GROUND-WATER QUALITY IN THE PIEDMONT/BLUE RIDGE UNCONFINED AQUIFER SYSTEM OF GEORGIA

John C. Donahue and Susan R. Kibler

GEORGIA DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION
WATERSHED PROTECTION BRANCH
REGULATORY SUPPORT PROGRAM

ATLANTA
2007

CIRCULAR 12U

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The preparation of this report was funded in part through a grant from the U.S. Environmental Protection Agency under the provisions of Section 106 of the Federal Water Pollution Control Act of 1972, as amended.

GEORGIA DEPARTMENT OF NATURAL RESOURCES
Noel Holcomb, Commissioner

ENVIRONMENTAL PROTECTION DIVISION
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WATERSHED PROTECTION BRANCH
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ATLANTA
2007

CIRCULAR 12U

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CHAPTER 1. INTRODUCTION

1.1 PURPOSE AND SCOPE

This report, covering the period December 2005 through December 2006, is the second in a series of summaries to examine potential ground-water impairment within specific areas of Georgia or involving specific types of wells. The previous series of summaries of the Circular 12 series, nineteen in all, dealt with the chemical quality of ground water Statewide.

These summaries are among the tools used by the Georgia Environmental Protection Division (EPD) to assess trends in the quality of the State's ground-water resources. EPD is the State organization with regulatory responsibility for maintaining and, where possible, improving ground-water quality and availability. EPD has implemented a comprehensive statewide ground-water management policy of anti-degradation (EPD, 1991; 1998). Five components comprise EPD's current ground-water quality assessment program:

1. The Georgia Ground-Water Monitoring Network. The Georgia Geologic Survey Branch (GGS) of EPD and its successor, the Regulatory Support Program of the Watershed Protection Branch, maintain this program. Early in calendar year 2004, a three-part monitoring program replaced the Statewide aquifer-specific monitoring network. The new program examines ground-water: a) in the coastal area for influx of connate brines, sea water, or low-quality surface water; b) in the Piedmont and Blue Ridge for impacts from development and rural land use as well as to gain a more thorough understanding of the area's ambient ground water; and c) from small public water systems to spot check for intermittent contamination that might escape detection under item 2) below. The current report summarizes findings for part b) of the program, the Piedmont/Blue Ridge Monitoring Project.

2. Sampling of public drinking water wells as part of the Safe Drinking Water Program, also of the Watershed Protection Branch. This program provides data on the quality of ground water that the residents of Georgia are using.

3. Special studies addressing specific water quality issues. Examples of these types of studies include a survey of nitrite/nitrate levels in shallow wells located throughout the State of Georgia (Shellenberger, et al., 1996; Stuart, et al., 1995), operation of a Pesticide Monitoring Network conducted jointly by the GGS and the Georgia Department of Agriculture (GDA) (Tolford, 1999; Glen, 2001), and the Domestic Well Pesticide Sampling

Project conducted jointly by the GGS and the GDA (Overacre, 2004, Berry, 2005).

4. Ground-water sampling at environmental facilities such as municipal solid waste landfills, RCRA facilities, and sludge disposal facilities. The primary branches responsible for monitoring these facilities are EPD's Land Protection, Watershed Protection, and Hazardous Waste Management Branches.

5. The wellhead protection program (WHP), which is designed to protect the area surrounding a municipal drinking water well from contaminants. The U.S. Environmental Protection Agency (EPA) approved Georgia's WHP Plan on September 30, 1992. The WHP Plan became a part of the Georgia Safe Drinking Water Rules, effective July 1, 1993. The protection of public water supply wells from contaminants is important not only for maintaining ground-water quality, but also for ensuring that public water supplies meet health standards.

1.2 PIEDMONT/BLUE RIDGE GROUND-WATER MONITORING NETWORK

The study area for the Piedmont/Blue Ridge Monitoring Project encompassed 74 counties lying wholly or partly within the Piedmont or the Blue Ridge physiographic provinces (Fig. 1-1). The Cartersville-Great Smoky fault system bounds the area to the northwest, and the Fall Line bounds the area to the southeast (Figure 1-1). The northeastern and southwestern boundaries are the South Carolina and Alabama State lines, respectively. The sole aquifer system in the area is the Piedmont/Blue Ridge unconfined aquifer system.

The current project sampled 120 wells, preferably shallow and as evenly distributed as possible throughout the study area (Figure 1-2). Sixty of the wells and springs are public water sources.

Waters from the sampled wells and springs were field tested for pH, conductivity, temperature, and dissolved oxygen. The sampled wells and springs were located using a global positioning system (GPS) receiver. Laboratory testing for the project included analyses for chloride, sulfate, nitrate/nitrite, total phosphorus, sulfide, and metals, including uranium. Sulfide testing later ceased after laboratory capacity became a concern and no detections occurred. Testing for radionuclides in addition to uranium was considered, but the project budget could not accommodate the additional analyses.

Project testing also included analyses for volatile organic compounds (VOCs) in high-growth counties. VOC testing was later extended to low-growth counties having urban core area (e.g., Fulton County) or established industrial towns (e.g. Upson County). Per request of the US EPA, Region 4, sample waters from two stations, Lin-1 and Mwr-1, were sent to a graduate student at

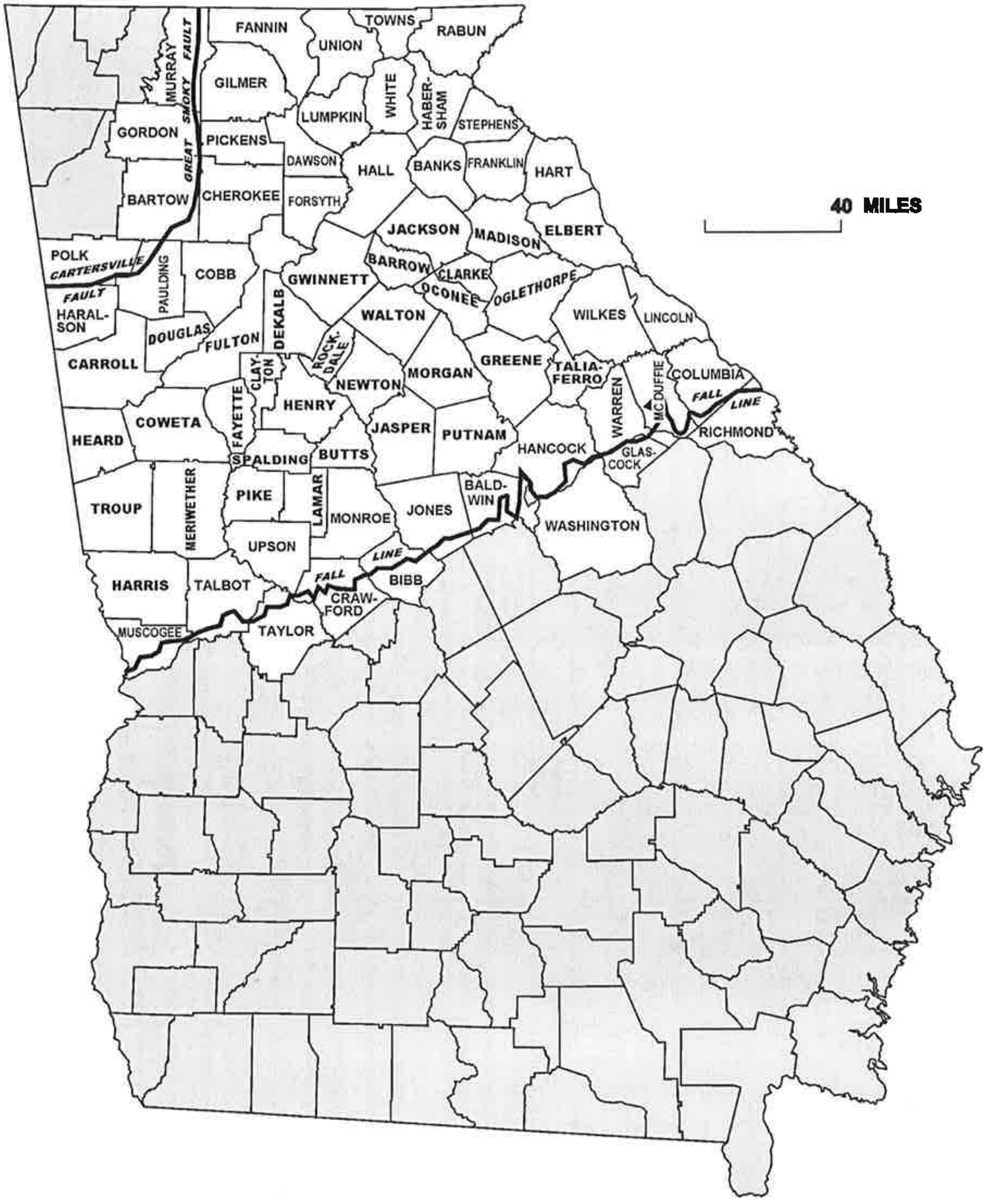

Figure 1-1. Map of Georgia, Showing the Counties that Lie Within the Study Area. Also Shown Are the Cartersville-Great Smoky Fault System and Fall Line.

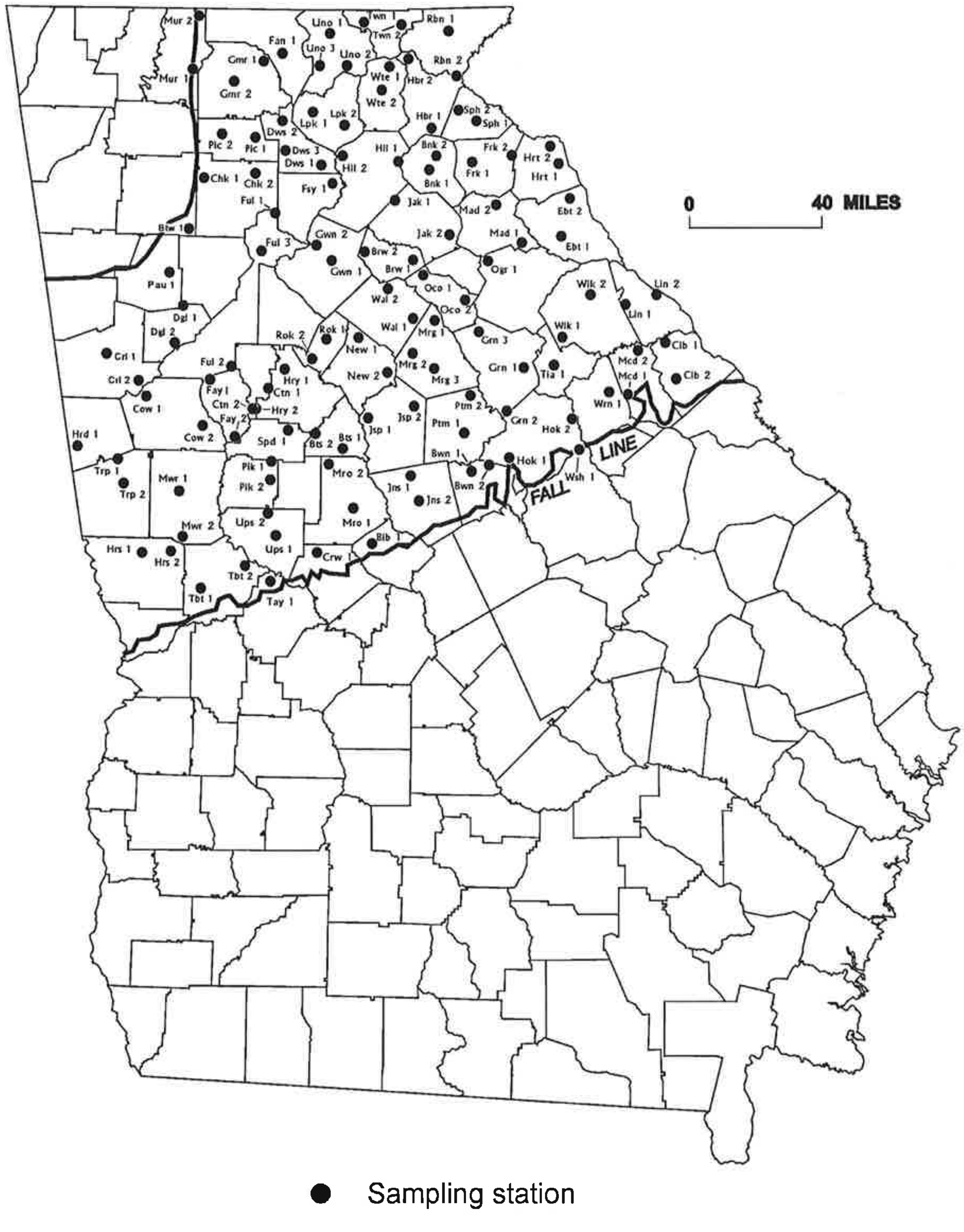

Figure 1-2. Location Map Showing Sampling Stations.

the University of California/Riverside to be analyzed for perchlorate as part of a nation-wide ground-water perchlorate study. No results have been forthcoming on the perchlorate analyses.

The State has established limits, termed Maximum Contaminant Levels (MCLs), on the concentrations of certain substances in water made available to the public. Primary MCLs apply to substances which pose a threat to health. Secondary MCLs apply to substances which, though not ordinarily a threat to health nevertheless impart an offensive quality to the water, such as bad taste or ability to stain. Although these standards apply only to treated water made available to the public, they are useful guidelines for evaluating the quality of raw (untreated) water.

Assembling the candidate wells and springs began in December 2005 and continued through much of the length of the project. Candidate wells came from a variety of sources. Lists of public water system licensees and public water sources provided the largest group of candidates. Other candidates came by way of the Georgia Forestry Commission (GFC). Many GFC offices are located in rural areas and depend on wells for drinking water or wash water. Employees at these offices, many living in rural areas themselves, offered the use of their private wells and gave referrals to other private well owners. The Georgia Department of Natural Resources (DNR) Wildlife Resources Division (WRD) made available wells or springs supplying water to work stations and hunting check stations. Some WRD employees were also able to offer their private wells or to provide references to other private well owners. The DNR Parks and Historic Sites Division also provided candidates. Most park wells are public water sources, but staff house wells and certain other park water sources are non-public. Employees of the EPD/Watershed Protection Branch/Regulatory Support Program offered a few private wells or references to private well owners.

1.3 POPULATION CHARACTERISTICS

1.3.1 High-Growth Counties

According to data available from the US Census Bureau (USCB) website at www.fedstats.gov/gf/states/13000/html (Feb. 6, 2007 edition), Georgia's population has grown from an estimated 8,230,155 to an estimated 8,918,129 between July 1, 2000 and July 1, 2004. This is an increase of about 8.36 percent. The lower limit for "high-growth" counties in the current study was, therefore, set at 8 percent. All counties with a population growth rate equal to or greater than the lower limit were considered high-growth counties (see Table A-1 in the Appendix).

Low-growth counties generally fall into three categories: rural, urban, and rural-industrial (see Table A-1 in the Appendix). Rural counties generally have relatively low population densities, about 50 people per square mile or less.

Rural-industrial counties usually have population densities of about 100 to 200 people per square mile and have long-established industrial centers (commonly, these are or used to be textile mill towns). Urban counties have population densities in excess of 500 people per square mile.

1.3.2 Low Income and Minority Areas

The minority and low-income data for this study was obtained by comparing the geographic location of each sampling station to data and maps from the 2000 United States Decennial Census Survey (2000 Survey), which is available on the USCB website at www.census.gov. Data from the 2000 Survey were used, as the 2005 US Census American Community Survey (2005 Survey) was not complete for all areas.

For the 2000 Survey, the USCB used a combination of income thresholds to establish the number of people living in poverty. The number is reported as a percentage of individuals living below the poverty level. More information as to how the income thresholds and the poverty level are established can be found on the USCB website. In the US, the percentage of people living below the poverty level is reported as 12.4 percent. Of the 120 sites that were sampled for this study, 40 sites (33 percent) were located in areas where the level of poverty exceeded the national average.

The sampling locations were also compared to the USCB data for two minority populations: Hispanic or Latino and Black or African American. The percentage of the population in the US that self-identify as Hispanic or Latino is reported as 12.5 percent. Of the 120 sites that were sampled for this study, two sites (2 percent) were located in areas that exceeded the 12.5 percent national average. The percentage of the population in the US that self-identify as Black or African American is reported as 12.3 percent. Of the 120 sites that were sampled for this study, 57 sites (48 percent) were located in areas that exceeded the 12.3 percent national average.

CHAPTER 2. HYDROGEOLOGIC FRAMEWORK

2.1 PIEDMONT/BLUE RIDGE AQUIFER SYSTEM

The Piedmont/Blue Ridge aquifer system in Georgia is part of the general Piedmont and mountain aquifer system that extends from New Jersey into Alabama (Daniel and Harned, 1997). The system is unconfined or semi-confined and is composed of two major hydrogeologic units: regolith and fractured igneous and metamorphic bedrock (Heath, 1980; Daniel and Harned, 1997).

2.1.1 Regolith

Typical regolith is composed of a surficial veneer of soil or, near stream bottoms and former stream bottoms, alluvium, underlain by saprolite (Heath, 1980). Saprolite is bedrock that has undergone extensive chemical weathering in place. Many of the structures and textures of the original bedrock are commonly preserved, with the saprolite appearing as a "rotten" version of the original rock. Saprolitization involves the leaching of alkali metals, alkaline earth and other divalent metals by downward percolating, typically acidic ground water from micas, feldspars, and other minerals composing the original rock, leaving behind a residual material rich in clay minerals.

The regolith possesses a high degree of porosity, mostly primary (35-55 percent) void space between mineral grains (Daniel and Harned, 1998), and constitutes the main reservoir holding ground water. The saprolite typically grades downward through a transition zone into unweathered fractured bedrock. The transition zone contains a mix of saprolite, partially weathered bedrock, and lumps of fresh bedrock. This zone commonly exhibits greater permeability than the overlying or underlying materials (Daniel and Harned, 1998). However, Williams et al. (2004) found areas of poor hydraulic communication between the bedrock and the regolith at Lawrenceville, Georgia.

The regolith serves as a reservoir that feeds ground water downward into the underlying fractured bedrock (Heath, 1980). The water table usually lies within the regolith and, at rest, is a subdued imitation of the topography, with flow proceeding from high areas to valleys. Streams can be viewed as outcroppings of the water table. Williams et al. (2004), however, found that pumping at the City of Lawrenceville's Rhodes Jordan Park well field influenced a water level station about a mile and a half away, across a locally major watershed divide.

2.1.2 Fractured Bedrock

The bedrock is igneous and metamorphic and comprises granitic rocks, a lesser amount of mafic and ultramafic rocks (diabase is the most common), gneisses, schists, amphibolites, quartzites, phyllites, marbles, granulites, and mylonites and other cataclastic rocks. Unlike the regolith, these rocks have almost no primary porosity, i.e., void space between mineral grains. Nearly all the ground water in these rocks is stored in fractures and solution voids (secondary porosity). In the North Carolina Piedmont, Daniel and Harned (1998) found 1-3% porosity typical for bedrock.

Fractures consist of faults, breaks in the rock with differential displacement, and joints, breaks in the rock with little differential displacement (Heath, 1980). Fractures generally are more numerous and wider near the bedrock surface. At about 600 feet, pressure from the overlying rock column becomes too great and fractures are held shut (Daniel and Harned, 1998). Fractures also serve to open the rock to weathering, which, in turn, can enlarge the fractures and alter the rock to saprolite. Large fractures in bedrock function as conduits, thus wells tapping bedrock can have larger yields than those tapping the regolith. Fractures can be concentrated along fault zones, shear zones, late-generation fold axes, foliation planes, lithologic contacts, compositional layers, or intrusion boundaries. Stress-relief fractures, nearly horizontal inverted saucer-shaped structures, may form in certain scenarios as the bedrock rebounds from the erosive removal of overlying material (Cressler et al., 1983). These structures may be on the order of a few inches in thickness and may range from about a hundred feet to a quarter mile in diameter. Schists contain dense networks of fine hairline fractures along foliations and have the best developed regolith/bedrock transition zones (Daniel and Harned, 1998). They are not good producers of water, as the fine fractures do not accommodate conduit flow. Fractures in more massive rocks tend to be wider and are more conducive to conduit flow.

2.2 FAVORABLE SCENARIOS FOR OBTAINING GROUND WATER

The regolith itself has been used as a ground-water source for small-scale purposes. The high-yielding wells (Cressler et al., 1988; Williams et al., 2004) derive water from bedrock fractures. Cressler et al. (1988) and Khallouf and Williams (2003) identified scenarios where one can obtain large amounts of ground water in the Piedmont and the Blue Ridge:

1) contact zones between rocks of contrasting character as between a massive granitic gneiss and a deep weathering feldspathic schist;

2) contact zones in multilayered rocks, as the compositionally layered gneisses in Rockdale County;

3) fault zones;

4) stress-relief fractures;

5) zones of fracture concentration, more applicable to massive rocks than to schists or phyllites;

6) small-scale structures that localize drainage;

7) late generation folds, those that post-date peak metamorphism and have fractured rocks in their hinges;

8) shear zones.

CHAPTER 3. METHODS

3.1 FIELD METHODS

Conductivity, pH, temperature, and, if possible, dissolved oxygen were monitored in the field with a Horiba Model U-10 water quality meter. A Garmin ® eTrex Legend GPS receiver was used to measure latitude and longitude at the sampling station. At most stations, gamma radiation readings were taken both over a five-gallon plastic bucket filled with sample water (sample reading) and over ground at a distance from the bucket (background reading) (Table A-2, Part A). Gamma radiation readings were taken utilizing a Mount Sopris Instrument Co., Model SC-132 handheld scintillation detector.

In most cases, wells had dedicated pumps with plumbing downstream of the wellhead that included spigots or other outlets. The outlet nearest the wellhead was typically used as the monitoring and collection point. A Y-tube formed of garden hose was fitted to the outlet. The Y-tube had a plastic pitcher fitted on one branch to accommodate the water quality meter probe; the other branch of the Y-tube was left open to be used for sampling. The meter probe was inserted into the pitcher and the wellhead pump was turned on to initiate the purging process. Every five minutes, conductivity, pH, dissolved oxygen, and temperature readings were taken and recorded. Monitoring continued until these parameters stabilized, which typically occurred after 15 to 20 minutes of continuous purging. The final recorded readings of pH, conductivity, dissolved oxygen, and temperature are reported in (Table A-2). For springs and for wells with outsized raw water outlets (such as four-inch purge pipes) where the Y-tube connection could not be made, the water quality meter's calibration cup was used to draw aliquots for monitoring. At some springs, a suitable container, such as the half-gallon plastic jug used for chloride and sulfate analyses (see below), was employed to draw sample water and to fill various other sample containers.

Once the field parameters stabilized, a metals sample was collected in a half-liter plastic bottle containing a nitric acid preservative; a nitrate/nitrite and phosphorus sample was collected in a plastic 125 milliliter bottle containing a sulfuric acid preservative; and a chloride and sulfate sample was collected in a half-gallon (approx. 2 liter) plastic jug. Where called for, VOC samples were collected in a triplet of septum vials containing a hydrochloric acid preservative.

When sampling was completed, the sample bottles, except for the half-gallon jug, were placed in doubled plastic bags. The bagged samples and the jug were then placed in ice water in a cooler. A trip blank, a septum vial containing clean water and a hydrochloric acid preservative prepared by EPD laboratory personnel, accompanied the VOC samples during transport.

Four wells underwent dual sampling: Fay-2, Ful-2, Hll-2, and Grn-2. The first three were resampled due to reported Primary MCL exceedances or synthetic organic chemical detections. At the last well, one sample was collected at the wellhead and another was collected at a spigot about 600 feet to the west of the wellhead.

3.2 LABORATORY METHODS

Laboratory measurements of the concentrations of VOCs, chloride, nitrate/nitrite, total phosphorus, and metals took place at the EPD laboratory. The US EPA has approved and assigned identification numbers to various testing procedures, termed EPA methods, used in environmental venues. The EPD lab used the methods given in the table below.

Table 3-1. Analytical Methods

Analyte	EPA Method	Method Type
Metals (1)	200.7	ICP
Metals (2)	200.8	ICP/MS
Chloride and Sulfate	300.0	Ion Chromatography
Nitrate/Nitrite	353.2	Colorimetric
Total Phosphorus	365.1	Colorimetric
Sulfide	376	Titrimetric
VOCs	524.2	GC/MS

The reporting limit is the lowest concentration of a substance that can be accurately measured. These limits are given in Table A-3 in the Appendix. The typical reporting limits for calcium, nitrate/nitrite, and sulfate are 1000 parts per billion (ppb), 0.02 parts per million (ppm) as nitrogen, and 10 ppm, respectively. During the current project, the high concentrations of these substances in some samples caused the reporting limits to be raised.

The ICP (inductively-coupled plasma spectrometry) method is generally the better method for analyzing major metals and abundant minor metals: calcium, magnesium, sodium, iron, manganese, and, to a degree, potassium. The values reported for calcium, cobalt, iron, potassium, magnesium, manganese, sodium, titanium, and vanadium were derived from ICP analysis.

The ICP method is subject to interferences when used for analyzing trace metals. These interferences can result in spuriously high reported concentrations for some metals. During this study, ICP analyses for zinc and nickel proved to be particularly vulnerable to interference. As a result, the values reported for chromium, nickel, copper, zinc, arsenic selenium, molybdenum, silver, cadmium, tin, antimony, barium, thallium, lead, and uranium were derived from ICP/MS (inductively-coupled plasma spectrometry/mass spectrometry) analysis. The ICP/MS method provides results for trace metals that are more accurate.

Chloride and sulfate were analyzed using ion chromatography, which depends on the affinity of the analyte for an ion-exchange medium. Nitrate/nitrite and total phosphorus were analyzed using colorimetric techniques. These methods involve converting the analyte to a strongly colored substance, which can then be compared with a color standard. The method used to test for sulfide is titrimetric, which involves embedding the analyte in a colored solution and then adding a solution with a substance of a known concentration that reacts with the analyte causing the color to disappear. VOCs were analyzed with the GC/MS (gas chromatography/mass spectrometry) technique.

CHAPTER 4. RESULTS

4.1 pH

One hundred and twenty six pH measurements were made on all 120 stations tapping the Piedmont/Blue Ridge aquifer system. The pHs ranged from 4.58 to 8.60. The sample water was acidic at 83 stations, basic at 36 stations, and fluctuated at one station. Three stations underwent follow-up sampling because of a reported Primary MCL exceedance or chlorinated hydrocarbon detection. One of these, the fluctuating station well Hll-2, gave basic water for the original sampling and acidic water for the follow-up sampling. At the other two stations, wells Fay-2 and Ful-2, the sample water remained basic although the pH declined. For station Grn-2, another of the dually sampled wells, the wellhead sample registered a lower pH than the sample at the distant spigot.

4.2 CONDUCTIVITY

One hundred and twenty six conductivity measurements were made covering all 120 stations. The conductivity measurements ranged from 6 microSiemenses per centimeter (uS/cm) to 563 uS/cm, with a little over half the stations producing waters with conductivities of 100 uS/cm or less. The two lowest conductivity measurements recorded for this study were made on waters drawn from quartzites: 6 uS/cm for well Mwr-2 tapping the Hollis Quartzite in Meriwether County (Hewitt and Crickmay, 1937) and 9 uS/cm for well Chk-1, drilled into the Pine Log Mountain Quartzite in Cherokee County (John Costello, personal communication). Inspection of Table A-2 shows that sample waters with lower conductivities generally tend to have acidic pHs and lower contents of sulfate and chloride and of the major metals calcium, magnesium, and sodium.

Concerning the four dually sampled wells, conductivities were higher in the second samples from Fay-2 and Hll-2, lower in the second sample from Ful-2, and identical in both samples from Grn-2.

4.3 ANIONS AD NON-METALS

Samples from all 120 stations received testing for chloride, sulfate, nitrate/nitrite, and total phosphorus. Due to an oversight, the original samples for stations Lin-1 and Wik-1 did not include the aliquot for nitrate/nitrite and total phosphorus. This aliquot was collected in a later sampling. On-site dissolved oxygen measurements are available for 82 stations. Samples from 26 stations underwent analyses for sulfide. Because of a lack of detections and concerns about laboratory capacity, sulfide testing was suspended in mid-June, 2006. Sulfide analyses are not further discussed. By request from a student at the University of California at Riverside via EPA Region 4, two samples (from wells

Lin-1 and Mwr-1) were forwarded to that university to be tested for perchlorate. No results have been forthcoming.

4.3.1 Chloride

The chloride contents of sampled waters ranged from undetectable to 22 ppm, far below the Secondary MCL of 250 ppm. Detectable chloride occurred in samples from 15 stations.

4.3.2 Sulfate

Analyses detected sulfate in samples from 41 stations. In the case of dually sampled well Hll-2, testing the initial sample did not detect sulfate, however, testing the follow-up sample resulted in a detection. For dually sampled well Fay-2, the sulfate content of the initial sample exceeded that of the follow-up by one ppm. Sulfate concentrations ranged from undetected to 180 ppm, all below the Secondary MCL of 250 ppm. Although waters with detectable sulfate constituted only about a third of the samples, these waters accounted for half or more of the detections of molybdenum, uranium, and manganese. The two-thirds of the samples with no detectable sulfate accounted for about 80% each of the lead and copper detections.

4.3.3 Nitrate/Nitrite

Nitrate/nitrite was detected in samples from 88 stations. Nitrate/nitrite ranged from undetected to 16 ppm as nitrogen. The sample with the 16 ppm level, taken from well Sph-1, is the only case in which the level exceeded the Primary MCL of 10 ppm as nitrogen. Well Sph-1 is a domestic well located adjacent to a kennel, with another kennel and a now-unused chicken house within a distance of a few hundred feet. Three other samples had nitrate/nitrite levels above the 5 ppm level, the level above which the Drinking Water Compliance Program can require intensive monitoring of treated water in a public water supply: domestic well Jak-1 (9 ppm), municipal supply well Jak-2 (5.5 ppm), and public restaurant well Mad-2 (5.3 ppm). Likely sources of nitrate/nitrite for these three stations were not immediately obvious. Samples from 113 stations contained nitrate/nitrite as nitrogen at levels below the 3 ppm level considered the minimum likely reflective of human influence (Madison and Brunett, 1985).

For the multiply sampled wells Fay-2, Ful-2, Hll-2, and Grn-1, nitrate/nitrite levels remained the same or nearly the same for both samplings at each station.

4.3.4 Dissolved Oxygen

Dissolved oxygen measurements are available for 82 stations. Dissolved oxygen was detected in sample waters from 77 stations and ranged up to 9.63 ppm. Sample waters with basic pHs commonly have low dissolved oxygen contents; 14 out of 21 stations with basic waters registered dissolved oxygen below 1 ppm. No MCLs exist for dissolved oxygen.

Though the monitoring/sampling apparatus is intended to minimize contact between the atmosphere and the sample water, air can nevertheless enter the sample water upstream of the apparatus and interfere with dissolved oxygen measurements. Jet pumps frequently admit air to the pump water column. Water can begin cascading in open-hole wells when the water level is pumped considerably below a productive fracture. In low recovery wells with small water columns, the water level can be pumped near to or at the pump's intake level and air can be entrained.

4.3.5 Total Phosphorus

Total phosphorus data are available for all 120 stations. Phosphorus was detected in samples from 81 stations. Phosphorus concentrations ranged from undetected to 1.3 ppm, though most are below 0.1 ppm. No obvious association between phosphorus and nitrate/nitrite was apparent. Samples with basic pHs, as a rule, had lower phosphorus contents than acidic samples. Excepting vanadium, no obvious association between phosphorus and metals was apparent. Vanadium was analyzed by the ICP method, and, if the analyses are accurate, all samples containing detectable vanadium also contained detectable phosphorus. No MCLs are assigned to phosphorus.

4.4 METALS

The metals analyzed for this project are given in Table A-2 in the Appendix. Analyses failed to detect arsenic, selenium, silver, cadmium, antimony, thallium, beryllium, and cobalt. These metals are not further discussed. Samples from all 120 stations received metals analysis.

4.4.1 Alkali Metals

The EPD laboratory tested for the alkali metals sodium and potassium using the ICP method. Owing to low analytical sensitivity (reporting limit 5,000 ppb), potassium was detected in samples from only three stations. The highest level was 6,400 ppb. No MCLs apply to sodium or potassium.

Sodium concentrations ranged from undetected to 41,000 ppb. Detectable levels of the metal occurred in samples from 116 stations. Two of the stations giving waters with no detectable sodium were wells drilled into quartzite, one deriving water from the Hollis Quartzite (station Mwr-2) and the other from the Pine Log Mountain Quartzite (station Chk-2). Two stations, Bts-1 and Ctn-1, tied for the highest sodium concentration, 41,000 ppb. Bts-1, Indian Spring, is a historical mineral spring in Butts County and the site of Indian Springs State Park. Ctn-1, the Pates Creek Well, is a 610-foot deep public well belonging to the Clayton County Water Authority. Water from this well showed the highest conductivity and the second-highest calcium and sulfate levels encountered in the study. As a general rule, waters with basic pHs and higher conductivities tend to have higher alkali metal contents.

For the dually sampled wells, the sodium levels were noticeably lower in the follow-up sample for Ful-2 but were equal or nearly so for follow-up samples for Fay-2 and Hll-2. For Grn-2, the sodium content of the wellhead sample was higher than of the distant sample. None of these samples had detectable potassium.

4.4.2 Alkaline Earth Metals

The current study examined ground-water levels of the alkaline earth metals calcium, magnesium, and barium. The EPD laboratory determined calcium and magnesium by the ICP method. The laboratory used the ICP/MS method to test for barium. A Primary MCL of 2,000 ppb applies to barium; no MCLs apply to calcium or magnesium.

Calcium was detected in samples from 115 stations, with the maximum level being 100,000 ppb in the sample from well Bwn-2, a public supply well serving a subdivision. This well also produced water with the highest sulfate level and the second highest conductivity observed during the study. The concentration of this metal tends to be depressed in waters with the lowest pHs (below about 6.00).

Magnesium was detected in samples from 95 stations. Two stations tied for the highest level of 16,000 ppb: Tbt-1, a domestic well in Talbot County, and Bib-1, a golf-course irrigation well in Bibb County. Both had conductivities in the moderate 200-300 uS/cm range. The high concentration of magnesium in the Bib-1 sample might be due in part to fertilizers used on the golf course. The concentration of this metal tends to be lower in waters at the lowest pHs (below about 6.00).

Barium was detected in samples from 114 stations. The analytical sensitivity afforded by ICP/MS testing for barium showed the metal to be a nearly ubiquitous trace element. The highest concentration of the metal, 590 ppb, was found in water from a domestic well Sph-1 in Stephens County. The water from this well, at 4.80, was in the lower range of pHs encountered in this project and contained excessive nitrate/nitrite (above 10 ppm as nitrogen) and manganese (above 50 ppb).

For the dually sampled stations Fay-2, Ful-2, Hll-2, and Grn-2, the concentrations of calcium, magnesium, and barium in each sample pair was the same or nearly so.

4.4.3 Copper, Lead, and Zinc

Copper was detected in samples at 24 stations, lead at 25 stations, and zinc at 58 stations. Copper concentrations ranged up to 90 ppb. This level is well below the Secondary MCL of 1,000 ppb and the action level of 1,300 ppb that apply for copper in treated public water. The maximum lead concentration found was 9.4 ppb. This level is below the 15 ppb action level established for lead in treated public water. The highest zinc level encountered was 1,600 ppb, below the 5,000 ppb Secondary MCL for that metal. The highest lead and copper levels occurred in samples from stations Ogr-1 and Ful-3, both domestic wells, and the highest zinc concentration occurred in Rok-1, an irrigation well in Rockdale County. Detectable copper and zinc concentrations seem slightly more likely to occur in acid waters, while detectable lead seems about equally likely to occur in acid waters as in basic waters. Detections of two or all three of these metals in a single sample were common.

For the dually sampled stations, only samples from Fay-2 and Grn-2 showed any copper, lead, or zinc. For Fay-2, the zinc and lead levels declined for the second sample and the copper level fell below detection. For Grn-2, zinc declined below detection in the distant sample.

4.4.4 Iron, Manganese, Nickel, Chromium

The EPD laboratory analyzed for these metals using the ICP method. Since they usually are trace metals, the laboratory also used the ICP/MS method for analyzing nickel and chromium. Secondary MCLs of 300 ppb and 50 ppb apply respectively to iron and manganese. Primary MCLs of 100 ppb apply to nickel and to chromium.

Iron was detected in samples from 67 stations, with exceedances at 25 stations, 14 of these stations being public supplies. Manganese was found in samples from 63 stations, with exceedances at 36 stations, of which 22 are public supplies. The ICP method returned a spurious nickel exceedance of 200 ppb for the sample from station Hll-2, resulting in a follow-up sampling being conducted. A later check of the ICP/MS results for that station led to the ICP nickel value being discarded. Nickel was accurately detected at three stations, with a high concentration of 18 ppb. Chromium was detected at a level below the Primary MCL at one station. Detectable iron or manganese do not necessarily accompany detectable nickel or chromium.

Iron levels in the samples ranged up to 5,600 ppb. Acid waters are somewhat more favorable for iron detections than basic waters, particularly if the iron concentration exceeds the Secondary MCL. For twelve stations where notes comment on sediment in the raw water, excessive iron was detected in samples from ten of those stations. The appearances of the sediments are as follows:

1) general cloudiness (Dws-1, Spd-1);

2) sand and silt-sized particles of weathered rock plus or minus clay (Btw-1, Fay-2, Gmr-1, Jsp-1, Trp-2), including in some cases weathered biotite (Bts-2, Ful-1, Rbn-1);

3) reddish to yellowish brown sludge (Lpk-2, New-2).

Concerning the dually sampled wells, the samples from Grn-2 contained no detectable iron. All samples from Fay-2, Ful-2, and Hll-2 contained excessive iron. For Ful-2, the iron level in the second sample increased, while, for Hll-2 and Fay-2, iron levels in the second samples decreased.

Manganese levels ranged up to 360 ppb. As with iron, acid waters were more favorable for manganese detections and manganese Secondary MCL exceedances than basic waters. For the above-mentioned twelve stations with sediment problems, manganese was detected at ten stations (no detections at Spd-1 and Btw-1) and was excessive at six (Trp-2, Rbn-1, New-2, Lpk-2, Jsp-1, Fay-2 – highest level). Manganese occurred along with iron in samples from 47 stations. For the dually sampled wells, the samples from Grn-2 and Ful-2 showed no detectable manganese. The manganese levels for Hll-2 decreased from slightly excessive for the first sampling to not detectable for the second, and, the manganese level at Fay-2 declined for the second sample.

4.4.5 Molybdenum, Uranium, Vanadium

The EPD laboratory found molybdenum in samples from eight stations, with levels ranging up to 10 ppb. No MCLs apply to molybdenum. Proportionately more of the molybdenum detections occurred in basic waters than in acid waters. Uranium accompanied molybdenum in samples from six stations, four of them in basic waters. Molybdenum detections occasionally coincide with zinc detections but do not coincide with iron, manganese, copper, or vanadium detections. None of the dually sampled wells gave samples with detectable molybdenum.

Uranium, found in samples from 35 stations, may be merely uncommon rather than rare. Concentrations ranged up to 43 ppb (station Fay-2), in excess of the Primary MCL of 30 ppb. This exceedance caused Fay-2, a municipal supply well, to undergo resampling, which again found excessive uranium. Uranium is more likely to occur in samples that contain chloride, nitrate, or sulfate. Uranium detections were more frequent in basic sample waters. Of the multiply sampled wells, Hll-2 and Ful-2 showed no detectable uranium. For Grn-2, the wellhead sample contained uranium, but the distal sample did not. For Fay-2, both samples contained excessive uranium at nearly equal concentrations.

Vanadium was detected in six samples from six stations, with a high concentration of 18 ppb. No MCLs apply to vanadium. Two detections of the metal occurred for stations with basic waters; the remaining four for stations with acidic waters. The two basic samples also contained detectable titanium. A possible association between vanadium and phosphorus was mentioned in section 4.3.5.

4.4.6 Aluminum and Titanium

Aluminum was detected in samples from 17 stations, five of them public supplies, with levels ranging up to 2,700 ppb. Most of the aluminum detections occurred in acidic waters, although the two highest levels came from stations yielding basic waters. Waters with detectable aluminum, as a rule, tended to have lower concentrations of calcium, magnesium, and sodium. Aluminum detections seemed to be proportionally more common in waters with detectable chloride. No obvious association between aluminum and sulfate is apparent. All aluminum detections occurred in waters with detectable nitrate/nitrite. Iron or manganese detections accompanied all aluminum detections. In half the cases in which field notes comment on sediment in the sample water, detectable aluminum was present in the water. For aluminum, a Secondary MCL range of 50 ppb to 200 ppb applies, due to the varying success which treatment operations have with controlling aluminum levels. All reportable aluminum for this study was above the 50 ppb level.

Titanium was detected using the ICP method in samples from five stations. The levels ranged up to 270 ppb. No MCLs exist for titanium. In all cases in which detectable titanium was present in the sample water, detectable aluminum was also present.

4.4.7 Volatile Organic Compounds

Analyses for VOCs were for the most part, performed at stations in counties with population growth rates greater than 8% during the period 2000-2004 (Table A-1). Exceptions were made for low-growth urban counties (e.g., Fulton) and low-growth rural- industrial counties (e.g., Troup and Upson). These two classes of counties could be considered to have increased chances for VOC-contaminated ground water due long-standing industrial and commercial activities.

The EPD laboratory analyzed 88 samples from 86 stations for VOCs. Thirteen samples from 12 stations tested positive for one or more of these compounds. Chloroform was the most widely occurring, being found in waters from wells Dws-1, Dws-2, Dws-3, Mad-2, Pau-1, Wal-1, and Wsh-1. Methyl-tert-butyl ether (MTBE) was next, being found in samples from three wells: Fay-2 (both first and follow-up samples), Gwn-1, and Mur-1. Tetrachloroethylene (PCE) was found in a sample from well Ful-2, and, trichloroethylene (TCE) was found in samples from wells Gwn-1 and New-1. None of the occurrences exceeded Primary MCLs (Table A-3 in Appendix). The follow-up sample taken at well Ful-2 did not contain detectable PCE.

4.5 Gamma Radiation

One hundred and eight pairs of gamma-ray measurements are available for 105 stations. The background measurement differed from the above-water measurement at just three stations. At spring Tia-1 the position of the overflow pipe prevented filling the five-gallon bucket in a reasonable length of time, so a gamma-ray measurement was taken directly above the overflow pool. The count above the pool was higher than the background most likely because of a heavy mineral lag deposit at the bottom of the overflow pool. At well Pic-2, the location of the well at the side of a crushed stone driveway on a steep hillside prevented obtaining a suitable background measurement. At well Jak-2, the over-water gamma-ray count exceeded the background gamma-ray count, even though the bucket was moved and paired readings were taken at several points near the well.

The uranium concentration in the sample water from well Jak-1 was a moderate 15 ppb, suggesting other radioactive materials may have been present in the water. The owner was advised to consider testing the water for radon and radium.

For the three dually sampled wells with gamma-ray data available, background and over-water measurements were higher at the wellhead than at the distal spigot at well Grn-2. For wells Hll-2 and Ful-2, background and over-water counts measured during the first sampling differed from those taken during the second sampling.

CHAPTER 5. SUMMARY AND CONCLUSIONS

5.1 FIELD PARAMETERS

One hundred and twenty six pH measurements were made on waters from all 120 stations drawing water from the Piedmont/Blue Ridge aquifer system. The pHs ranged from 4.58 to 8.60. The sample water was acidic at 83 stations and basic at 36 stations. For well Grn-2, the rise in the pH of sample water between the wellhead and the distant spigot showed that plumbing can affect sample water.

One hundred and twenty six conductivity measurements were made covering all 120 stations. The conductivity measurements ranged from 6 uS/cm to 563 uS/cm. Sample waters drawn from quartzites registered the two lowest conductivity measurements recorded for this study: 6uS/cm and 9uS/cm. Inspection of Table A-2 shows that sample waters with lower conductivities generally tend to have acidic pHs and lower contents of sulfate and chloride and of the major metals calcium, magnesium, and sodium.

5.2 ANIONS AND NON-METALS

Samples from all 120 stations received testing for chloride, sulfate, nitrate/nitrite, and total phosphorus. On-site dissolved oxygen measurements are available for 82 stations. Samples from 26 stations underwent analyses for sulfide. At the request of a student at the University of California/Riverside, sent through EPA Region 4, two samples (Lin-1 and Mwr-1) were forwarded to that university for perchlorate analysis.

The chloride contents of sampled waters ranged from undetectable to 22 ppm. Detectable chloride occurred in samples from 15 stations.

Analyses detected sulfate in samples from 41 stations. Although waters with detectable sulfate constituted only about a third of the samples, these waters accounted for half or more of the detections of molybdenum, uranium, and manganese. On the other hand, the two-thirds of the samples with no detectable sulfate accounted for about 80% each of the lead and copper detections.

Nitrate/nitrite was detected in samples from 88 stations and ranged up to 16 ppm as nitrogen. The sample with the 16 ppm nitrate/nitrite content came from a domestic well and represented the only nitrate/nitrite Primary MCL exceedance in the project. An adjacent kennel likely contributes to the nitrate/nitrite content of the well water. Another kennel and a now-unused chicken house at distances of a few hundred feet from the well may also be contributors. Three other samples, two from public wells, had nitrate/nitrite above the 5 ppm level, the level above which the Drinking Water Compliance Program can require intensive monitoring. No sources of nitrate/nitrite for these wells were immediately obvious. Samples from 113 stations contained nitrate/nitrite as nitrogen at levels less than 3 ppm, the level above which human influence on the nitrate-nitrogen content is considered likely.

Dissolved oxygen measurements are available for 82 stations. Sample waters at 77 of the stations contained detectable dissolved oxygen, with concentrations ranging up to 9.63 ppm. Sample waters with basic pHs commonly have low dissolved oxygen contents. Dissolved oxygen measurements are subject to interference from well and plumbing configurations that admit air to the sample water.

Total phosphorus data are available from all 120 stations. Phosphorus was detected in samples from 81 stations and ranged up to to 1.3 ppm. All samples containing detectable vanadium also contained detectable phosphorus.

5.3 METALS

Metals were analyzed in samples for all 120 stations, using ICP and ICP/MS methods. The ICP method has generally lower sensitivity and is subject to interferences. The method generally works well for the more abundant metals in ground water such as calcium, magnesium, aluminum, iron, manganese, and sodium. ICP/MS analysis works well for trace metals and can be especially sensitive. This analytical method has showed barium to be a widespread trace metal and has proved uranium to occur more widely than otherwise might be believed. The method did not detect any arsenic, selenium, cadmium, antimony, thallium, silver, or cobalt.

The EPD laboratory tested samples from all 120 stations for the alkali metals sodium and potassium. The low analytical sensitivity for potassium resulted in only three detections, with a high level of 6,400 ppb. Sodium was detected in samples from 116 stations, with a high level of 41,000 ppb in samples from two wells. Two of the stations providing waters with no detectable sodium were wells drilled into quartzite. One of the wells (Ctn-1) with the highest sodium content also showed the highest conductivity and the second-highest calcium and sulfate levels encountered in the study. As a general rule, waters with basic pHs and higher conductivities tend to have higher alkali metal contents.

Calcium was detected in samples from 115 stations, with the maximum level being 100,000 ppb in the sample from well Bwn-2, a public supply well. This well produced water with the highest sulfate level and the second highest conductivity observed during the study. Magnesium was detected in samples from 95 stations, with a high of 16,000 ppb occurring in samples from two wells. One of these two wells is used for irrigating a golf course, and the magnesium could partly come from fertilizers applied to the course. The concentrations of both metals tend to be depressed in waters with the lowest pHs (below about 6.00).

The ICP/MS method detected barium in samples from 114 stations, with a high level of 590 ppb. This concentration is well below the Primary MCL of 2,000 ppb. The analytical sensitivity afforded by ICP/MS testing for barium showed the metal to be a widespread trace element.

Copper was detected for 24 stations, lead for 25 stations, and zinc for 58 stations. Copper concentrations ranged up to 90 ppb. The maximum lead concentration found was 9.4 ppb. The highest zinc level encountered was 1,600 ppb. These levels were below applicable action levels and MCLs, both Primary and Secondary, for the three metals. Detectable copper and zinc concentrations seem slightly more likely to occur in acid waters, while detectable lead seems about equally likely to occur in acid waters as in basic waters. The three metals commonly occurred in various combinations in single samples.

Iron was detected in samples from 67 stations, with Secondary MCL exceedances at 25 stations, 14 of them public supply stations. Manganese was found in samples from 63 stations, with Secondary MCL exceedances at 36 stations, 22 of them public supply stations. Nickel was detected at three stations and chromium at one. The high nickel concentration was 18 ppb.

Iron levels in the samples ranged up to 5,600 ppb. Iron detections and exceedances tend to be more numerous in acid waters than in basic waters. Turbid sample waters generally had iron present, commonly in excess of the Secondary MCL.

Manganese levels ranged up to 360 ppb. As with iron, acid waters were more favorable for manganese detections and manganese Secondary MCL exceedances than basic waters. Manganese occurred along with iron in samples from 47 stations.

The EPD laboratory found molybdenum in samples from eight stations, with levels ranging up to 10 ppb. Proportionately more of the molybdenum detections occurred in basic waters than in acid waters. Uranium accompanied molybdenum in samples from six stations, four of them in basic waters. Molybdenum detections occasionally coincide with zinc detections but do not coincide with iron, manganese, copper, or vanadium detections.

Uranium, found in samples from 35 stations, may be uncommon rather than rare. Concentrations ranged up to 43 ppb (well Fay-2), in excess of the Primary MCL of 30 ppb. This exceedance caused Fay-2 to undergo resampling, which again found excessive uranium. Uranium is more likely to occur in samples that contain chloride, nitrate, or sulfate. Uranium detections are more frequent in basic sample waters.

Vanadium was detected in six samples from six stations, with a high concentration of 18 ppb. The metal is more common in acidic sample waters than in basic ones. The two basic samples examined for this study also contained detectable titanium. A possible association exists between vanadium and phosphorus.

Aluminum was detected in samples from 17 stations, five of them public supply stations, with levels ranging up to 2,700 ppb. Most of the aluminum detections occurred in acidic waters, although the two highest levels came from stations yielding basic waters. Waters with detectable aluminum, as a rule, tended to have lower concentrations of calcium, magnesium, and sodium. Aluminum detections seemed to be proportionally more common in waters with detectable chloride. No obvious association between aluminum and sulfate is apparent. In this study, aluminum seems strongly associated with nitrate/nitrite, iron, and manganese. Turbid sample waters can contain considerable aluminum.

Titanium was detected in samples from five stations. The levels ranged up to 270 ppb. Sample waters containing detectable titanium also contained detectable aluminum.

The EPD laboratory analyzed 88 samples from 86 stations for VOCs. Thirteen samples from 12 stations tested positive for one or more of these compounds. Chloroform was the most widely occurring, being found in waters from seven stations. MTBE was next, being found in four samples from three stations. Tetrachloroethylene was found in a sample from one station, and, trichloroethylene was found in samples from two stations. None of the occurrences exceeded Primary MCLs .

5.4 PAIRED SAMPLES

Paired samples were taken at four wells, Fay-2, Ful-2, Hll-2, and Grn-2. The first three underwent follow-up sampling in response to a Primary MCL exceedance or a VOC detection. At the last well, one sample was taken at the wellhead and another at a spigot about 600 feet away from the wellhead. The results for these wells illustrate the effects that plumbing and the passage of time can have on various parameters and solute concentrations. For well Grn-2, the pH increased between the wellhead and the distant spigot; the conductivity stayed the same. For wells Fay-2, Ful-2, and Hll-2, the pH and the conductivity declined for the second sampling. For well Grn-2, the zinc level rose during passage to the distant spigot. For the other three stations, levels of various solutes varied over time. The levels of the metals iron, manganese, aluminum, copper and zinc seemed to undergo the most severe changes. For all four stations, the levels of nitrate/nitrite and of phosphorus seemed to undergo a minimum amount of change.

5.5 OCCURRENCES OF NUTRIENTS AND VOCS ACCORDING TO COUNTY CLASS

One of the objectives the project sought to examine was the existence of obvious differences in nutrient (nitrate/nitrite and total phosphorus) and VOC contents of ground waters according to county types. Seventy-four of the 120 stations were located in "high-growth" counties. Of the 46 "low-growth counties", 27 are classified as "low-growth rural", 15 are classified as "low-growth rural-industrial", and four are classified as "low-growth urban".

5.5.1 VOCs

The detected VOCs consist of chloroform, MTBE, PCE, and TCE. Samples from 12 stations contained detectable VOCs. Nine of these 12 stations are situated in high-growth counties, one is in a low-growth urban county, and two are located in low-growth rural counties. Low-growth urban and rural-industrial counties might be thought to have increased chances of VOC contamination because of long standing heightened industrial and commercial activities.

No VOCs were found in samples from any of the low-growth rural-industrial counties. All of the samples containing TCE and MTBE and five of the seven samples containing chloroform originated in high-growth " counties. The sample containing PCE came from a low-growth urban county. The lack of VOC detections in samples from low-growth rural-industrial counties may indicate a need for an increase in the sampling station density.

5.5.2 Nutrients

Nutrient testing examined the sample waters for nitrate/nitrite and total phosphorus. Detectable nitrate/nitrite occurred in samples from 88 stations (about 73% of all stations). By county class, nitrate/nitrite was found in samples from:

18 of 27 "low-growth rural" stations (about 66%);
11 of 15 "low-growth rural-industrial" stations (about 73%);
56 of 74 "high-growth" stations (about 76%);
four of four "low-growth urban" stations (100%).

The sample with the highest nitrate/nitrite concentration came from a domestic well in a "low-growth rural-industrial" county. The high proportion of "low-growth urban" stations contributing samples with detectable nitrite/nitrite owes to the relatively small size of the sample set.

Phosphorus was detected in samples from 79 stations:

1) 23 of 27 “low-growth rural” stations (about 85%);
2) 8 of 15 “low-growth rural-industrial” stations (about 53%);
3) 46 of 74 “high-growth” stations (about 62%);
4) 3 of 4 “low-growth urban” stations (75%).

Again, the size of the sample set may affect some of the above-mentioned findings.

Phosphorus levels seem to be overall higher in ground-waters from low-growth rural counties. VOCs and nitrate/nitrite, on the other hand, seem to be somewhat inclined to concentrate in ground water in high-growth counties.

5.6 OVERALL QUALITY OF GROUND WATER IN THE PIEDMONT/BLUE RIDGE REGION

From the standpoint of human health, the chemical quality of ground water in the Piedmont/Blue Ridge region is generally good. Only two of the 120 stations visited for the study yielded water with Primary MCL exceedances. One, a domestic well located near animal enclosures, produced water with excessive nitrate/nitrite. The other, a municipal public water source, produced water with naturally excessive uranium. Copper, chromium, nickel and lead are subject to health-related limits, but the study found no exceedances for any of these metals. Chromium and nickel are naturally occurring, while copper and lead are mostly derived from plumbing.

Iron, manganese and aluminum are present naturally and occur widely in ground waters from the Piedmont/Blue Ridge region. These metals exceeded Secondary MCLs in samples from 46 of the 120 stations and are a major cause of poor chemical and physical quality for ground water in the region. These three metals are often associated with turbid ground waters. Secondary MCLs apply to the metals copper and zinc and to the anions chloride and sulfate. The study found none of these in excess of its Secondary MCL. Copper and zinc, though possibly naturally occurring in cases, seem mostly derived from plumbing. Chloride and sulfate are naturally occurring.

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APPENDIX

Laboratory and Well Data

LABORATORY AND WELL DATA

Table A-1 shows by county the estimated percent population change between July 1, 2000 and July 1, 2004 and the estimated population density in people per square mile on July 1, 2004. Also shown is the county growth class: high-growth (high), low-growth rural (low/rural), low-growth urban (low/urban), low-growth rural-industrial (low/rural-industrial).

Table A-2 lists the values for both laboratory parameters and field parameters for each well or spring. For this table, the following abbreviations are used:

assn =association
bg =background
chk sta =WMA hunting check station
Cl =chloride
Co. =county
cond. =conductivity
cps =counts per second (Geiger counter)
Cr. =creek
diss O_2 =dissolved oxygen
GFC =Georgia Forestry Commission
maint. =maintenance
temp =temperature (degrees Celsius)
mgr =manager
MTBE =methyl-tert-butyl ether
NA = not available or not analyzed
ND = not detected
NOx =nitrate/nitrite
PCE =tetrachloroethylene (perchloroethylene)
POA =property owners' association
ppm = milligrams per liter (parts per million)
ppm N = milligrams per liter as nitrogen
ppb = micrograms per liter (parts per billion)
SO4 =sulfate
TCE =trichloroethylene
uS/cm = microsiemens/centimeter
VOC =volatile organic compound
WMA =Wildlife Management Area
Wtr. Auth. =water authority

Table A-3 gives the reporting limits for the various analytes. The list of abbreviations used in Table A-2 also applies to Table A-3.

TABLE A-1 GEORGIA PIEDMONT/BLUE RIDGE COUNTIES, POPULATION GROWTH AND DENSITIES.

County	**Est. Population Change 2000-2004, 8.36% State-Wide**	**2004 Population Density, Folks/Mile^2**	**Population Growth Characteristics**
Athens-Clarke Co	2.4%	860	low /urban
Baldwin County	1.1%	175	low/rural-industrial
Banks County	8.8%	67	high
Barrow County	22.3%	348	high
Bartow County	14.4%	189	high
Bibb County	0.8%	621	low /urban
Butts County	14.7%	120	high
Carroll County	16.4%	203	high
Cherokee County	23.1%	412	high
Clayton County	12.0%	1858	high
Cobb County	7.6%	1922	low /urban
Columbia County	12.7%	347	high
Coweta County	18.1%	238	high
Crawford County	3.1%	40	low/rural
Dawson County	19.2%	90	high
DeKalb County	1.4%	2519	low /urban
Douglas County	16.3%	538	high
Elbert County	1.9%	57	low/rural-industrial
Fannin County	9.2%	56	high
Fayette County	11.0%	513	high
Forsyth County	34.0%	584	high
Franklin County	5.8%	81	low/rural
Fulton County	-0.2%	1540	low /urban
Gilmer County	14.1%	63	high
Glascock County	2.9%	18	low/rural
Gordon County	11.3%	138	high
Greene County	8.6%	40	high
Gwinnett County	19.1%	1619	high
Habersham County	8.6%	140	high
Hall County	15.5%	409	high
Hancock County	-2.6%	21	rural
Haralson County	9.3%	99	high
Harris County	13.1%	58	high
Hart County	1.6%	101	low/rural-industrial
Heard County	2.5%	38	low/rural
Henry County	33.6%	494	high
Jackson County	19.1%	145	high
Jasper County	12.6%	35	high
Jones County	11.0%	67	high

TABLE A-1 GEORGIA PIEDMONT/BLUE RIDGE COUNTIES, POPULATION GROWTH AND DENSITIES, CONTINUED.

County	Est. Population Change 2000-2004, 8.36% State-Wide	2004 Population Density, Folks/Mile^2	Population Growth Characteristics
Lamar County	3.1%	89	low/rural
Lincoln County	0.6%	40	low/rural
Lumpkin County	14.0%	84	high growth
Madison County	6.1%	83	low/rural
McDuffie County	1.3%	96	low/rural-industrial
Meriwether County	1.0%	45	low/rural
Monroe County	7.6%	59	low/rural
Morgan County	10.1%	49	high growth
Murray County	11.1%	118	high growth
Muscogee County	-1.8%	845	low /urban
Newton County	31.5%	295	high growth
Oconee County	10.4%	156	high growth
Oglethorpe County	7.3%	31	low/rural
Paulding County	29.7%	338	high growth
Pickens County	20.8%	120	high growth
Pike County	15.1%	72	high growth
Polk County	5.6%	129	low/rural-industrial
Putnam County	5.0%	57	low/rural
Rabun County	6.4%	43	low/rural
Richmond County	-1.8%	606	low /urban
Rockdale County	9.6%	588	high growth
Spalding County	4.2%	308	low/rural-industrial
Stephens County	-1.8%	139	low/rural-industrial
Talbot County	1.4%	17	low/rural
Taliaferro County	-8.7%	10	low/rural
Taylor County	1.9%	24	low/rural
Towns County	8.7%	61	high growth
Troup County	4.1%	148	low/rural-industrial
Union County	13.4%	61	high growth
Upson County	1.8%	86	low/rural-industrial
Walton County	18.5%	218	high growth
Warren County	-1.3%	22	low/rural
Washington County	-0.5%	31	low/rural
White County	18.3%	98	high growth
Wilkes County	-1.0%	22	low/rural

Table A-2. Ground-Water Quality Analyses for the Piedmont/Blue Ridge Unconfined Aquifer System.
Part A: Station Identification and Location, Date of Sampling, Field Parameters, VOCs, Anions, and Non-Metals.

Station No. County	Well/Spring Name (use)	Latitude Longitude	Date Sampled	pH	cond. uS/cm	diss O_2 ppm	Temp °C	γ radiation cps		VOCs ppb	Cl ppm	SO4 ppm	NOx ppm N	S ppm	P ppm
								bg.	water						
Bwn-1 Baldwin	Meriwether/Golden Pond #1 (public)	33°09'27.1" 83°19'50.4"	12/05/06	6.62	175	NA	18.5	60	60	ND	ND	18	ND	NA	0.02
Bwn-2 Baldwin	Erin Shores #1 (public)	33°10'25.5" 83°14'27.9"	12/06/06	6.94	411	NA	19.6	60	60	ND	12	180	0.03	NA	0.02
Bnk-1 Banks	Homer Big Well (#101) (public)	34°20'13.7" 83°30'09.6"	03/22/06	7.94	198	0.29	19.6	90	90	ND	ND	84	0.06	ND	ND
Bnk-2 Banks	Irvin farm well (wash)	34°24'16.1" 83°29'13.3"	03/22/06	6.86	60	6.90	17.2	100	100	ND	ND	ND	0.87	ND	0.07
Brw-1 Barrow	Statham Main Spring (public)	33°58'16.3" 83°36'02.9"	07/20/06	5.12	39	6.17	18.4	NA	NA	ND	ND	ND	3.60	NA	ND
Brw-2 Barrow	Auburn Mobile Home Park well (public)	34°01'02.6" 83°48'44.5"	07/20/06	6.49	93	NA	18.2	120	120	ND	ND	ND	3.80	NA	0.06
Btw-1 Bartow	Glade Marina #1 (public)	34°07'05.0" 84°41'51.0"	08/30/06	5.94	63	NA	17.0	40	40	ND	ND	ND	0.25	NA	0.14
Bib-1 Bibb	Oak Haven Golf Club south green well (irrigation)	32°51'37.5" 83°47'53.2"	08/24/06	7.16	226	NA	19.4	40	40	ND	22	ND	0.55	NA	0.15
Bts-1 Butts	Indian Spring (historic)	33°14'48.7" 83°55'17.8"	06/15/06	7.38	163	NA	18.5	NA	NA	ND	13	29	ND	NA	ND
Bts-2 Butts	Welch house well (domestic)	33°18'46.7" 84°03'20.7"	06/16/06	6.44	64	0.72	18.2	100	100	ND	ND	15	0.37	NA	0.06
Crl-1 Carroll	Tanner State Park well (public)	33°35'51.0" 85°10'01.1"	08/23/06	5.40	11	NA	16.0	NA	NA	ND	ND	ND	0.57	NA	ND
Crl-2 Carroll	McIntosh Reserve well (public)	33°26'58.4" 84°56'58.5"	08/23/06	6.78	100	NA	16.8	50	50	ND	ND	ND	ND	NA	0.10

Table A-2. Ground-Water Quality Analyses for the Piedmont/Blue Ridge Unconfined Aquifer System.
Part B: Metals.

Station No.	Cr ppb	Ni ppb	Cu ppb	Zn ppb	Mo ppb	Ba ppb	Pb ppb	U ppb	Al ppb	Ca ppb	Fe ppb	K ppb	Mg ppb	Mn ppb	Na ppb	Ti ppb	V ppb
Bwn-1	ND	ND	ND	13	ND	6.9	ND	ND	ND	47K	800	ND	4300	200	12K	ND	ND
Bwn-2	ND	ND	ND	370	ND	22	3.3	3.7	830	110K	280	ND	5800	310	26K	ND	ND
Bnk-1	ND	ND	ND	ND	5.6	18	ND	14	ND	39K	ND	ND	1100	ND	28K	ND	ND
Bnk-2	ND	ND	ND	ND	7.1	9.7	ND	ND	ND	7600	ND	ND	2700	ND	8600	ND	ND
Brw-1	ND	ND	ND	12	ND	30	ND	ND	ND	3100	ND	ND	1400	51	5300	ND	ND
Brw-2	ND	ND	ND	11	6.6	ND	ND	2.5	ND	11K	ND	ND	3900	ND	13K	ND	ND
Btw-1	ND	ND	ND	12	ND	19	ND	ND	ND	8500	44	ND	1200	ND	10K	ND	ND
Bib-1	ND	ND	ND	ND	ND	2.6	ND	1.3	ND	36K	ND	ND	16K	ND	18K	ND	ND
Bts-1	ND	ND	ND	11	ND	2.1	ND	ND	ND	15K	ND	ND	2600	19	41K	ND	ND
Bts-2	ND	ND	ND	ND	ND	22	ND	ND	68	9600	510	ND	2100	22	7600	ND	ND
Crl-1	ND	ND	6.5	14	ND	8.2	ND	ND	ND	ND	30	ND	ND	ND	1800	ND	ND
Crl-2	ND	ND	ND	19	ND	3.3	ND	ND	ND	20K	1300	ND	6400	110	5900	ND	ND

Table A-2. Ground-Water Quality Analyses for the Piedmont/Blue Ridge Unconfined Aquifer System, Continued.
Part A: Station Identification and Location, Date of Sampling, Field Parameters, VOCs, Anions, and Non-Metals.

Station No. County	Well Name (use)	Latitude Longitude	Date Sampled	pH	cond. uS/cm	diss O_2 ppm	Temp °C	γ radiation cps		VOCs ppb	Cl ppm	SO4 ppm	NOx ppm N	S ppm	P ppm
								bg.	water						
Chk-1 Cherokee	Lake Arrowhead #16 (public)	34°19'49.2" 84°35'52.3"	08/31/06	5.16	9	NA	15.8	60	60	ND	ND	ND	0.04	NA	0.02
Chk-2 Cherokee	Ball Ground #1 (public)	34°20'09.4" 84°22'28.2"	11/28/06	7.58	171	NA	15.8	90	90	ND	ND	ND	1.20	NA	ND
Ctn-1 Clayton	Clayton County Wtr. Auth. Pates Cr. Well (public)	33°28'34.6" 84°17'39.9"	11/09/06	7.60	563	NA	17.4	80	80	ND	18	140	ND	NA	ND
Ctn-2 Clayton	Camp Calvin Lower Well (public)	33°23'05.9" 84°21'58.0"	11/16/06	6.92	101	7.85	14.6	50	50	ND	ND	ND	0.35	NA	0.03
Clb-1 Columbia	Mistletoe State Park mgr's house well (domestic)	33°38'32.0" 82°22'59.6"	05/10/06	6.08	86	6.56	18.8	100	100	ND	12	ND	1.80	ND	0.40
Clb-2 Columbia	Columbia 2 house well (domestic)	33°28'44.6" 82°15'55.1"	05/10/06	5.54	45	NA	18.6	NA	NA	ND	ND	ND	2.70	ND	ND
Cow-1 Coweta	Jackson house well (domestic)	33°27'36.3" 84°52'06.2"	01/25/06	6.63	42	7.74	17.2	50	50	ND	ND	ND	1.40	ND	0.08
Cow-2 Coweta	Turin #1 (public)	33°19'27.0" 84°38'00.6"	02/02/06	7.34	120	0.00	18.3	80	80	ND	ND	14	ND	NA	ND
Crw-1 Crawford	Musella #1 (public)	32°47'45.8" 84°01'33.2"	08/24/06	7.15	225	NA	19.2	50	50	NA	ND	49	0.03	NA	ND
Dws-1 Dawson	GFC Dawson Unit staff house well (domestic)	34°22'49.5" 84°03'35.3"	05/16/06	5.34	88	0.24	15.6	100	100	$CHCl_3$=0.73	16	ND	2.00	NA	0.10
Dws-2 Dawson	Amicalola Falls State Park #1 (public)	34°33'34.1" 84°14'54.5"	05/16/06	5.22	13	8.14	14.7	NA	NA	$CHCl_3$=0.75	ND	ND	0.02	NA	ND
Dws-3 Dawson	Dawson Forest WMA chk sta well (domestic)	34°25'30.2" 84°12'27.1"	10/05/06	7.11	179	0.08	16.1	90	90	$CHCl_3$=2.2	ND	11	ND	NA	0.03

Table A-2. Ground-Water Quality Analyses for the Piedmont/Blue Ridge Unconfined Aquifer System. Part B: Metals.

Station No.	Cr ppb	Ni ppb	Cu ppb	Zn ppb	Mo ppb	Ba ppb	Pb ppb	U ppb	Al ppb	Ca ppb	Fe ppb	K ppb	Mg ppb	Mn ppb	Na ppb	Ti ppb	V ppb
Chk-1	ND	ND	ND	ND	ND	41	ND	ND	ND	ND	ND	ND	ND	19	ND	ND	ND
Chk-2	ND	ND	ND	ND	ND	21	ND	ND	ND	52K	ND	ND	4600	ND	2300	ND	ND
Ctn-1	ND	ND	ND	19	ND	7.2	ND	3.7	ND	73K	ND	ND	2400	27	41K	ND	ND
Ctn-2	ND	ND	ND	16	ND	5.2	ND	ND	ND	11K	ND	ND	3200	ND	5800	ND	ND
Clb-1	ND	ND	5.8	ND	ND	ND	1.4	7.6	ND	8000	ND	ND	3900	ND	13K	ND	ND
Clb-2	ND	ND	7.8	ND	ND	46	ND	ND	ND	2900	ND	ND	1500	16	7800	ND	ND
Cow-1	ND	ND	ND	ND	ND	9	ND	ND	ND	5300	ND	ND	1200	ND	6800	ND	11
Cow-2	ND	ND	ND	ND	ND	5.9	ND	ND	ND	22K	410	ND	2700	90	10K	ND	ND
Crw-1	ND	ND	ND	ND	ND	11	ND	1.6	ND	51K	44	ND	8400	100	13K	ND	ND
Dws-1	ND	ND	ND	ND	ND	82	1.2	ND	83	9000	330	ND	3700	27	8400	ND	ND
Dws-2	ND	ND	ND	ND	ND	8.8	ND	ND	ND	1100	ND	ND	ND	ND	1700	ND	ND
Dws-3	ND	ND	ND	ND	ND	7.1	ND	ND	ND	30K	54	ND	1500	ND	7100	ND	ND

Table A-2. Ground-Water Quality Analyses for the Piedmont/Blue Ridge Unconfined Aquifer System, Continued.
Part A: Station Identification and Location, Date of Sampling, Field Parameters, VOCs, Anions, and Non-Metals.

Station No. County	Well Name (use)	Latitude Longitude	Date Sampled	pH	cond. uS/cm	diss O_2 ppm	Temp °C	γ radiation cps		VOCs ppb	Cl ppm	SO4 ppm	NOx ppm N	S ppm	P ppm
								bg.	water						
Dgl-1 Douglas	Spencer house well (domestic)	33°47'05.9" 84°43'24.4"	02/16/06	5.73	29	6.76	15.7	80	80	ND	ND	ND	ND	NA	0.03
Dgl-2 Douglas	Staton house well (domestic)	33°39'48.1" 84°45'08.7"	02/16/06	5.84	22	8.05	16.3	90	90	ND	ND	ND	ND	NA	0.04
Ebt-1 Elbert	GFC Elbert-Madison Co. Unit (domestic)	34°05'23.1" 82°55'19.2"	03/01/06	5.53	53	5.91	17.9	120	120	NA	ND	ND	0.92	ND	0.19
Ebt-2 Elbert	Wiles house well (domestic)	34°13'30.2" 82°49'58.0"	03/01/06	8.21	117	0.00	16.7	180	180	NA	ND	11	ND	ND	0.06
Fan-1 Fannin	Toccoa River Restaurant well (public)	34°47'00.0" 84°15'51.9"	11/29/06	8.25	90	NA	14.8	90	90	ND	ND	12	ND	NA	ND
Fay-1 Fayette	Wendell Coffee Golf Center well (public)	33°30'52.3" 84°34'14.6"	11/07/06	6.19	58	NA	17.3	50	50	ND	ND	ND	1.90	NA	0.07
Fay-2 Fayette	Brooks #1 (public)	33°17'26.0" 84°27'36.0"	11/08/06	7.59	210	NA	18.2	NA	NA	MTBE=3.7	ND	14	0.11	NA	ND
Fay-2 Fayette	Brooks #1 **Repeat** (public)	33°17'26.0" 84°27'36.0"	12/20/06	7.28	320	NA	18.4	NA	NA	MTBE=3.3	ND	15	0.12	NA	0.02
Fsy-1 Forsyth	Colonial Club Estates #1 (public)	34°15'45.2" 84°02'40.7"	11/17/06	7.75	182	0.94	18.4	60	60	ND	ND	16	0.09	NA	0.03
Frk-1 Franklin	O'Connor house well (domestic)	34°23'14.2" 83°19'03.2"	03/01/06	7.28	118	0.00	16.9	30	30	NA	ND	ND	ND	ND	0.10
Frk-2 Franklin	GFC Franklin-Hart Co. Unit well (domestic)	34°23'52.8" 83°06'16.6"	03/02/06	7.34	93	0.00	17.3	90	90	NA	ND	11	ND	ND	ND
Ful-1 Fulton	Costello house well (domestic)	34°10'57.7" 84°16'19.7"	06/14/06	6.06	46	7.32	17.3	60	60	ND	ND	ND	0.70	NA	0.09

Table A-2. Ground-Water Quality Analyses for the Piedmont/Blue Ridge Unconfined Aquifer System.
Part B: Metals.

Station No.	Cr ppb	Ni ppb	Cu ppb	Zn ppb	Mo ppb	Ba ppb	Pb ppb	U ppb	Al ppb	Ca ppb	Fe ppb	K ppb	Mg ppb	Mn ppb	Na ppb	Ti ppb	V ppb
Dgl-1	ND	ND	ND	ND	ND	20	ND	ND	ND	4900	36	ND	1100	ND	3300	ND	ND
Dgl-2	ND	ND	ND	45	ND	5.1	ND	ND	ND	2400	25	ND	1200	ND	2300	ND	ND
Ebt-1	ND	ND	ND	ND	ND	56	1.0	ND	ND	5500	ND	ND	1700	ND	8100	ND	ND
Ebt-2	ND	ND	ND	ND	ND	4.7	ND	ND	ND	22K	21	ND	4500	29	10K	ND	ND
Fan-1	ND	ND	ND	ND	ND	ND	ND	ND	ND	22K	ND	ND	ND	ND	9300	ND	ND
Fay-1	ND	ND	ND	ND	ND	9.8	ND	ND	ND	8400	66	ND	1500	ND	10K	ND	ND
Fay-2	ND	10	8.6	640	ND	13	4.6	43	140	56K	930	ND	4800	360	13K	ND	ND
Fay-2	ND	ND	ND	490	ND	12	2.8	42	70	53K	570	ND	4500	320	12K	ND	ND
Fsy-1	ND	ND	ND	59	ND	23	ND	ND	ND	20K	28	ND	2900	17	12K	ND	ND
Frk-1	ND	ND	ND	ND	ND	34	ND	5.7	ND	19K	ND	6400	6400	120	6900	ND	ND
Frk-2	ND	ND	ND	34	ND	7.1	ND	8.7	ND	18K	410	ND	2500	62	6600	ND	ND
Ful-1	ND	ND	50	10	ND	57	2.6	ND	ND	10K	720	ND	1200	22	4300	ND	ND

Table A-2. Ground-Water Quality Analyses for the Piedmont/Blue Ridge Unconfined Aquifer System, Continued.
Part A: Station Identification and Location, Date of Sampling, Field Parameters, VOCs, Anions, and Non-Metals.

Station No. County	Well Name (use)	Latitude Longitude	Date Sampled	pH	cond. uS/cm	diss O_2 ppm	Temp °C	γ radiation cps		VOCs ppb	Cl ppm	SO4 ppm	NOx ppm N	S ppm	P ppm
								bg.	water						
Ful-2 Fulton	Chestnut Hill Academy well (public)	33°33'42.2" 84°27'52.4"	10/25/06	6.09	57	5.93	18.1	40	40	PCE=0.50	ND	ND	1.60	NA	0.04
Ful-2 Fulton	Chestnut Hill Academy well (public) **Repeat**	33°33'42.2" 84°27'52.4"	12/07/06	5.65	36	NA	17.9	60	60	ND	ND	ND	1.60	NA	0.04
Ful-3 Fulton	Rahbar house well (domestic)	34°03'44.1" 84°22'37.4"	11/06/06	5.10	14	NA	15.9	100	100	ND	ND	ND	0.82	NA	ND
Gmr-1 Gilmer	Rich Mountain WMA check station spring (domestic)	34°46'52.0" 84°19'40.3"	10/04/06	6.01	13	8.42	16.6	80	80	ND	ND	ND	0.04	NA	0.04
Gmr-2 Gilmer	WRD Coosawatee maint. station well (domestic)	34°416'01.2" 84°31'21.8"	10/26/06	5.29	20	4.86	17.2	80	80	ND	ND	ND	0.06	NA	ND
Grn-1 Greene	GFC Greene Co. Unit well (domestic)	33°34'50.7" 83°04'13.1"	04/26/06	6.95	90	4.57	19.0	80	80	ND	ND	ND	0.12	ND	0.09
Grn-2A Greene	Oconee WMA chk sta well (domestic) dress rack bibb	33°23'22.5" 83°07'15.2"	10/18/06	7.20	88	NA	18.6	80	80	ND	ND	ND	1.00	NA	0.05
Grn-2B Greene	Oconee WMA chk sta well (domestic) wellhead bibb	33°23'25.0" 83°07'05.2"	10/18/06	7.09	88	NA	18.6	140	140	ND	ND	ND	1.00	NA	0.05
Grn-3 Greene	Redlands WMA check station well (domestic)	33°40'49.5" 83°16'21.5"	10/18/06	6.51	66	NA	18.1	80	80	ND	ND	ND	0.95	NA	0.10
Gwn-1 Gwinnett	Rhodes Jordan Park #2 (public)	33°57'34.6" 83°58'44.1"	11/15/06	6.56	241	0.01	17.6	90	90	TCE=0.52 MTBE=6.2	ND	23	ND	NA	ND
Gwn-2 Gwinnett	Suwanee #1 (public)	34°03'14.7" 84°04'21.3"	11/15/06	7.56	333	0.16	17.6	90	90	ND	ND	16	0.37	NA	0.06
Hbr-1 Habersham	Mt. Airy City Hall Well (public)	34°30'57.9" 83°30'07.6"	07/26/06	6.66	142	0.67	16.3	100	100	ND	ND	20	0.17	NA	ND

Table A-2. Ground-Water Quality Analyses for the Piedmont/Blue Ridge Unconfined Aquifer System. Part B: Metals.

Station No.	Cr ppb	Ni ppb	Cu ppb	Zn ppb	Mo ppb	Ba ppb	Pb ppb	U ppb	Al ppb	Ca ppb	Fe ppb	K ppb	Mg ppb	Mn ppb	Na ppb	Ti ppb	V ppb
Ful-2	ND	ND	ND	ND	ND	30	ND	ND	ND	3800	ND	ND	1700	ND	6400	ND	ND
Ful-2 repea	ND	ND	ND	ND	ND	31	ND	ND	140	3900	29	ND	1600	ND	5300	ND	ND
Ful-3	ND	ND	90	ND	ND	15	1.6	ND	ND	ND	ND	ND	ND	ND	1900	ND	ND
Gmr-1	ND	ND	ND	ND	ND	9.8	ND	ND	250	1000	330	ND	ND	19	1300	14	ND
Gmr-2	ND	ND	7.7	ND	ND	17	1.1	ND	760	1400	600	ND	ND	15	ND	43	ND
Grn-1	ND	ND	12	33	ND	19	ND	ND	ND	15K	ND	ND	5300	ND	10K	ND	18
Grn-2A	ND	ND	ND	16	ND	ND	ND	ND	ND	16K	ND	ND	4600	ND	12K	ND	ND
Grn-2B	ND	ND	ND	ND	ND	ND	ND	1.0	ND	15K	ND	ND	4500	ND	13K	ND	ND
Grn-3	ND	ND	ND	1100	ND	8.1	ND	ND	ND	10K	66	ND	3600	ND	9500	ND	ND
Gwn-1	ND	ND	ND	ND	10	41	ND	ND	ND	24K	1800	ND	8100	230	9700	ND	ND
Gwn-2	ND	ND	ND	15	ND	200	ND	3	ND	46K	ND	ND	9000	58	12K	ND	ND
Hbr-1	ND	ND	ND	11	ND	5.4	ND	2.9	ND	35K	1900	ND	5000	180	8600	ND	ND

Table A-2. Ground-Water Quality Analyses for the Piedmont/Blue Ridge Unconfined Aquifer System, Continued.
Part A: Station Identification and Location, Date of Sampling, Field Parameters, VOCs, Anions, and Non-Metals.

Station No. County	Well Name (use)	Latitude Longitude	Date Sampled	pH	cond. uS/cm	diss O_2 ppm	Temp °C	γ radiation cps bg.	γ radiation cps water	VOCs ppb	Cl ppm	SO4 ppm	NOx ppm N	S ppm	P ppm
Hbr-2 Habersham	Hollifield Spring (public)	34°39'55.5" 83°38'17.8"	09/21/06	5.15	16	7.01	16.2	NA	100	ND	ND	ND	ND	NA	0.04
Hll-1 Hall	GFC Hall-Banks Unit well (domestic)	34°23'02.0" 83°40'58.7"	03/22/06	7.14	76	4.56	16.7	100	100	ND	ND	ND	0.75	ND	0.02
Hll-2 Hall	Mount Shores Condo Assn well (public)	34°24'50.4" 83°57'01.0"	10/27/06	7.12	155	2.53	15.8	80	80	ND	ND	ND	0.20	NA	0.02
Hll-2 Hall	Mount Shores Condo Assn well (public) **Repeat**	34°24'50.4" 83°57'01.0"	12/19/06	6.54	160	2.36	15.8	40	40	ND	ND	15	0.19	ND	ND
Hrs-1 Harris	Hucheson house well (domestic)	32°48'57.5" 84°56'37.7"	05/11/06	6.74	91	0.02	20.0	60	60	NA	ND	ND	ND	ND	0.26
Hrs-2 Harris	Lee house well (domestic)	32°47'43.9" 84°44'47.4"	10/18/06	6.58	84	NA	20.1	80	80	NA	ND	10	1.60	NA	0.02
Hok-1 Hancock	Kennedy house well (domestic)	33°10'24.3" 83°04'35.2"	02/02/06	4.85	26	7.10	17.7	100	100	ND	ND	ND	1.20	NA	0.03
Hok-2 Hancock	Mayfield Utilities #2 (public)	33°21'22.0" 82°49'05.6"	01/26/06	5.29	27	8.08	17.1	190	190	ND	ND	ND	0.08	ND	0.03
Hrt-1 Hart	Wiles II house well (domestic)	34°24'10.5" 82°55'01.3"	03/23/06	6.87	110	0.00	16.6	100	100	NA	ND	13	0.02	ND	0.25
Hrt-2 Hart	Bruce lake house well (domestic)	34°27'12.2" 82°54'33.1"	04/27/06	7.21	89	5.58	17.1	50	50	NA	ND	ND	0.82	ND	ND
Hrd-1 Heard	Allen house well (domestic)	33°13'13.8" 85°13'29.6"	03/29/06	5.49	29	7.63	17.2	40	40	NA	ND	ND	0.33	NA	0.02
Hry-1 Henry	Stockbridge #T1 (public)	33°33'39.1" 84°12'16.2"	10/19/06	6.02	119	NA	17.1	80	80	ND	ND	27	0.46	NA	0.03

Table A-2. Ground-Water Quality Analyses for the Piedmont/Blue Ridge Unconfined Aquifer System. Part B: Metals.

Station No.	Cr ppb	Ni ppb	Cu ppb	Zn ppb	Mo ppb	Ba ppb	Pb ppb	U ppb	Al ppb	Ca ppb	Fe ppb	K ppb	Mg ppb	Mn ppb	Na ppb	Ti ppb	V ppb
Hbr-2	ND	ND	ND	ND	ND	11	ND	ND	ND	ND	ND	ND	ND	ND	1100	ND	ND
Hll-1	ND	ND	ND	56	ND	13	1.6	ND	ND	13K	190	ND	3500	ND	7500	ND	ND
Hll-2	ND	ND	ND	ND	ND	24	ND	ND	ND	21K	180	ND	5200	52	5600	ND	ND
Hll-2 repeat	ND	ND	ND	ND	ND	24	ND	ND	ND	21K	22	ND	5100	ND	5600	ND	ND
Hok-1	ND	ND	ND	36	ND	140	ND	ND	ND	7300	1600	ND	2800	190	17K	ND	ND
Hok-2	ND	ND	ND	27	8.0	6.6	ND	13	ND	17K	ND	ND	2000	ND	11K	ND	ND
Hrs-1	ND	ND	ND	ND	ND	90	ND	ND	93	1600	99	ND	1100	16	3700	ND	ND
Hrs-2	ND	ND	ND	ND	ND	12	ND	ND	96	4000	62	ND	ND	ND	3300	ND	ND
Hrt-1	ND	ND	ND	30	ND	13	1.5	ND	ND	20K	5600	ND	4800	120	11K	ND	ND
Hrt-2	ND	ND	9.3	93	ND	22	ND	ND	ND	27K	ND	ND	ND	ND	1500	ND	ND
Hrd-1	ND	ND	11	ND	ND	73	1.0	ND	ND	3500	ND	ND	ND	ND	3600	ND	ND
Hry-1	ND	ND	ND	ND	ND	21	ND	ND	ND	16K	ND	ND	3700	ND	19K	ND	ND

Table A-2. Ground-Water Quality Analyses for the Piedmont/Blue Ridge Unconfined Aquifer System, Continued.
Part A: Station Identification and Location, Date of Sampling, Field Parameters, VOCs, Anions, and Non-Metals.

Station No.	Well Name	Latitude	Date	pH	cond.	diss	Temp	γ radiation cps		VOCs	Cl	SO4	NOx	S	P
County	(use)	Longitude	Sampled		uS/cm	O_2 ppm	°C	bg.	water	ppb	ppm	ppm	ppm N	ppm	ppm
Hry-2 Henry	Fortson 4-H Center office well (public)	33°22'35.7" 84°21'21.1"	10/19/06	6.13	46	NA	17.4	60	60	ND	ND	ND	0.46	NA	0.08
Jak-1 Jackson	Burnett house well (domestic)	34°13'19.7" 83°42'09.0"	07/26/06	7.26	133	0.45	17.0	70	80	ND	ND	ND	9.00	NA	ND
Jak-2 Jackson	Nicholson Water Authority #1 (public)	34°06'46.5" 83°25'45.0"	09/20/06	5.33	109	6.69	17.2	100	100	NA	ND	ND	5.50	NA	0.05
Jsp-1 Jasper	Turtle Cove POA Bobolink Well (#108) (public)	33°22'00.2" 83°50'22.8"	07/19/06	6.88	149	NA	18.6	180	180	ND	ND	37	ND	NA	0.02
Jsp-2 Jasper	Shady Dale Park Well (#101) (public)	33°23' 54.0" 83°35'32.7"	07/19/06	6.13	95	5.54	18.4	80	80	ND	12	ND	3.20	NA	0.08
Jns-1 Jones	GFC Jasper-Jones Unit well (domestic)	33°07'11.0" 83°37'34.0"	06/15/06	7.71	163	0.96	19.3	60	60	ND	ND	30	0.05	NA	ND
Jns-2 Jones	Gray - Roberts Well (public)	33°00'50.5" 83°31'18.1"	11/30/06	6.40	204	NA	19.1	90	90	ND	ND	60	0.04	NA	0.03
Lin-1 Lincoln	Mercier house well (domestic)	33°48'13.0" 82°34'27.6"	12/14/05	6.87	106	0.63	17.7	40	40	NA	ND	12	NA	ND	NA
Lin-1 Lincoln	Mercier house well (domestic) **Partial Repeat**	33°48'13.0" 82°34'27.6"	03/23/06	6.99	101	0.41	17.8	NA	NA	NA	NA	NA	ND	NA	0.06
Lin-2 Lincoln	Elijah Clarke State Park #1 (public)	33°51'26.5" 82°24'46.7"	05/10/06	6.55	94	4.37	17.7	20	20	NA	ND	ND	0.32	ND	0.15
Lpk-1 Lumpkin	Butler house well (domestic)	34°34'57.1" 84°01'52.9"	05/16/06	6.71	35	9.63	15.7	NA	NA	ND	ND	ND	ND	NA	0.06
Lpk-2 Lumpkin	Long Branch School Well (public)	34°31'21.9" 83°55'12.9"	07/27/06	7.51	116	0.04	16.0	80	80	ND	ND	19	0.12	NA	ND

Table A-2. Ground-Water Quality Analyses for the Piedmont/Blue Ridge Unconfined Aquifer System.
Part B: Metals.

Station No.	Cr ppb	Ni ppb	Cu ppb	Zn ppb	Mo ppb	Ba ppb	Pb ppb	U ppb	Al ppb	Ca ppb	Fe ppb	K ppb	Mg ppb	Mn ppb	Na ppb	Ti ppb	V ppb
Hry-2	ND	ND	ND	ND	ND	13	ND	ND	ND	6100	ND	ND	3000	ND	5800	ND	ND
Jak-1	ND	ND	ND	ND	5.0	6.2	ND	15	ND	24K	ND	ND	8000	ND	11K	ND	ND
Jak-2	ND	ND	ND	11	ND	96	ND	1.3	ND	6800	ND	ND	3900	14	7200	ND	ND
Jsp-1	ND	ND	ND	ND	ND	4.4	ND	ND	ND	29K	370	ND	3700	110	14K	ND	ND
Jsp-2	5.6	ND	ND	ND	ND	44	ND	2.2	ND	14K	ND	ND	3800	ND	11K	ND	ND
Jns-1	ND	ND	ND	110	ND	ND	ND	13	ND	36K	47	ND	5900	10	11K	ND	ND
Jns-2	ND	ND	ND	ND	ND	14	ND	1.1	ND	48K	1100	ND	6500	120	16K	ND	ND
Lin-1	ND	ND	9.9	ND	ND	5.2	ND	ND	ND	16K	170	ND	5600	63	9200	ND	ND
Lin-1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lin-2	ND	ND	ND	ND	ND	24	ND	ND	ND	12K	ND	ND	4900	ND	12K	ND	14
Lpk-1	ND	ND	ND	11	ND	11	ND	ND	ND	4800	ND	ND	1200	17	4700	ND	ND
Lpk-2	ND	ND	ND	220	ND	74	ND	1.2	ND	32K	51	ND	2900	53	5600	ND	ND

Table A-2. Ground-Water Quality Analyses for the Piedmont/Blue Ridge Unconfined Aquifer System, Continued.
Part A: Station Identification and Location, Date of Sampling, Field Parameters, VOCs, Anions, and Non-Metals.

Station No.	Well Name	Latitude	Date	pH	cond.	diss	Temp	γ radiation cps		VOCs	Cl	SO4	NOx	S	P
County	(use)	Longitude	Sampled		uS/cm	O_2 ppm	°C	bg.	water	ppb	ppm	ppm	ppm N	ppm	ppm
Mcd-1 McDuffie	GFC McDuffie/Warren Unit well (domestic)	33°26'42.5" 82°32'31.2"	08/09/06	5.82	68	6.36	19.5	NA	NA	ND	12	ND	1.00	NA	0.08
Mcd-2 McDuffie	Big Hart Creek Camp Well (public)	33°36'58.9" 82°30'16.6"	08/09/06	6.71	218	4.42	20.4	80	80	ND	20	ND	0.24	NA	0.08
Mad-1 Madison	Watson Mill Bridge State Park Horse Trail Well (livestock)	34°02'18.3" 83°03'47.9"	07/26/06	5.49	21	NA	17.6	100	100	NA	ND	ND	0.94	NA	0.02
Mad-2 Madison	Zeb's Place well (public)	34°11'57.9" 83°11'52.1"	09/20/06	4.79	127	5.54	17.7	160	160	$CHCl_3$=3.2	17	ND	5.30	NA	ND
Mwr-1 Meriwether	GFC Meriwether County Unit well (domestic)	33°01'49.5" 84°45'24.0"	01/26/06	6.04	44	7.51	18.1	120	120	NA	ND	ND	1.90	ND	0.07
Mwr-2 Meriwether	FDR Wilderness Camp #1 (public)	32°51'55.9" 84°43'40.8"	08/23/06	4.88	6	NA	17.1	60	60	NA	ND	ND	ND	NA	0.07
Mro-1 Monroe	Benson farm well (livestock)	33°00'27.5" 83°53'13.9"	06/28/06	8.60	126	0.04	19.5	90	90	NA	ND	12	0.05	NA	ND
Mro-2 Monroe	High Falls State Park (#1) day use well (public)	33°10'46.2" 84°01'04.6"	08/24/06	7.09	146	NA	19.3	170	170	NA	ND	ND	0.03	NA	0.06
Mrg-1 Morgan	Price Mill Rd. house well (domestic)	33°45'15.6" 83°29'36.2"	06/29/06	6.75	84	2.51	18.7	110	110	ND	ND	11	0.65	NA	0.04
Mrg-2 Morgan	Rutledge house well (domestic)	33°36'48.5" 83°34'36.9"	06/29/06	5.45	19	8.62	17.6	90	90	ND	ND	ND	0.39	NA	ND
Mrg-3 Morgan	Country Boys RV Park well (public)	33°32'07.5" 83°27'15.4"	08/09/06	7.14	73	2.86	18.5	NA	NA	ND	ND	ND	0.32	NA	0.07
Mur-1 Murray	Fort Mountain State Park #1 (public)	34°45'34.0" 84°42'00.9"	05/17/06	5.00	17	5.73	13.8	60	60	MTBE=1.7	ND	ND	0.64	NA	ND

Table A-2. Ground-Water Quality Analyses for the Piedmont/Blue Ridge Unconfined Aquifer System. Part B: Metals.

Station No.	Cr ppb	Ni ppb	Cu ppb	Zn ppb	Mo ppb	Ba ppb	Pb ppb	U ppb	Al ppb	Ca ppb	Fe ppb	K ppb	Mg ppb	Mn ppb	Na ppb	Ti ppb	V ppb
Mcd-1	ND	ND	ND	ND	ND	22	2.4	1.2	87	13K	26	ND	ND	ND	8100	ND	ND
Mcd-2	ND	18	ND	12	ND	93	ND	2.9	ND	36K	ND	ND	11K	ND	21K	ND	ND
Mad-1	ND	ND	ND	ND	ND	19	ND	ND	ND	1500	ND	ND	ND	23	3500	ND	ND
Mad-2	ND	ND	ND	21	ND	120	4.9	ND	110	2500	65	ND	2700	91	14K	ND	ND
Mwr-1	ND	ND	ND	47	ND	34	ND	ND	ND	3900	ND	ND	1300	ND	7400	ND	ND
Mwr-2	ND	ND	18	13	ND	2.5	1.4	ND	ND	ND	37	ND	ND	ND	ND	ND	ND
Mro-1	ND	ND	ND	ND	ND	2.2	ND	ND	ND	14K	290	ND	ND	ND	38K	ND	ND
Mro-2	ND	ND	ND	ND	ND	2.3	1.3	ND	ND	29K	170	ND	2700	92	20K	ND	ND
Mrg-1	ND	ND	ND	ND	ND	3.8	ND	ND	ND	19K	470	ND	2800	76	8000	ND	ND
Mrg-2	ND	ND	ND	14	ND	41	ND	ND	ND	1500	ND	ND	1400	ND	2200	ND	ND
Mrg-3	ND	ND	ND	ND	ND	25	1.7	1.2	ND	13K	ND	ND	1700	ND	11K	ND	ND
Mur-1	ND	ND	9.9	95	ND	19	ND	ND	ND	ND	260	ND	ND	39	2300	ND	ND

Table A-2. Ground-Water Quality Analyses for the Piedmont/Blue Ridge Unconfined Aquifer System, Continued.
Part A: Station Identification and Location, Date of Sampling, Field Parameters, VOCs, Anions, and Non-Metals.

Station No. County	Well Name (use)	Latitude Longitude	Date Sampled	pH	cond. uS/cm	diss O_2 ppm	Temp °C	γ radiation cps bg.	γ radiation cps water	VOCs ppb	Cl ppm	SO4 ppm	NOx ppm N	S ppm	P ppm
Mur-2 Murray	Cohutta WMA Cisco check station spring (domestic)	34°56'46.6" 84°41'36.6"	10/04/06	7.77	272	NA	16.0	NA	NA	ND	ND	ND	ND	NA	0.06
New-1 Newton	Dial Water System #4 (public)	33°39'42.8" 83°50'48.1"	11/08/06	7.67	115	NA	18.6	40	40	ND	ND	14	0.19	NA	ND
New-2 Newton	Mansfield - Kellogg Street Reserve Well (public)	33°30'53.3" 83°44'13.7"	12/14/06	6.56	106	NA	18.6	100	100	TCE=3.9	ND	12	1.80	NA	0.04
Oco-1 Oconee	Circle C Mobile Home Park well (public)	33°55'13.6" 83°32'06.0"	07/20/06	6.88	91	3.35	17.4	100	100	ND	ND	ND	0.23	NA	1.00
Oco-2 Oconee	Creekside Country Club well (public)	33°51'16.5" 83°18'42.7"	09/20/06	5.86	42	7.92	18.7	100	100	ND	ND	ND	0.56	NA	0.04
Ogr-1 Oglethorpe	Mathews house well (domestic)	33°59'08.7" 83°14'42.9"	03/02/06	5.32	23	7.73	17.9	1400	1400	NA	ND	ND	1.10	ND	0.04
Pau-1 Paulding	Hiram #1 (public)	33°52'30.4" 84°45'42.5"	10/24/06	6.93	371	0.81	17.6	80	80	$CHCl_3$=1.2	ND	71	0.67	NA	ND
Pic-1 Pickens	Yeargin house well (domestic)	34°29'16.5" 84°22'43.1"	10/05/06	6.42	136	1.60	16.0	50	50	ND	ND	11	ND	NA	ND
Pic-2 Pickens	Yeargin rental house well (domestic)	34°27'21.8" 84°31'42.7"	10/26/06	7.41	147	0.21	16.0	80	60	ND	ND	ND	ND	NA	0.02
Pik-1 Pike	GFC Pike/Spalding/Lamar Un well (domestic)	33°11'19.5" 84°16'03.9"	06/28/06	7.36	87	0.05	18.9	NA	NA	ND	ND	11	ND	NA	ND
Pik-2 Pike	Kenerly house well (domestic)	33°07'59.3" 84°16'57.6"	08/16/06	5.03	21	6.69	18.9	40	40	ND	ND	ND	0.98	NA	ND
Ptm-1 Putnam	GFC Putnam Unit well (domestic)	33°16'32.3" 83°21'58.1"	04/26/06	6.98	100	3.26	19.3	40	40	NA	ND	ND	1.70	ND	0.07

Table A-2. Ground-Water Quality Analyses for the Piedmont/Blue Ridge Unconfined Aquifer System. Part B: Metals.

Station No.	Cr ppb	Ni ppb	Cu ppb	Zn ppb	Mo ppb	Ba ppb	Pb ppb	U ppb	Al ppb	Ca ppb	Fe ppb	K ppb	Mg ppb	Mn ppb	Na ppb	Ti ppb	V ppb
Mur-2	ND	ND	ND	ND	ND	67	ND	ND	ND	29K	290	ND	14K	ND	11K	ND	ND
New-1	ND	ND	ND	13	ND	17	ND	9.0	ND	23K	ND	5000	3500	30	9200	ND	ND
New-2	ND	ND	ND	62	ND	12	ND	15	ND	22K	750	ND	2500	170	8900	ND	ND
Oco-1	ND	ND	ND	ND	ND	130	ND	ND	ND	14K	ND	ND	4900	ND	6500	ND	ND
Oco-2	ND	ND	ND	33	ND	7	ND	ND	ND	3800	ND	ND	ND	ND	3000	ND	ND
Ogr-1	ND	ND	84	ND	ND	76	9.4	ND	ND	1800	32	ND	ND	17	2900	ND	ND
Pau-1	ND	ND	ND	94	ND	13	ND	1.9	ND	55K	ND	ND	7800	82	11K	ND	ND
Pic-1	ND	ND	ND	14	ND	2.8	ND	ND	ND	23K	2700	ND	1900	72	5900	ND	ND
Pic-2	ND	ND	ND	25	ND	6.3	ND	ND	ND	20K	290	ND	2000	110	8100	ND	ND
Pik-1	ND	ND	ND	ND	ND	5.8	ND	ND	ND	16K	230	ND	2100	57	12K	ND	ND
Pik-2	ND	ND	ND	14	ND	42	ND	ND	ND	1700	ND	ND	ND	56	4300	ND	ND
Ptm-1	ND	ND	ND	56	ND	40	ND	ND	ND	13K	53	ND	7200	ND	11K	ND	12

Table A-2. Ground-Water Quality Analyses for the Piedmont/Blue Ridge Unconfined Aquifer System, Continued.
Part A: Station Identification and Location, Date of Sampling, Field Parameters, VOCs, Anions, and Non-Metals.

Station No.	Well Name	Latitude	Date	pH	cond.	diss	Temp	γ radiation cps		VOCs	Cl	SO4	NOx	S	P
County	(use)	Longitude	Sampled		uS/cm	O_2 ppm	°C	bg.	water	ppb	ppm	ppm	ppm N	ppm	ppm
Ptm-2 Putnam	Sugar Creek Farms Property Owners Assn. Well (public)	33°27'50.9" 83°18'10.0"	07/19/06	7.18	172	4.68	18.2	60	60	NA	ND	26	0.31	NA	1.30
Rbn-1 Rabun	Moccasin Creek State Park Entrance Well (public)	34°50'41.0" 83°35'21.7"	05/18/06	7.14	62	7.26	15.4	NA	NA	NA	ND	ND	0.11	NA	0.16
Rbn-2 Raburn	Tallulah Falls #1 (public)	34°44'08.0" 83°23'45.1"	05/18/06	6.58	79	NA	15.7	NA	NA	NA	ND	13	ND	NA	0.06
Rok-1 Rockdale	Rockdale Medical Center irrigation well (irrigation)	33°40'47.4" 84°00'13.8"	10/19/06	5.76	60	NA	18.4	160	160	ND	ND	ND	0.67	NA	0.04
Rok-2 Rockdale	Holy Spirit Monastery spring (public)	33°35'21.2" 84°04'09.2"	11/21/06	5.67	40	NA	16.8	NA	NA	ND	ND	ND	2.80	NA	ND
Spd-1 Spalding	Camp Cecil Jackson #1 (public)	33°17'52.3" 84°12'27.4"	11/16/06	6.43	127	2.34	17.5	160	160	ND	ND	ND	0.21	NA	0.04
Sph-1 Stephens	Cheek well (domestic)	34°32'40.5" 83°16'20.4"	03/02/06	4.80	137	8.90	15.9	80	80	NA	20	ND	16.00	ND	ND
Sph-2 Stephens	Toccoa Falls College #2 (public)	34°35'45.9" 83°21'29.6"	08/10/06	7.14	159	1.14	19.0	100	100	NA	ND	12	ND	NA	0.03
Tbt-1 Talbot	Hucheson farm well (domestic)	32°38'10.7" 84°37'31.4"	02/02/06	6.80	297	0.58	16.6	60	60	NA	19	11	0.23	NA	0.03
Tbt-2 Talbot	Big Lazer Creek WMA well (wash)	32°46'26.5" 84°24'16.3"	03/30/06	6.57	179	0.05	17.6	60	60	NA	16	14	ND	NA	0.03
Tia-1 Taliaferro	A. H. Stephens State Park spring (historic)	33°33'46.8" 82°53'54.5"	05/11/06	5.95	68	NA	16.7	60	200	NA	ND	ND	0.20	ND	0.19
Tay-1 Taylor	Antioch Baptist Church well (wash)	32°41'54.1" 84°15'37.1"	01/25/06	4.95	16	5.88	18.4	100	100	NA	ND	ND	0.06	ND	ND

Table A-2. Ground-Water Quality Analyses for the Piedmont/Blue Ridge Unconfined Aquifer System.
Part B: Metals.

Station No.	Cr ppb	Ni ppb	Cu ppb	Zn ppb	Mo ppb	Ba ppb	Pb ppb	U ppb	Al ppb	Ca ppb	Fe ppb	K ppb	Mg ppb	Mn ppb	Na ppb	Ti ppb	V ppb
Ptm-2	ND	ND	13	290	ND	55	7.3	ND	2700	40K	4600	5100	7000	110	14K	270	16
Rbn-1	ND	ND	9.3	43	ND	14	1.8	ND	2600	11K	5500	ND	4800	73	4600	260	11
Rbn-2	ND	ND	ND	34	ND	11	ND	ND	ND	15K	4600	ND	1500	340	3200	ND	ND
Rok-1	ND	14	ND	1600	ND	20	2.2	19	ND	9400	62	ND	2000	22	8700	ND	ND
Rok-2	ND	ND	ND	73	ND	54	4.7	ND	ND	3900	130	ND	1900	ND	4300	ND	ND
Spd-1	ND	ND	ND	37	ND	7.9	ND	ND	ND	15K	600	ND	2700	ND	8500	ND	ND
Sph-1	ND	ND	69	22	ND	590	2.7	1.1	220	15K	58	ND	7300	350	5600	ND	ND
Sph-2	ND	ND	ND	63	8.5	13	ND	1.3	ND	39K	ND	ND	7100	ND	7900	ND	ND
Tbt-1	ND	ND	13	28	ND	25	1.1	6.8	79	46K	66	ND	16K	ND	26K	ND	ND
Tbt-2	ND	ND	ND	ND	ND	4.1	ND	ND	ND	29K	940	ND	11K	200	16K	ND	ND
Tia-1	ND	ND	ND	ND	ND	43	ND	ND	ND	8400	ND	ND	2600	ND	11K	ND	ND
Tay-1	ND	ND	ND	ND	ND	230	ND	3.9	ND	37K	ND	ND	5400	19	18K	ND	ND

Table A-2. Ground-Water Quality Analyses for the Piedmont/Blue Ridge Unconfined Aquifer System, Continued.
Part A: Station Identification and Location, Date of Sampling, Field Parameters, VOCs, Anions, and Non-Metals.

Station No.	Well Name	Latitude	Date	pH	cond.	diss	Temp	γ radiation cps		VOCs	Cl	SO4	NOx	S	P
County	(use)	Longitude	Sampled		uS/cm	O_2 ppm	°C	bg.	water	ppb	ppm	ppm	ppm N	ppm	ppm
Twn-1 Towns	Young Harris Swanson Rd. Well (public)	34°55'28.0" 83°51'32.2"	08/24/06	7.90	170	NA	19.5	70	70	ND	ND	10	ND	NA	0.03
Twn-2 Towns	Hiawassee Mountain Home Owners Assn. Well (public)	34°55'28.4" 83°38'38.2"	11/29/06	7.10	96	NA	15.6	20	20	ND	ND	21	0.04	NA	ND
Trp-1 Troup	GFC Troup/Heard Unit well (wash)	33°11'33.1" 85°01'27.7"	08/10/06	6.58	37	3.43	14.0	65	65	ND	ND	ND	ND	NA	0.08
Trp-2 Troup	Brundage house well (domestic)	33°08'04.0" 85°00'44.1"	01/25/06	4.57	26	3.49	17.2	100	100	NA	ND	ND	0.04	ND	0.06
Tay-1 Taylor	Antioch Baptist Church well (wash)	32°41'54.1" 84°15'37.1"	01/25/06	4.95	16	5.88	18.4	100	100	NA	ND	ND	0.06	ND	ND
Uno-1 Union	Notla Water Authority #3 (public)	34°52'47.8" 83°58'54.3"	05/17/06	5.38	34	6.16	15.2	80	80	ND	ND	ND	0.92	NA	0.04
Uno-2 Union	Vogel State Park #1 (public)	34°45'50.6" 83°55'42.0"	05/17/06	6.49	36	NA	13.6	70	70	ND	ND	ND	ND	NA	0.09
Uno-3 Union	Coopers Creek WMA check station spring (domestic)	34°46'19.9" 84°04'09.9"	10/04/06	5.76	22	8.38	15.1	70	70	ND	ND	ND	0.06	NA	ND
Ups-1 Upson	GFC Upson Unit well (domestic)	32°54'40.3" 84°15'57.9"	06/28/06	8.21	112	0.12	19.4	80	80	NA	ND	ND	ND	NA	ND
Ups-2 Upson	Teal house well (domestic)	32°57'55.7" 84°22'46.5"	08/16/06	5.18	21	4.97	18.2	120	120	ND	ND	ND	0.92	NA	ND
Wal-1 Walton	GFC Walton/Morgan Unit well (domestic)	33°45'37.1" 83°33'06.6"	06/29/06	5.45	25	6.67	17.2	120	120	$CHCl_3$=0.61	ND	ND	1.30	NA	ND
Wal-2 Walton	Strater house well (domestic)	33°53'47.1" 83°42'12.0"	06/29/06	5.73	37	6.92	16.5	90	90	ND	ND	ND	0.10	NA	ND
Wrn-1 Warren	Norwood #1 (public)	33°27'46.5" 82°41'54.7"	08/09/06	7.67	123	0.03	19.5	80	80	NA	ND	ND	ND	NA	0.05

Table A-2. Ground-Water Quality Analyses for the Piedmont/Blue Ridge Unconfined Aquifer System.
Part B: Metals.

Station No.	Cr ppb	Ni ppb	Cu ppb	Zn ppb	Mo ppb	Ba ppb	Pb ppb	U ppb	Al ppb	Ca ppb	Fe ppb	K ppb	Mg ppb	Mn ppb	Na ppb	Ti ppb	V ppb
Twn-1	ND	ND	ND	ND	ND	81	ND	7	ND	20K	ND	ND	4400	21	3800	ND	ND
Twn-2	ND	ND	ND	ND	ND	28	ND	ND	ND	6400	32	ND	2200	45	3900	ND	ND
Trp-1	ND	ND	9.1	36	ND	53	ND	ND	ND	2800	33	ND	ND	ND	3300	ND	ND
Trp-2	ND	ND	10	26	ND	28	ND	ND	1400	3000	2900	ND	1600	62	3300	100	ND
Uno-1	ND	ND	ND	ND	ND	50	ND	ND	ND	3500	ND	ND	1500	10	3400	ND	ND
Uno-2	ND	ND	ND	13	ND	19	ND	ND	ND	4700	ND	ND	1700	ND	4200	ND	ND
Uno-3	ND	ND	ND	ND	ND	11	ND	ND	ND	1900	ND	ND	ND	ND	1400	ND	ND
Ups-1	ND	ND	ND	82	ND	5.5	ND	ND	ND	18K	ND	ND	1100	ND	24K	ND	ND
Ups-2	ND	ND	6.4	12	ND	36	1.8	ND	ND	2200	24	ND	ND	25	2500	ND	ND
Wal-1	ND	ND	11	12	ND	32	ND	ND	ND	3500	66	ND	ND	18	2800	ND	ND
Wal-2	ND	ND	ND	ND	ND	23	ND	ND	ND	6500	ND	ND	2400	ND	2300	ND	ND
Wrn-1	ND	ND	ND	ND	ND	ND	ND	ND	ND	14K	38	ND	1700	ND	11K	ND	ND

Table A-2. Ground-Water Quality Analyses for the Piedmont/Blue Ridge Unconfined Aquifer System, Continued.
Part A: Station Identification and Location, Date of Sampling, Field Parameters, VOCs, Anions, and Non-Metals.

Station No. County	Well Name (use)	Latitude Longitude	Date Sampled	pH	cond. uS/cm	diss O_2 ppm	Temp °C	γ radiation cps		VOCs ppb	Cl ppm	SO4 ppm	NOx ppm N	S ppm	P ppm
								bg.	water						
Wsh-1 Washington	Hamburg State Park well (public)	33°12'25.8" 82°46'40.2"	12/13/06	7.27	142	NA	19.1	60	60	$CHCl_3$=0.68	13	ND	0.05	NA	0.13
Wte-1 White	Unicoi State Park #2 (public)	34°43'41.2" 83°43'10.2"	05/18/06	6.35	56	8.01	15.2	90	90	ND	ND	ND	ND	NA	0.06
Wte-2 White	White Creek Christian Academy well (public)	34°35'23.4" 83°43'25.8"	09/21/06	5.24	48	8.24	17.5	100	100	ND	ND	ND	3.40	NA	ND
Wik-1 Wilkes	Lee house well (domestic)	33°40'12.7" 82°52'35.3"	12/14/05	6.47	118	3.55	17.1	44	44	NA	17	ND	NA	ND	NA
Wik-1 Wilkes	Lee house well (domestic) **Partial Repeat**	33°40'12.7" 82°52'35.3"	03/23/06	6.86	111	3.65	16.9	NA	NA	NA	NA	NA	1.70	NA	0.08
Wik-2 Wilkes	Tignall #6 (public)	33°52'24.8" 82°45'17.4"	04/27/06	7.55	150	0.76	19.5	40	40	NA	ND	34	0.42	ND	0.03

Table A-2. Ground-Water Quality Analyses for the Piedmont/Blue Ridge Unconfined Aquifer System. Part B: Metals.

Station No.	Cr ppb	Ni ppb	Cu ppb	Zn ppb	Mo ppb	Ba ppb	Pb ppb	U ppb	Al ppb	Ca ppb	Fe ppb	K ppb	Mg ppb	Mn ppb	Na ppb	Ti ppb	V ppb
Wsh-1	ND	ND	ND	ND	ND	86	ND	11	ND	27K	77	ND	2800	260	19K	ND	ND
Wte-1	ND	ND	ND	ND	ND	7.3	ND	4.5	ND	11K	ND	ND	ND	ND	3900	ND	ND
Wte-2	ND	ND	11	ND	ND	98	ND	ND	ND	1700	46	ND	1700	14	3000	ND	ND
Wik-1	ND	ND	21	ND	ND	79	1.9	ND	100	24K	100	ND	3400	14	7000	ND	ND
Wik-1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Wik-2	ND	ND	ND	ND	10	17	ND	2.5	ND	31K	ND	ND	ND	ND	19K	ND	ND

TABLE A-3. CHEMICAL COMPONENTS AND REPORTING LIMITS

Component	Reporting Limit	Component	Reporting Limit
Vinyl Chloride	0.5 ppb	Dichlorodifluoromethane	0.5 ppb
1,1-Dichloroethylene	0.5 ppb	Chloromethane	0.5 ppb
Dichloromethane	0.5 ppb	Bromomethane	0.5 ppb
Trans-1,2-Dichloroethylene	0.5 ppb	Chloroethane	0.5 ppb
Cis-1,2-Dichloroethylene	0.5 ppb	Fluorotrichloromethane	0.5 ppb
1,1,1-Trichloroethane	0.5 ppb	1,1-Dichloroethane	0.5 ppb
Carbon Tetrachloride	0.5 ppb	2,2-Dichloropropane	0.5 ppb
Benzene	0.5 ppb	Bromochloromethane	0.5 ppb
1,2-Dichloroethane	0.5 ppb	Chloroform	0.5 ppb
Trichloroethylene	0.5 ppb	1,1-Dichloropropene	0.5 ppb
1,2-Dichloropropane	0.5 ppb	Dibromomethane	0.5 ppb
Toluene	0.5 ppb	Bromodichloromethane	0.5 ppb
1,1,2-Trichloroethane	0.5 ppb	cis-1,3-Dichloropropene	0.5 ppb
Tetrachloroethylene	0.5 ppb	Tans-1,3-Dichloropropene	0.5 ppb
Chlorobenzene	0.5 ppb	1,3-Dichloropropane	0.5 ppb
Ethylbenzene	0.5 ppb	Chlorodibromomethane	0.5 ppb
Total Xylenes	0.5 ppb	1,2-Dibromoethane	0.5 ppb
Styrene	0.5 ppb	1,1,1,2-Tetrachloroethane	0.5 ppb
p-Chlorobenzene	0.5 ppb	Bromoform	0.5 ppb
o-Chlorobenzene	0.5 ppb	Isopropylbenzene	0.5 ppb
1,2,4-Trichlorobenzene	0.5 ppb	1,1,2,2-Tetrachloroethane	0.5 ppb

TABLE A-3. CHEMICAL COMPONENTS AND REPORTING LIMITS, CONTINUED.

Component	Reporting Limit	Component	Reporting Limit
Bromobenzene	0.5 ppb	Total Phosphorus	0.02 ppm
1,2,3-Trichloropropane	0.5 ppb	Silver (ICP)	10 ppb
n-Propylbenzene	0.5 ppb	Aluminum (ICP)	60 ppb
o-Chlorotoluene	0.5 ppb	Arsenic (ICP)	80 ppb
1,3,5-Trimethylbenzene	0.5 ppb	Barium (ICP)	10 ppb
p-Chlorotoluene	0.5 ppb	Beryllium (ICP)	10 ppb
Tert-Butylbenzene	0.5 ppb	Calcium (ICP)	2000 ppb
1,2,4-Trimethylbenzene	0.5 ppb	Cobalt (ICP)	10 ppb
Sec-Butylbenzene	0.5 ppb	Chromium (ICP)	20 ppb
p-Isopropyltoluene	0.5 ppb	Copper (ICP)	20 ppb
m-Dichlorobenzene	0.5 ppb	Iron (ICP)	20 ppb
n-Butylbenzene	0.5 ppb	Potassium (ICP)	5000 ppb
1,2-Dibromo-3-chloropropane	0.5 ppb	Magnesium (ICP)	1000 ppb
Hexachlorobutadiene	0.5 ppb	Manganese (ICP)	10 ppb
Naphthalene	0.5 ppb	Sodium (ICP)	1000 ppb
1,2,3-Trichlorobenzene	0.5 ppb	Nickel (ICP)	20 ppb
Methyl-tert-butyl ether (MTBE)	0.5 ppb	Lead (ICP)	90 ppb
Chloride	10 ppm	Antimony (ICP)	120 ppb
Sulfate	10 ppm	Selenium (ICP)	190 ppb
Nitrate/nitrite	0.02 ppm as Nitrogen	Titanium (ICP)	10 ppb
Sulfide	0.10 ppm	Thallium (ICP)	200 ppb

TABLE A-3. CHEMICAL COMPONENTS AND REPORTING LIMITS, CONTINUED.

Component	Reporting Limit	Component	Reporting Limit
Bromobenzene	0.5 ppb	Total Phosphorus	0.02 ppm
1,2,3-Trichloropropane	0.5 ppb	Silver (ICP)	10 ppb
n-Propylbenzene	0.5 ppb	Aluminum (ICP)	60 ppb
o-Chlorotoluene	0.5 ppb	Arsenic (ICP)	80 ppb
1,3,5-Trimethylbenzene	0.5 ppb	Barium (ICP)	10 ppb
p-Chlorotoluene	0.5 ppb	Beryllium (ICP)	10 ppb
Tert-Butylbenzene	0.5 ppb	Calcium (ICP)	2000 ppb
1,2,4-Trimethylbenzene	0.5 ppb	Cobalt (ICP)	10 ppb
Sec-Butylbenzene	0.5 ppb	Chromium (ICP)	20 ppb
p-Isopropyltoluene	0.5 ppb	Copper (ICP)	20 ppb
m-Dichlorobenzene	0.5 ppb	Iron (ICP)	20 ppb
n-Butylbenzene	0.5 ppb	Potassium (ICP)	5000 ppb
1,2-Dibromo-3-chloropropane	0.5 ppb	Magnesium (ICP)	1000 ppb
Hexachlorobutadiene	0.5 ppb	Manganese (ICP)	10 ppb
Naphthalene	0.5 ppb	Sodium (ICP)	1000 ppb
1,2,3-Trichlorobenzene	0.5 ppb	Nickel (ICP)	20 ppb
Methyl-tert-butyl ether (MTBE)	0.5 ppb	Lead (ICP)	90 ppb
Chloride	10 ppm	Antimony (ICP)	120 ppb
Sulfate	10 ppm	Selenium (ICP)	190 ppb
Nitrate/nitrite	0.02 ppm as Nitrogen	Titanium (ICP)	10 ppb
Sulfide	0.10 ppm	Thallium (ICP)	200 ppb

TABLE A-3. CHEMICAL COMPONENTS AND REPORTING LIMITS, CONTINUED.

Component	Reporting Limit	Component	Reporting Limit
Vanadium (ICP)	10 ppb	Silver (ICP/MS)	5 ppb
Zinc (ICP)	20 ppb	Cadmium (ICP/MS)	0.7 ppb
Chromium (ICP/MS)	5 ppb	Tin (ICP/MS)	30 ppb
Nickel (ICP/MS)	10 ppb	Antimony (ICP/MS)	5 ppb
Copper (ICP/MS)	5 ppb	Barium (ICP/MS)	2 ppb
Zinc (ICP/MS)	10 ppb	Thallium (ICP/MS)	1 ppb
Arsenic (ICP/MS)	5 ppb	Lead (ICP/MS)	1 ppb
Selenium (ICP/MS)	5 ppb	Uranium (ICP/MS)	1 ppb
Molybdenum (ICP/MS)	5 ppb		