UNION COUNTY GROUNDWATER ASSESSMENT

NC Environmental Quality

DWR Division of Water Resources

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INTRODUCTION

This report was prepared by the North Carolina Department of Environmental Quality (NCDEQ) Division of Water Resources (DWR) as a general assessment of groundwater quality in Union County, North Carolina. In contrast to other environmental media, the management of groundwater as a resource is fragmented. Several agencies have responsibility for a specific regulatory program related to groundwater, such as underground petroleum storage tanks or the land application of wastewater, but there is no current program to examine the groundwater resource as a whole and to analyze the various sources of groundwater quality data from a resource management point of view. One result of the stakeholder process which guided the development of this report is an awareness of the need to address water quantity concerns as well as water quality. Some attempt has been made to scratch the surface of water quantity issues, and future reports will improve on that. This report is primarily a baseline water quality assessment to refer to when future assessments are made.

PURPOSE AND SCOPE

The objective of this report is to provide basic information related to groundwater issues in Union County and to serve as a starting point to those interested in learning more about groundwater quality in the county. In order to accomplish our objectives, we have obtained groundwater data from a multitude of sources. Groundwater quality data in North Carolina is very fragmented; that is, there are many different state and federal regulatory and natural resource management agencies that collect this data, and they store and manage it in many different formats. We have gathered this data together to present it in a concise and practical form. Finally, we have analyzed the existing groundwater quality data from a hydrogeologist's perspective in order to assess the trends in water quality and identify potential areas of concern. Because groundwater systems can be vulnerable to pollution, but take relatively long periods of time to remediate, it is essential to recognize declining water quality as soon as possible in order to prevent long term damage to the resource. The value of this assessment will be compounded if it can be repeated at regular intervals. A byproduct of this exercise is a better understanding of the gaps in North Carolina's groundwater resource management and in the management of the data collected in that endeavor.

Some basic understanding of the water cycle and the interaction of water with the underlying geology and the landscape is helpful to put groundwater management in context. This report is primarily a description of the physical characteristics of Union County and an assessment of the available groundwater data. Appendix A provides some resources for those who are interested in a deeper understanding of groundwater in general.

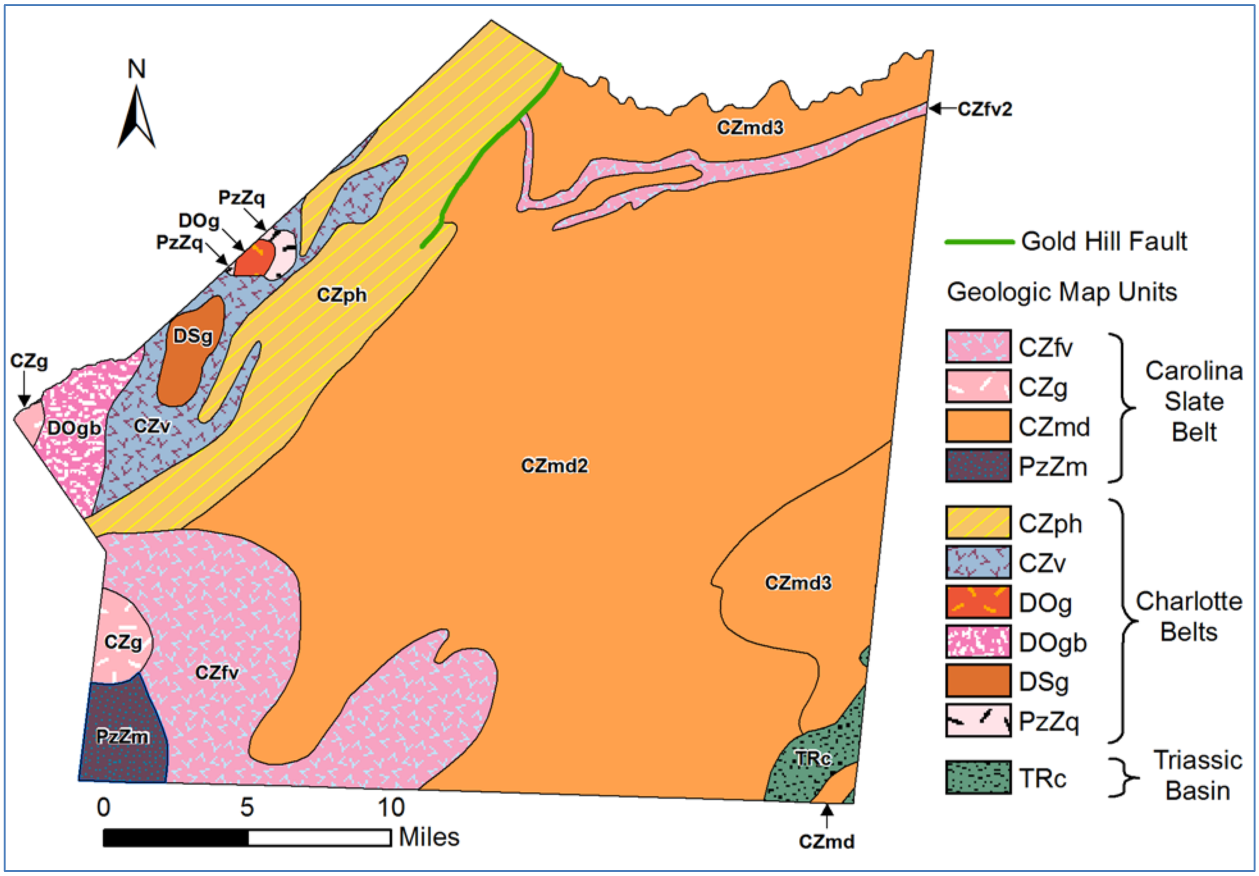
PHYSICAL CHARACTERISTICS

Union County covers 632 square miles in the southern Piedmont Physiographic province of North Carolina. The landscape is characterized by rolling hills with gentle relief, and land elevation ranges from approximately 283 feet to approximately 790 feet above mean sea level. The climate is humid sub-tropical, which is characterized by warm humid summers and cool, wet winters. Rainfall averages about 49 to 50 inches per year in Union County (USDA-NRCS, 2012). Of this, only a small portion infiltrates to the groundwater table.

GEOLOGY AND HYDROGEOLOGY

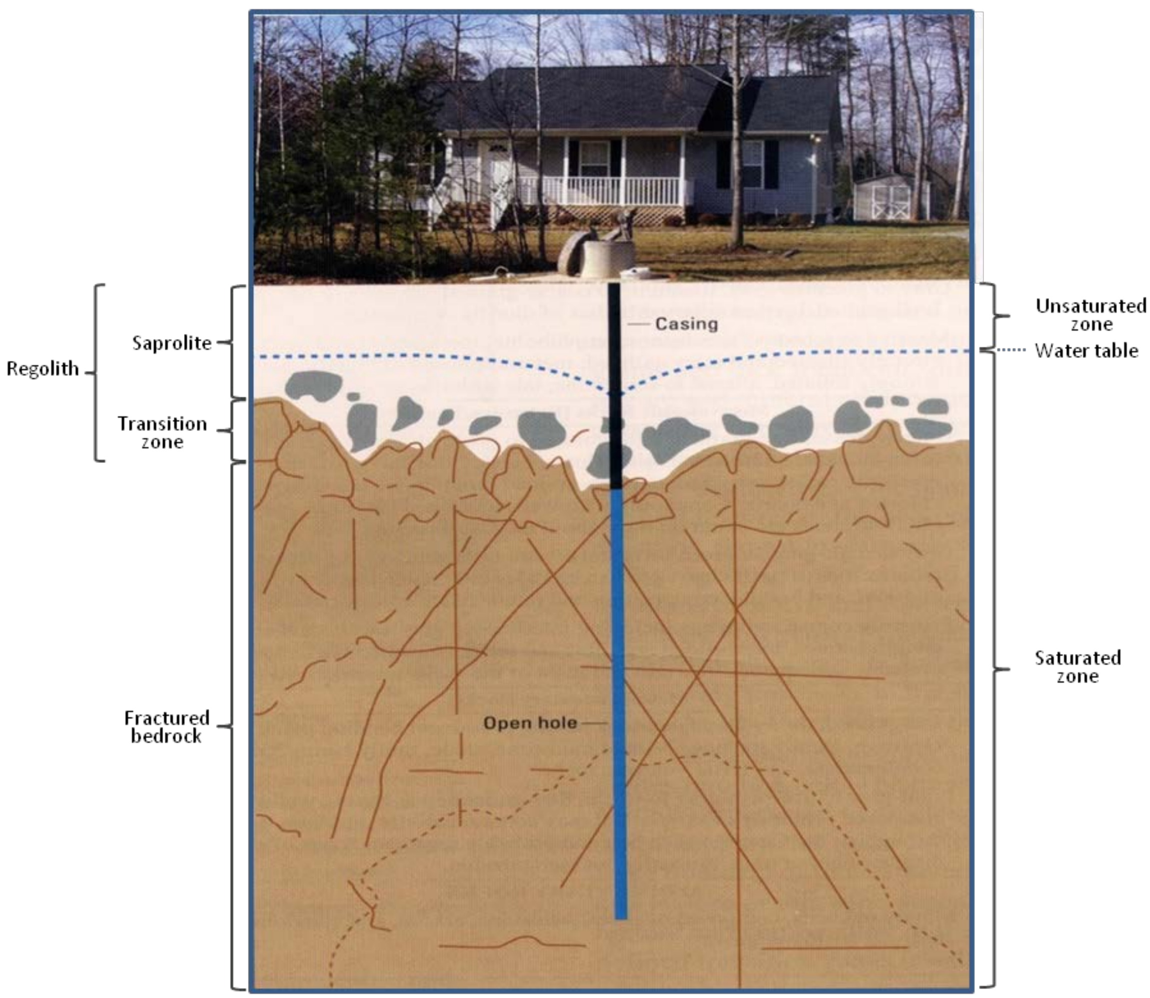
Union County lies mostly within the geologic unit known as the Carolina Terrane and mainly consists of lightly metamorphosed sedimentary rocks. The rocks have a slaty cleavage and appearance; hence the term “Slate belt” has been historically used to denote this area. There are also numerous, small igneous intrusive rocks occurring as dikes and sills. At the western edge of Union County, the Gold Hill fault zone separates the Carolina and Charlotte Terranes. The Charlotte Terrane is characterized by higher grade metamorphic rocks. To the east of the Carolina Terrane is the Deep River Triassic basin consisting of sedimentary rocks. A geologic map of Union County, based on the 1985 Geologic Map of North Carolina (NCDNR, 1985), is shown in Figure 1.

Figure 1: Union County Geologic Map, 1985



The groundwater system in the Piedmont region is essentially a two-part system comprised of the regolith and the underlying bedrock (Figure 2). The regolith serves as the principal groundwater storage reservoir. Precipitation infiltrates the regolith until it reaches the saturated zone, typically in saprolite, where it is stored as groundwater in inter-granular pore spaces. In many locations, the regolith includes a transition zone between saprolite and fractured bedrock. The transition zone consists of coarse fragments of partially weathered bedrock and lesser amounts of saprolite (Daniel & Payne, 1990). Within the fractured bedrock, fractures are generally more numerous and more open in the shallow portion of the bedrock, and typically become less numerous and less open with increasing depth.

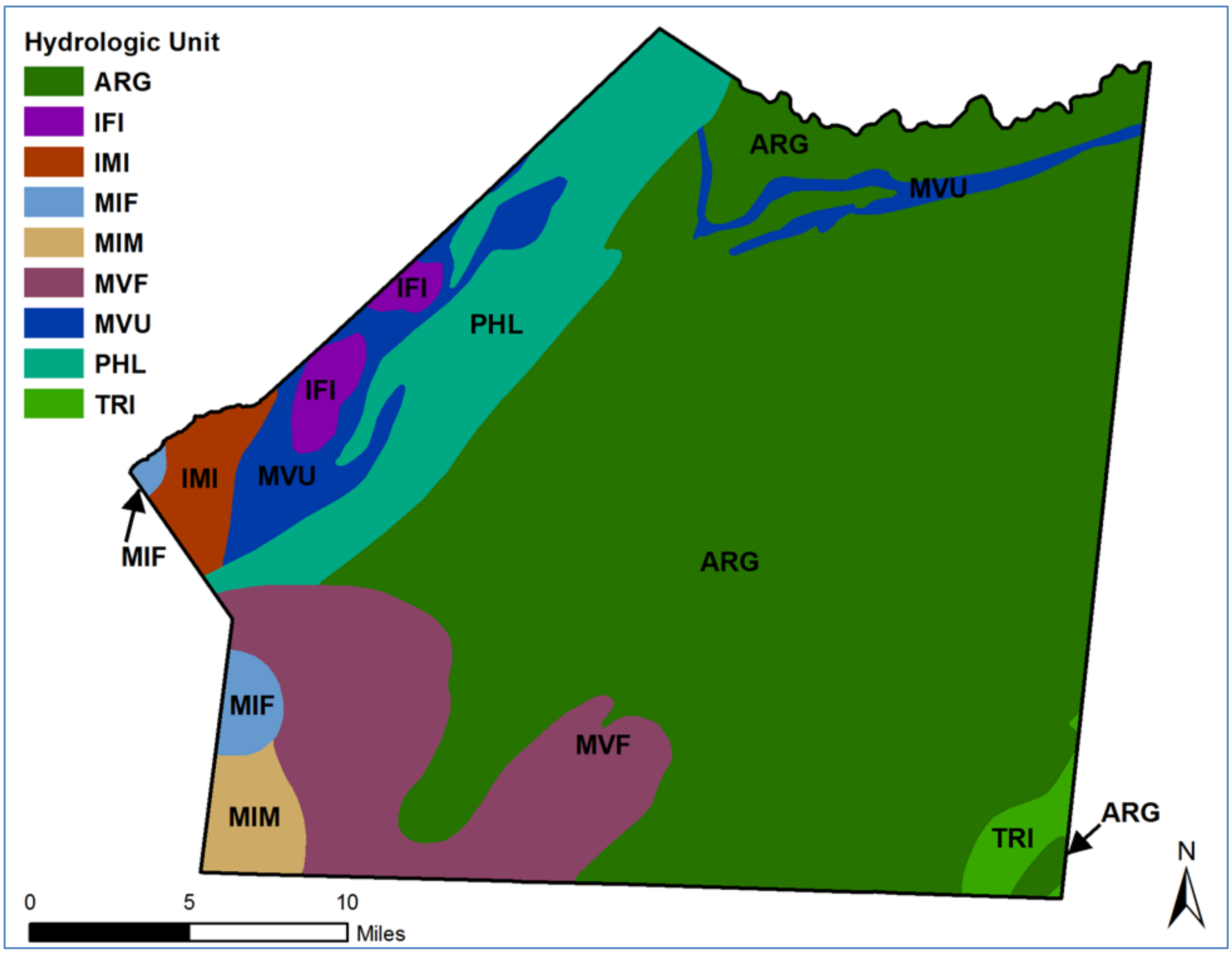
Figure 2: Cross-section of the crystalline bedrock aquifer system (Cunningham & Daniel, 2001)



In areas close to rivers and streams, alluvial aquifers may lie on top of the regolith or bedrock. These aquifers are composed of the sediments deposited on the floodplains and banks of rivers and streams. These aquifers are capable of yielding large quantities of water when a supply well taps into thick, coarse sediments such as sand and gravel. The alluvial aquifers are usually relatively thin and occupy only narrow areas close to streams or rivers, and they are subject to periodic flooding during major storm events. For these reasons, few wells in the area tap into the alluvial aquifers.

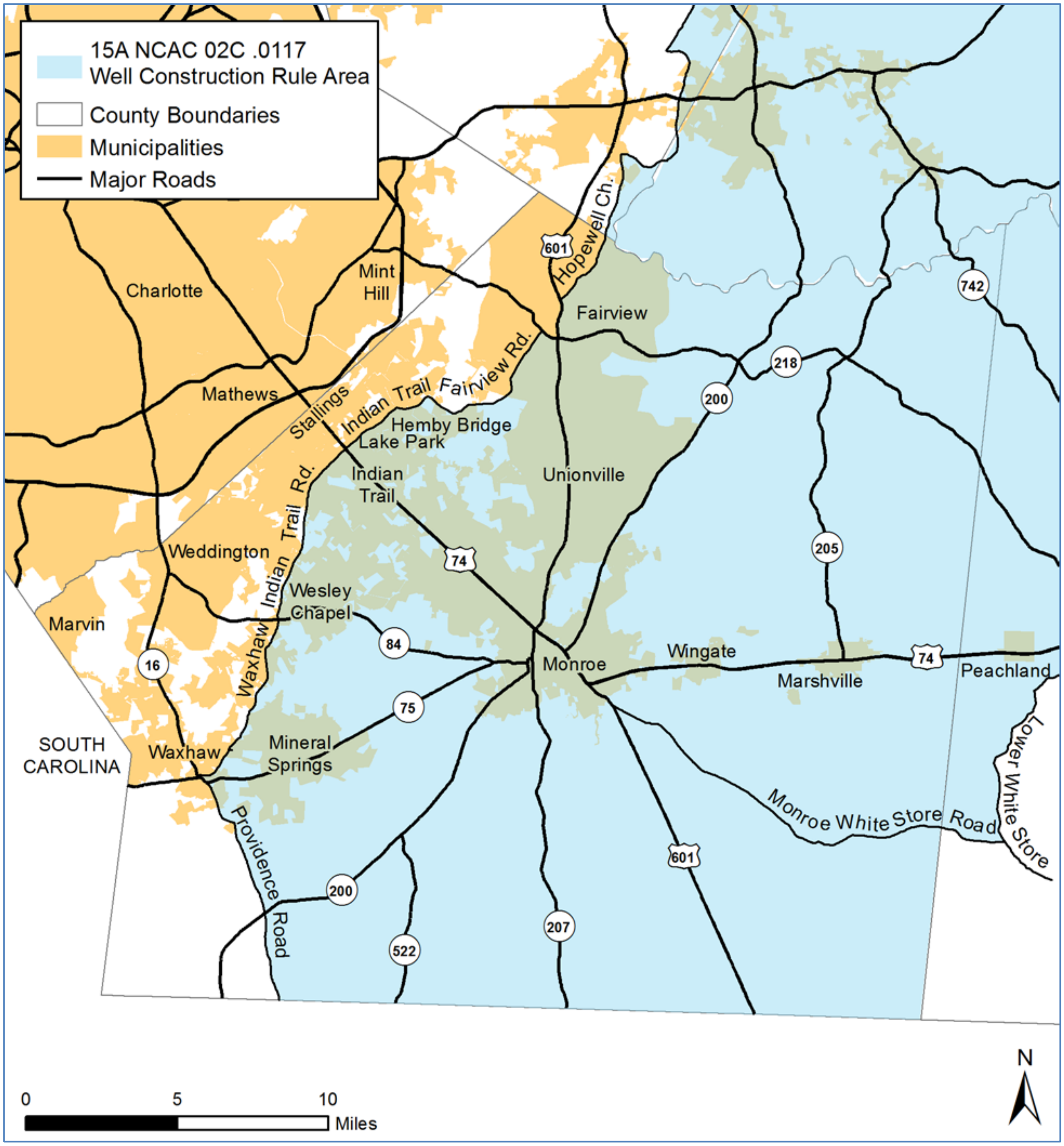
Figure 3 shows the hydrogeologic unit map for Union County (Daniel & Payne, 1990). From this map it is apparent that argillite (ARG), followed by felsic metavolcanic (MVF) and phyllite (PHL) rocks are the predominant hydrogeologic units in Union County. The ARG unit consists mainly of meta-sedimentary rocks and is fine-grained and thinly laminated rock. The MVF unit rocks are dense and fine-grained. Phyllite is light-colored and fine grained with well-developed cleavage (Daniel C. C., 1987).

Figure 3: Map of Hydrogeologic Units of Union County



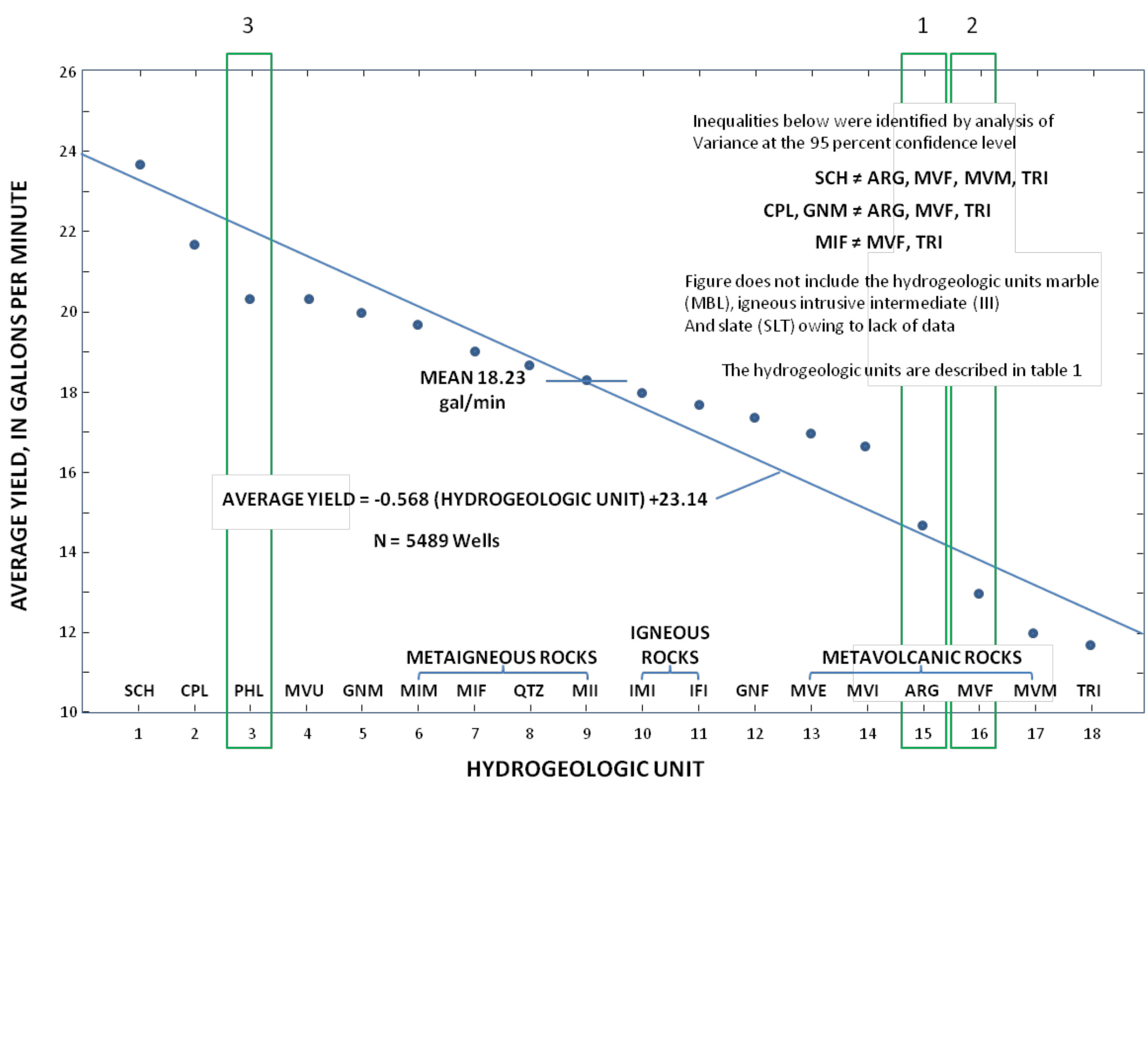
The ARG unit is also characterized by a tendency to fracture along near- vertical foliation planes. These features of this hydrogeologic unit make it more likely that a fracture could conduct contaminants to the bottom of the casing. For this reason, Rule .0117 of the Subchapter 2C Well Construction Standards requires casing in water supply wells in most of the county to extend to a minimum depth of 35 feet. The area where this rule applies is shown in Figure 4.

Figure 4: The area in Union County where 35 feet of casing is required by Rule 15A NCAC 2C .0117



A 1987 study by the USGS examined over 6,200 water well records across the Piedmont and Blue Ridge provinces of North Carolina to identify the geologic, topographic, and construction factors associated with high-yielding wells. In addition to associations between well yield and topographic setting and between well yield and well diameter, this study established an association between well yield and underlying hydrogeologic units. Figure 5 indicates this association across the Blue Ridge and Piedmont and highlights the most common hydrogeologic units in Union County. Green boxes (numbered 1, 2, and 3) indicate primary rock types of Union County, by area (Daniel C. C., 1987).

Figure 5: Average yield of wells of average construction in the hydrogeologic units of the Piedmont and Blue Ridge provinces of North Carolina (Daniel C. C., 1987).



PRINCIPAL AQUIFERS USED

According to the latest available data on water usage (Kenny et al, 2009), approximately 31% of the total population of Union County relied upon groundwater for potable water in 2005, as shown in Table 1. The vast majority of the groundwater users in the county are supplied by private water supply wells. With almost a third of the population in the county dependent on groundwater for their drinking water, it is an important resource in this county. In addition, groundwater is used for irrigation of crops and golf courses, and for watering livestock (Table 1).

Table 1: Groundwater Use in Union County

Groundwater Use	Population Served in 2005	Percentage of Total Population	Withdrawals in 2005 (million gallons/day)
Public Water Systems	730	0.4%	0.04
Private Wells	49,197	30.2%	3.44
Irrigation			1.00
Livestock			6.77
Total Withdrawals			11.25

The dominant aquifer used for water supply in Union County is the fractured bedrock aquifer. A few, typically older, water supply wells obtain water from the soil/saprolite portion of the regolith. These wells are usually larger diameter (approx. 2 feet) wells that were excavated by hand or by a bucket auger or cable tool drilling rig and may be referred to as “bored wells.” The soil/saprolite system is capable of yielding low to moderate amounts of water to wells, but the typical high silt and clay content of this material often results in low well yields. Hence, the soil/saprolite system is not a major source of water in this area. The soil/saprolite system is, however, an important water storage and filtering feature for the bedrock aquifer, so it is desirable to have a thick soil/saprolite layer on top of the bedrock for reliable well yields. Wells completed in the soil/saprolite are vulnerable to contamination from surface spills and other releases, and they are prone to going dry during periods of extended drought.

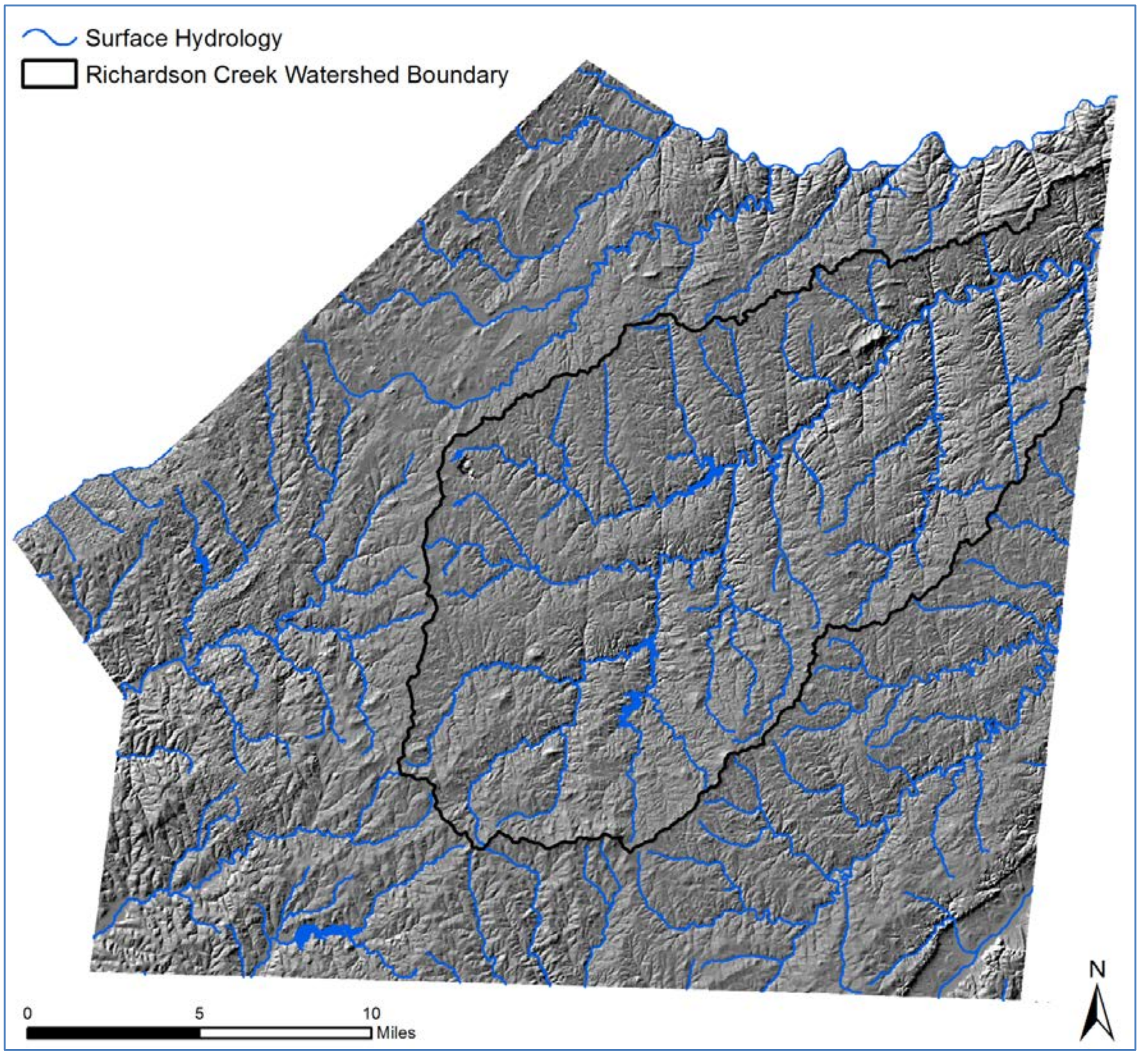
The majority of water supply wells in Union County are completed as open-hole bedrock wells that are designed to intercept water bearing fractures in the underlying crystalline bedrock. It is desirable to place and construct wells in such a manner as to intercept as many of these fractures as possible to achieve the desired water yield. Geologic and topographic maps can be used to identify regional fracture patterns that can help improve the chances of siting a well in an area where water yielding fractures are more likely to be encountered. Well drillers are required to send well construction records to the state for every well they drill. DEQ has recorded information from these driller-submitted well construction forms in a database. The database is limited to those wells where drillers have complied with their obligation to submit records and by DWR’s ability to enter records in a timely manner. The statistics for wells of select types constructed in Union County since 1982 are in Table 2.

Table 2: Well construction statistics for wells constructed in Union County from 1982 to February of 2015

	Total Depth (ft)	Casing Depth (ft)	Static Water Level (ft bls)	Yield (gpm)
All wells (2720 recorded wells)				
Median	185	40	25	10
Mean	204	51	24	17
Standard deviation	164	39	32	25
Residential Wells (2427 wells)				
Median	225	46	30	10
Mean	259	59	26	15
Standard deviation	132	32	24	20
Irrigation and Agricultural Wells (287 wells)				
Median	325	52	25	20
Mean	358	61	19	29
Standard deviation	165	29	23	28
Source: GW1 Database, Union County Wells constructed 1982-2015				

Figure 6 is a high resolution digital elevation map generated from Light Detection and Ranging (LIDAR) elevation data that reveals many linear features in the topography of Union County, particularly in the Richardson Creek Watershed, indicating underlying geologic structures such as faults and fractures. Such structures often reflect the presence of potential water-bearing fractures in the bedrock. Daniel and Payne, 1987 established that, in general in the Piedmont and Blue Ridge, wells drilled in draws and valleys tend to have higher yields than those drilled on hills and ridges, and that larger diameter wells had higher yields.

Figure 6: Topographical Relief Map based on LIDAR Data



Ideally, data for every water supply well drilled in NC including the location, date, owner, well depth, well yield, grouting information, and other data on well construction are collected in the state's well construction database. The current status of and potential for this database is discussed in the Current Data Evaluation section.

HUMAN FACTORS

The purpose of this section is to improve awareness of human factors that affect groundwater quality and to catalog data collected by various agencies on potential contamination sources and contaminated sites in Union County. This data may then be used to assess water quality issues facing county planners and residents. Humans influence the health of the environment in several ways. Some, such as population density and land cover change, may increase pressure on the environment but are not considered contaminants. Others have the potential to contaminate the environment and are thus managed and sometimes regulated in order to prevent pollution. The environment has some capacity to absorb and mitigate non-natural additives to it and the primary goal of many regulatory programs is to prevent additions that are beyond that capacity.

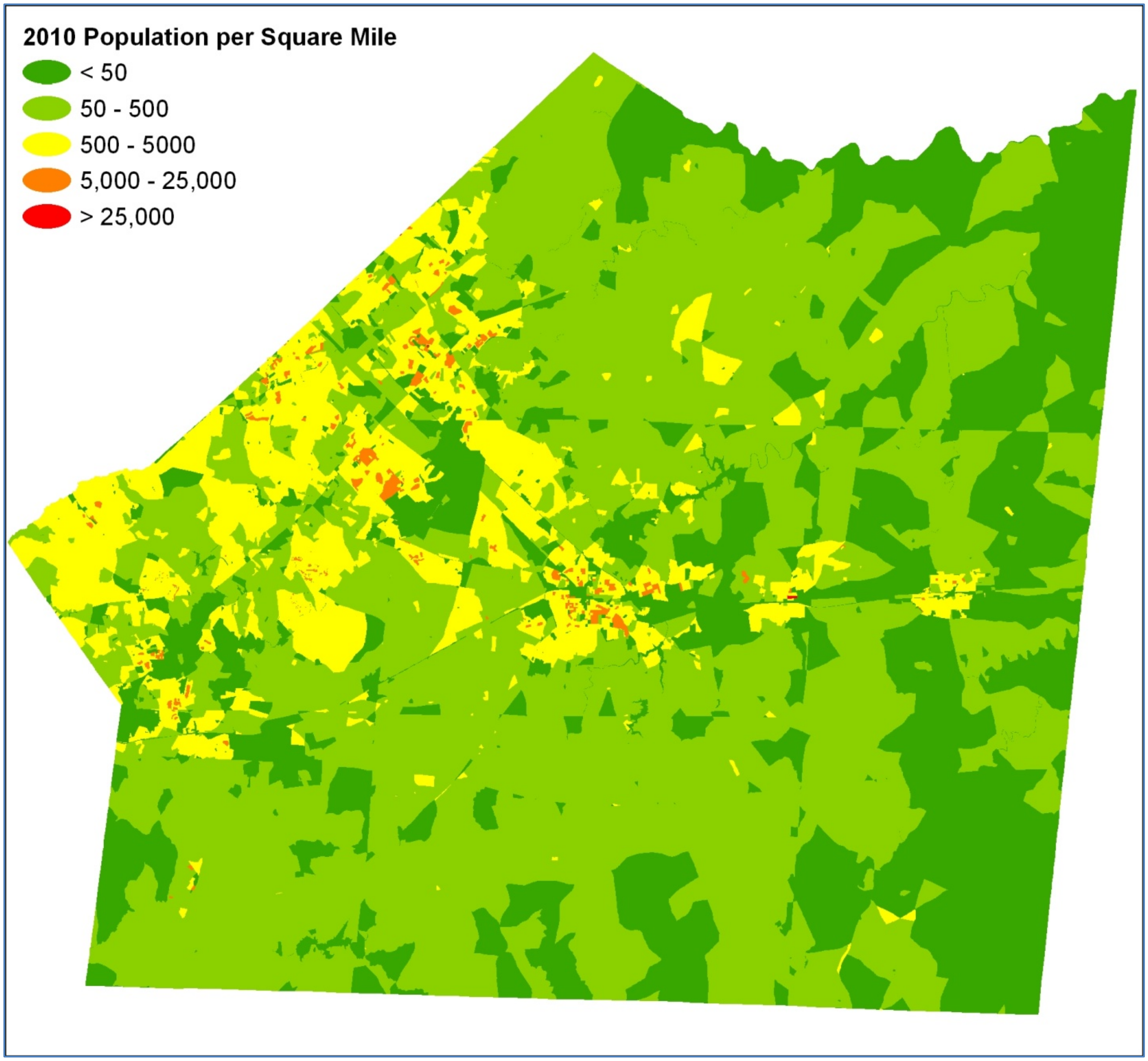
POPULATION TRENDS, LAND COVER, AND IMPERVIOUS SURFACE

From 2000 to 2010 the population of Union County grew by 62.8%, from 123,677 to 201,292 (Table 3). Significant increases in population in recent years are attributed to its close proximity to the Charlotte metropolitan area and to its blend of urban and rural character, providing a desirable place to live, and to work in sectors such as agriculture, business, and industry. Most of the growth has occurred in the western half of the county with the expansion of the Charlotte suburban areas (Figure 7). While Monroe has remained the largest municipality in the county, smaller municipalities such as Marvin, Stallings, Waxhaw, Wesley Chapel and Indian Trail have more than doubled in size since 2000.

Table 3: Municipal Populations

Municipality	2000 Pop.	2010 Pop.	Percent Change
Fairview	2,495	3,324	33.2
Hemby Bridge	897	1,520	69.5
Indian Trail	11,905	33,518	181.5
Lake Park	2,093	3,422	63.5
Marshville	2,360	2,402	1.8
Marvin	1,039	5,579	437.0
Mineral Springs	1,370	2,639	92.6
Monroe	26,228	32,797	25.0
Stallings	3,189	13,831	333.7
Unionville	4,797	5,929	23.6
Waxhaw	2,625	9,859	275.6
Weddington	6,696	9,459	41.3
Wesley Chapel	2,549	7,463	192.8
Wingate	2,406	3,491	45.1
Union County	123,677	201,292	62.8
Source: 2000 and 2010 US Census			

Figure 7: 2010 Population per Square Mile by Census Block



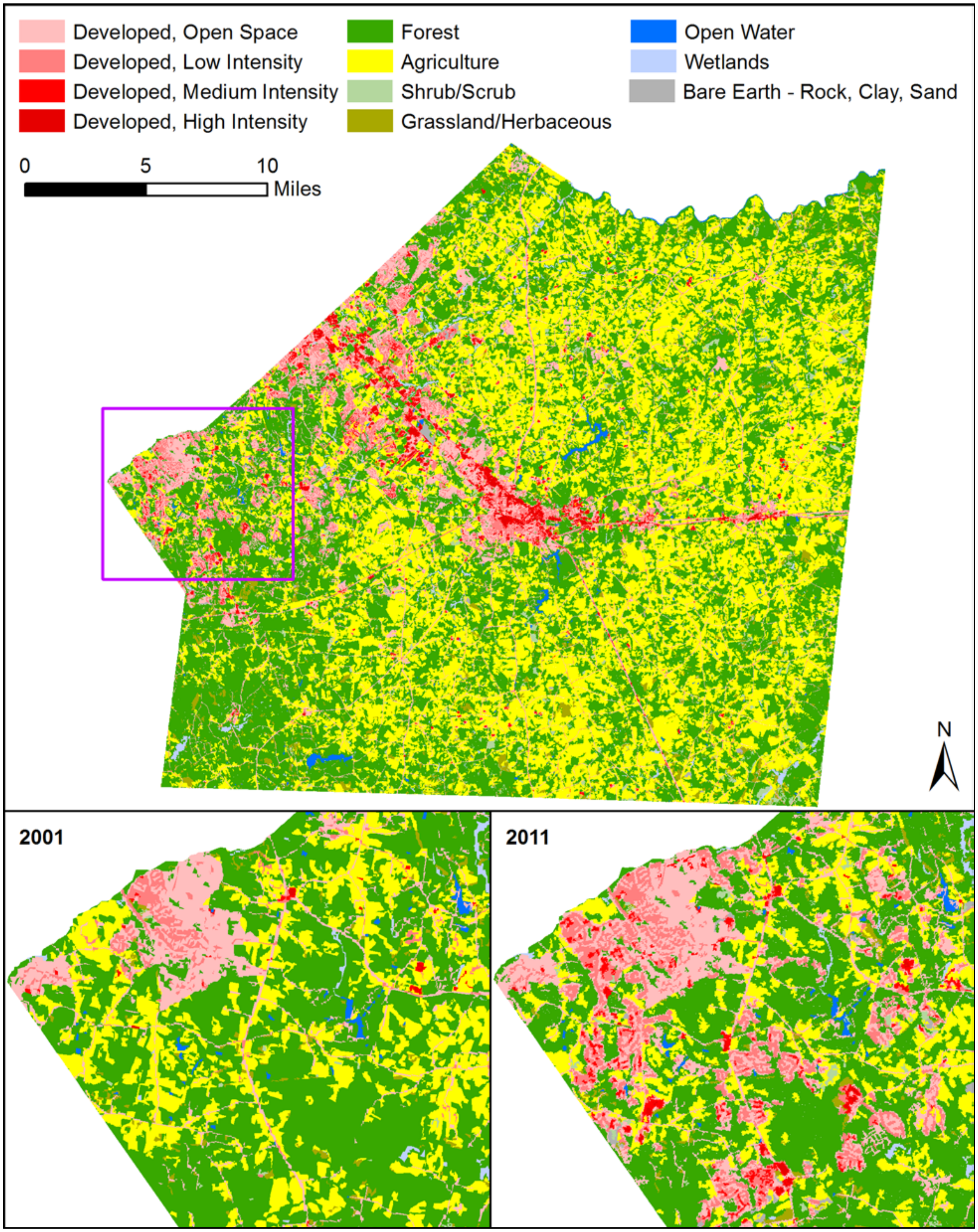
Land cover and land use have a major impact on groundwater quantity and quality (USEPA, 2008). Land cover is the physical surface of the land, both naturally occurring conditions and human alterations. Land cover changes can affect environmental variables such as water quality, watershed hydrology, and habitat. Land use concerns the activities taking place on the land, such as agriculture, residential, industrial, mining, and recreational uses. Land use changes can have specific and cumulative effects on air and water quality, watershed function, waste generation, the extent and quality of wildlife habitat, and human health. As land cover and land use change, the types of water quality issues will differ. Land use affects the types of contamination possible and the number of households potentially affected. Land cover may alter the potential for dispersion of pollutants in and on the environment. As changes occur, planners must consider the number of households affected, the historical land use, naturally occurring contamination, and whether to construct public water and sewer systems. Table 4 summarizes and compares the percentage of each land cover in the county in 2001, 2006, and 2011. Figure 8 illustrates the spatial distribution of the land cover types in 2011.

Table 4: 2001, 2006; 2011 Land Cover Percentages

Land Cover/Land Use Type	2001 Percentage	2006 Percentage	2011 Percentage
Developed – Open Space	7.2	8.2	8.9
Developed – Low Intensity	2.3	3.3	3.6
Developed – Medium Intensity	0.6	0.9	1.2
Developed – High Intensity	0.4	0.4	0.5
Developed	10.6	12.8	14.2
Forest – Deciduous	31.6	31.6	30.6
Forest – Evergreen	8.6	10.2	9.0
Forest – Mixed	2.1	1.9	1.9
Forest	42.2	43.7	41.4
Pasture / Hay	42.0	37.8	36.6
Cultivated Crops	1.6	1.4	2.3
Agriculture	43.6	39.2	38.9
Emergent Herbaceous Wetlands	0.0	0.0	0.0
Woody Wetlands	0.7	0.7	0.7
Wetlands	0.8	0.7	0.7
Barren Land (Rock/Clay/Sand)	0.0	0.3	0.2
Grassland Herbaceous	2.5	2.8	3.0
Shrub / Scrub	0.4	0.4	1.1
Source: Multi-resolution Land Characteristics Consortium			

As population increases, the primary land cover change is an increase in impervious surfaces. When an area becomes more impervious, less water infiltrates to the groundwater table and more water runs off into streams. This change in the water cycle has several effects: recharge to groundwater decreases, stream flow becomes “flashy” during rainfall events, and base flow during times of drought is reduced. In addition, stormwater runoff carries pollution from the land surface into water bodies. Reducing or limiting the amount of impervious surfaces allows for greater infiltration thereby increasing recharge and pollutant removal. There are ways to minimize impervious surfaces while continuing to develop. Part of the solution may be to prevent or manage stormwater runoff. While the goal of the North Carolina Stormwater Program is to protect surface water, improved stormwater management may have a positive effect on groundwater quantity and quality. For more information on stormwater management practices contact the NC Stormwater Program.

Figure 8: 2011 Union County Land Cover



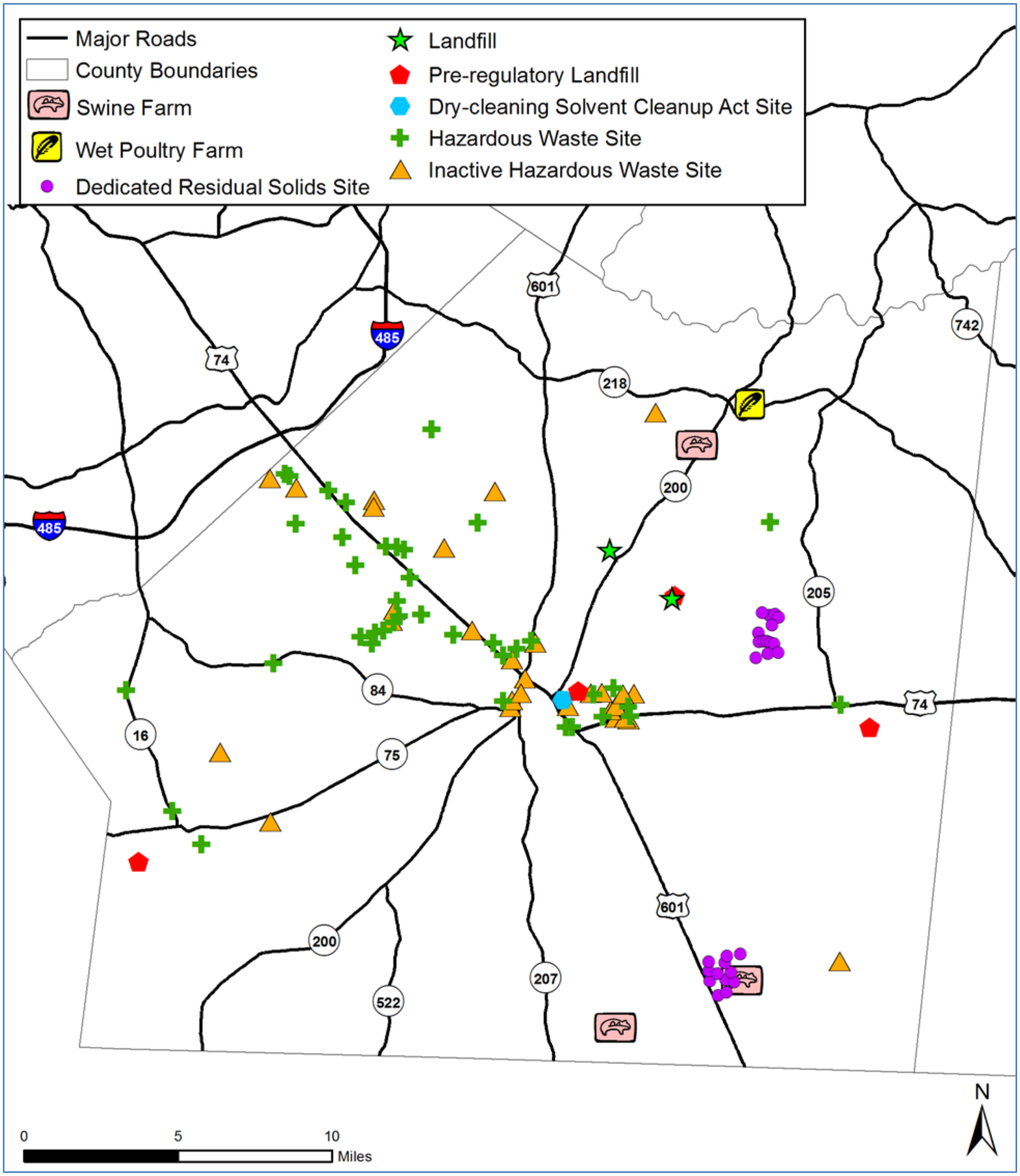
POTENTIAL AND KNOWN CONTAMINATION SOURCES

Potential sources of contamination are those facilities, sites, and activities that have the potential to affect the underlying ground water aquifers or nearby surface waters. Many of these potential sources are regulated by DEQ and require a permit. The purpose of regulation is to require waste disposal and other activities to be managed in such a way to not pollute groundwater or surface water. The permit includes conditions and limits intended to achieve that goal. For more information on any of the permitting programs mentioned here, see the NCDEQ Permit Handbook (http://portal.ncDEQ.org/web/deao/permit-directory/) where descriptions of 150+ types of permits are listed by permit name and by environmental category. The categories are Air, Coastal Management, Land, Marine Fisheries, Other, Parks and Recreation, Waste, Water, Wildlife. These programs are intended to prevent contamination from occurring and to mitigate impacts if contamination does occur.

Contamination can also result from unregulated activities such as over-application of fertilizers, pesticides and herbicides, as well as from leaks and spills. For information about programs to manage contamination that has already occurred, see links in Appendix B. It should be noted that there are contaminants that occur naturally due to geochemical reactions between the rock and the water percolating through the rock. Naturally occurring contaminants will be discussed in the Groundwater Quality Issues section.

Within the county the geographic distribution of various contamination sites and potential groundwater contamination sources is shown in Figure 9. This map shows many of the potential and known groundwater contamination sources. The data provided in this section were extracted from several sources – the DWR Basinwide Information Management System (BIMS) database, annual reports submitted by the permit owners, the North Carolina Division of Waste Management (DWM), and the United States Environmental Protection Agency (US EPA).

Figure 9: Potential and Known Groundwater Contamination Sources in Union County



> "In the 2000 National Water Quality Inventory, states reported that agricultural nonpoint source (NPS) pollution was the leading source of water quality impacts on surveyed rivers and lakes, the second largest source of impairments to wetlands, and a major contributor to contamination of surveyed estuaries and ground water. Agricultural activities that cause NPS pollution include poorly located or managed animal feeding operations; overgrazing; plowing too often or at the wrong time; and improper, excessive or poorly timed application of pesticides, irrigation water, and fertilizer." (USEPA, 2002)

In North Carolina, cattle, swine, and poultry facilities that meet the definition of an animal operation under G.S. 143-215.10B are required to obtain a permit from DWR. While there are only four animal operations with a DWR issued animal operations permit in Union county, there may be many more animal operation facilities that are not required to obtain a permit; under G.S. 143-215.10B, only poultry facilities with a liquid waste management system are required to seek permit coverage. Dry litter poultry operations are permitted by regulation or "deemed" permitted under 15A NCAC 02T .1303. Union County has a significant number of broiler operations, ranking third in broiler production in North Carolina, but without a permit program DEQ has no data on these operations and thus they are not characterized in this report. Table 5 provides a summary of animal operation facilities in the county with active permits. Table 6 lists estimates of livestock production in Union County.

Table 5: Permitted Animal Operations in Union County

Permit Type	Facilities	Animal Counts
Cattle	0	0
Swine	3	9,800
Wet Poultry	1	120,000
Dry Poultry	N/A	N/A
Source: DWR BIMS Database January 2, 2014		

Table 6: Estimated Livestock Production in Union County

Animal Type	2009	2010	2011
Broiler Chickens (produced yearly)	78,000,000	72,000,000	64,300,000
Non-Broiler Chickens (on farms Dec. 1)	1,000,000	1,250,000	1,300,000
Turkeys Raised	3,000,000	2,750,000	2,900,000
Hogs (on farms Dec. 1)	Not Reported	Not Reported	Not Reported
Cattle – Beef (on farms Jan. 1)	Not Reported	Not Reported	Not Reported
Cattle – Dairy (on farms Jan. 1)	Not Reported	Not Reported	Not Reported
Cattle – All (on farms Jan. 1)	23,000	21,500	21,000
Source: NC Department of Agriculture and Consumer Services, Agriculture Statistics Division			

Other forms of agriculture do not require permits but some practices may lead to groundwater contamination. Overuse of fertilizers, whether derived from chemicals, composts and other organic matter, or wastes, such as sewage sludge and certain industrial wastes, have been known to contaminate groundwater. Such contamination may take many years to attenuate. There are several programs that work to educate citizens and farmers on best management practices (BMPs) and to install BMPs on farms throughout the state. The NC Cooperative Extension Service is a good resource for further information.

Historical uses of pesticides and herbicides on agricultural and forest lands as well as residential area treatments can also affect groundwater quality. Although these compounds were generally considered to be bound to the organics and clays in soil, it has since been shown that some of these pesticides can become mobile in soil, potentially contaminating groundwater. Pesticides can reach groundwater from applications onto crop fields, seepage of contaminated surface water, accidental spills and leaks, improper disposal, and even through injection of waste material into wells. The effects of past and present land-use practices may take decades to become apparent in groundwater. There are many hundreds of these compounds, and extensive tests and studies of their effect on humans have not been completed. Some pesticides have had a designated Maximum Contaminant Limit (MCL) in drinking water set by the U.S. Environmental Protection Agency (EPA), but many have not (USGS, 2006). For further information refer to Gilliom & Hamilton, 2006.

SEPTIC SYSTEMS

Based on the 1990 U.S. census, the most recent year in which this question was asked, 67% of households in Union County relied on septic systems as a means for treatment and disposal of waste. These subsurface systems are managed by NC Department of Health and Human Services (NCDHHS) On-site Water Protection Branch. Properly sited and well maintained septic systems are a safe way to dispose of wastewater, however malfunctioning or improperly sited septic systems have the potential to contaminate groundwater and surface water.

NON-DISCHARGE PERMITTING PROGRAM

Treated wastewater, wastewater residual solids, contaminated soil, animal waste and stormwater are sometimes applied to fields for disposal and for use as fertilizer or for mitigation purposes. Several types of permits and programs manage these waste disposals, as outlined in NCAC Title 15A-Subchapter 2T and the NCDEQ Permits Handbook. The purpose of the permitting is to manage nutrients, metals, and pathogens, ensuring that these constituents are applied in amounts that do not overwhelm the absorptive or remediation capacity of the soil. Much research has been done to determine the application rates of various constituents for particular soil and crop types. Some nonpoint sources of pollution are managed via the non-discharge permitting program outlined in NCAC Title 15A-Subchapter 2T, “Waste not discharged to surface waters”. This program permits waste that is discharged onto or below land surface.

Table 7 summarizes the acres of permitted land application activities in the county by type of application. This summary excludes land application fields used under permits for the distribution of residual solids, animal operation permits or septage permits. Distribution of Residual Solids permits are for Class A residual solids which have undergone additional pathogen reduction. Therefore their application location is not required to be tracked (Tutwiler, 2012). Septage permits are issued by the Division of Waste Management and are discussed in the section below on waste disposal sites.

Table 7: Land Application Fields in Union County

Permit Type	Fields Permitted	Acres Permitted	Fields Utilized 2010	Acres Utilized 2010
Land Application of Residual Solids	314	11,205.55	*68	*2,329.65
Land Application of Petroleum Contaminated Soil	1	2.67	1	1
Wastewater Irrigation	52	411.72	**23	**169.52
High Rate Infiltration	0	0	**0	**0
Reclaimed Water	3	16.47	**0	**0
Single-Family Residence	7	1.49	Unknown	Unknown
Source: DWR BIMS Database June 24, 2014. *Tutwiler, 2012. **Tutwiler, 2013.				

DISPOSAL SITES

Solid waste, including municipal solid waste, industrial waste, construction and demolition waste, land-clearing waste, scrap tires, medical waste, compost, and septage are managed by NCDEQ Division of Waste Management (DWM). There is one open landfill in the county; it receives only Land Clearing and Inert Debris (LCID). There are four closed pre-regulatory landfills in the county. A pre-regulatory landfill is "any land area, whether publicly or privately owned, on which municipal solid waste disposal occurred prior to January 1, 1983, but not thereafter" (http://portal.ncDEQ.org/web/wm/sf/ihs/ihsoldlf). There are no hazardous waste disposal sites or septage sites in the county.

NCDWM has programs to manage and track materials that have the potential for toxic chemical releases via leaks or spills. The Resource Conservation and Recovery Act (RCRA) is intended to manage hazardous waste from "cradle to grave", including generation, transportation, treatment, storage and disposal of hazardous waste (USEPA, 2014). As of March 25, 2014, there were 198 RCRA sites, and 8 Hazardous Waste Large Quantity Generator's (LQG's) in the county. In addition, DWM had registered 459 underground storage tanks (USTs).

CONTAMINATED SITES

There are several programs managing known releases of contaminants. In Union County, as of March 25, 2014, there were eight Inactive Hazardous Site Program (IHSP) sites and one Dry-cleaning Solvent Cleanup Act (DSCA) program site. As of July 28, 2015, there are 467 Underground Storage Tank (UST) sites and 700 Non-UST sites with documented petroleum release to soil and/or groundwater managed by the UST Section. Of these UST Section sites, 32 of the UST sites have a potable supply well located within 1,000 feet and/or a non-potable well located within 250 feet. There are also 14 Non-UST (Above Ground Tanks, spills, etc.) release sites with potable wells within 1,000 feet and/or a non-potable well within 250 feet. These sites are managed by the NCDWM. USEPA manages seven active and eight archived Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites. There are no sites currently on the National Priority List (NPL) in the county.

GROUNDWATER QUALITY ASSESSMENT

There are several sources of groundwater quality data available for Union County which can be used to assess current ambient water quality in the county at a general level. We can use historic data to discern changes in water chemistry over time. The intention is to reassess ambient conditions at some regular interval in the future in order to identify changes. Groundwater quality in its natural state is unlikely to change but human activities can have effects, particularly at the site specific level. In addition, there are some natural conditions which may contribute to less than ideal water quality. It is important to be aware of where these conditions occur and to test well water accordingly.

The most extensive groundwater quality data is from public and private drinking water wells. Public water systems using groundwater sources serve some businesses, schools, churches, and communities. Operators of such systems are required to test system well water quality regularly and report the results to the state. Since 2008, testing is required for a limited number of parameters for all new private wells. The water quality data for the public water supply wells was obtained from the NCDEQ Public Water Supply Section, and the private well water quality data was obtained from the NCDHHS Public Health Laboratory. A limited amount of water quality data is available for Union County from published reports and from the USGS water quality monitoring programs. Data from older reports is considered "ambient" or "historical" and may point to long-term trends in water quality. In addition, DWR has conducted detailed investigations of groundwater quality at two sites in Union County. The following sections summarize the available groundwater quality data from each of these sources.

The data resulting from water quality analysis were compared with two sets of standards, or limits on the amount of a contaminant allowable in drinking water. The USEPA establishes Maximum Contaminant Levels (MCLs) under the National Primary Drinking Water Regulations (NPDWR). North Carolina has the option to adopt the MCL for each chemical or to establish a stricter limit. The NC concentration limits may be found in the 2L Groundwater Standards (NCAC 15A 2L). Exceedance of these limits may suggest that further action should be considered. See the glossary for further information and resources regarding NPDWR, MCLs, SMCLs, and 2L standards.

PUBLIC AND PRIVATE DRINKING WATER WELL QUALITY

PUBLIC WATER SUPPLY WELLS

Public water systems are those which provide piped drinking water to at least 15 connections or 25 or more people for 60 days or more per year. The NCDEQ Division of Water Resources Public Water Supply (PWS) Section regulates public water supply systems. Public water supply systems are required to test water samples from their systems on a regular basis in order to comply with state and federal requirements. Many public water supply systems obtain their water from wells, therefore the compliance monitoring samples from PWS systems that use wells provide a very good source of groundwater quality data. Public water supply wells are routinely tested for metals, bacteria, volatile and semi-volatile organic compounds, nitrate and nitrite, and certain radionuclides.

Currently, there are 54 public water supply wells located within Union County. The locations of these wells are shown on Figure 10. Data obtained from the Public Water Supply Section for wells within the county from the period of January 1, 2009 to April 1, 2014 reveal three violations during this period (Table 8). One well exceeded the MCL for Nitrate one time in 2009 and is no longer being used as a drinking water source. Another well exceeded the secondary MCL (SMCL) for sulfate once in 2010 and again in 2013. The sulfate SMCL is a secondary drinking water standard meaning that it does not affect human health but it may affect aesthetic issues such as taste and odor.

Figure 10: Union County Public Water Supply Map

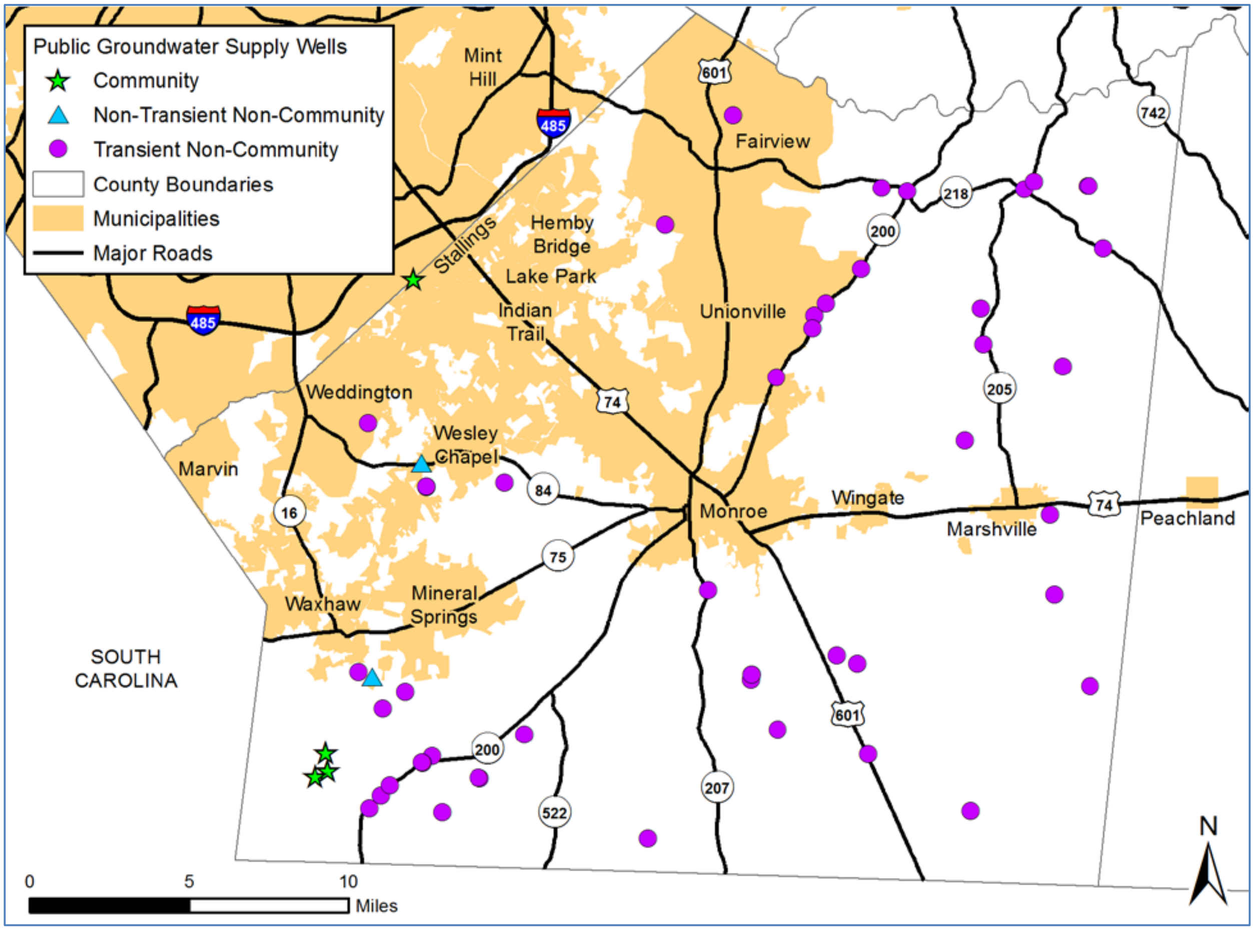


Table 8: Public Water Supply Sampling Results January 1, 2009 – April 1, 2014

Parameter	Wells Sampled	Samples Collected	Non-Detects	Samples exceeding MCL	Wells with Samples exceeding MCL
Inorganics					
Antimony	7	12	12	0	0
Arsenic	7	12	10	0	0
Barium	7	12	9	0	0
Beryllium	7	12	12	0	0
Cadmium	7	12	12	0	0
Chromium	7	12	12	0	0
Cyanide	7	12	12	0	0
Fluoride*	7	12	7	*0	*0

Parameter	Wells Sampled	Samples Collected	Non-Detects	Samples exceeding MCL	Wells with Samples exceeding MCL
Iron*	7	12	10	*0	*0
Manganese*	7	12	8	*0	*0
Mercury	7	12	12	0	0
Selenium	7	12	11	0	0
Sodium	7	12	0	0	0
Sulfate*	6	11	6	*2	*1
Thallium	7	12	12	0	0
*Parameter with Secondary MCL only					
Volatile Organic Compounds					
1,1-Dichloroethylene	7	21	21	0	0
1,1,1-Trichloroethane	7	21	21	0	0
1,1,2-Trichoroethane	7	21	21	0	0
1,2-Dichloroethane	7	21	21	0	0
1,2-Dichloropropane	7	21	21	0	0
1,2,4-Trichlorobenzene	7	21	21	0	0
Benzene	7	21	21	0	0
Carbon Tetrachloride	7	21	21	0	0
Chlorobenzene	7	21	21	0	0
CIS-1,2-Dichloromethane	7	21	21	0	0
Dichloromethane	7	21	21	0	0
Ethylbenze	7	21	17	0	0
O-Dichlorobenzene	7	21	21	0	0
P-Dichlorobenzene	7	21	21	0	0
Styrene	7	21	21	0	0
Tetrachloroethylene	7	21	21	0	0
Toluene	7	21	21	0	0
Trans-1,2-Dichloroethylene	7	21	21	0	0
Trichloroethylene	7	21	21	0	0
Vinyl Chloride	7	21	21	0	0
Total Xylenes	7	21	14	0	0
Semi-Volatile Organic Compounds					
1,2-Dibromo-3-Chloropropane	7	12	12	0	0
2,4-D	7	15	15	0	0
2,4,5-TP	7	15	15	0	0
Atrazine	7	12	12	0	0
Benzo(A)Pyrene	7	12	12	0	0
BHC-Gamma	7	12	12	0	0
Carbofuran	7	12	12	0	0
Chlordane	7	12	12	0	0
Dalapon	7	15	15	0	0
Di(2-Ethlhexyl) Adipate	7	12	12	0	0
Di(2-Ethlhexyl) Phthalate	7	12	12	0	0
Dinoseb	7	15	15	0	0
Endrin	7	12	12	0	0
Ethylene Dibromide	7	12	12	0	0

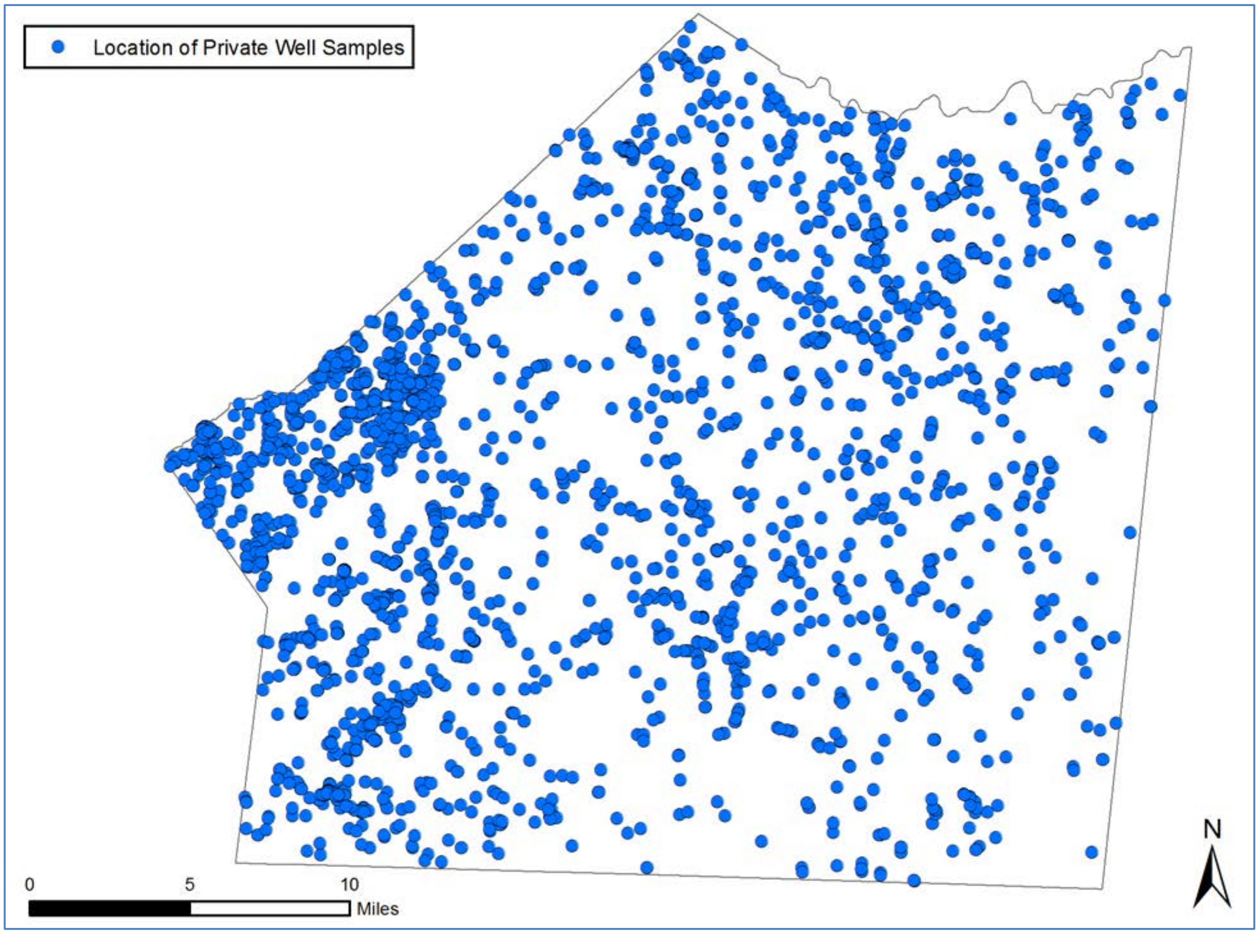
Parameter	Wells Sampled	Samples Collected	Non-Detects	Samples exceeding MCL	Wells with Samples exceeding MCL
Heptachlor	7	12	12	0	0
Heptachlor Epoxide	7	12	12	0	0
Hexachlorobenzene	7	12	12	0	0
Hexachlorocyclpentadiene	7	12	12	0	0
Lasso	7	12	12	0	0
Methoxychlor	7	12	12	0	0
Oxamyl	7	12	12	0	0
Pentachlorophenol	7	15	15	0	0
Picloram	7	15	15	0	0
Simazine	7	12	12	0	0
PCBs	7	12	12	0	0
Toxaphene	7	12	12	0	0
Nutrients					
Nitrate	61	288	206	1	1
Nitrite	10	11	11	0	0
Radionuclides					
Combined Uranium	3	3	3	0	0
Combined Radium	3	3	0	0	0
Radium-228	3	3	2	0	0
Radium-226	3	3		0	0
Gross Alpha excluding Radon and Uranium	3	3	2	0	0

PRIVATE DRINKING WATER WELLS

State law requires that all new private water supply wells installed after July 1, 2008 be tested for metals, nutrients, major ions, and coliform bacteria. Union County began a similar program in 2007 and ended it when the state program began in July, 2008. Before this legislation was passed, local health departments would sample private wells in response to citizen complaints, often about objectionable taste or odor of their well water, or if there was reason to suspect contamination or improper well construction. As a result, private wells sampled in Union County before July 1, 2007 yield water quality results that may be somewhat biased towards “poor” water quality and improper well construction. The new legislative well sampling requirement removes this bias somewhat, but well samples resulting from citizen complaints are also included in the groundwater quality data that is available from the DHHS Public Health Laboratory database.

Though this dataset provides a rich source of information on groundwater quality, it has two major deficiencies as a groundwater quality monitoring source. First, the dataset lacks consistent, reliable location information. Only a portion of the samples in the database have sufficient location information (street address, GPS coordinates, etc.) to locate them on a map with reasonable precision. For this reason, the data is primarily useful in aggregate for drawing broad inferences about groundwater quality, rather than making specific correlations to patterns of land use or geology, factors which are very important to groundwater quality. Figure 11 shows the locations of the small number of private water supply wells in Union County that have reliable location data. While this represents a small portion of all private wells in the watershed, it does illustrate that groundwater is relied upon as a water source throughout the county.

Figure 11: Private Wells Sampled in Union County, NC between January 1, 2000 and January 5, 2011



Second, the private well sampling dataset does not include consistent information about organic contaminants, such as those in petroleum products or pesticides. Sampling of private wells for these types of contaminants is driven by well owner complaints or special requests; therefore the dataset for organic contaminants is biased towards sites where such contaminants are most likely to be found.

In order to use this dataset as a gauge of overall groundwater quality in Union County, the results of private water supply wells sampled during the period from January 1, 2000 to January 5, 2011 were compared to the federal MCLs and the NC 2L standards. The number and percentage of samples exceeding each standard were then tallied from this comparison. Results of this comparison are presented in Table 9. Coliform bacteria results were not analyzed as a part of this report; coliform problems generally indicate a localized problem with well construction or maintenance, or nearby contaminant sources, rather than a pervasive problem with groundwater quality.

The most common exceedances of state groundwater standards in Union County were for arsenic (21%), iron (19%), and manganese (26.5%). Arsenic in groundwater may have either natural or anthropogenic origins. Potential sources of arsenic are discussed further in the "Naturally Occurring Contaminants" section of this report. Iron and manganese are also naturally occurring elements that are commonly found in groundwater in the Piedmont. They do not normally pose a health hazard for human consumption but can present an aesthetic concern because they can discolor water, plumbing fixtures, or laundry. Approximately 5.8 percent of the private well samples had pH values outside the range of 6.5 to 8.5 set by the North Carolina groundwater standards. Low pH could result from naturally occurring organic acids. High pH could be the result of well grout contamination if the well was improperly grouted. While pH itself does not pose a health risk it can affect the taste of the water. In addition, low pH can allow metals to leach from pipes, and high pH can cause scale deposits to form in pipes.

Table 9: Private Wells Sampled in Union County January 1, 2000 – January 5, 2011

Parameter	Number of Samples Analyzed	NC (2L) Groundwater Standard (mg/L)	EPA MCL Standard (mg/L)	Number of Samples Exceeding NC (2L) Standard	Percent of Samples Exceeding NC (2L) Standard	Number of Samples Exceeding EPA MCL Standard	Percent of Samples Exceeding EPA MCL Standard
Arsenic	2,993	0.01	0.01	630	21.0	630	21.0
Barium	796	0.7	2	0	0	0	0
Cadmium	796	0.002	0.005	0	0	0	0
Chloride	2,715	250	NA	73	2.6	NA	NA
Chromium	794	0.01	0.1	3	0.4	1	0.1
Copper	2,986	1	NA	30	1.0	NA	NA
Fluoride	2,983	2	4	7	0.2	1	0.0
Iron	2,986	0.3	NA	567	19.0	NA	NA
Lead	2,987	0.015	0.015	10	0.3	10	0.3
Manganese	2,986	0.05	NA	791	26.5	NA	NA
Mercury	749	0.001	0.002	0	0	0	0
Nitrate	445	10	10	6	1.3	6	1.3
Nitrite	445	1	1	0	0	0	0
pH	2985	6.5-8.5	NA	173	5.8	NA	NA
Selenium	791	0.02	0.05	7	0.9	0	0
Silver	791	0.02	NA	0	0	NA	NA
Sulfate	403	250	NA	15	3.7	NA	NA
Zinc	2,985	1	NA	11	0.4	NA	NA

AMBIENT GROUNDWATER QUALITY DATA

Ambient and historical groundwater data was examined to determine whether the quality of groundwater obtained from drinking water wells is consistent with the quality of groundwater observed at sites chosen to be reflective of natural conditions. Documentation of these natural conditions can also help determine whether there have been significant changes over time in overall water quality in the county. Data are limited and are not drawn from the same wells as the modern drinking water sampling results above, but may be useful in looking for broad changes over longer time scales.

The United States Geological Survey (USGS) maintains a database of historical groundwater and surface water quality data. This database is referred to as the National Water Information System (NWIS). The NWIS database includes groundwater quality data from three monitoring wells in Union County. Data from these wells are provided in Table 10.

Table 10: Summary of NWIS Water Quality Data for Wells in Union County

	UN-146	UN-145	UN-143
Well Depth (feet below land)	250	255	160
Date Sampled	12/4/2007	12/4/2007	7/15/1998
Depth to water (feet below land)	44.1	96.1	19.9
Number of samples	1	1	1
Temperature (oC)	16.3	16.7	17.0
Hardness (mg/L)	151	132	30.5
pH	6.6	7.2	5.9
Specific Conductance (uS/cm)	568	335	84
Dissolved Oxygen (mg/L)	2.7	1.8	6.9
Bicarbonate (mg/L)	125	131	45
Nitrate + Nitrite (mg/L)	4.47	1.84	<0.05
Iron (mg/L)	0.0045	<0.008	<0.0100
Manganese (ug/L)	1.4	1.27	3.26
Calcium (mg/L)	48.4	42.6	8.38
Magnesium (mg/L)	7.2	6.1	2.3
Sodium (mg/L)	26	16	5.19
Potassium (mg/L)	0.31	0.3	1.29
Aluminum (mg/L)	<0.0016	--	0.003
Lithium (mg/L)	0.0072	0.0129	--
Chloride (mg/L)	55	23	3.2
Sulfate (mg/L)	5.44	5.24	0.68
Arsenic (mg/L)	0.0106	0.0383	<0.001
Barium (mg/L)	0.0586	0.00359	0.00236
Thallium (mg/L)	<0.000040	<0.000040	--
Silica (mg/L)	22.2	26.2	29.3
Zinc (mg/L)	0.0019	0.0035	0.0265
Strontium (mg/L)	0.312	0.239	na
Vanadium (ug/L)	0.00015	0.00078	na
Selenium (mg/L)	0.00062	0.0075	<0.001
Tritium (pCi/L)	24.03	--	--
Ra-226 (pCi/L)	0.107	0.091	--
Ra-222 (pCi/L)	2120	4330	1630
Uranium (ug/L)	0.355	0.611	<0.001
Atrazine (ug/L)	0.009	<0.007	<0.001
Tricholoromethane (ug/L)	0.11	0.21	0.04
Total Dissolved Solids (mg/L)	260	203	80

In the late 1970's the USGS coordinated a nationwide assessment of potential uranium resources known as the National Uranium Resource Evaluation (NURE) project in which water supply wells were analyzed for radioactive elements and other indicators for the possible presence of uranium. Sixty four wells from Union County were sampled as part of this project; 61 of these wells were water supply wells. The well locations are shown in Figure 12 and the data is summarized in Table 11. The NURE data indicate an average concentration of 179 µg/L for manganese and a median concentration of 62 µg/L for manganese, exceeding the 50 µg/L 2L standard for manganese in drinking water. Additionally, the data indicate relatively high conductivity, probably due to relatively high concentrations of sodium and chloride. Other target parameters, including uranium, show low or normal concentrations commonly found in the N.C. Piedmont. Due to the limited scope of the NURE project and subsequent limited number of sample parameters and lack of standard inorganic compound parameter analyses, this data is not very useful for the purposes of standard groundwater quality analysis and historical comparisons.

Table 11: Summary of Data Collected in Union County by the National Uranium Recovery Project

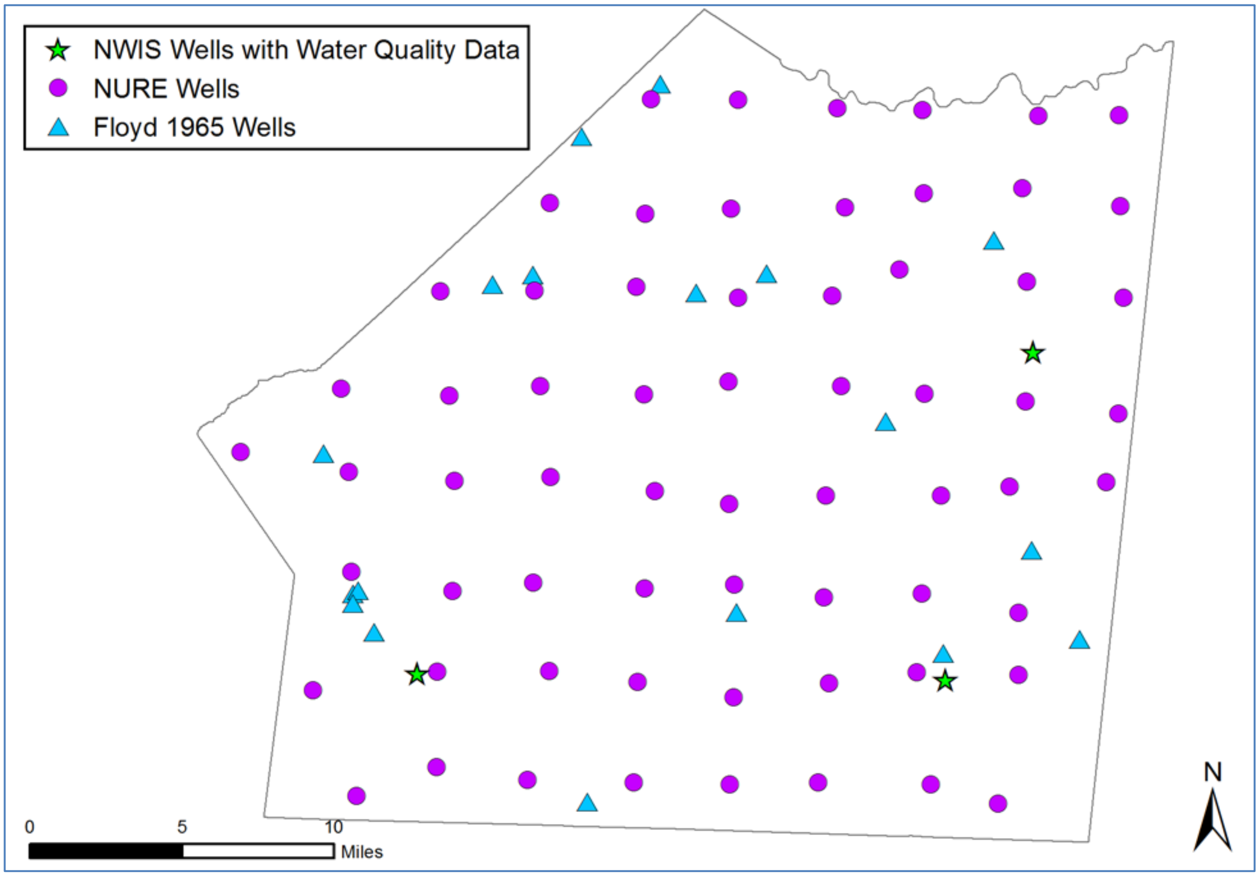
	Depth (feet)	pH (s.u.)	U (ug/L)	Al (ug/L)	Cl^- (mg/L)	F^- (mg/L)	Mg (mg/L)	Mn (ug/L)	N (mg/L)	V (ug/L)
Count	56	64	64	64	64	64	64	64	47	64
Avg.	127	7.0	0.40	99	36	6.7	7.7	179	20	0.57
Std. Dev.	88	0.65	0.90	257	74	20	12	241	20	1.8
Min	17	5.3	0.019	0	0	0	0	0	2.8	0.05
Max	465	8.2	6.2	1469	400	124	58	1115	96	13
Median	100	7.2	0.081	21	13	0	4.7	62	13	0.05

Additional limited groundwater quality data is contained in Floyd, 1965. This report contains analysis data for pH, iron, calcium, magnesium, sodium, potassium, bicarbonate, chloride, sulfate, and nitrate concentrations in 18 wells across Union County (Table 12). The well locations are displayed in Figure 12 and the depths range from 30 to 301 feet deep with a median of 100 feet. These results indicate an average concentration of 630 ug/L for iron and a median concentration of 110 ug/L for iron. The 2L standard for iron in drinking water is 300 ug/L. Manganese concentrations were not reported in Floyd, 1965.

Table 12: Summary of Historical Groundwater Quality Data (Floyd, 1965)

	Depth	pH	Fe	Ca	Mg	Na	K	HCO_3^-	Cl^-	SO_4^{2-}	NO_3^-
Count	17	18	18	18	18	18	15	18	18	18	8.0
Avg.	124	6.6	0.63	20	8.7	9.7	0.69	80	15	19	2.7
Std. Dev.	75	0.42	1.3	20	10	4.3	0.62	64	27	27	5.0
Min.	30	6.0	0.01	2.4	0.5	0.7	0.10	22	1.0	1.3	0.10
Max.	301	7.5	4.6	75	42	18	2.2	220	106	88	15
Median	100	6.5	0.11	11	5.6	9.2	0.50	59	4.2	5.9	1.0
All measurements are in mg/L, except well depth (feet) and pH (standard units)											

Figure 12: Map of Wells with Historical Water Quality Data



GROUNDWATER QUALITY ISSUES

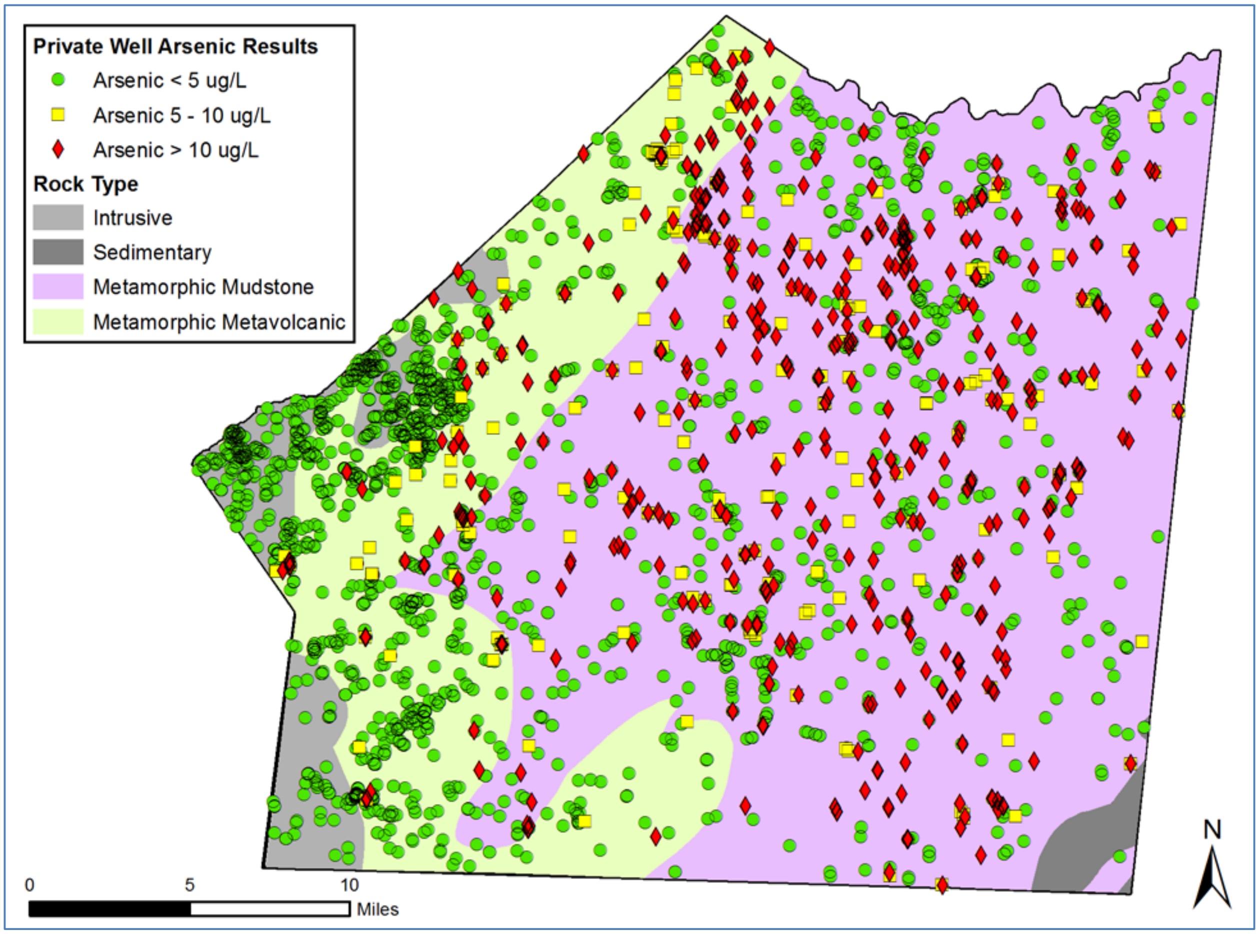
NATURALLY OCCURRING CONTAMINANTS

Groundwater flowing through the bedrock aquifer can interact chemically with the minerals in the rock matrix and may result in elevated levels of naturally occurring elements that can affect human health such as arsenic, lead, and radionuclides. An analysis of the available groundwater quality data from Union County reveals that groundwater quality in this area is generally good, with the exception of a potential for elevated concentrations of arsenic, iron, and manganese. Since a large portion of Union County is underlain by rocks of the Carolina Terrane, which is known to be associated with elevated levels of naturally occurring arsenic in groundwater, consumption of untreated well water is only advised after the water has been tested for arsenic. Elevated concentrations of other naturally-occurring elements such as iron and manganese may occur in the Charlotte Terrane as well as the Carolina Terrane; however, iron and manganese are currently listed as contaminants primarily affecting the aesthetics of drinking water. Studies are currently underway examining the health effects of manganese in drinking water.

As presented in the section on Private Drinking Water Wells, arsenic is a required testing parameter for private wells, thus the DHHS private well sampling data can be used to help provide information on groundwater arsenic concentrations. There were 2,993 private wells sampled for arsenic in Union County from of January 1, 2000 to January 5, 2011. Figure 13 shows the concentration of arsenic in these well samples superimposed on the hydrogeologic unit map for the county. A small number of these samples may have been duplicates and/or re-samples, but this data provides a reasonable assessment of the probability of elevated levels of arsenic in the groundwater of Union County. As indicated in Figure 13, arsenic was detected above the drinking water standard of 10 ug/L, primarily in areas underlain by meta-mudstone. Elevated concentrations are also noted in the area where meta-mudstones transition to meta-volcanic rocks, though the arsenic concentration in groundwater in wells hosted in the meta-volcanic rocks is generally lower. This suggests a correlation between geologic units and arsenic concentrations. Elevated concentrations of iron and manganese are found statewide in many rock types.

The results of groundwater quality monitoring conducted by DWR in Union County corroborate the association of elevated concentrations of arsenic in wells hosted in meta-mudstones and low concentrations of arsenic in wells hosted in meta-volcanic rocks (Abraham, 2009). Arsenic appears to be released from sulfide minerals in bedrock by oxidation-reduction and by changes in pH. These changes may be either natural or human-induced. It is also likely that some arsenic in groundwater may be derived from historic uses of arsenical pesticides. Shallow dug wells or wells cased above the transition-zone are particularly prone to arsenic from surficial or shallow bedrock sources such as arsenical pesticides.

Figure 13: Arsenic concentration in private wells, Union County, NC



Regardless of the source, long-term exposure to arsenic in drinking water can have serious health effects. Well users in Union County and other counties in the North Carolina Piedmont, particularly in the Carolina Terrane, are urged to test their well water for arsenic, iron, and manganese as part of a comprehensive analysis, and to take appropriate precautions or treatments if needed. Periodic testing of water every few years is also recommended, since human-induced activities are known to release naturally-occurring and organic contaminants into the groundwater system.

ANTHROPOGENIC CONTAMINANTS

Since the eastern part of Union County is mostly rural, there are few possibilities for groundwater contamination from human activities except those that could be attributed to agricultural practices. The groundwater quality data collected for this report is generally consistent with expectations for a rural area in the North Carolina Piedmont. Public water supply monitoring results do not show pervasive problems with volatile organic compounds (VOCs) or other contaminants from industrial or commercial sources; however, public water supply well locations are very carefully researched and monitored to ensure that the risk of such contamination is minimized. There is no consistent sampling of private wells for VOCs, so there is no reliable indicator of the extent to which private wells may be impacted by VOCs.

The western part of Union County has undergone significant urbanization during the past decade. In these areas, groundwater contaminated by VOCs or other contaminants from industrial or commercial sources may be more common. Since most of the urbanized areas are served by public water supply, which are required to meet federal drinking water standards, there is less risk for the general public of exposure to groundwater contaminants. Nonetheless, private wells near the urbanized areas may be prone to local groundwater contamination from various sources. Well users near potential contamination sources such as petroleum storage tanks, drycleaning solvent releases, and others discussed in this report should consult with their local health department to determine their well sampling needs. These well users should have their well tested periodically to detect anthropogenic contaminants in their drinking water supply. Figure 9 provides an overview of the locations of these and other potential contaminant sources.

DISCUSSION AND RECOMMENDATIONS

CURRENT DATA EVALUATION

Groundwater quality data for Union County, although not substantial, are evenly distributed throughout the county. Hence, current data evaluation provides a fairly accurate interpretation of natural and man-made sources of groundwater contamination across the county. However, current datasets limit identification of groundwater contamination at a large number of agricultural operations, including animal feeding operations in the county. Agricultural land constituted 44% of the total land area in Union County in 2007. At present there is no means to identify which of multiple potential groundwater contamination sources is most critical at many of these agricultural lands. There are occasional elevated levels of nitrates noted in private well sampling data, but there is insufficient information to determine the exact source of the nitrate pollution, and the Division has not been tracking this dataset long enough to evaluate trends.

The most comprehensive data on groundwater quality in Union County is from the private well testing program begun in 2008. While the private well testing data available prior to 2008 may be biased towards potential problems with groundwater quality, the post-2008 private well data provides the most extensive and valuable indicator of groundwater quality in this county. However, even that data is subject to some bias from trends in population growth. Additionally, this dataset does not include any information on VOCs, and the small number of wells with reliable location information limits its usefulness.

The Division of Water Resources maintains a repository of well construction data for all water wells drilled in NC. This database has the potential to be quite valuable in evaluating groundwater conditions, especially if it could be linked to the water quality data currently obtained for private wells. Unfortunately, due to the large number of well construction records and staffing shortages, only a portion of the total number of well construction records have been entered into the electronic database in recent years. A new system for recording this vital information in a publicly available database is under development in 2015.

ADDRESSING POTENTIAL WATER QUALITY ISSUES

As population and business operations in Union County increase, the demand for a reliable source of clean water will increase. Water supply wells may be capable of meeting an increased demand for clean water, but only if the resource is protected and growth is managed. Future residential or industrial development onto areas currently occupied by farming operations may encounter residual agricultural chemicals and nutrients in the groundwater. In addition to the existing private and public water supply well testing programs, it is advisable that private wells be re-tested at a two to five-year frequency, especially in areas of former agricultural use, in the vicinity of waste disposal operations, and in areas of commercial development. This sampling frequency is recommended due to the highly variable groundwater flow velocities in the North Carolina Piedmont. Well users living on former agricultural land may also wish to have their wells tested for parameters such as VOCs and pesticides, which are beyond the standard suite of parameters required for new wells.

Proper management of human and animal waste applications is a critical issue for Union County. Because of its proximity to the Charlotte metropolitan area, large amounts of wastewater residuals (biosolids) from Charlotte – Mecklenburg utilities are applied on agricultural lands in Union County. There are also treated industrial wastewaters applied on agricultural lands in the county. While the data examined in this assessment do not suggest that human and animal wastes are currently creating significant groundwater contamination that would pose public health concerns, proper management of wastewater residuals is essential for the continued protection of groundwater quality. Similarly, septic systems must be maintained properly and leaking systems corrected or replaced to ensure protection of groundwater quality.

Union County's proximity to urban areas and its rural character also play a role in the relatively large number of poultry and cattle farming operations found in the county. Increasing human populations in the surrounding urban centers will likely result in increasing demand for poultry and cattle products, which will in turn result in increasing volumes of animal waste for disposal.

DATA NEEDS, FURTHER STUDY

Targeted long term groundwater quality monitoring stations in appropriate locations would be an invaluable tool for use in assessing any potential impacts from large scale animal farming operations and other anthropogenic pollution sources. The groundwater monitoring stations should be placed in strategic locations hydraulically downgradient from representative areas of concern such as poultry farms, biosolids application fields, or other waste disposal areas. A "background" ambient groundwater quality monitoring station located in an undeveloped area of the watershed would be useful for comparison and to monitor groundwater quality changes over time. Barring establishment of dedicated monitoring stations, a monitoring network could also be implemented through data mining of permit-required groundwater monitoring and by periodic re-sampling of existing water supply wells.

In either case, the collection and storage of groundwater quality data need to be standardized throughout the regulatory programs that collect this data if either of these options is to be feasible. Accurate well location information is a critical element for groundwater quality assessments. A shared, standardized method to identify well locations in the databases maintained by DEQ-DWR, the DEQ Division of Waste Management and the DHHS Public Health Lab would be of great value.

The development of a centralized groundwater monitoring database to be used for all groundwater data collected by DEQ is underway and will also be an invaluable tool for providing the public and decision makers with better information about groundwater quality. In addition to these data management needs, there is a need to develop quality assurance plans and statistical tools that specifically address the development of regional (watershed or county-level) assessments from data that was collected for the purposes of site-specific assessments.

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GLOSSARY OF TERMS

2L Groundwater Standard - Groundwater quality standards are the maximum allowable concentrations of pollutants in groundwater which may be tolerated without creating a threat to human health or which would otherwise render the groundwater unsuitable for use as a drinking water source. These standards are set by the State of North Carolina in accordance with 15A NCAC 02L .0202 (http://portal.ncDEQ.org/web/wq/ps/csu/gwstandards)

Alluvium – Sediment that has been deposited or re-shaped by modern rivers and streams.

Felsic - Rock that is rich in silica and typically light-colored, such as granite and rhyolite.

Igneous – Rock created by the cooling of magma or lava.

Inorganic compound – a chemical compound that does not contain the element carbon

Metamorphic – Rock created by exposure of parent rock to extreme heat and/or pressures.

Metavolcanic – Volcanic rock that has been exposed to some degree of heat and/or pressure to slightly alter its mineral composition and texture.

NonDischarge Permitting Program – NCAC Title 15A, Subchapter 2T – Waste not discharged to surface waters. Waste is discharged onto or below land surface. The goal is to prevent nonpoint source pollution.

NonPoint Source Pollution - any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act. It generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage or hydrologic modification.

Organic compound – a chemical compound that contains the element carbon

Physiographic province – A region of similar geologic structure and climate that has had a unified geomorphic history.

Recharge – The entry of water into the groundwater system, generally from rainfall or other precipitation soaking into the ground.

Regolith – The unconsolidated material overlying bedrock. The regolith may be comprised of layers of alluvium, soil, and saprolite.

Saprolite – The weathering product of underlying bedrock. Saprolite is typically composed of clay to boulder sized material and may reflect the texture of the rock from which it formed.

Maximum Contaminant Level (MCL) - MCLs are enforceable standards, the highest level of a contaminant that is allowed in drinking water. This level applies to public drinking water systems and is set by USEPA. When establishing an MCL, EPA takes the best available treatment technology and cost into consideration. (http://water.epa.gov/drink/contaminants/

Nutrient – any substance assimilated by living things that promotes growth. The term is generally applied to nitrogen and phosphorus

National Primary Drinking Water Regulations - legally enforceable regulations that apply to public water systems. Primary standards protect public health by limiting the levels of contaminants in drinking water. Regulated contaminants and their allowable levels (MCLs) are listed at http://water.epa.gov/drink/contaminants/

Sceondary Maximum Contaminant Level (SMCL) - non-mandatory water quality standards for 15 contaminants established only as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color and odor. These contaminants are not considered to present a risk to human health at the SMCL.

Radionuclide – an unstable form of a chemical element that radioactively decays

Semi-Volatile organic compound (SVOC) – a chemical compound composed primarily of carbon and hydrogen atoms, having a boiling point greater than 200°C. Common SVOCs include phenols and phthalates

Transition Zone – A zone of partially weathered rock at the base of the regolith, between the saprolite layer and bedrock. Groundwater typically flows more rapidly through the transition zone than through saprolite due to higher permeability

Volatile organic compound (VOC) – organic compounds capable of evaporating under normal indoor atmospheric conditions of temperature and pressure