

Southern Coastal Plain Capacity Use Investigation

North Carolina
Division of Water Resources
Environmental Management Commission

June 2004

Introduction

Ground water level declines in the Black Creek and Upper Cape Fear aquifers in the Southern Coastal Plain have been documented and described by the Division of Water Resources (DWR) and the U.S. Geological Survey over the past several years. On October 2, 2002, at the request of the Environmental Management Commission, the Division of Water Resources distributed a report entitled “Bladen County Preliminary Capacity Use Assessment.” A review of the report by officials of the Lumber River Council of Governments, Town of Elizabethtown, and the Water Allocation Committee of the EMC led to a request for a follow-up report entitled “Proposed Bladen County Capacity Use Investigation Scope of Work and Timeline for Completion.” This report was presented to the Water Allocation Committee in December 2002, and the Division of Water Resources was requested to present findings of the capacity use investigation to the Water Allocation Committee at the July 2004 meeting. This report summarizes the results of those findings.

Components of a Capacity Use Investigation

The Water Use Act of 1967, section GS 143-215.13(c) states that the “Commission {EMC} may declare and delineate capacity use areas” after directing the Department to investigate and report to the commission. The following components are required in a Capacity Use Investigation:

1. consultation with all interested persons, groups, and agencies;
2. consideration of all factors relevant to the conservation and use of water in the area;
3. indication of whether the water use problems involve surface or ground waters or both;
4. recommended boundaries of a capacity use area;
5. alternative measures to regulation;
6. a written report to the EMC with a recommendation as to whether a capacity use declaration should be made.

The Division of Water Resources has met on numerous occasions with representatives of the Lumber River Council of Governments (LRCOG), and other interested parties, to discuss water use and conservation issues in the Southern Coastal Plain as well as alternative measures to regulation. The LRCOG contracted two private consulting firms, Groundwater Management Associates and The Wooten Company, to conduct a study of the six-county region to determine surface and ground water demand, supply, availability and quality. Water conservation and use alternatives were also studied. The report produced as an outcome of this study was entitled “Water Resources Plan – The Southern Coastal Plain Comprehensive Ground Water Study & Assessment,” December 2003. This study provided much needed information for the Capacity Use Investigation, helping the Division of Water Resources to focus on the problem areas identified in the region.

Background and Scope

The capacity use investigation encompassed Bladen, Robeson, northern Columbus, Sampson, and southern Cumberland Counties (figure 1). The geographic area selected was based on where high volume ground water withdrawals occur and where large cones of depression have formed with drawdown rates that could potentially threaten an aquifer. Ground water usage is limited to five aquifers in the area. These include from deepest to shallowest, the Lower Cape Fear, Upper Cape Fear, Black Creek, Peedee and surficial aquifers. Of these five, the majority of the total volume withdrawn is from the Upper Cape Fear and Black Creek aquifers. The Lower and Upper Cape Fear, Black Creek and Peedee are confined aquifers, meaning that they are overlain by confining beds. A tightly cased well that is open exclusively to a confined aquifer will exhibit a water level that is above the top of the aquifer. As the well is pumped the water level will continuously decline if the pumping rate exceeds the rate at which the aquifer is being recharged. If the water level in a confined aquifer declines to a point where it is below the top of the aquifer, dewatering will occur. Dewatering results in a serious loss of yield and storage ability due to loss of pressure and compaction of sediments. Studies of North Carolina Coastal Plain confined aquifers indicate that they are recharged at a very slow rate, generally around one half inch per year. Deeper aquifers receive recharge at a slower rate than shallower aquifers, because the source of recharge is from precipitation that percolates downward into the subsurface. This report addresses water level declines that are occurring in the Upper Cape Fear and Black Creek aquifers, which are heavily used in certain locations, and thus susceptible to damage due to overpumping.

Since the date of the December 2002 report to the Water Allocation Committee, the Division of Water Resources has collected information from numerous wells drilled in the area of investigation, including geophysical, geologic, water level and chloride concentration data. In addition, DWR constructed four new ground water monitoring stations in order to better define the hydrogeologic framework, monitor ground water levels and determine the extent of drawdown from the Elizabethtown and Smithfield Foods Inc. pumping centers in Bladen County. The monitoring stations were installed near Dupont in northern Bladen County, at Bladen County Community College near Dublin, in southeastern Cumberland County at Bushy Lake State Park, and Bushy Lake Firetower (figure 2).

Ground Water Usage

Ground water use occurs from four different sources in the region. Sources include municipal, domestic self supplied, agricultural and industrial self supplied. Municipal usage was determined from the 1997 local water supply plans and is exhibited in figure 3. Each withdrawal location is indicated by a colored circle to show which aquifer is being used and the average amount of ground water being pumped in gallons per day. Water use data for domestic, agricultural and industrial users were taken from the GMA-Wooten Company report entitled "Water Resources Plan – The Southern Coastal Plain Comprehensive Ground Water Study & Assessment" (December 2003) and

reported in table 1. Information on domestic and industrial use in the GMA-Wooten report was based on survey data. Agricultural data was based on the USGS report entitled "Water Use in North Carolina 2000." Data collected in 2002 by the NC Department of Agriculture for agricultural ground water usage in the central coastal plain indicated that the actual usage number was around 28 percent of what was reported by the USGS. More reliable agricultural usage figures are expected at a later date through a survey being conducted by the LRCOG for the southern coastal plain counties.

Aquifer Conditions

Lower Cape Fear Aquifer

The Lower Cape Fear aquifer is the deepest freshwater aquifer in the area of investigation, ranging in elevation between 200 and 650 feet below sea level. The western limit of the aquifer occurs along a line trending from southeastern Robeson through western Bladen and central Sampson Counties (figure 4). To the east of lines representing the fresh water-salt water transition zone, the aquifer contains salt water. It is used by the cities of Elizabethtown in Bladen County, and Clinton in Sampson County (figure 3). Very little water level data is available to map regional water level trends in the Lower Cape Fear aquifer across the area. Future construction of ground water monitoring stations and upgrading of existing stations will help to gain more information about water levels and water level decline rates. The proximity of the Lower Cape Fear salt water transition zone to the town of Elizabethtown (figure 4) could become a problem if water level decline rates were high enough, but no problems of elevated chloride levels in the Elizabethtown well field have been reported.

Upper Cape Fear Aquifer

The Upper Cape Fear aquifer ranges in elevation from 50 feet below sea level in central Cumberland County to 450 feet below sea level in northern Columbus County (figure 5). The aquifer contains salt water in southeastern Bladen and eastern Columbus Counties as indicated by the position of the fresh water-salt water interface in figure 5.

A contour map of water levels (potentiometric surface map, figure 6) measured from the Upper Cape Fear aquifer indicates two areas where large cones of depression have formed due to ground water withdrawals. One is the result of a 1.974 gallon per day average withdrawal from both the Upper Cape Fear and Black Creek aquifers at Smithfield Foods, Inc., near the town of Tarheel, in Bladen County. The area affected by the Smithfield Foods withdrawal covers all of western Bladen County, part of eastern Robeson County, and part of southwestern Cumberland County. The other cone of depression has formed around Elizabethtown where a total of 903,000 gallons per day is being withdrawn from the city well field in the Black Creek, Upper and Lower Cape Fear aquifers. The nearby town of White Lake also pulls approximately 276,000 gpd from the Black Creek and Upper Cape Fear combined. This cone of depression merges with the Smithfield cone as displayed on the potentiometric surface map, and affects water levels in the Upper Cape Fear aquifer all the way into northern Columbus County.

Large scale ground water withdrawals began at the Smithfield Foods plant in September, 1992, at which time the plant was pumping approximately 2.3 million gallons per day (gpd). By 1996, pumping rates increased to as high as 3.5 gpd (verbal communication with Charles Fiero). By 1997, water reuse measures were implemented at the facility, and pumping rates were reduced to 2.5 mgd. The pumping rate was reduced by further reuse measures to a present day average of 1.974 mgd.

Water level data collection began at the Smithfield Foods plant in September 1992 and continues to present as depicted by the hydrograph in figure 7. A rapid decline in Upper Cape Fear water levels is apparent between the period of September 1992 and early 2001. The water level in well BL-142 dropped 140.67 feet during this period, or an average of 16.7 feet per year. Seven miles to the northwest at Dupont, the water level dropped approximately 10.5 feet per year during the same time period. The impact of reuse measures begun at Smithfield Foods in 1997 is evident by a reduction in the rate of decline. By early 2001 water levels began to equilibrate and have continued on that course up to present. Similar response patterns are observed in Upper Cape Fear monitoring wells at Dupont, at the Town of White Oak, and at the Town of Dublin in northwestern Bladen County (figure 8). An April 2004 potentiometric surface map of the Upper Cape Fear aquifer (figure 6) indicates that water levels are approximately 70 feet above the top of the aquifer in the middle of the pumping center. This is exhibited along a north-south cross section extending from the DWR Dupont monitoring station to Smithfield Foods to the DWR Bladen Community College monitoring station (figure 9). If Smithfield Foods maintains the current pumping rate, water levels should remain stable or rise at a slow rate, unless additional pumping stresses are added.

An additional concern at the Smithfield Foods site is the presence of elevated chloride concentration values (>250 parts per million) which indicate that upconing of salt water from beneath the Upper Cape Fear aquifer has occurred. The source of the salt water is believed to be from localized entrapment in fractures in the underlying basement rock.

At Elizabethtown, the April 2004 potentiometric surface map of the Upper Cape Fear exhibits water levels ranging from 18.42 feet above sea level to 39.9 feet below sea level. Since the wells used for these measurements are open to multiple aquifers (Black Creek, Upper and Lower Cape Fear), the levels are not truly representative of the Upper Cape Fear aquifer. However, water level measurements from the wells plotted on hydrographs are useful for studying historic trends in response to changes in pumping conditions. Water level declines in the Alamac Knit Fabrics well BL-131 (at Elizabethtown) dropped from 69 feet below sea level in late 1988, to 90 feet below sea level in September 2000 (figure 10). With cessation of pumping of approximately 1.84 mgd at Alamac Knit Fabrics, water levels rose dramatically in BL-131, BL-121, and BL-129. In order to determine the actual distance between the top of the Upper Cape Fear aquifer and the potentiometric surface, and monitor water levels that are unique to the aquifer, the Division of Water Resources will need to construct a monitoring station in

the vicinity of Elizabethtown. The rebounding of levels in the Elizabethtown well field is, however, encouraging.

The Upper Cape Fear aquifer is particularly sensitive to pumping because it is well confined by thick overlying clay beds which highly limit the amount of vertical recharge. The aquifer is also relatively thin in the Tarheel-Elizabethtown area, which limits its ability to transmit water. Thus, large cones of depression are able to form due to relatively low volume pumping.

Black Creek Aquifer

The Black Creek aquifer overlies the Upper Cape Fear confining unit, and ranges in elevation from 150 feet above sea level to 250 feet below sea level in the area of investigation (figure 11). The aquifer is most heavily used in Robeson County, where it is the chief water source for the county, and for the cities of Lumberton, Pembroke, Red Springs, etc., as well as for several industries (figure 3). Despite the high volume of withdrawals in Robeson County, water levels are not being severely impacted due to higher recharge rates and high transmissivity. In Bladen County, the aquifer is sensitive to relatively small volumes of pumping, due apparently to lower transmissivity and recharge rates.

A potentiometric surface map of the aquifer (figure 12) indicates that prominent cones of depression have formed at the Tarheel-Smithfield Foods site and in the vicinity of Elizabethtown in Bladen County. It is unknown how much of the total volume of water withdrawn is attributable to the Black Creek, since in both areas most of the wells are screened or gravel packed in multiple aquifers.

Where monitoring wells are available to measure Black Creek aquifer water levels at the Smithfield Foods site, the level has been drawn down as low as 39.15 feet above sea level as displayed on the potentiometric surface map in figure 12, and cross section A-A' (figure 9). The top of the aquifer at the same well where this measurement was taken is 81 feet above sea level. Therefore the water level is 41.85 feet below the top of the aquifer. Although water levels within the well field are not reflective of true static conditions, it appears that localized dewatering is taking place in the Black Creek aquifer. Water levels in the longest term (September 1992 to May 2004) Black Creek monitoring well at the Smithfield Foods site indicate a decline rate of 1.8 feet per year. The nearby Town of Tarheel uses the Black Creek aquifer as its sole source of water. Comparison of the water level map of the Black Creek with the elevation of the top of the aquifer at Tarheel indicates that the water level is right at the top of the aquifer.

As mentioned earlier, the Division of Water Resources plans to install a ground water monitoring station near the Smithfield Foods site to better understand and monitor ground water conditions in both the Black Creek and Upper Cape Fear aquifers. Black Creek water levels in wells away from the Smithfield Foods pumping center at the DWR Dupont station in Bladen County, Bladen Community College station near Dublin in Bladen County, and Littlefield station in eastern Robeson County do not show decline

rates that pose a threat to the aquifer in the immediate future. It is apparent, however that protective measures are needed to prevent further damage to the Black Creek aquifer at Smithfield Foods.

Water level histories in the Black Creek aquifer as displayed by hydrographs from wells in the Elizabethtown well field and at the old Alamac Knit Fabrics plant indicate that when pumping ceased at the Alamac Plant, levels in nearby well BL-210 recovered dramatically (figure 10). Black Creek well BL-212 was not heavily influenced by pumping from Alamac and remained fairly stable during the monitoring period, reflecting only seasonal pumping response. The recovery of wells in the Black Creek aquifer in the Elizabethtown area is an encouraging trend, however carefully constructed monitoring wells are needed to insure data accuracy.

The Division of Water Resources plans to install a Black Creek monitoring well in the Lumberton area in order to monitor declines that are occurring at a rate of 1.4 feet per year as observed in well RB-199 in the Lumberton well field (figure 13). If the slow, steady decline continues for a period of years, problems could eventually develop in the aquifer.

Conclusions and Recommendations

The results of a capacity use investigation of the subject Southern Coastal Plain counties indicates the following problem areas that will require action and further study.

1. Large cones of depression have developed in the Upper Cape Fear and Black Creek aquifers as a result of ground water withdrawals at Smithfield Foods in Bladen County. Available monitoring data indicates that localized dewatering of the Black Creek aquifer has occurred at the Smithfield Foods plant site, and possibly at the nearby Town of Tarheel well field. Upper Cape Fear aquifer water levels appear to be recovering due to cutbacks in ground water withdrawals. Elevated chloride levels in the Smithfield well field indicate localized upconing of salt water trapped in underlying basement rock. Further monitoring, including additional monitoring station installation will be necessary to monitor water level trends with adequate accuracy and geographic coverage.
2. Ground water withdrawals from the Upper Cape Fear and Black Creek aquifers in the Elizabethtown and Town of White Lake well fields have resulted in the formation of large cones of depression. Limited monitoring data in the Black Creek aquifer in the Elizabethtown area indicates rebounding of water levels as a result of cessation of pumping by Alamac Knit Fabrics in Elizabethtown. It appears that Upper Cape Fear aquifer water levels are rebounding as well, but careful monitoring via installation of a monitoring station will be necessary to track water level histories in individual aquifers.
3. Slow but steady water level declines in the Lumberton well field and vicinity are not a concern at present, but may become a problem in the future. Careful

monitoring of Black Creek aquifer water levels in the area will be necessary. The Division of Water Resources will construct a monitoring station in order to track declines.

The Division of Water Resources recommends to the EMC Water Allocation Committee that designation of a Capacity Use Area in the Southern Coastal Plain is not necessary at this time. Although ground water depletion is a concern in this area, DWR feels that the problems are more localized in comparison to the Central Coastal Plain. Problems in the Southern Coastal plain are a result of relatively few pumping locations. Furthermore, there is no evidence or danger of salt water intrusion or dewatering on a regional basis as is found in the Central Coastal Plain. In light of these findings, the Division of Water Resources recommends that an agreement between local governments and other stakeholders, the Lumber River Council of Governments and DWR be formed in order to implement ground water resource monitoring and protection in this area.

References

Lautier, J.C., 2002, "Hydrogeologic Framework and Ground Water Conditions in the North Carolina Central Coastal Plain", North Carolina Division of Water Resources

"Water Resources Plan – The Southern Coastal Plain Comprehensive Ground Water Study & Assessment," 2003, Groundwater Management Associates, The Wooten Company

Strickland, A.G., 2000, "Water Level Conditions in the Black Creek Aquifer, 1992-1998, in Parts of Bladen, Hoke, Robeson, and Scotland Counties, North Carolina," U.S. Geological Survey Water Resources Investigations Report 00-4138, 23 p.

Strickland, A.G., 1999, "Water-Level Conditions in the Upper Cape Fear Aquifer, 1994-98, in Parts of Bladen and Robeson Counties, North Carolina," U.S. Geological Survey Water Resources Investigations Report 99-4127.

Winner, M. and Coble, R., 1989, "Hydrogeologic Framework of the North Carolina Coastal Plain Aquifer System," U.S. Geological Survey Open File Report 87-690, 155 p.

Definitions

Aquifer: A layer of rock or sediment which is porous and permeable enough to store and transmit water in useable quantities to a well.

Confined Aquifer: An aquifer that is overlain by a layer or layers of low permeability material such as clay. Due to the fact that a confined aquifer is under pressure, a well that is drilled and tightly cased will exhibit a water level that is above the top of the aquifer.

Cone of Depression: When withdrawals from a well begin, the water level in the well begins to decline as water is removed from storage in the well. The water level in the well falls below the level in the surrounding aquifer. As a result, water begins to move from the aquifer into the well. The movement of water from the aquifer to the well results in the formation of a cone of depression, because water must converge on the well from all directions.

Drawdown: A decline in water level in an aquifer due to pumping.

Potentiometric Surface: A surface that represents the level to which water will rise in a tightly cased well. The potentiometric surface of a confined aquifer is normally above the elevation of the top of the aquifer, because the aquifer is under pressure.

Salt Water Intrusion: If a salt water source is sufficiently close to a well field, either laterally in the same aquifer, or deeper in the subsurface, and the water levels fall to a low enough depth, salt water can move into or toward the well field.

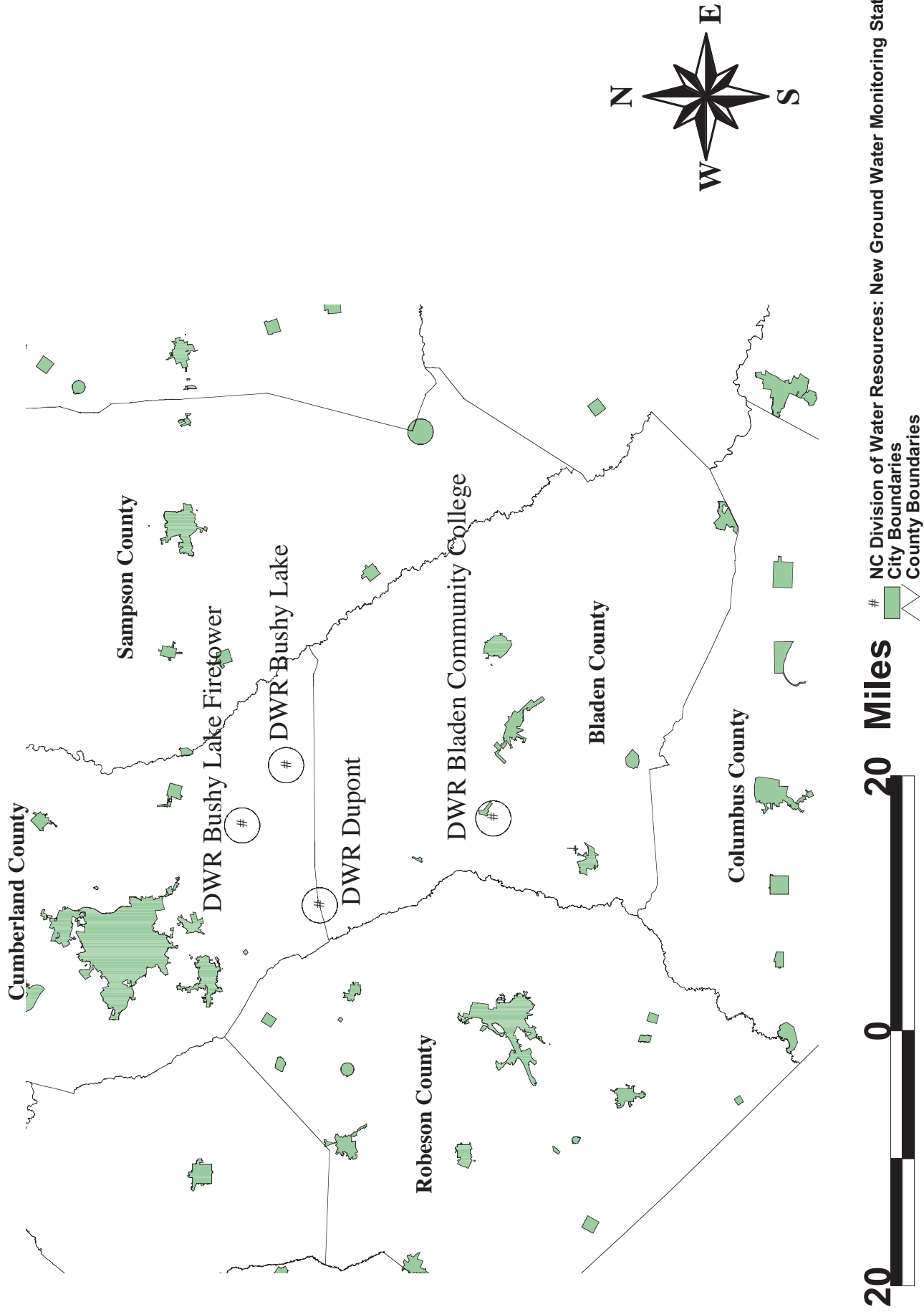
Static Water Level: A non-pump influenced water level measured in a well.

Transmissivity: The ability of an aquifer to transmit the flow of water.

**Figure 1: NC Division of Water Resources
Southern Coastal Plain Capacity Use Investigation Area**



**Figure 2: NC Division of Water Resources: New Ground Water Monitoring Station Sites
Monitoring Station sites in the Southern Coastal Plain Capacity Use Investigation area**



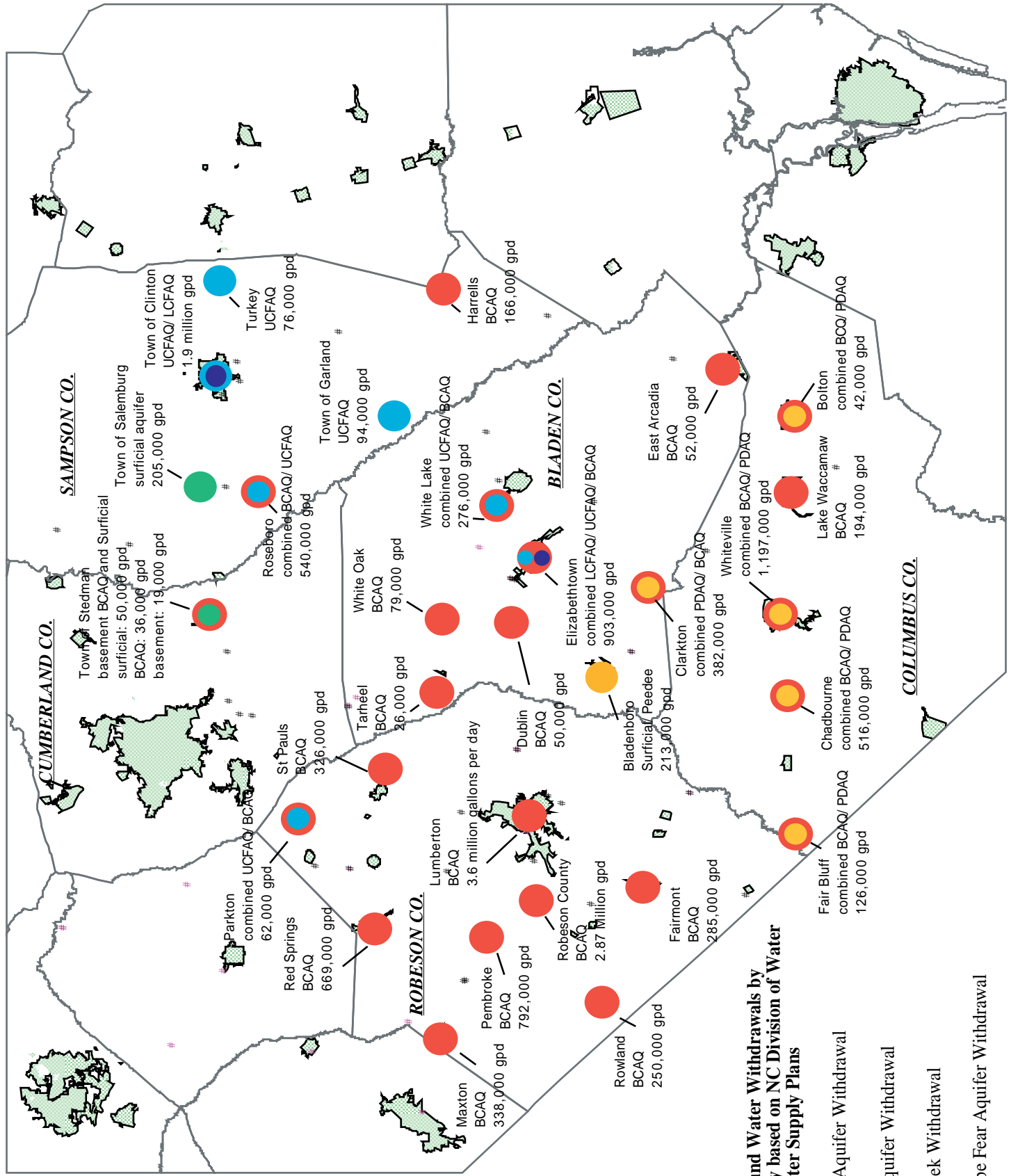


Figure 3: Municipal Ground Water Withdrawals by aquifer in Gallons per day based on NC Division of Water Resources 1997 Local Water Supply Plans

- Surficial Aquifer Withdrawal
- Peedee Aquifer Withdrawal
- Black Creek Withdrawal
- Upper Cape Fear Aquifer Withdrawal
- Lower Cape Fear Aquifer Withdrawal

Table 1: 2001 Water Demands by source in million gallons per day*

Industrial Self-Supplied 2001 Water Demands

Industrial, by County (mgd)	SW	GW	Total
Bladen	12.910	1.950	14.860
Columbus	40.000	0	40.000
Robeson	.990	1.560	2.550
Sampson	0	0.900	0.900
4-County Total	53.9	4.41	58.31

Livestock and Agriculture 2001 Water Demands

Livestock, by County (mgd)	SW	GW	Total
Bladen	.150	2.850	3.000
Columbus	.050	1.000	1.050
Robeson	.200	1.690	1.890
Sampson	0	8.630	8.630
4-County Total	.400	14.170	14.570

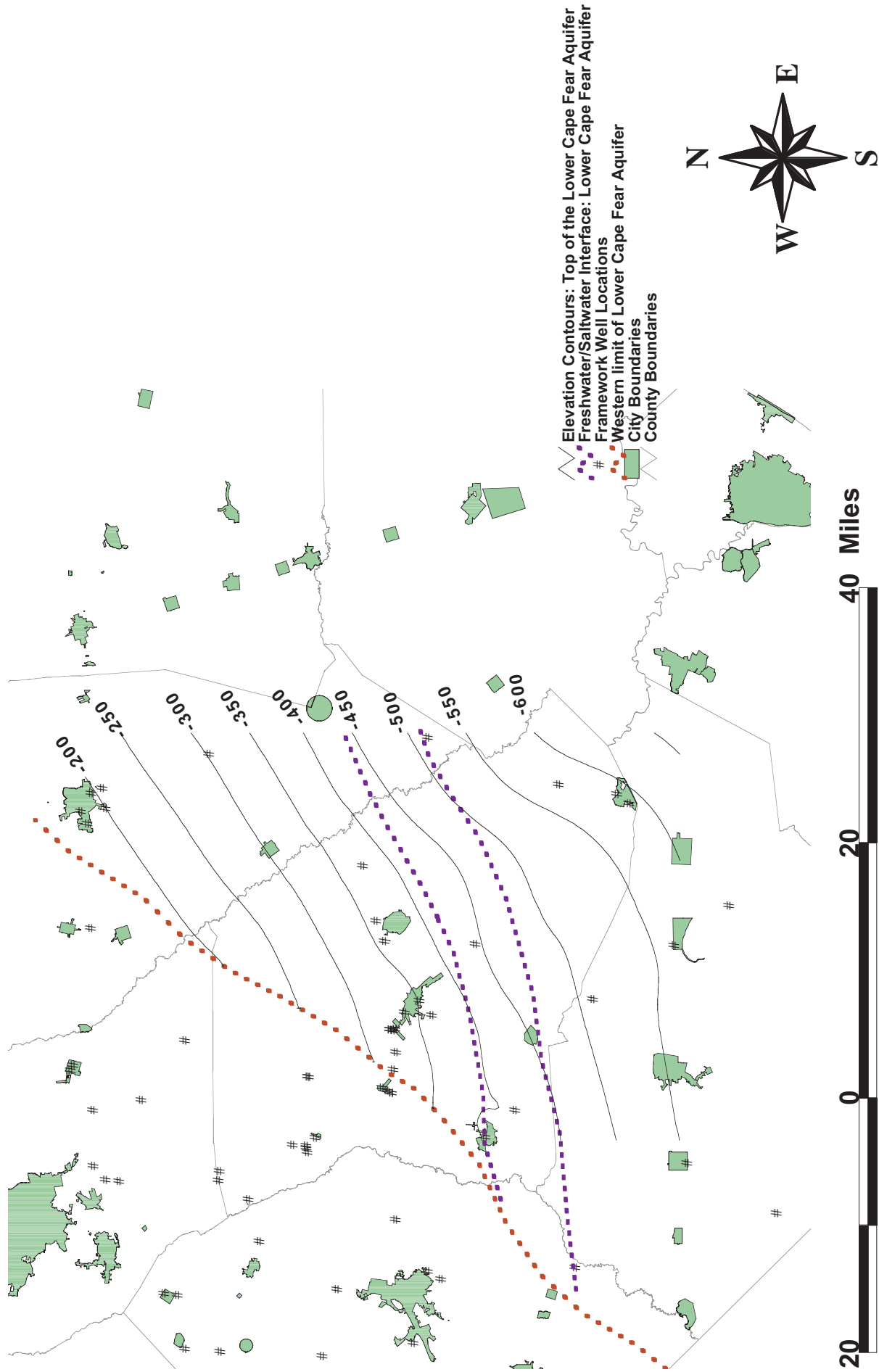
Crops, by County (mgd)	SW	GW	Total
Bladen	.870	.400	1.280
Columbus	.800	.340	1.140
Robeson	.910	.420	1.330
Sampson	5.150	1.290	6.440
4-County Total	7.730	2.450	10.190

Domestic Self-Supplied 2001 Water Demands

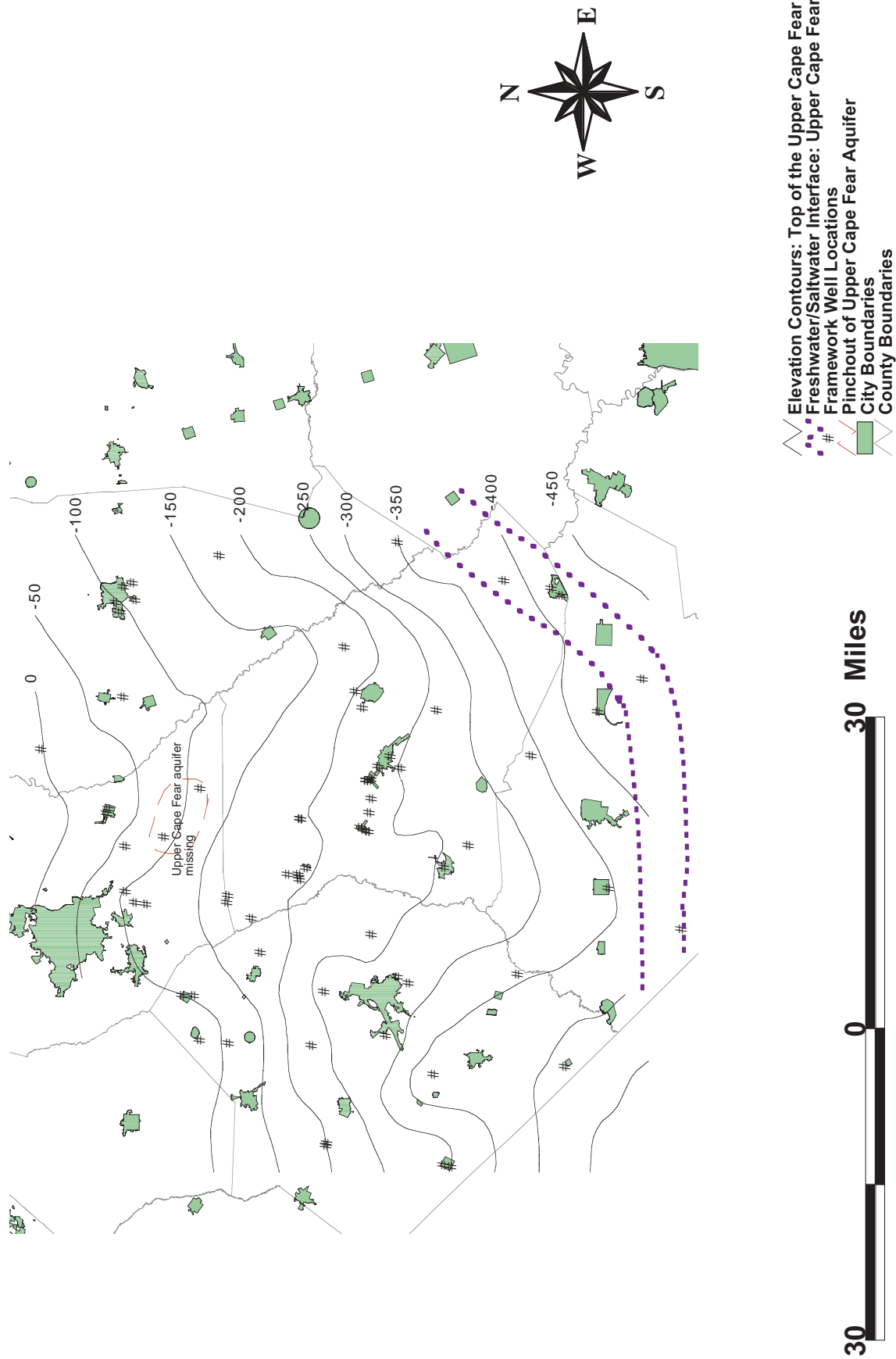
Domestic Self-Supplied, Golf Irrigation and Aquaculture (mgd)	SW	GW	Total
Bladen	.310	.890	1.200
Columbus	.410	2.370	2.780
Robeson	1.040	2.770	3.810
Sampson	.940	2.410	3.350
4-County Total	2.700	8.440	11.140

* GMA/Wooten Company: Water Resources Plan – The Southern Coastal Plain Comprehensive Ground Water Study & Assessment, December 2003

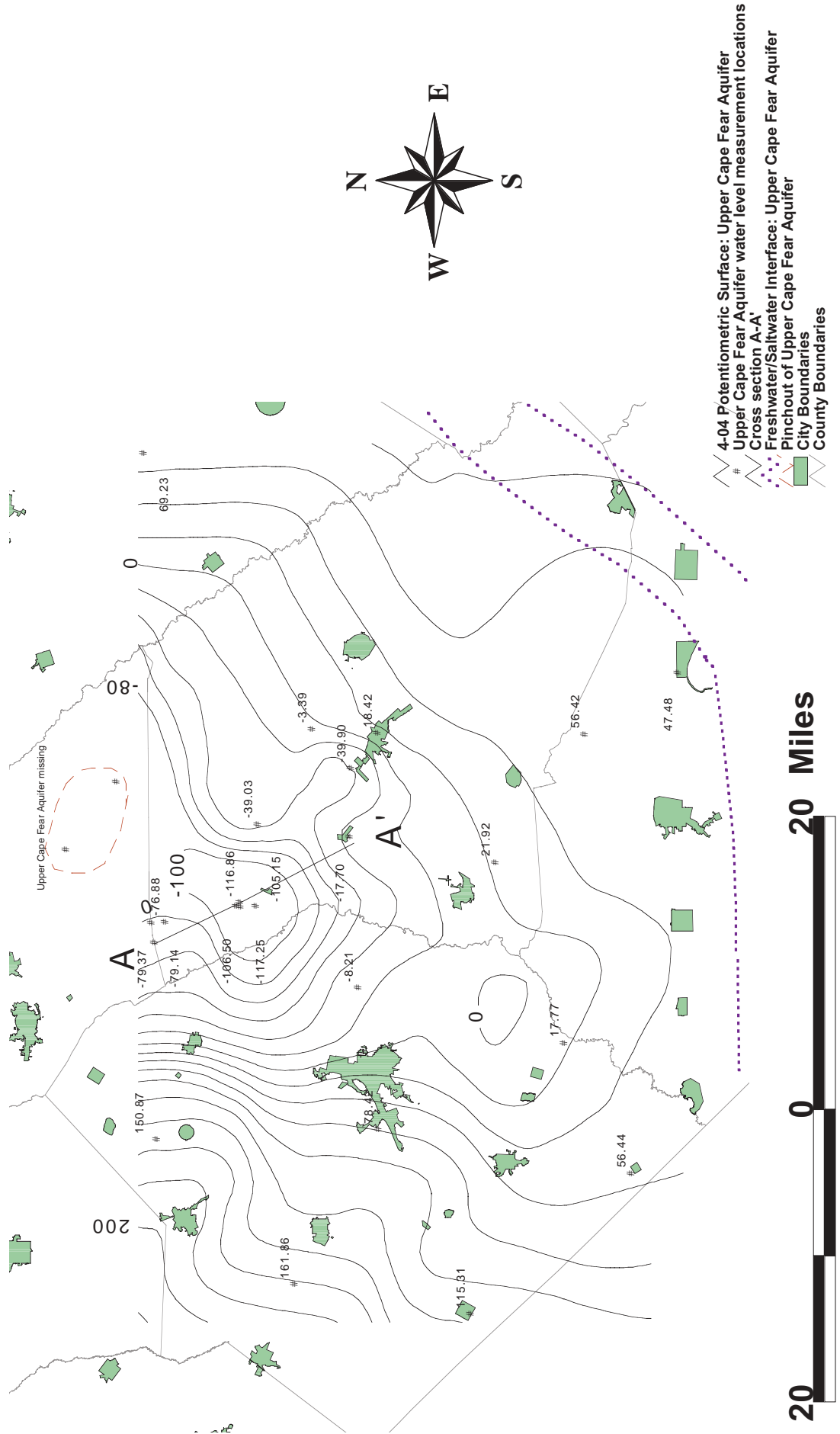
Figure 4:
NC Division of Water Resources
Elevation Map of the Lower
Cape Fear Aquifer in the Southern Coastal Plain Capacity Use Investigation Area



**Figure 5:
 NC Division of Water Resources
 Elevation Map of the top of the Upper
 Cape Fear Aquifer in the Southern Coastal Plain Capacity Use Investigation Area**



**Figure 6: NC Division of Water Resources
 April, 2004 Potentiometric Surface of
 the Upper Cape Fear Aquifer in NC Southern Coastal Plain Capacity Use
 Investigation area**



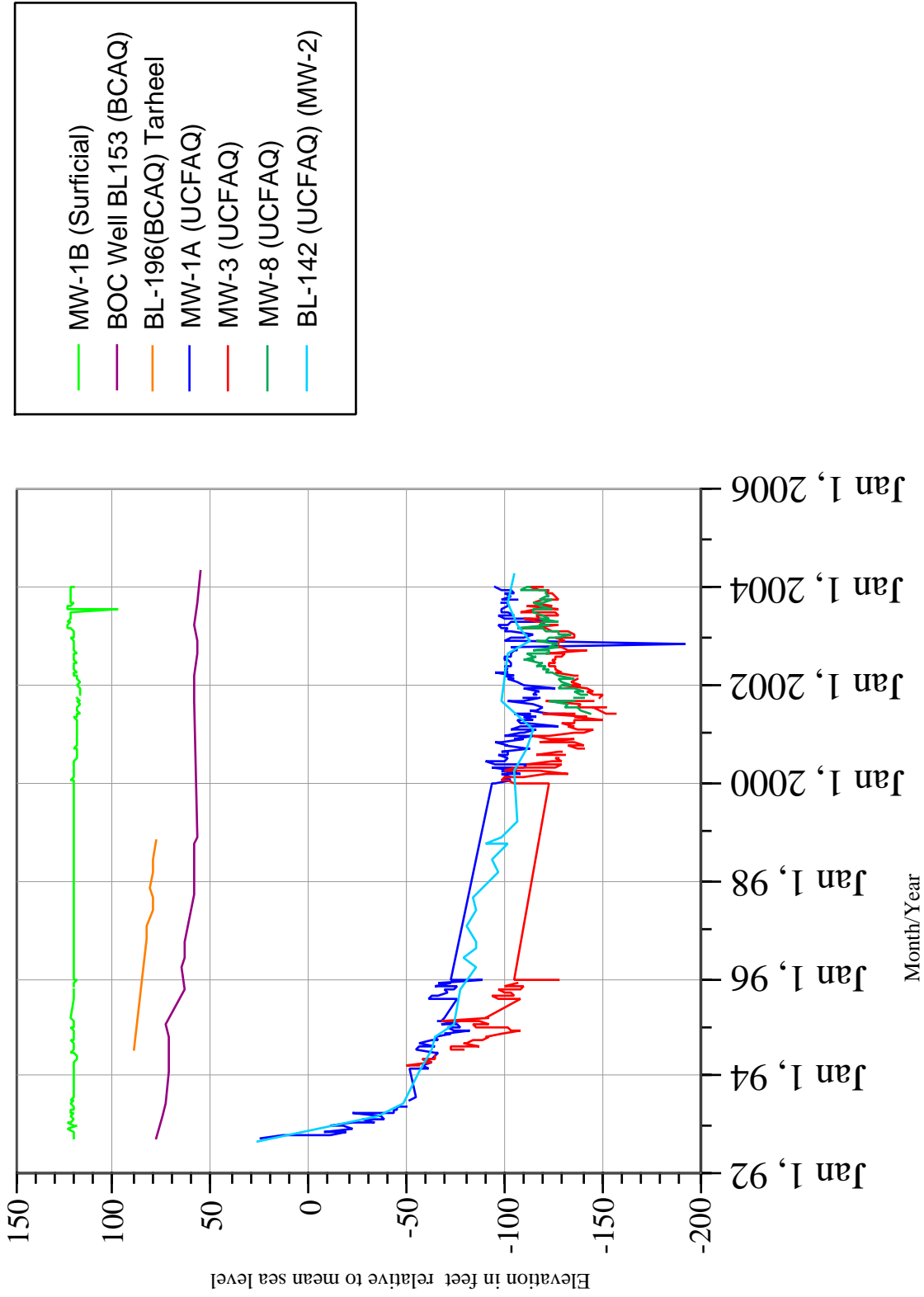


FIGURE 7: Hydrographs from wells at the Smithfield Packing site and Town of Tarheel, Bladen County, North Carolina

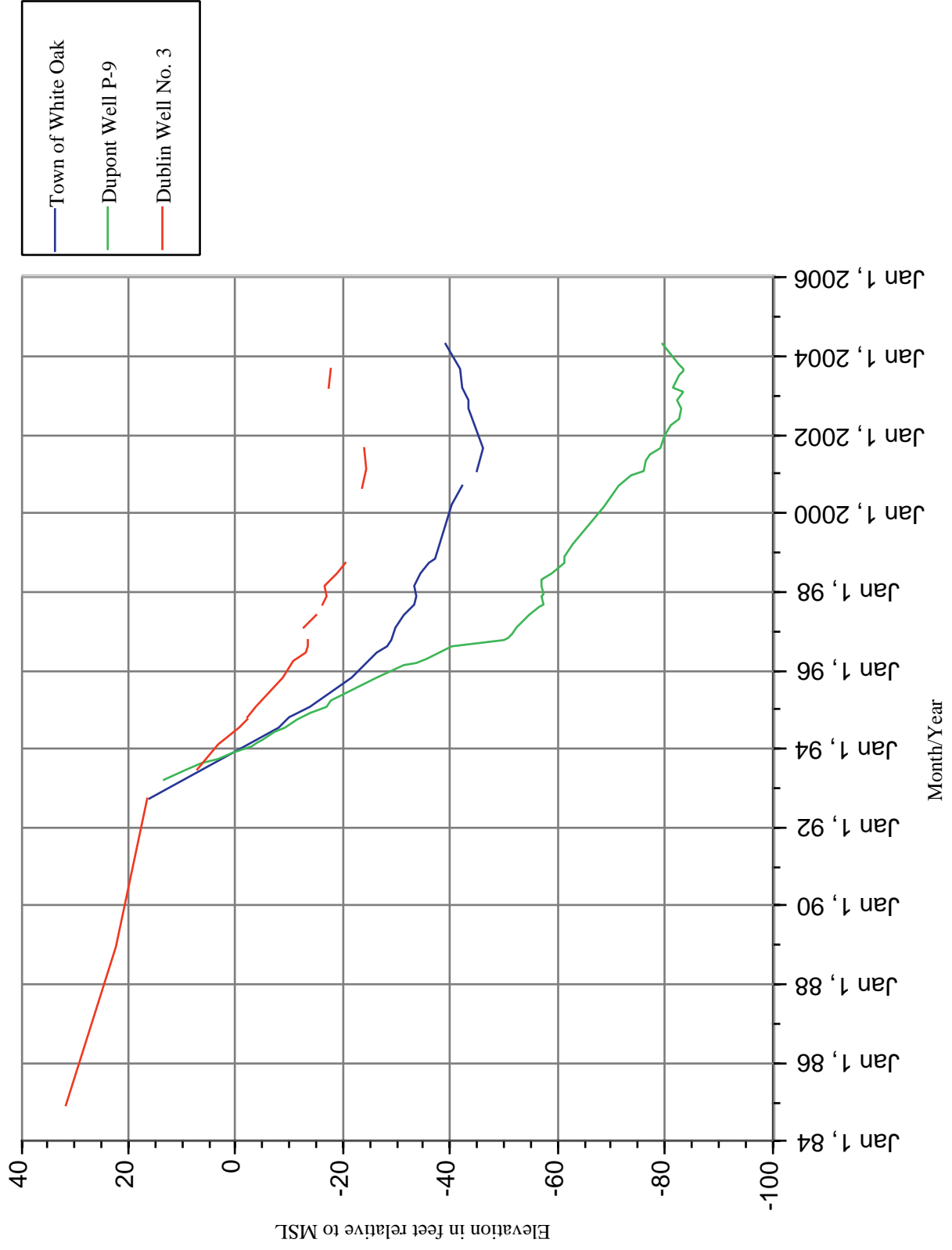


Figure 8: Upper Cape Fear Aquifer Water Levels at Town of White Oak, Dupont, and Town of Dublin in Bladen County

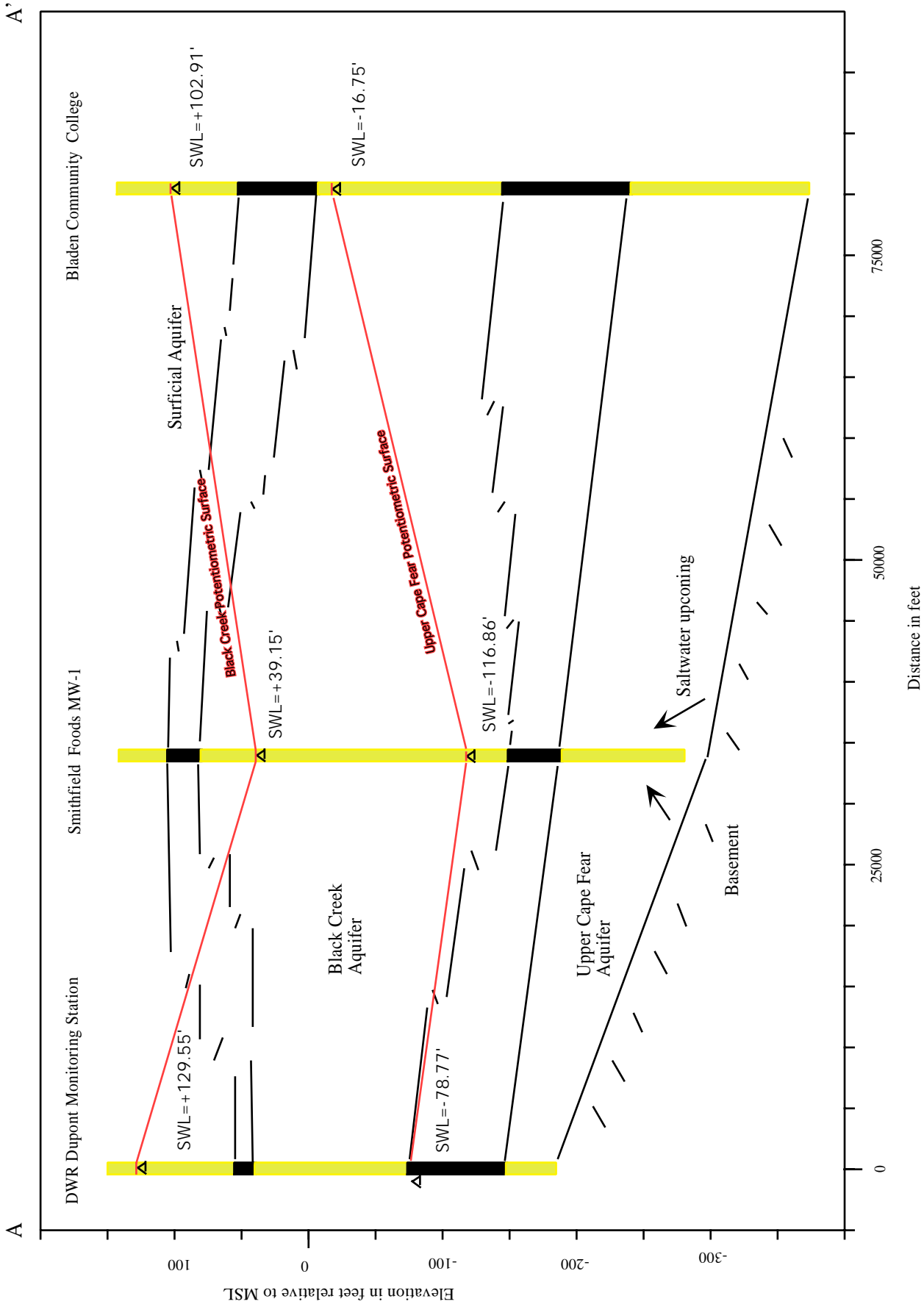


Figure 9: North-South Hydrogeologic Cross Section A-A' through western Bladen County showing May, 2004 potentiometric surfaces in the Upper Cape Fear and Black Creek aquifers

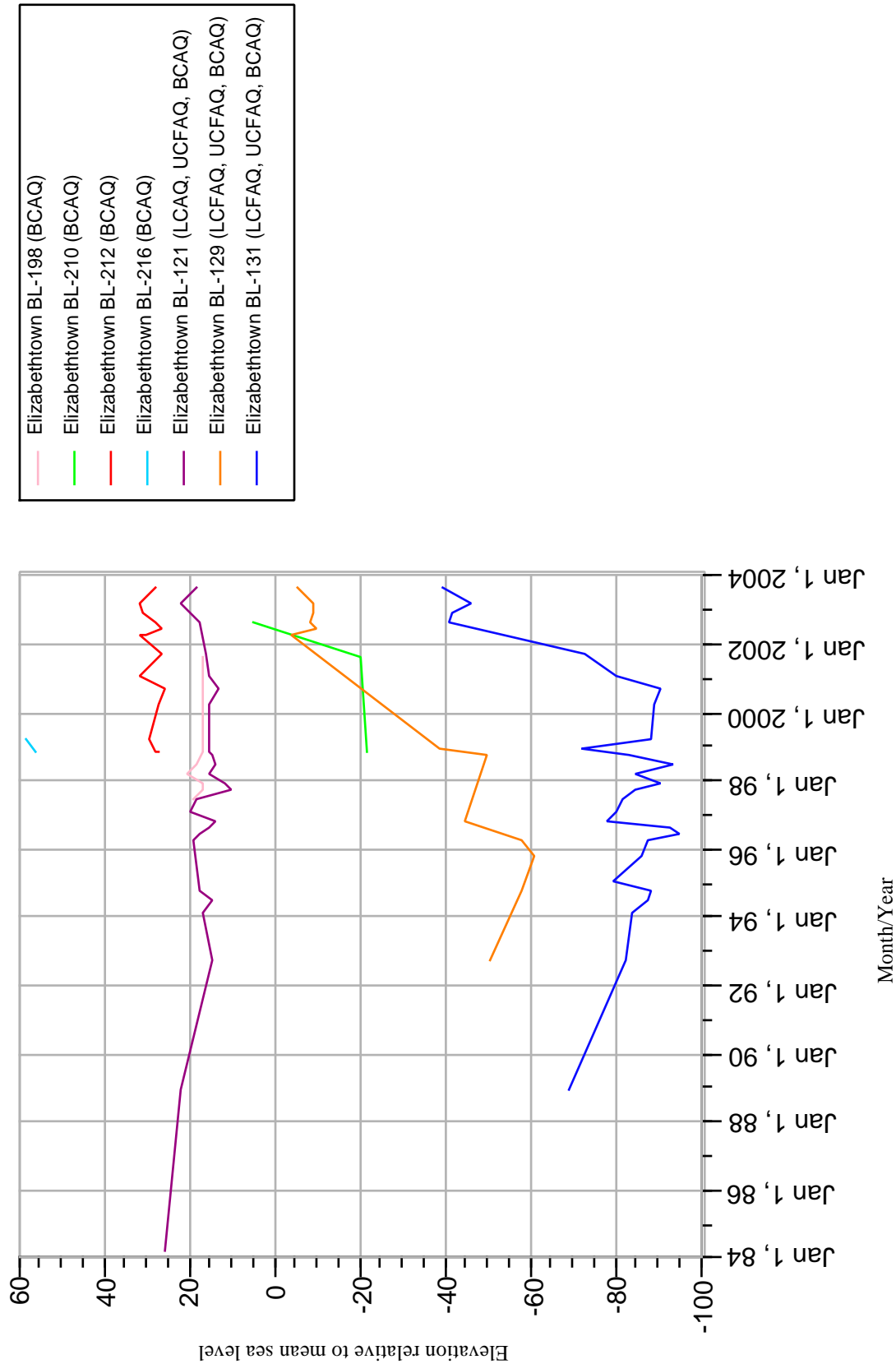
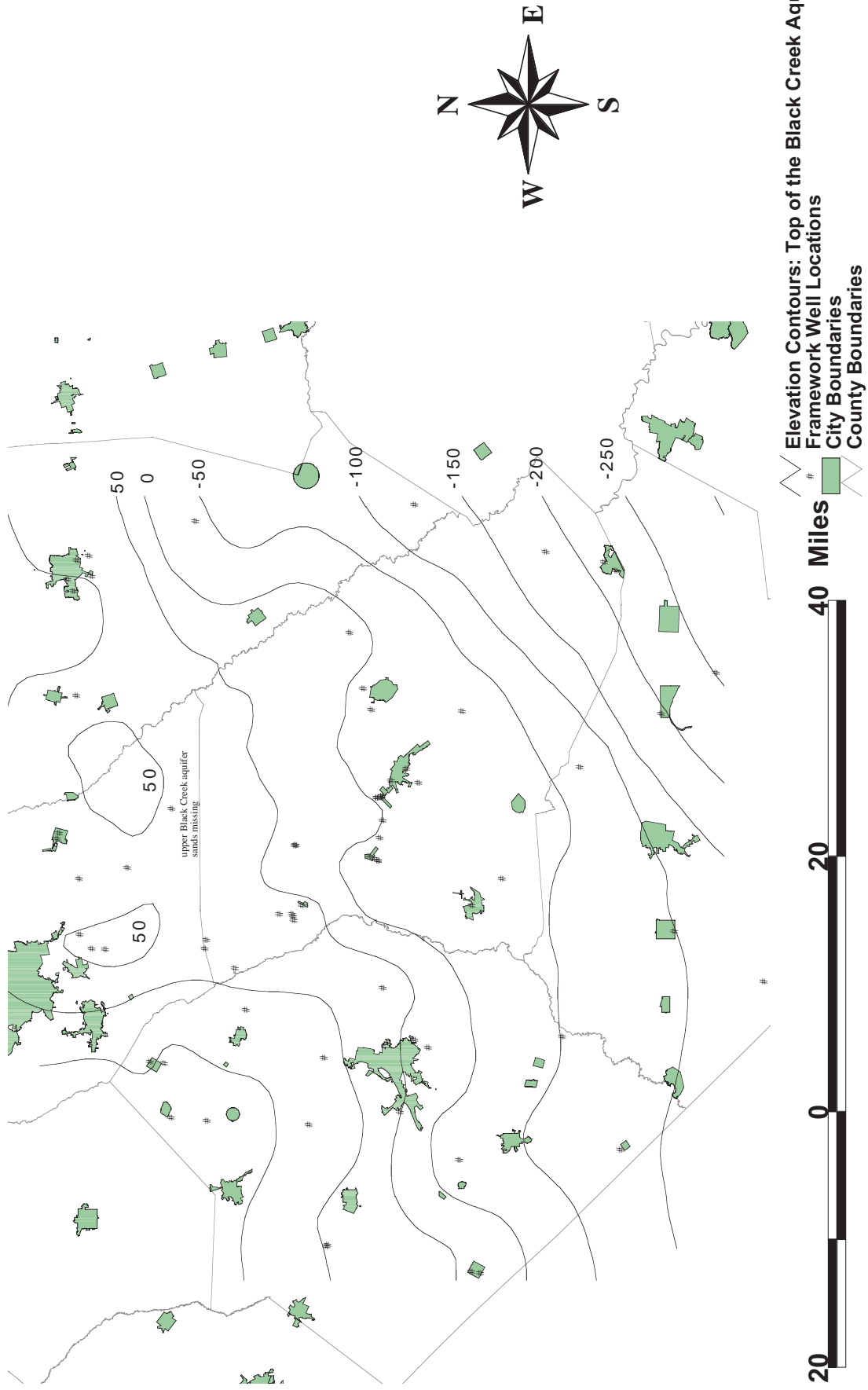
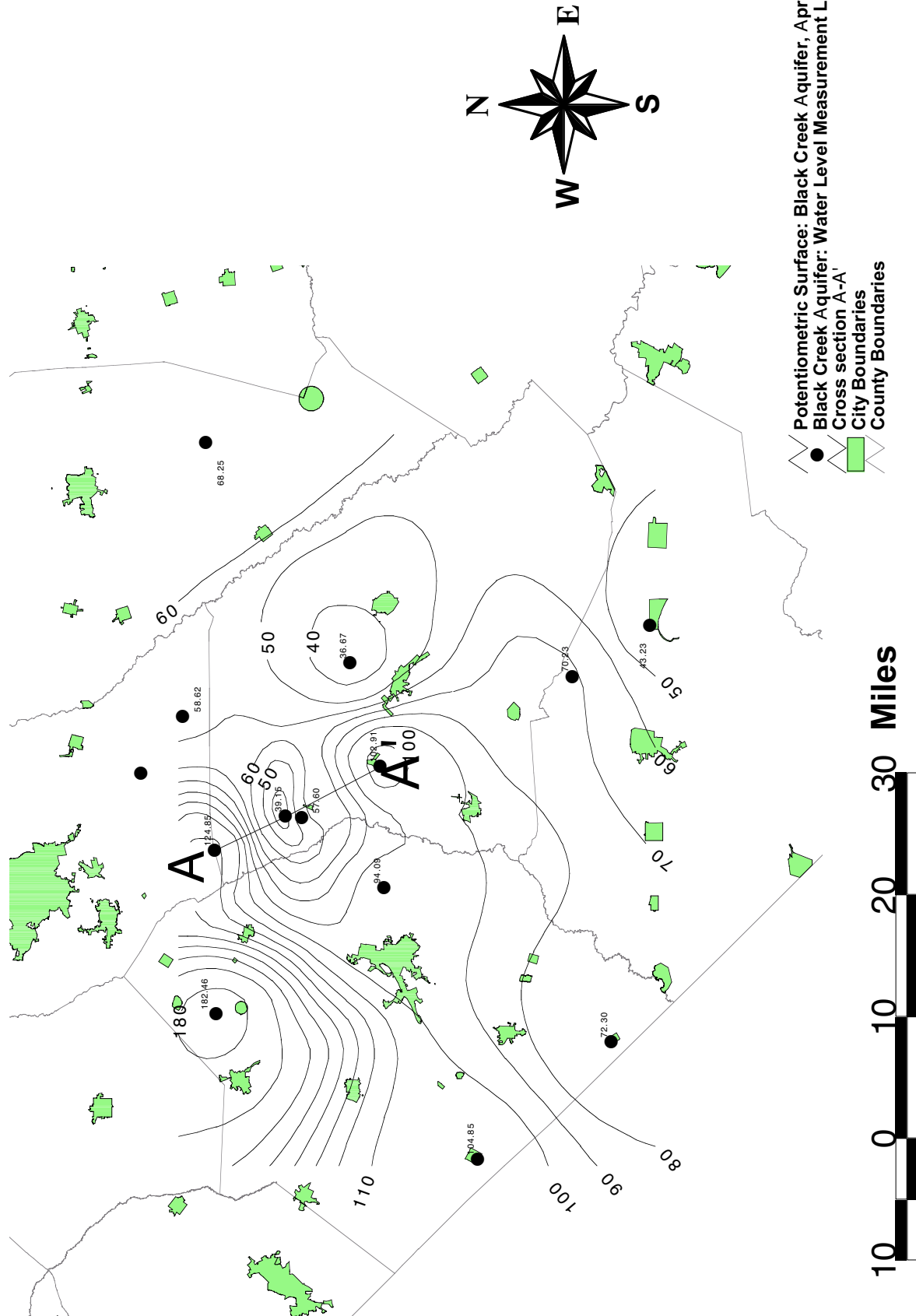


FIGURE 10: Hydrographs in the Town of Elizabethtown Well Field, Bladen County, North Carolina

**Figure 11: NC Division of Water Resources:
Elevation Map of the top of the Black
Creek aquifer in the Southern Coastal Plain Capacity Use Investigation Area**



**Figure 12: NC Division of Water Resources
 April, 2004 Potentiometric Surface of
 the Black Creek Aquifer in NC Southern Coastal Plain Capacity Use Investigation Area**



- Potentiometric Surface: Black Creek Aquifer, April, 2004
- Cross section A-A'
- City Boundaries
- ▨ County Boundaries

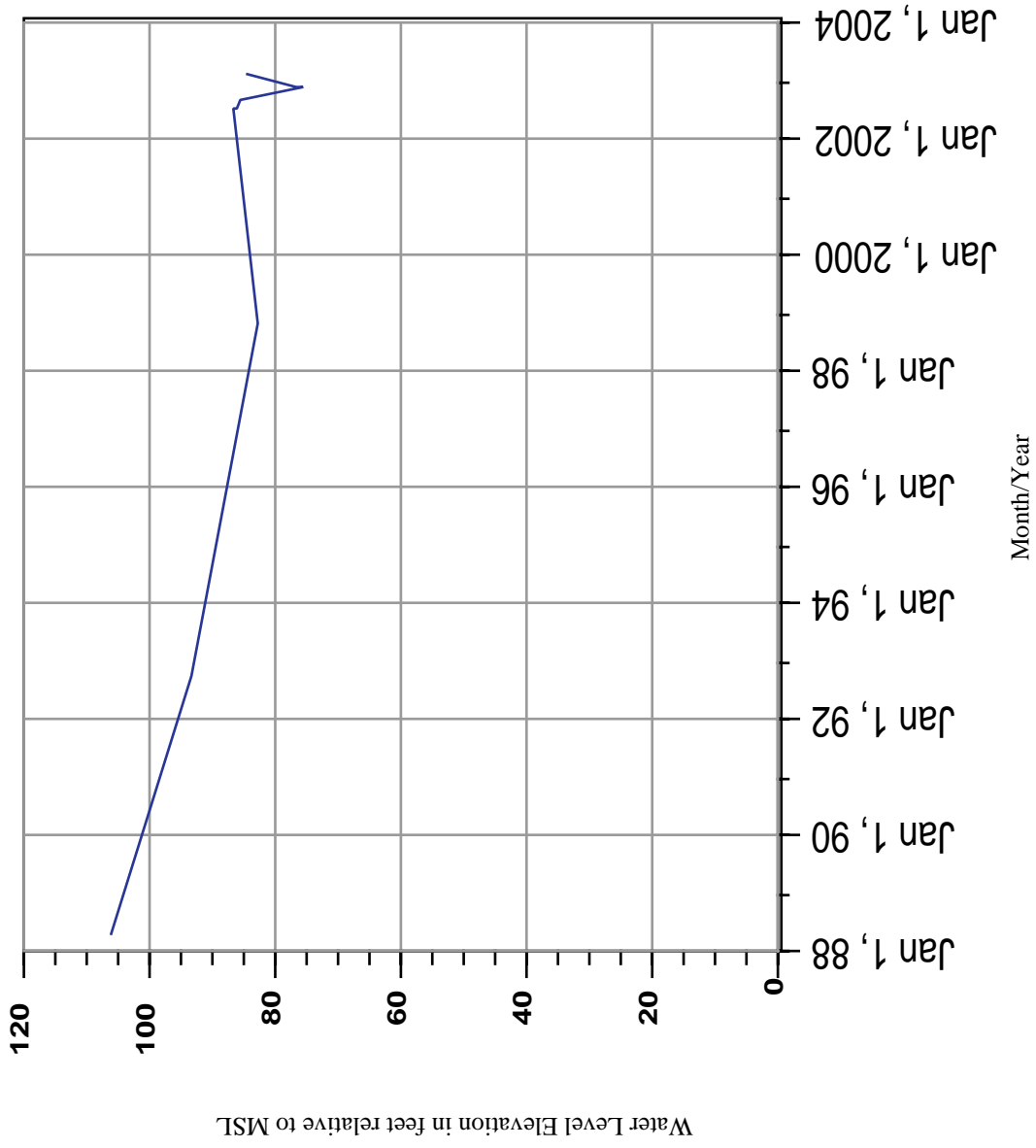


Figure 13: Black Creek Aquifer water levels in the City of Lumberton Well Field (Well RB-199)