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Inventory of well yields in Avery and Watauga Counties, North Carolina
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Abstract

More than 1,500 well records were compiled for Avery and Watauga Counties, North Carolina, as part of a study of ground-water resources. Wells in this area of the Blue Ridge Physiographic Province produce water from the fractured-bedrock aquifer. Prior to this study, only about 132 wells were included in the U.S. Geological Survey's National Water Information System, as a result of a study conducted during the late 1960s. The large number of additional well records provide a better data set to evaluate the ground-water resources. From the more recent well inventory conducted in 2007, the range of well yields in these two counties is from 0 to 400 gallons per minute. Total depth of the wells ranged from 20 to 1,204 feet below land surface, and depth to primary fracture zones ranged from 25 to 1,000 feet below land surface.

Introduction

In many rural areas of North Carolina (NC), ground water is the sole resource for drinking water. With increasing population, many more wells are being drilled, and information on this important resource needs to be updated. In February 2007, the U.S. Geological Survey (USGS) initiated a study in cooperation with the High Country Council of Governments, through a grant received by the North Carolina Rural Economic Development Center, to better quantify available ground-water resources in two rural counties (Avery and Watauga) in the northern North Carolina mountains. Many small towns in Avery and Watauga counties are dependent on wells from local fractured-bedrock aquifers, and local officials are concerned about the sustainability of the resource for support of economic development and population growth. In 2005, all residents in Avery County were served by ground-water resources, while 37 percent of the population in Watauga County was served by ground water (D.G. Smith, U.S. Geological Survey, written commun., 2007)

Study area

Avery and Watauga Counties are located in the northern mountains of North Carolina (inset map), and include the towns of Boone, Blowing Rock, Seven Devils, Banner Elk, Sugar Mountain, Grandfather Village, Linville, Crossnore, Newland, Elk Park, and Beech Mountain. These resort towns have populations that increase seasonally to as much as five times the base year-round population. Water supplies for most resort towns can meet current demands but may not be able to support additional growth from large developments, such as condominiums. Boone has the largest population in the area, about 14,473 residents in 2006 (North Carolina State Demographics, 2006), excluding the student population of Appalachian State University (ASU). Boone relies on withdrawals from nearby surface-water resources for public water supplies (North Carolina Department of Environment and Natural Resources, Division of Water Resources, 2007).

Detailed hydrogeologic information on local ground-water resources has not been compiled for this area since the 1960s (Sumsion and Laney, 1967), and the region has experienced substantial growth during the last four decades. From 1960 to 2005, the population of Avery County increased from an estimated 12,009 people in 1960 to 18,174 people by 2006 (U.S. Census Bureau, 1960; North Carolina State Demographics, 2006). The population of Watauga County has grown much faster, likely from the expansion of ASU and increased development of retirement and second-home communities in the area. The population in Watauga County increased from an estimate of about 17,529 people in 1960 to more than 43,410 people in 2006 (U.S. Census Bureau, 1960; North Carolina State Demographic, 2006). Total area for Avery County is about 247 square miles (mi^2), and Watauga County has an area of about 313 mi^2 (U.S. Census Bureau, 2005).

Hydrogeology

The ground-water system of the Blue Ridge Physiographic Province of western North Carolina is composed of geologic and hydrogeologic settings that include various assemblages of rocks that have undergone multiple periods of structural deformation, metamorphism, and igneous intrusion. The complex rock assemblages are grouped as "geologic belts or terranes" that contain similar lithologies having common geologic history (North Carolina Geological Survey, 1985). The ground-water system is composed of shallow, weathered regolith (commonly referred to as saprolite) at land surface, and deeper, fractured bedrock (Heath, 1984). In the mountainous topographic settings, well-developed regolith may not be present. The bedrock often crops out at the surface as a result of the ongoing erosional processes on steep slopes. In some areas, debris-flow deposits from landslides may provide ground-water storage. If regolith or debris-flow deposits are not present at land surface, then managing the ground-water resources in the bedrock becomes more difficult because of the lack of storage in the fracture network. Hydrogeologic units delineated in Avery and Watauga Counties include metaigneous, mafic (MIM); igneous, felsic intrusive (IFI); gneiss, mafic (GNM); gneiss, felsic (GNF); phyllite (PHL); schist (SCH); and quartzite (QTZ); Daniel and Payne, 1990). Hydrogeologic units throughout the Blue Ridge and Piedmont Physiographic Provinces are delineated further in Daniel and Payne (1990).

Methods

In this report, both domestic (individual) and public-supply wells and associated well-construction data, such as depth and yield, are presented for Avery and Watauga Counties, North Carolina. Well data were obtained from the USGS National Water Information System (NWIS); the North Carolina Department of Environment and Natural Resources (NCDENR) Division of Water Quality (DWQ) and Division of Environmental Health Public Water Supply Section (PWSS); several towns (Elk Park, Newland, and Banner Elk); and from inspection of well driller's tags on the well casings during field visits.

Well data were compiled from paper and electronic records obtained from the DWQ and PWSS, Asheville and Winston-Salem Regional Offices. The DWQ receives well-construction records or "GW-1" forms from drillers, and the PWSS receives pumpage reports from community-supply wells providing 15 or more connections for 25 or more people (North Carolina Department of Environment and Natural Resources, 1990). Paper copies of the GW-1 forms were obtained for wells drilled between 1999-2007 in Avery County and for wells drilled between 2004-2007 in Watauga County. Electronic spreadsheets of well data for both counties were obtained for 1986-2005 (Walt Haven, North Carolina Department of Environment and Natural Resources, Division of Water Quality, written commun., March 2007). Well data includes the following information (when available): owner information, general location, date drilled, well depth, casing depth, well yield (gallons per minute), and depth to contributing fracture(s). All data collected as part of this study were entered into the USGS Ground-Water Site Inventory (GWSI) database and exported into a geographic information system (GIS) database for mapping and statistical analysis.

Only a small percentage of the inventoried wells could be field located within the timeframe of this study. However, some of the more recent GW-1's (2006-2007) include geographic coordinates of the well locations. Coordinates were assigned to the other wells using mapping software once the location of the well-owner parcel was identified from county GIS coverages. Parcel locations were identified from the GIS coverages using owner information on driller's well records. Also, when available, location sketches and street addresses on the GW-1's were used to verify the parcel locations. Once the parcel was located, mapping software was used to assign coordinates. Well coordinates were assigned using the location of the approximate center of the parcel. The accuracy of the coordinates is approximately one second or 100 feet (for a 1-acre parcel). The accuracy of the well locations decreases with increasing parcel size. Typically, wells located on larger parcels (greater than 5 acres) were not used.

Well records for community-supply wells were obtained from the PWSS. Also, GIS shapefiles containing well data and locations of these wells were obtained from NC OneMap (http://www.nconemap.com/Default.aspx?tabid=286). Well locations were determined by the PWSS using global positioning system (GPS) equipment with differential correction. The accuracy of the GPS location data is about 6 to 16 feet (approximately 2 to 5 meters). Several towns also supplied well data, aquifer-test reports, and pumpage records. The Town of Elk Park supplied well data (including coordinates) and pumping-test reports for two supply wells. The Town of Newland supplied well-construction information for four supply wells and aquifer- test data from one well. The Town of Banner Elk supplied well-construction information, including daily production, in million gallons per day (Mgal/d), for four supply wells. Daily permitted withdrawals for the Banner Elk production wells range from 0.072 to 0.173 Mgal/d. The information recorded from well driller's tags generally included date drilled, total depth, depth of casing, and well yield. Coordinates were assigned to the wells using hand-held GPS equipment with accuracies of about 10 to 25 feet.

Summary of Data Compilation and Findings

Data for 1,572 wells (653 wells in Avery and 919 wells in Watauga Counties) were compiled during June-September 2007. Of these, 132 wells were from a study conducted in the 1960's (Sumsion and Laney, 1967), 45 wells were physically located using a GPS unit in the field, 313 well coordinates were provided by the PWSS, and 1,082 wells were located using owner information from GW-1 construction records and the county GIS. Well data include location, date drilled, well depth, casing depth, well yield, and depth to the primary contributing fracture zone (when available).

The range and mean values for well depth, yield, and primary fracture depths for each hydrogeologic unit for Avery and Watauga Counties are listed in table 1, and the two counties combined in table 2. The total depth of wells ranged from 20 to 1,204 feet below land surface, the well yield ranged from 0 to 400 gallons per minute, and depth to the primary fracture zones ranged from 25 to 1,000 feet below land surface. The highest mean well yield of 32 gallons per minute was observed in data from the phyllite hydrogeologic unit, and the lowest mean well yield of 12 gallons per minute was noted in data from the mafic gneiss unit.

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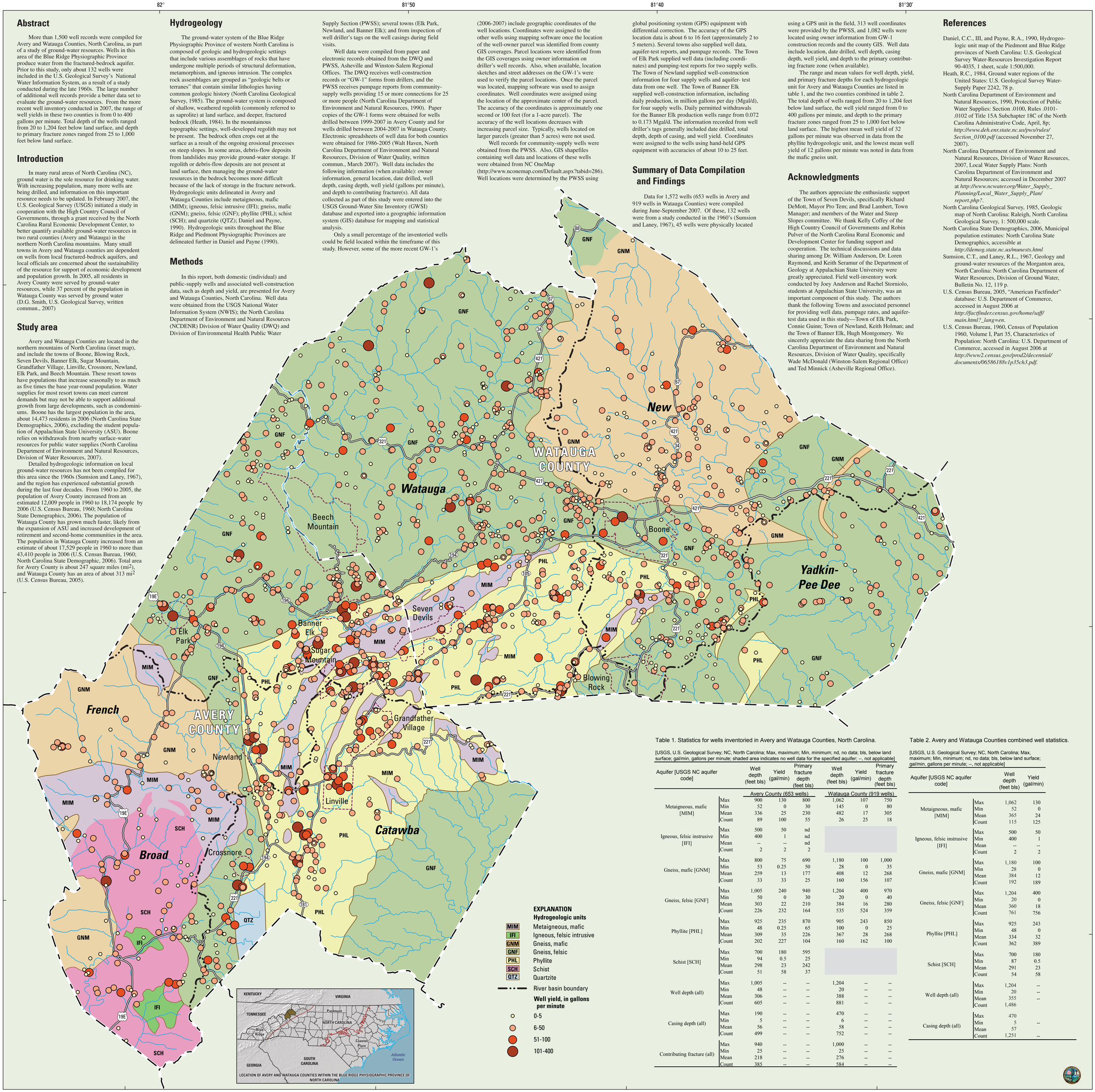

Table 1. Statistics for wells inventoried in Avery and Watauga Counties, North Carolina.

[USGS, U.S. Geological Survey; NC, North Carolina; Max, maximum; Min, minimum; nd, no data; bls, below land surface; gal/min, gallons per minute; shaded area indicates no well data for the specified aquifer; --, not applicable]

Aquifer [USGS NC aquifer code]		Well depth (feet bls)	Yield (gal/min)	Primary fracture depth (feet bls)	Well depth (feet bls)	Yield (gal/min)	Primary fracture depth (feet bls)
		Avery County (653 wells)			Watauga County (919 wells)		
Metaigneous, mafic [MIM]	Max	900	130	800	1,062	107	750
	Min	52	0	30	145	0	80
	Mean	336	25	230	482	17	305
	Count	89	100	55	26	25	18
Igneous, felsic instrusive [IFI]	Max	500	50	nd			
	Min	400	1	nd			
	Mean	--	--	nd			
	Count	2	2	2			
Gneiss, mafic [GNM]	Max	800	75	690	1,180	100	1,000
	Min	53	0.25	50	28	0	35
	Mean	259	13	177	408	12	268
	Count	33	33	25	160	156	107
Gneiss, felsic [GNF]	Max	1,005	240	940	1,204	400	970
	Min	50	0	30	20	0	40
	Mean	303	22	210	384	16	280
	Count	226	232	164	535	524	359
Phyllite [PHL]	Max	925	235	870	905	243	850
	Min	48	0.25	65	100	0	25
	Mean	309	35	226	367	28	268
	Count	202	227	104	160	162	100
Schist [SCH]	Max	700	180	595			
	Min	94	0.5	25			
	Mean	298	23	242			
	Count	51	58	37			
Well depth (all)	Max	1,005	--	--	1,204	--	--
	Min	48	--	--	20	--	--
	Mean	306	--	--	388	--	--
	Count	605	--	--	881	--	--
Casing depth (all)	Max	190	--	--	470	--	--
	Min	5	--	--	6	--	--
	Mean	56	--	--	58	--	--
	Count	499	--	--	752	--	--
Contributing fracture (all)	Max	940	--	--	1,000	--	--
	Min	25	--	--	25	--	--
	Mean	218	--	--	276	--	--
	Count	385	--	--	584	--	--

Table 2. Avery and Watauga Counties combined well statistics.

[USGS, U.S. Geological Survey; NC, North Carolina; Max, maximum; Min, minimum; nd, no data; bls, below land surface; gal/min, gallons per minute; --, not applicable]

Aquifer [USGS NC aquifer code]		Well depth (feet bls)	Yield (gal/min)
Metaigneous, mafic [MIM]	Max	1,062	130
	Min	52	0
	Mean	365	24
	Count	115	125
Igneous, felsic instrusive [IFI]	Max	500	50
	Min	400	1
	Mean	--	--
	Count	2	2
Gneiss, mafic [GNM]	Max	1,180	100
	Min	28	0
	Mean	384	12
	Count	192	189
Gneiss, felsic [GNF]	Max	1,204	400
	Min	20	0
	Mean	360	18
	Count	761	756
Phyllite [PHL]	Max	925	243
	Min	48	0
	Mean	334	32
	Count	362	389
Schist [SCH]	Max	700	180
	Min	87	0.5
	Mean	291	23
	Count	54	58
Well depth (all)	Max	1,204	--
	Min	20	--
	Mean	355	--
	Count	1,486	
Casing depth (all)	Max	470	
	Min	5	--
	Mean	57	
	Count	1,251	--

National Elevation Dataset
U.S. Census Bureau
Department of Transportation, North Carolina
National Hydrography Dataset 1 1:100,000 scale

Inventory of Well Yields in Avery and Watauga Counties, North Carolina

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2008

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