,047	23	83		16,201	
Wayne	19,371,200	4,340,026	2,010,532	4,956,476	8	63	1,167,890		12,415,666
Wilson	6,464,160	658,883	491,218	1,293,019			371,149	89,509	8,666,291
Totals:	614,157,565	56,674,864	19,041,958	136,412,744	333**	72	15,952,636	890,292	84,015,388

Yearly permit limits are linked to withdrawals from the Cretaceous aquifers where reductions are mandated. As phased reductions occur, annual limits allow permit holders more flexibility to plan when withdrawals are made. ABR refers to "Approved Base Rate" and is the annual rate calculated based on 1997 or August 1, 1999 through July 31, 2000 withdrawals. The ABR is the annual rate from which reductions take place (see CCPCUA FAQs). "Yearly (2018)" is the final rate of withdrawal if all three phases of reduction are administered. Figures in the "by all permits" columns are total withdrawals reported by all permit holders (max day and yearly).

** A few permits have sources in two counties, so those permits are counted twice.

Permitted				Reported for 2022					
Current Permit Limits				Ground Water					Surface Water
Type of Use	max daily	yearly (ABRs)	yearly (2018)	by all permits	# of permits	% reported	by yearly permits	by registrations	by registrations
Agricultural	193,497,325	620,612	400,004	6,192,276	136	56	108,930	110,697	891,678
Golf Course Irrigation	3,622,800	85,589	85,589	91,649	11	45	5,458	48,395	150,765
Industrial	15,355,200	4,473,115	2,471,853	3,912,776	13	100	1,135,412	221,034	45,226,822
Mine Dewatering	254,678,080			71,254,137	66	79		71,836	
Other	8,524,480	368,561	300,003	408,805	14	50	112,233		
Public Water Supply	138,479,680	51,126,987	15,784,510	54,553,101	86	93	14,590,603	438,330	37,746,124
Thermal Electric Power					86	93			
Totals:	614,157,565	56,674,864	19,041,958	136,412,744	326	71	15,952,636	890,292	84,015,388

Permitted				Reported for 2022				
Current Permit Limits				Ground Water				
Aquifer	max daily	yearly (ABRs)	yearly (2018)	by all permits	# of permits	% reported	by yearly permits	by registrations
Basement rock	13,606,060			2,068,753	10	70		231,674
Black Creek	31,966,363	21,884,121	7,173,409	12,079,251	75	72	8,821,147	172,210
Peedee	18,940,050	6,877,228	1,785,236	1,372,340	20	75	87,399	77,874
Upper Cape Fear	50,143,962	27,863,514	10,033,312	11,658,109	91	81	7,018,496	99,955
Lower Cape Fear		50,001	50,001	62,340	1	100	25,595	
Surficial	133,737,630			27,228,230	76	70		189,844
Castle Hayne	328,493,250			81,150,918	126	64		684,129
Beaufort	3,495,250							51,977
Upper Tertiary								
Yorktown	33,775,000			792,802	17	55		19,832
Totals:	614,157,565	56,674,864	19,041,958	136,412,744	415**	71	15,952,636	890,292

** Many permits use multiple aquifers, so those permits are counted more than once.

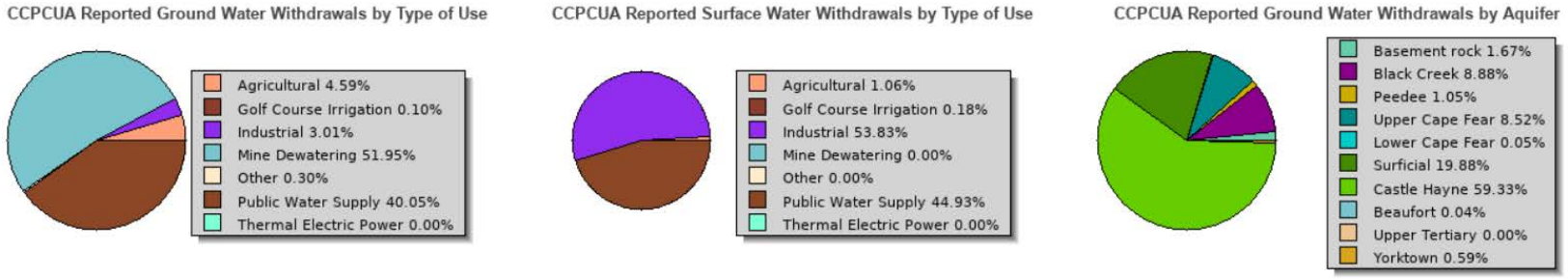


Figure 25. 2022 Calendar Year CCPCUA Water Withdrawal Summary Tables

9.0 Report Summary

DWR and its predecessor agencies have maintained and monitored a statewide network of groundwater monitoring wells used to assess North Carolina's groundwater supply since the 1960s.

Data collected from the MWN are available to the public through DWR's Internet website, https://www.ncwater.org/GWMB. These data include, but are not limited to, groundwater levels, chloride measurements, well construction information, lithological and geophysical logs, groundwater monitoring station locations, well coordinates and elevations, and data from many non-DWR wells.

The MWN consists of 699 monitoring wells at 236 individual stations. From July 2021 through June 2022, groundwater level data were collected from 705 wells within the MWN. These data include manual measurements taken quarterly from wells plus hourly water levels collected using automatic data recorders from 594 wells.

There are three local networks whose water level data are currently being uploaded to the DWR database. The OWN in Orange County, the Guilford County network, and the WCHRS in Jackson County water level data can be viewed by the public on the DWR website.

Thirteen STS units were upgraded and installed in FY2023 on drought monitoring network wells. The addition of the STS units replace monthly site visits, allow access to current water level data, and provide positive economic impacts. Fourteen of the STS data logger units did not collect data due to equipment failure at some point in the FY2023. Lewiston, (H22I3), was removed from the STS network due to lack of 4G wireless availability in the area.

Chloride sampling was performed on 413 wells from March through May 2022. Sampling results indicated that there continues to be concern for saltwater encroachment especially near larger pumping centers located near the freshwater-saltwater interface.

Chloride levels were collected in 48 Black Creek wells. Of these, eight wells showed chloride increases since 2019, seven wells showed chloride decreases since 2019, and ten wells exceeded 250 ppm.

Chloride levels were collected in 45 Upper Cape Fear wells. Of these, ten wells showed chloride increases since 2019, seven wells showed chloride decreases since 2019, and nine wells exceeded 250 ppm.

Chloride levels were collected in 23 Lower Cape Fear wells. Of these, twelve wells showed chloride increases since 2019, three wells showed chloride decreases since 2019, and twelve wells exceeded 250 ppm.

Groundwater quality staff collected groundwater samples from 116 wells at 44 monitoring stations in FY2023. Samples were analyzed and results were added to the water quality database.

Three monitoring wells, Keeper Quarters Well (Y14L1), Carteret County, Turnbull State Forest (X38Y2), and Turnbull State Forest (X39T6), Brunswick County, were acquired and added to the MWN.

Three wells, Wallace Vaughan (B39X2), Granville County, Powell Drive (K40M1), Wake County and Bear Pen (EE36K4), Brunswick County, were moved to inactive status.

Northside Elementary (C34L1) in Warren County was repaired in FY2023 after the well was damaged by a fallen tree.

Eleven wells, Six Runs, (V35T4 and V35T5), Sampson County, Southern Pines Water Plant (R48G1 and R48G2), Moore County, Calico (P22F6 and P22F7) and Creeping Swamp (O22V6 and O22V7), Pitt County and Highway 102 (O21Q1, O21Q2, and O21Q3), Beaufort County were abandoned.

Survey monuments have been installed at each of the well stations. Survey Grade GPS will be performed on acquired well stations during FY2024.

Fifteen counties in the Central Coastal Plain are governed by the Central Coastal Plain Capacity Use Area rules which replaced the Capacity Use Area #1 on August 1, 2002. Data collected from the monitoring well network is being used to assess aquifer conditions and determine whether or not changes to the rules are warranted. Based on the results of the 2018 assessment, concluding with the EMC's approval of the report on October 10, 2018, DWR did not pursue rule changes. Instead, DWR will continue issuing temporary permits under rule 15A NCAC 2E .0502 which can ease withdrawal reduction requirements for certain permit holders but adds other permit conditions.

N.C. General Statute 150B-21.3A requires state agencies to review existing rules every 10 years, determine which rules are still necessary, and either re-adopt or repeal each rule as appropriate. In May of 2021, a public hearing was held for the Rules Re-adoption of 15A NCAC O2E (Water Use Registration and Allocation). The public comment period ended July 2, 2021. DWR staff submitted the Hearing Officers report to the Environmental Management Commission on November 18, 2021, which the EMC approved. The re-adopted rules became effective on January 1, 2022, which can be viewed at https:/www.ncwater.org/CCPCUA under the Laws and Rules link.

For questions or comments concerning this report and the monitoring well network, please contact Susan Laughinghouse at 252-229-3349, susan.laughinghouse@deq.nc.gov. For questions and concerns associated with water quality sampling and laboratory analytical results, please contact Andy Neal at 919-707-9113, andy.neal@deq.nc.gov. For questions and concerns related to the CCPCUA rules and permitting, please contact Stephanie DeVries at 919-707-9032 (office) or 919-5023-1082 (mobile), stephanie.devries@deq.nc.gov, or Mike Bauer at 919-707-9004, michael.bauer@deq.nc.gov.