

**GROUND-WATER QUALITY IN GEORGIA
FOR 2011**

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**GEORGIA DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION
WATERSHED PROTECTION BRANCH
WATERSHED PLANNING AND MONITORING PROGRAM**

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CHAPTER 1 INTRODUCTION

1.1 PURPOSE AND SCOPE

This report, covering the calendar year 2011, is the twenty-fifth of the Circular 12 series. The first 19 reports, Circulars 12A through 12S, summarized the chemical quality of ground water statewide across Georgia and utilized a static array of sampling stations that were sampled periodically, typically on a semiannual, annual, or biennial basis. The next five reports, Circulars 12T through 12X, dealt with specialized chemical ground-water quality issues: water quality in the Coastal region, water quality available to small public water systems, water quality in the Piedmont/Blue Ridge physiographic province, ground-water uranium in Georgia, and ground-water arsenic in the Gulf Trough area of Georgia. With this report, monitoring the chemical quality of ground water returns to using a static array of stations sampled periodically.

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). Four components comprise EPD's current ground-water quality assessment program:

1. The Georgia Ground-Water Monitoring Network. EPD's Watershed Protection Branch, Source Water Assessment Program, took over the Georgia Ground-Water Monitoring Network from the Regulatory Support Program when that program disbanded. The Monitoring Network is designed to evaluate the ambient ground-water quality of eight aquifer systems present in the State of Georgia. The data collected from sampling of the Ground-Water Monitoring Network form the basis for this report.
2. Sampling of public drinking water wells as part of the Drinking Water – Water Withdrawal Program (Watershed Protection Branch, Water Supply Section). This program provides data on the quality of ground water that the residents of Georgia are using.
3. Ground-water sampling at environmental facilities such as municipal solid waste landfills, RCRA facilities, underground storage tank sites, land application sites, and sludge disposal facilities. The primary agencies responsible for monitoring these facilities are EPD's Land Protection and Watershed Protection Branches.

4. The Wellhead Protection Program (WHP), which is designed to protect areas surrounding municipal drinking water wells 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 supply wells from contaminants is important not only for maintaining ground-water quality, but also for ensuring that public water supplies meet health standards.

Analyses of water samples collected for the Georgia Ground-Water Monitoring Network during the period March 2011 through December 2011 and from previous years form the database for this summary. The Georgia Ground-Water Monitoring Network is presently comprised of 77 wells and springs. Thirteen of the stations are scheduled for quarterly sampling, and the remainder is scheduled to be sampled yearly. Each sample receives laboratory analyses for chloride, sulfate, nitrate/nitrite, total phosphorus, 26 metals, and volatile organic compounds (VOCs). Samples from the mineral spring and the main well at Indian Springs State Park (stations P12A and P23) also receive analysis for fluoride. Field measurements of pH, conductivity, and temperature are performed on the sample water from each station. Field dissolved oxygen measurements are made on sample water from wells.

During the March 2011 through December 2011 period, Ground-Water Monitoring staff collected 99 samples from 71 wells and six springs. A review of the data from this period and comparison of these data with those for samples collected for preceding monitoring efforts indicated that ground-water quality at most of the 77 stations has remained good.

1.2 FACTORS AFFECTING CHEMICAL GROUND-WATER QUALITY

The chemical quality of ground water is the result of complex physical, chemical, and biological processes. Among the more significant controls are the chemical quality of the water entering the ground-water flow system, the reactions of the infiltrating water with the soils and rocks that are encountered, and the effects of the well-and-pump system.

Most water enters the ground-water system in upland recharge areas. Water seeps through interconnected pore spaces and fractures in the soils and rocks until discharged to a surface water body (e.g., stream, lake, or ocean). The initial water chemistry, the amount of recharge, and the attenuation capacity of soils have a strong influence on the quality of ground water in recharge areas. Chemical interactions between the water and the aquifer host rocks have an increasing significance with longer residence times. As a result, ground water

from discharge areas tends to be more highly mineralized than ground water in recharge areas.

The well-and-pump system can also have a strong influence on the quality of the well water. Well plumbing, through compositional breakdown, can contribute metals (e.g., zinc from galvanized steel fittings) and organic compounds (e.g., tetrahydrofurans from PVC pipe cement) to the water. Pumps can aerate the water being drawn up and discharged. An improperly constructed or failing well can offer a conduit that allows local pollutants to enter the ground-water flow system.

1.3 HYDROGEOLOGIC PROVINCES OF GEORGIA

This report defines three hydrogeologic provinces by their general geologic and hydrologic characteristics (Figure 1-1). These provinces consist of:

1. The Coastal Plain Province of south Georgia;
2. The Piedmont/Blue Ridge Province, which includes all but the northwestern corner of north Georgia;
3. The combined Valley and Ridge and Appalachian Plateau Province of northwest Georgia;

1.3.1 Coastal Plain Province

Georgia's Coastal Plain Province generally comprises a wedge of loosely consolidated sediments that gently dip and thicken to the south and southeast. Ground water in the Coastal Plain flows through interconnected pore space between grains and through solution-enlarged voids in rock.

The oldest outcropping sedimentary formations (Cretaceous) are exposed along the Fall Line (Figure 1-1), which is the northern limit of the Coastal Plain Province. Successively younger formations occur at the surface to the south and southeast.

The Coastal Plain of Georgia contains a number of confined and unconfined aquifers. Confined aquifers are those in which the readily permeable layer of aquifer medium is interposed between two layers of poorly permeable material (e.g. clay or shale). If the water pressure in such an aquifer exceeds atmospheric pressure, the aquifer is artesian. Water from precipitation and runoff enters the aquifers and aquifer systems in their updip outcrop areas, where permeable sediments hosting the aquifer are exposed. Water may also enter the aquifers downdip from the recharge areas through leakage from

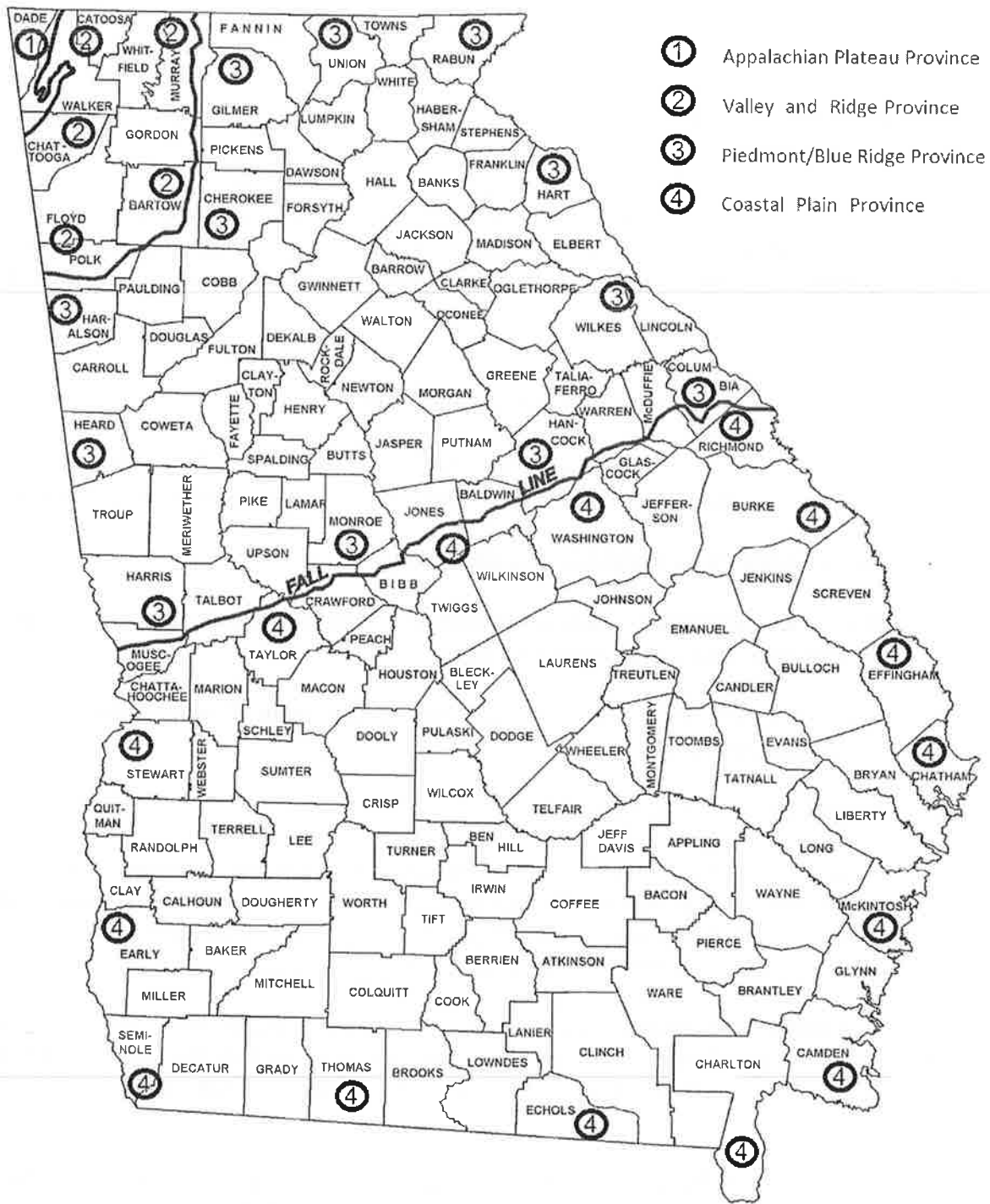


Figure 1-1. The Hydrogeologic Provinces of Georgia

overlying or underlying aquifers. Most Coastal Plain aquifers are unconfined in their updip outcrop areas, but become confined in downdip areas to the south and southeast, where they are overlain by successively younger rock formations. Ground-water flow is generally to the south and southeast, in the direction of dip of the sedimentary layers.

The sediments forming the major aquifer systems in the Coastal Plain range in age from Cretaceous to Holocene. Horizontal and vertical changes in the sediment layers that form these aquifer systems determine the thickness and extent of the aquifer systems. Several aquifer systems may be present in a single geographic area forming a vertical "stack".

The Cretaceous and Jacksonian aquifer systems (primarily sands) are a common source of drinking water within a 35-mile wide band that lies adjacent to and south of the Fall Line. Southwestern Georgia relies on three vertically stacked aquifer systems plus the upper part of the Cretaceous aquifer system for drinking water supplies: the Clayton, the Claiborne, and the Floridan aquifer systems. The Miocene/Surficial aquifer system (primarily sands) is the principal shallow aquifer system occupying much of the same broad area occupied by the Floridan aquifer system. The system is unconfined over most of its inland extent, but becomes locally confined both in the coastal area and in Grady, Thomas, Brooks, and Lowndes County area of South Georgia.

1.3.2 Piedmont/Blue Ridge Province

Though the Piedmont and Blue Ridge Physiographic Provinces differ geologically and geomorphologically, the two physiographic provinces share common hydrogeological characteristics and thus can be treated as a single hydrogeologic province. A two-part aquifer system characterizes the Piedmont/Blue Ridge Province (Daniel and Harned, 1997). The upper part of the system is the regolith aquifer, composed of saprolite and overlying soils and alluvium. The regolith aquifer is unconfined, and, the water resides primarily in intergranular pore spaces (primary porosity). The lower aquifer in the Piedmont/Blue Ridge aquifer system is the bedrock aquifer. This aquifer is developed in metamorphic and igneous bedrock (mostly Paleozoic and Precambrian in age), and, the water resides largely in fractures (secondary porosity). Secondary porosity in some specialized rock types, e.g. marbles, may also include solution voids. In contrast to the regolith aquifer, no intergranular (primary) porosity exists in the bedrock aquifer. The bedrock aquifer is semi-confined, with the overlying regolith aquifer media offering local confinement. The regolith aquifer also serves as the reservoir that recharges the bedrock aquifer.

1.3.3 The Valley and Ridge Province

Faulted and folded consolidated Paleozoic sedimentary formations exclusive of Mississippian and Pennsylvanian rocks characterize the Valley and Ridge Province. The principal porosity present in aquifer media consists of fractures and solution-enlarged voids; intergranular porosity may be important in some places. Locally, ground-water and surface-water systems closely interconnect. Dolostones and limestones of the Knox Group are the principal aquifers where they occur at the axes of broad valleys. The greater hydraulic conductivities of the thick carbonate sections in this province permit higher yielding wells than in the Piedmont/Blue Ridge Province.

1.3.4 The Appalachian Plateau Province

Rocks in this province consist of consolidated Paleozoic sediments inclusive of the Mississippian and Pennsylvanian. Faulting and folding are less intense than in the Valley and Ridge province. As in the Valley and Ridge Province, secondary porosity is the most important type of porosity. The highly fractured Fort Payne Chert and the Knox Group are major water-bearing units in this province.

Only a small part of this province extends into of Georgia, at the State's far northwest corner (Dade County and parts of Chattooga and Walker Counties). Due its small extent in Georgia and its lack of monitoring stations for the current project, the Appalachian Plateau Province is combined with the Valley and Ridge Province for the purposes of this report.

1.4 REGIONAL GROUND-WATER PROBLEMS

Data from ground-water investigations in Georgia, including those from the Ground-Water Monitoring Network, indicate that virtually all of Georgia has shallow ground water sufficient for domestic supply. Iron, aluminum, and manganese are the only constituents that occur routinely in concentrations exceeding drinking water standards. These metals are mostly naturally occurring and do not pose a health risk. Iron and manganese can cause reddish or yellowish-brown to dark brown or black stains on objects and can give water a bitter metallic taste. Aluminum can cause water to appear cloudy.

In the karstic carbonate terranes of the Valley and Ridge Province, interconnection between the surface water systems and the ground-water systems can be extensive enough such that waters supplying some wells and springs (e.g., Crawfish Spring and Cedartown Spring) have been deemed under direct surface influence and require surface-water type treatment if used for public supplies.

In the Piedmont/Blue Ridge Province, water available to wells drilled into bedrock consisting of granitic intrusive rocks, granitic gneisses, or hornblende gneiss/amphibolite assemblages occasionally contains excessive naturally occurring uranium.

Aquifers in the outcrop areas of Cretaceous sediments immediately south of the Fall Line typically yield water sufficiently acidic to require treatment. The acidity occurs naturally and results from the inability of the sandy aquifer sediments to neutralize acidic rainwater and from biologically influenced reactions between infiltrating water and soils.

Nitrate/nitrite concentrations in shallow ground water from the farm belt in southern Georgia are usually within drinking water standards, but are somewhat higher than levels found in other areas of the State.

Three areas of naturally reduced ground-water quality occur in the Floridan aquifer. The first is the karstic Dougherty Plain of southwestern Georgia, where, as with the carbonate terranes of northwestern Georgia, surface waters and the pollutants and contaminants they entrain can directly access the aquifer. The second is the Gulf Trough area. The Gulf Trough is a linear subsurface geologic feature extending from southwestern Decatur County through northern Effingham County and may represent a filled-in marine current channel way (Huddlestun, 1993). Floridan ground water in and near the trough is typically high in total dissolved solids and may contain elevated levels of sulfate, barium, radionuclides, and arsenic (Kellam and Gorday, 1990; Donahue et al., 2013). The third is in the coastal area of Georgia, when influx of water with high dissolved solids contents can dramatically raise levels of sodium, calcium, magnesium, sulfate, and chloride. In the Brunswick area, ground-water withdrawal from the upper portions of Floridan results in the upwelling of ground water with high dissolved solids content from the deeper parts of the aquifer (Krause and Clarke, 2001). In the Savannah area, a cone of depression caused by pumping in and around Savannah has induced seawater to enter the Floridan aquifer via breaches in the Miocene confining unit along the bottoms of waterways and sand-filled paleochannels offshore of the Beaufort/Hilton Head area of South Carolina and to flow down-gradient toward Savannah (Foyle et al., 2001; Krause and Clarke, 2001).

CHAPTER 2 GEORGIA GROUND-WATER MONITORING NETWORK

2.1 MONITORING STATIONS

For the period March 2011 through December 2011, attempts were made to have sampling stations in the major aquifer systems of the Coastal Plain Province, the Piedmont/Blue Ridge Province, and the Valley and Ridge/Appalachian Plateau Provinces (Table 2-1). Stations are restricted to wells or springs tapping a single aquifer or aquifer system. Attempts were made to have some monitoring stations located in the following critical settings:

1. areas of recharge;
2. areas of possible pollution or contamination related to regional activities (e.g., agricultural and industrial areas) or to hydrogeologic settings (e.g., granitic intrusions, Dougherty Plain);
3. areas of significant ground-water use.

Most of the monitoring stations are municipal, industrial, and domestic wells that have well construction data.

2.2 USES AND LIMITATIONS

Regular sampling of wells and springs of the Ground-Water Monitoring Network permits analysis of ground-water quality with respect to location (spatial trends) and time of sample collection (temporal trends). Spatial trends are useful for assessing the effects of the geologic framework of the aquifer and regional land-use activities on ground-water quality. Temporal trends permit an assessment of the effects of rainfall and drought periods on ground-water quality and quantity. Both trends are useful for the detection of non-point source pollution. Non-point source pollution arises from broad-scale phenomena such as acid rain deposition or application of agricultural chemicals on crop lands.

It should be noted that the data of the Ground-Water Monitoring Network represent water quality in only limited areas of Georgia. Monitoring water quality at the 77 sites located throughout Georgia provides an indication of ground-water quality at the locality sampled and at the horizon corresponding to the open interval in the well or to the head of the spring at each station in the Monitoring Network. Caution should be exercised in drawing unqualified conclusions and applying any results reported in this study to ground waters that are not being monitored.

Table 2-1. Georgia Ground-Water Monitoring Network, Calendar Year 2011.

Aquifer/Aquifer System	Number of Stations Visited (Samples Taken)	Primary Stratigraphic Equivalents	Age of Aquifer Rock Units
Cretaceous/ Providence	12 stations (12 samples)	Ripley Formation, Cusseta Sand, Blufftown Formation, Eutaw Formation, Tuscaloosa Formation, Providence Sand, Steel Creek Formation, Gaillard Formation, Pio Nono Formation	Late Cretaceous
Clayton	1 station (1 sample)	Clayton Formation	Paleocene
Claiborne	3 stations (3 samples)	Claiborne Group	Middle Eocene
Jacksonian	3 stations (3 samples)	Barnwell Group	Late Eocene
Floridan	28 stations (48 samples)	Ocala Group, Suwanee Limestone	Middle Eocene to Early Oligocene
Miocene/ Surficial	6 stations (6 samples)	Hawthorne Group, Miccosukee Formation, Cypresshead Formation	Miocene to Recent
Piedmont/Blue Ridge	18 stations (19 samples)	Various igneous and metamorphic complexes	Precambrian, Paleozoic, Mesozoic
Valley and Ridge/Appalachian Plateau	6 stations (7 samples)	Shady Dolomite, Knox Group, Conasauga Group, Ft. Payne Chert, Bangor and unnamed Mississippian limestones, Pottsville Formation	Cambrian and Ordovician; Mississippian and Pennsylvanian

Stations of the Ground-Water Monitoring Network are intentionally located away from known point sources of pollution. The stations are intended to provide baseline data on ambient water quality in Georgia. EPD requires other forms of ground-water monitoring for activities that may result in point source pollution (e.g., landfills, hazardous waste facilities, and land application sites) through its environmental facilities permit programs.

Ground-water quality changes gradually and predictably in the areally extensive aquifer systems of the Coastal Plain Province. The Monitoring Network allows for some definition of the chemical processes occurring in large confined aquifers. Unconfined aquifers in northern Georgia and in the surface recharge areas of southern Georgia are of comparatively small extent and more open to interactions with land use activities. The wide spacing of most monitoring stations does not permit equal characterization of water-quality processes in these settings. The quality of water from monitoring stations drawing from unconfined aquifers represents only the general nature of ground water in the vicinity of the stations. Ground water in the recharge areas of the Coastal Plain aquifer systems is a future drinking-water resource. Monitoring stations in these recharge areas, in effect, constitute an early warning system for potential future water quality problems in confined portions of the Coastal Plain aquifer systems.

2.3 ANALYSES AND DATA RETENTION

Analyses are available for 99 water samples collected from 77 stations (71 wells and 6 springs) during the period March 2011 through December 2011. In 1984, the first year of the Ground-Water Monitoring Network, EPD staff sampled from 39 wells in the Piedmont/Blue Ridge and Coastal Plain Provinces. Between 1984 and 2004, the network had expanded to include 128 stations situated in all three hydrogeologic provinces, with most of the stations being in the Coastal Plain Province.

Ground water from all monitoring stations is tested for chloride, sulfate, nitrate/nitrite, total phosphorus, metals by inductively coupled plasma spectrometry (ICP) and inductively coupled plasma spectrometry/mass spectrometry (ICPMS), and VOCs. Water from stations P12A and P23 also receives testing for fluoride.

Testing for aluminum, beryllium, calcium, cobalt, iron, potassium, magnesium, manganese, sodium, titanium, and vanadium was undertaken using the ICP method. Silver, arsenic, cadmium, chromium, copper, nickel, lead, antimony, selenium, thallium, and zinc were also analyzed using ICP, although inductively-coupled plasma mass spectrometry (ICPMS) gives better results for these metals. A high reporting limit attends the lab's current procedure for

analyzing potassium and is the reason for the lack of potassium detections. The ICPMS method was used to analyze chromium, nickel, copper, zinc, arsenic, selenium, molybdenum, silver, cadmium, tin, antimony, barium, thallium, lead, and uranium. This method generally works better for trace metals.

The results of the chemical tests are reported in this Circular. For metals for which both methods were employed, the ICPMS results are reported. Before collecting a sample, EPD personnel also observe certain field measurements – pH, conductivity, dissolved oxygen, and temperature. This Circular also reports these measurements.

Pursuant to the Georgia Safe Drinking Water Act of 1977, EPD has established MCLs for certain parameters included in analyses performed on Ground-Water Monitoring samples (EPD, 2009). Primary MCLs pertain to parameters that may have adverse effects on human health if their values are exceeded. Secondary MCLs pertain to parameters that may give drinking water objectionable, though not health-threatening, properties that may cause persons served by a public water system to cease using the water. Unpleasant taste and the capability to cause stains are examples of such properties. MCLs apply only to treated water offered for public consumption; nevertheless, they are useful guide lines for evaluating the quality of untreated (raw) water. Table A-10 in the Appendix lists the Primary and Secondary MCLs for Ground-Water Monitoring Network parameters.

Most wells currently on the Monitoring Network have in-place pumps. Using such pumps to purge wells and collect samples reduces the potential for cross-contamination that would attend the use of portable pumps. Two wells, PA9C and MI17, are flowing, which dispenses altogether with pumps and negates the effects of the pump-well system on sample water. The pump on well MI9A, a shallow bored well formerly used for garden watering, is now out of operation, and, a bailer is used for sampling.

Sampling procedures are adapted from techniques used by USGS and USEPA. For all wells except PA9C, MI9A, and MI17, EPD personnel purge the wells (EPA recommends removing three to five times the volume of the water column in the well) before collecting a sample to reduce the influence of the well, pump, and plumbing system on water quality. A purge of 15 to 20 minutes is usually sufficient to allow for readings of pH, conductivity, temperature, and dissolved oxygen to stabilize and for corrosion films on the plumbing to be flushed away.

The apparatus used for monitoring field measurements and collecting samples consists of a garden hose with two branches at its end and a container. One branch conveys water to the container; the other branch allows the water to flow freely. On the container branch, water enters the bottom of the container, flows past the probe of the instrument taking field measurements, and discharges

over the top of the container. Such an apparatus minimizes the exposure of the sample water to atmosphere. Once the field measurements have stabilized, sample containers are then filled with water discharging from the end of the free-flowing branch. As a rule, trends for field measurements with increasing purge time include a lowering of pH, conductivity, and dissolved oxygen. For shallower wells, the temperature tends to approach the mean atmospheric temperature. For deeper wells, geothermal heating may raise the water temperature above the mean atmospheric level.

Once the sample bottles are filled, they are promptly placed on ice to preserve water quality. EPD personnel transport samples to the laboratory on or before the Friday of the week during which the samples were collected, well before holding time for the samples lapse. Field measurements and analytical results are provided in the Appendix.

Files at EPD contain records of the field measurements and chemical analyses. Owners of wells or springs receive copies of the laboratory analysis sheets as well as cover letters and laboratory sheet summaries. The cover letters state whether or not any MCLs were exceeded. The Drinking Water Program's Compliance and Enforcement Unit receives notification of Primary MCL exceedances involving public water supplies.

CHAPTER 3 GROUND-WATER QUALITY IN GEORGIA

3.1 OVERVIEW

Georgia's major aquifer systems are grouped into three hydrogeologic provinces for the purposes of this report.

The Coastal Plain Province major aquifers and aquifer systems are restricted to specific regions and depths within the Province (Figure 3-1). These major aquifer systems commonly incorporate smaller aquifers that are locally confined. Ground-Water Monitoring Network wells in the Coastal Plain aquifer systems are generally located in three settings:

1. Recharge (or outcrop) areas that are located in regions that are geologically updip and generally north of confined portions of these aquifers and aquifer systems;
2. Updip, confined areas that are located in regions that are proximal to the recharge areas, yet are confined by overlying geologic formations. These are generally south to southeast of the recharge areas;
3. DOWNDIP, confined areas, located to the south or southeast in the deeper, confined portions of the aquifer systems, distal to the recharge areas.

The Piedmont/Blue Ridge Province comprises two regional aquifers, the regolith aquifer and the bedrock aquifer (Daniel and Harned, 1997). The regolith aquifer is composed of saprolite – bedrock that has undergone intense chemical weathering -- plus soil and alluvium. The regolith aquifer, highly porous and appreciably permeable, serves as the reservoir that recharges the bedrock. The igneous and metamorphic bedrock exhibits low porosity – nearly all of the porosity consists of fractures -- but can be very permeable as fractures can transmit water rapidly. Despite the regional scale of these two aquifers, flow systems are small-scale and localized, unlike those of the Coastal Plain.

Sedimentary formations characterize the Valley and Ridge/Appalachian Plateau Province, although, unlike in the Coastal Plain, these sedimentary formations are consolidated and have been subjected to faulting and folding. Whereas extensive regional aquifers characterize the Coastal Plain Province, faulting and folding has resulted in the creation of numerous localized flow systems in the Valley and Ridge Province. The major water-bearing units in this province are carbonate rocks. Faulting and fracturing of the carbonates has led to the

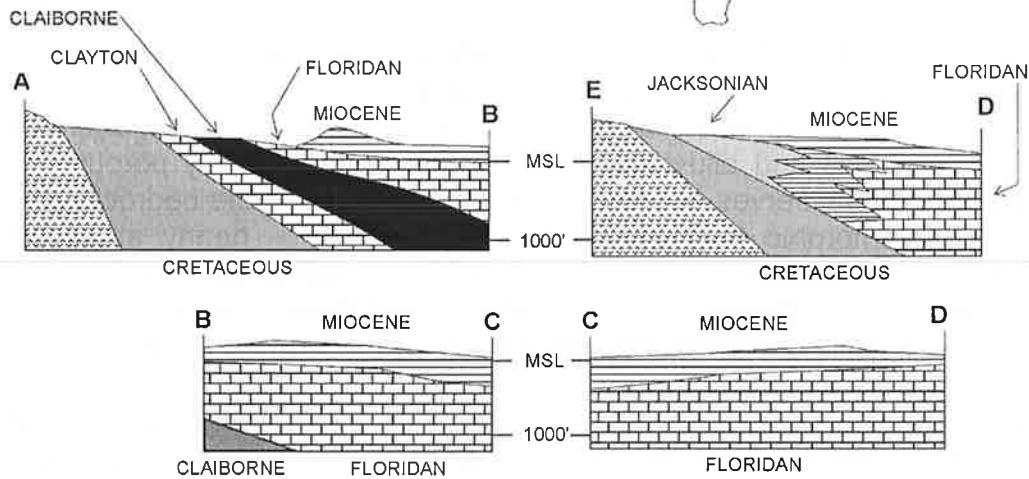
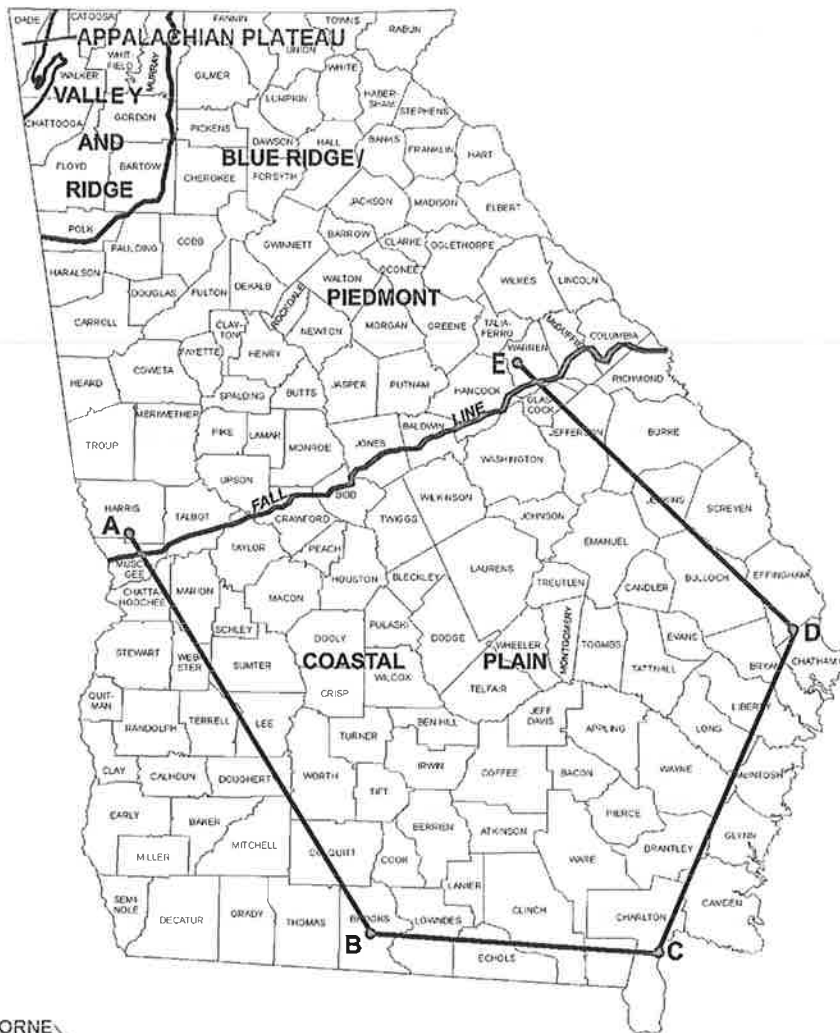


Figure 3-1. The Major Aquifers and Aquifer Systems of the Coastal Plain Province (after Davis, 1990).

widespread development of karst features, which significantly enhance porosity and permeability and exert a strong influence on local flow patterns.

3.2 CRETACEOUS/PROVIDENCE AQUIFER SYSTEM

The Cretaceous aquifer system is a complexly interconnected group of aquifer subsystems developed in the late Cretaceous sands of the Coastal Plain Province. These sands crop out in an extensive recharge area immediately south of the Fall Line in west and central Georgia (Fig. 3-2). In east Georgia, overlying Tertiary sediments restrict Cretaceous outcrops to valley bottoms. Five distinct subsystems of the Cretaceous aquifer system, including the Providence aquifer system, are recognized west of the Ocmulgee River (Pollard and Vorhis, 1980). These merge into three subsystems to the east (Clarke et al, 1985; Huddleston and Summerour, 1996). The aquifer thickens southward from the Fall line, where the clays and sands pinch out against crystalline Piedmont rocks to a column approximately 2,000 feet thick at the southern limits of the main aquifer use area (limit of utilization, Figure 3-2).

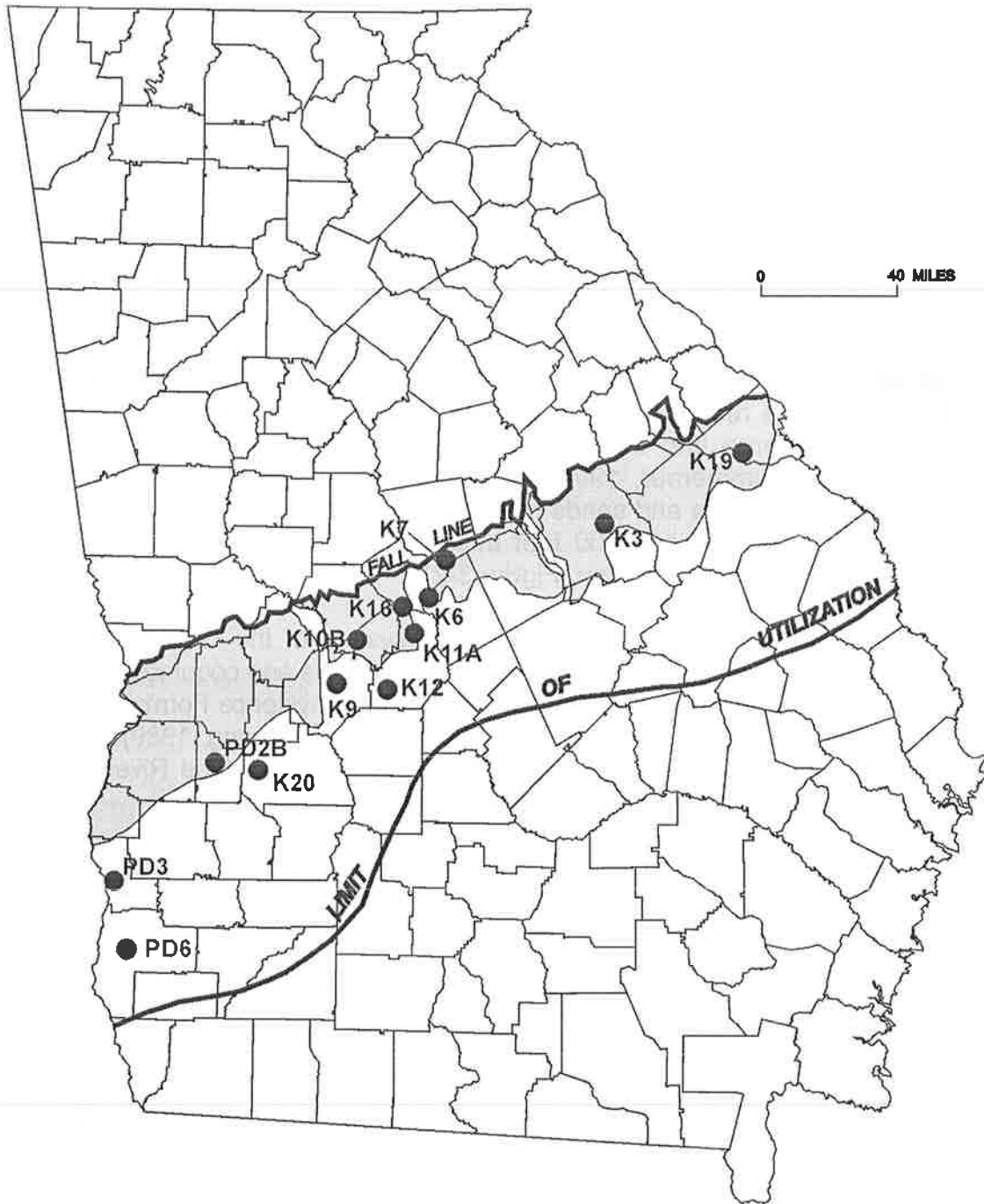
The Providence aquifer, a prominent subsystem of the Cretaceous aquifer system in the western Coastal Plain, is developed in sands and coquinoid limestones at the top of the Cretaceous column. The permeable Providence Formation-Clayton Formation interval forms a single aquifer in the updip areas (Long, 1989) and to the east of the Flint River (Clarke et al., 1983). East of the Ocmulgee River, this joint permeable interval is termed the Dublin aquifer (Clarke et al., 1985).

EPD used 12 wells to monitor the Cretaceous/Providence aquifer system. Reported depths ranged from 128 feet (K7) to 1025 feet (PD6). All except well K6 are local government-owned public supply wells. Well K6 produces process water for a kaolin mill. All wells are sampled yearly. Table A-1 in the Appendix reports field and laboratory results.

3.2.1 Field parameters

The pHs of sample waters from all 12 wells ranged from 3.07 (K12) to 8.40 (PD6). As a rule, pHs of waters from the deeper wells are basic, while those from shallower wells are acidic. Well PD3 seems to be the exception, a well with a moderate reported depth of 456 feet, giving water with a pH of 8.37, characteristic of waters from wells twice its depth. Conductivities are available for all 12 wells and ranged from 10 uS/cm (K19) to 362 uS/cm (PD3), with a median of 34 uS/cm. As a rule, the deeper wells gave water with the higher conductivities. Again, well PD3 was the exception.

The temperatures measured should be viewed as approximations of the temperature of the water in the aquifer. Temperatures for all 12 wells ranged



- General recharge area (from Davis et al., 1989)
- Sampling station

Figure 3-2. Locations of Stations Monitoring the Cretaceous Aquifer System.

from 17.6 °C (K7) to 28.6 °C (K20). A review of the well depths shows that the deeper wells yield water with higher temperatures.

Dissolved oxygen measurements are available for eight of the 12 wells. Concentrations ranged from 8.90 mg/L (Marshallville #2, K9A) down to 0.59 mg/L (Fort Gaines #2, PD3). Dissolved oxygen measurements can suffer from various interferences, processes that can expose the ground water to oxygen. An inadequately purged well may deliver water that has been in contact with air in the well bore. Pumping the water level in the well below a recharging horizon allows the water to “cascade” or fall freely down the well bore, splash, and aerate.

3.2.2 Major Anions, Non-Metals, and Volatile Organic Compounds

Testing for chloride, sulfate, combined nitrate/nitrite, total phosphorus, and volatile organic compounds (VOCs) was done for samples from all 12 wells. Detectable chloride, at a concentration of 12 mg/L, occurred in a sample from only one well (PD3). Sulfate was detected in samples from five wells, with concentrations at or below 14 mg/L. Nitrate/nitrite, detected in samples from eight wells, ranged up to 2.0 mg/L. Samples from six wells contained detectable phosphorus, with concentrations ranging up to 0.99 mg/L.

3.2.3 Metals by Inductively-Coupled Plasma Spectrometry (ICP)

Testing for metals was performed on samples from all 12 stations using the ICP method. All 12 samples contained detectable sodium, which ranged from 1,000 ug/L (K9A) to 82,000 ug/L (PD3). Three wells - K20, PD3, and PD6 – gave samples with sodium contents far higher than the remainder of the wells. Two of these, K20 and PD6, were also the two deepest wells.

Eight wells gave samples with detectable aluminum, with concentrations up to 460 ug/L (K12). Seven samples contained detectable calcium, and, seven contained detectable iron. Calcium levels ranged up to 22,000 ug/L. Iron levels ranged up to 320 ug/L (K12) with only well K12 exceeding the Secondary MCL of 300 ug/L. Samples from four wells contained detectable magnesium, with a maximum value of 3,800 ug/L. Two wells gave samples with detectable manganese, and, one with detectable vanadium. Beryllium, cobalt, potassium, and titanium were undetected.

3.2.4 Metals by Inductively-Coupled Plasma Mass Spectrometry (ICPMS)

ICPMS analysis found only copper, zinc, barium, lead, and uranium. Barium was detected in 11 samples, with a maximum concentration of 23 ug/L (K3). Lead was detected in samples from seven wells, with a concentration range

up to 330 ug/L (K9A). The concentration in the sample from well K9A far exceeded the action level of 15 ug/L and seems to be due to entrainment from a corrosion film on a little-used spigot into the sample water. Copper was detected in six samples and ranged in concentration up to 120 ug/L (K9A). Zinc was detected in three samples, at levels up to 64 ug/L (K9A). Copper, lead, and zinc are commonly introduced into sample water from plumbing and are not necessarily present naturally. Uranium was detected in one sample (K6) at a level of 1.3 ug/L.

3.3 CLAYTON AQUIFER

The Clayton aquifer of southwestern Georgia is developed mainly in the middle limestone unit of the Paleocene Clayton Formation. Limestones and calcareous sands of the Clayton aquifer crop out in a narrow belt extending from northeastern Clay County to southwestern Schley County (Figure 3-3). Aquifer thickness varies, ranging from about 50 feet in the outcrop area to 265 feet in southeastern Mitchell County (Clarke et al., 1984). Leakage from the underlying Providence aquifer system and from overlying permeable units in the Wilcox Formation confining zone provides significant recharge in downdip areas (Clarke et al., 1984). As mentioned previously, permeable portions of the Clayton and Providence Formations merge to form a single aquifer in the updip area and east of the Ocmulgee River. East of that river these combined permeable zones are called the Dublin aquifer.

Only one well (CT8), an 80-foot deep domestic well, was available to monitor the Clayton aquifer system (Figure 3-3) (Appendix Table A-2). The well is sampled yearly. The well water had a pH of 4.22, an electrical conductivity of 41 uS/cm, and a temperature of 18.00 °C. Dissolved oxygen was 8.00 mg/L and nitrate/nitrite registered at 1.8 mg/L as nitrogen. The water contained sodium at 2,800 ug/L, potassium at a level of 1,100 ug/L, aluminum at a level of 100 ug/L, and manganese at a level of 25 ug/L. Copper at a concentration of 8 ug/L and barium at a concentration of 20 ug/L were the two trace metals detected.

3.4 CLAIBORNE AQUIFER

The Claiborne aquifer is developed primarily in the sandy units in the middle and lower portion of the Middle Eocene Claiborne Group of southwestern Georgia. Claiborne Group sands crop out in a belt extending from northern Early County through western Dooly County. Recharge to the aquifer occurs both as direct infiltration of precipitation in the recharge area and as leakage from the overlying Floridan aquifer system (Hicks et al., 1981; Gorday et al., 1997). The

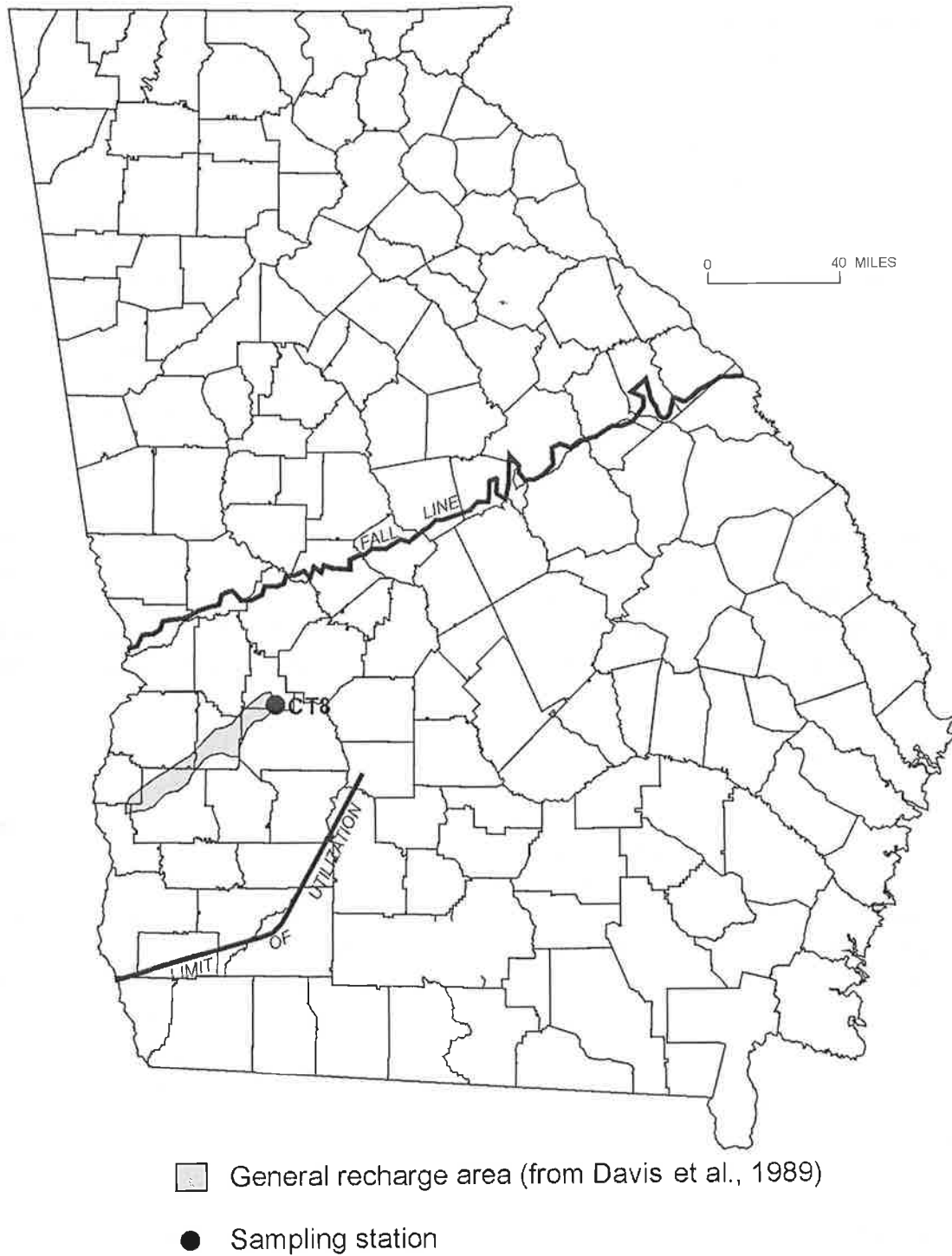


Figure 3-3. Location of the Station Monitoring the Clayton Aquifer.

discharge boundaries for the updip portion of the aquifer are the Ocmulgee River to the east and the Chattahoochee River to the west. The aquifer is more than 350 feet thick near its downdip limit of utilization (Figure 3-4) (Tuohy, 1984).

The aquifer generally thickens to the southeast. The clay-rich upper portion of the Claiborne Group, the Lisbon Formation, acts as a confining layer and separates the Claiborne aquifer system from the overlying Floridan aquifer system (McFadden and Perriello, 1983; Long, 1989; Huddlestun and Summerour, 1996). The lower, water-bearing parts of the group had been correlated with the Tallahatta Formation (e.g., McFadden and Perriello, 1983; Long, 1989; Clarke et al., 1996) or more recently, have been divided into two formations, the upper one termed the Still Branch Sand and the lower one correlated to the Congaree Formation (Huddlestun and Summerour, 1996). East of the Ocmulgee River, permeable Congaree-equivalent sands are included in the Gordon aquifer (Brooks et al., 1985).

Three stations, all in or near the recharge area, were available to monitor the Claiborne aquifer system (Figure 3-4) (Appendix Table A-3). Wells CL2 and CL4A are municipal public supply wells, and, well CL8 supplies water for drinking and other purposes for a State forestry nursery. Well CL2 is 315 feet deep, and, CL4A is 230 feet deep. The depth of CL8 is not known precisely, but is in the vicinity of 100 feet.

3.4.1 Field parameters

The pHs of sample waters from two wells was mildly acidic (CL8 at 5.96 and CL4A at 6.86) while the third was mildly basic (CL2 at 7.29). Conductivities registered at 84 uS/cm (CL8), 151 uS/cm (CL4A), and 200 uS/cm (CL2); and, temperatures registered at 20.0 °C (CL4A), 20.2 °C (CL2), and 21.4 °C (CL8). The somewhat higher temperature for sample water from well CL8 is likely due to the fact that the well was sampled at a point about 200 feet from the well head during warm weather (springtime, late afternoon), whereas the sampling points for the other two wells are at the wellheads. Dissolved oxygen contents measured at 0.58 mg/L (CL8), 3.18 mg/L (CL2), and 10.00 mg/L (CL4A). The CL4A sampling point was a small spigot that would not accommodate the sampling apparatus. Thus the sample water was well exposed to air and entrained much oxygen.

3.4.2 Major Anions, Non-Metals, and Volatile Organic Compounds

None of the samples contained detectable chloride or VOCs. Samples from wells CL4A and CL8 contained, respectively, 12 mg/L and 10 mg/L sulfate. Well CL2 gave a sample with a nitrate/nitrite concentration of 0.39 mg/L as nitrogen. Samples from all three wells contained detectable phosphorus (CL2 at 0.03 mg/L, CL4A at 0.35 mg/L, CL8 at 0.51 mg/L).

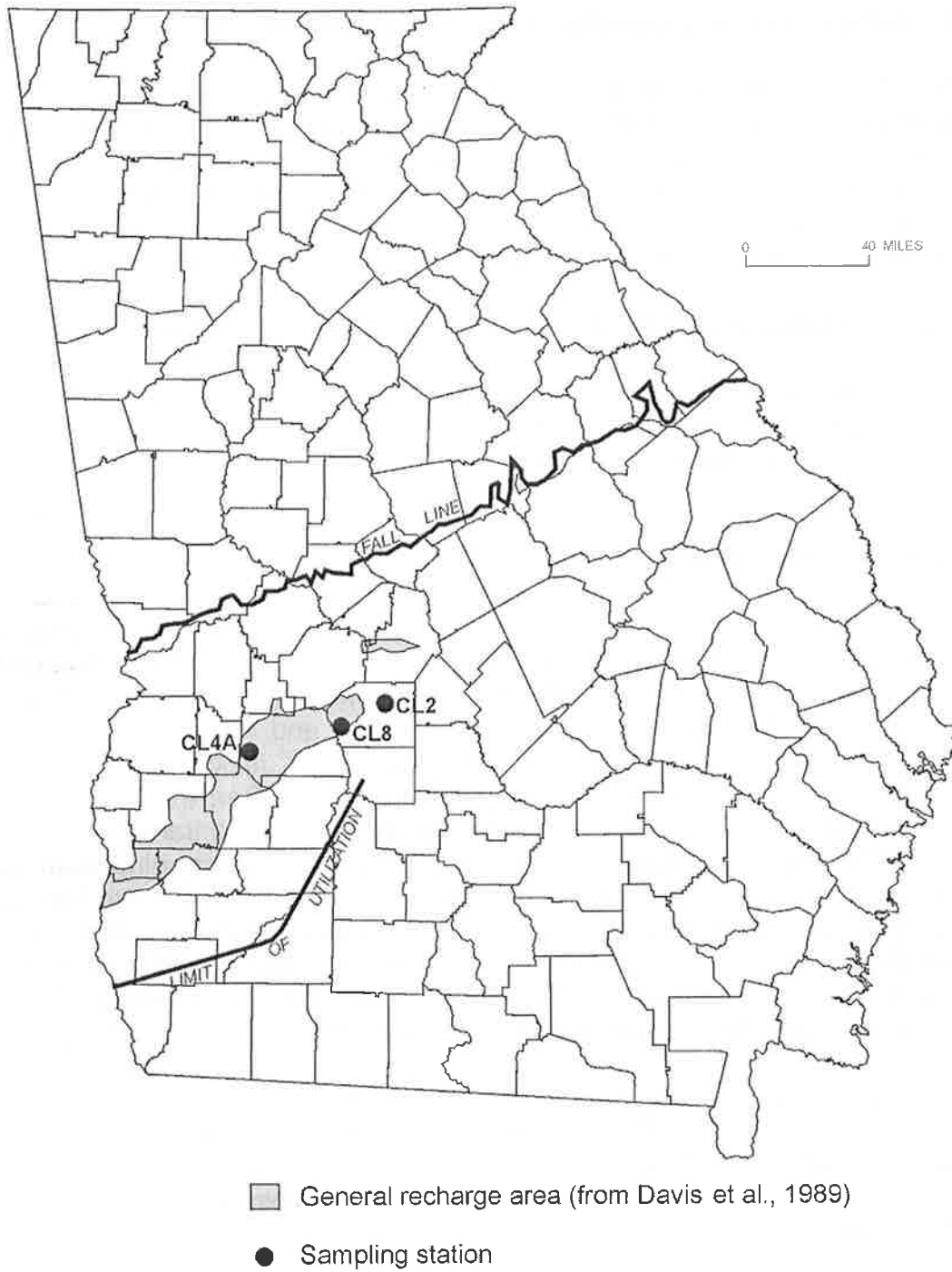


Figure 3-4. Locations of Stations Monitoring the Claiborne Aquifer.

3.4.3 Metals by Inductively-Coupled Plasma Spectrometry (ICP)

Well CL2 was the only well to give a sample with detectable aluminum (60 ug/L). Wells CL4A and CL8 both gave samples containing detectable iron and manganese. With iron levels of 1,900 ug/L for the CL4A sample and 850 ug/L for the CL8 sample and waters from both wells exceeded the 300 ug/L Secondary MCL for iron. Likewise, the manganese levels of 69 ug/L for CL4A and 56 ug/L for CL8 both exceeded the Secondary MCL for that metal of 50 ug/L.

3.4.4 Metals by Inductively-Coupled Plasma Mass Spectrometry (ICPMS)

ICPMS analyses found no trace metals other than barium in any of the samples. Barium levels were 11 ug/L for the CL2 sample, 15 ug/L for the CL4A sample, and 36 ug/L for the CL8 sample.

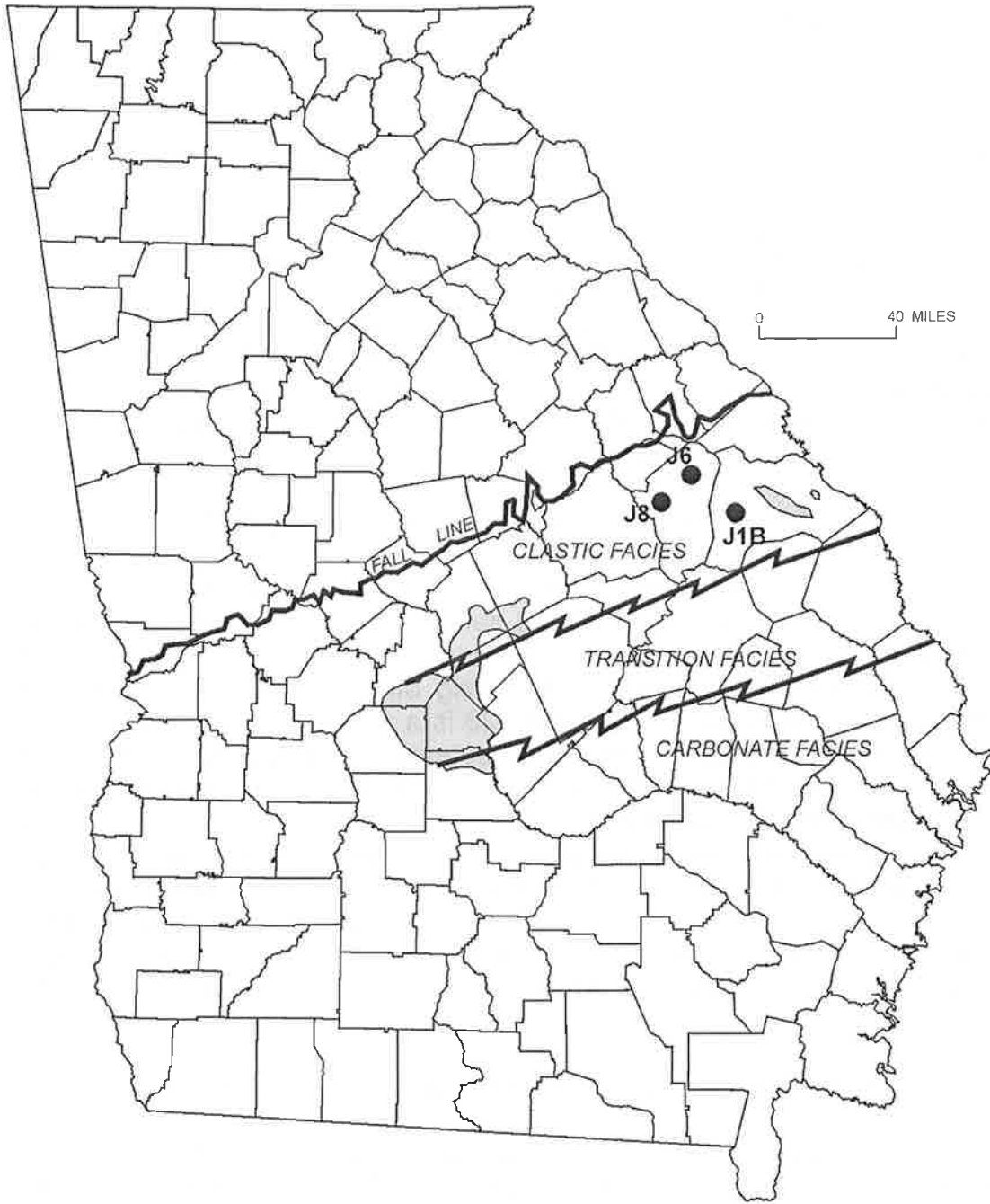
3.5 JACKSONIAN AQUIFER

The Jacksonian aquifer of central and east-central Georgia is developed primarily in sands of the Eocene Barnwell Group, though isolated limestone bodies are locally important. Barnwell Group outcrops extend from Macon and Crawford Counties (Hetrick, 1990) eastward to Burke and Richmond Counties (Hetrick, 1992). Figure 3-5 shows the most significant Jacksonian recharge areas. Aquifer sands form a northern clastic facies of the Barnwell Group; the sands grade southward into less permeable silts and clays of a transition facies (Vincent, 1982). The water-bearing sands are relatively thin, ranging from 10 to 50 feet in thickness. Limestones equivalent to the Barnwell Group form a southern carbonate facies and are included in the Floridan aquifer system. The Savannah River and the Ocmulgee River are the eastern and western discharge boundaries for the updip parts of the Jacksonian aquifer. The Jacksonian aquifer is equivalent to the Upper Three Runs aquifer as used in Summerour et al. (1994).

Three wells were available to monitor the Jacksonian aquifer (Figure 3-5, Appendix Table A-4). Wells J1B and J8 are domestic wells, while well J6 is a public supply well. Well J8 is a shallow bored well in the up-dip outcrop area, whereas J1B (approximately 100 feet deep) and J6 (200 feet deep) are deeper drilled wells. All wells are sampled yearly.

3.5.1 Field parameters

The pHs for wells J1B and J6 were slightly basic, at 7.07 and 7.08 respectively; pH of J8 was acidic at 4.74. Conductivities were higher for J1B and J6 at 283 uS/cm and 260 uS/cm respectively. The conductivity for well J8 was 74 uS/cm. Temperatures for all three well waters were nearly the same at 19.2 °C for J1B, 19.6 °C for J6, and 19.4 °C for J8. Dissolved oxygen concentrations were highest



- General recharge area (from Davis et al., 1989)
- Sampling station

Figure 3-5. Locations of Stations Monitoring the Jacksonian Aquifer.

at 8.14 mg/L in water from the shallow well J8 and lowest at 0.71 mg/L in municipal well J6. Water from domestic well J1B registered a dissolved oxygen content of 5.13 mg/L.

3.5.2 Major Anions, Non-Metals, and Volatile Organic Compounds

Chloride was detected in sample waters from well J1B (11 mg/L) and well J8 (10 mg/L). Sample water from well J6 contained detectable sulfate (14 mg/L). Nitrate/nitrite was detected in samples from wells J1B and J8. The content in the J1B sample at 2.4 mg/L as nitrogen was within the presumably natural range of 3.0 mg/L or less. The content in the J8 sample at 4.8 mg/L as nitrogen was in the human-influenced range of greater than 3 mg/L (Daniels and Messner, 2010). Phosphorus was detected in water from well J1B (0.04 mg/L) and in water from well J6 (0.15 mg/L). No VOCs were detected.

3.5.3 Metals by Inductively-Coupled Plasma Spectrometry (ICP)

Waters from all three wells contained detectable aluminum, with the J1B sample registering 310 ug/L, the J6 sample registering 67 ug/L, and the J8 sample registering 110 ug/L. The Secondary MCL for aluminum is a range from 50 ug/L to 200 ug/L, depending on the ability of a treatment system to remove aluminum. Only well J6 is a public well with a treatment system. All three wells gave waters with detectable calcium, with well water from J1B containing 54,000 ug/L, well water from J6 containing 47,000 ug/L, and well water from J8 containing 6,800 ug/L. Waters from all three wells also contained sodium, with water from J1B containing 4,200 ug/L, from J6 containing 1,800 ug/L, and from J8 containing 3,700 ug/L. Magnesium was detected in samples from two wells, J6 (1,400 mg/L) and J8 (1,200 ug/L). Well J6 gave a sample containing 76 ug/L iron; and, well J8 gave a sample containing 51 ug/L manganese, which exceeds the Secondary MCL of 50 ug/L.

3.5.4 Metals by Inductively-Coupled Plasma Mass Spectrometry (ICPMS)

All three wells contained detectable barium, with the sample from J1B registering 23 ug/L, the sample from J6 registering 8.5 ug/L, and the sample from J8 registering 30 ug/L. The sample from J8 contained a variety of trace metals besides barium: nickel (11 ug/L), zinc (30 ug/L), cadmium (0.96 ug/L), and lead (2.9 ug/L). Samples from the other two wells contained no detectable trace metals other than barium. The cadmium content did not exceed the Primary MCL of 5 ug/L. The lead and zinc and, possibly, the cadmium and nickel were probably leached from materials used to construct the well and its plumbing.

3.6 FLORIDAN AQUIFER SYSTEM

The Floridan aquifer system is developed predominantly in Eocene and Oligocene limestones and dolostones that underlie most of the Coastal Plain Province. The aquifer is a major source of ground water for much of its outcrop area and throughout its downdip extent to the south and east.

The upper water-bearing units of the Floridan are the Eocene Ocala Group and the Oligocene Suwanee Limestone (Crews and Huddlestun, 1984). These limestones crop out in the Dougherty Plain (a karstic area in southwestern Georgia) and in adjacent areas along strike to the northeast. In parts of Camden and Wayne Counties, the Oligocene unit is absent, and, the upper part of the Floridan is restricted to units of Eocene age (Clarke et al., 1990). The lower permeable zone of the Floridan consists mainly of dolomitic limestone of middle and early Eocene age and pelletal, vuggy, dolomitic limestone of Paleocene age but extends into the late Cretaceous in Glynn County. From its up-dip limit, defined by clays of the Barnwell Group, the aquifer system thickens to well over 700 feet in coastal Georgia. A dense limestone facies along the trend of the Gulf Trough locally limits ground-water quality and availability (Kellam and Gorday, 1990; Applied Coastal Research Laboratory, 2002). The Gulf Trough probably is a filled marine-current channel that extends from southwestern Decatur County through northern Effingham County.

A ground-water divide separates a smaller southwestward flow regime in the Floridan aquifer system in the Dougherty Plain from the large southeastward flow regime in the remainder of Georgia. Rainfall infiltration in outcrop areas and downward leakage from extensive surficial residuum recharge the Dougherty Plain flow system (Hayes et al., 1983). The main body of the Floridan aquifer system to the east is recharged by leakage from the Jacksonian aquifer system and by rainfall infiltration in outcrop areas and in areas where overlying strata are thin. Significant recharge also occurs in the area of Brooks, Echols, Lowndes, Cook, and Lanier Counties, where the Withlacoochee River and numerous sinkholes breach the upper confining units (Krause, 1979).

Monitoring water quality in the Floridan aquifer system made use of 28 wells, with 18 scheduled for sampling on a yearly basis and 10 on a quarterly basis (sampled three times during 2011) (Figure 3-6). The total number of samples collected from the wells was 48. All 28 wells are drilled wells. Twenty four of the wells are local-government owned public supply wells. Two of the wells supply industrial process water. One of the wells is a domestic-type well supplying a church and a pastorium, and, another is a former USGS test well. Depths range from 97 feet (PA49, church well) to 1,211 feet (PA9C, test well). Table A-6 in the Appendix gives field and laboratory results.

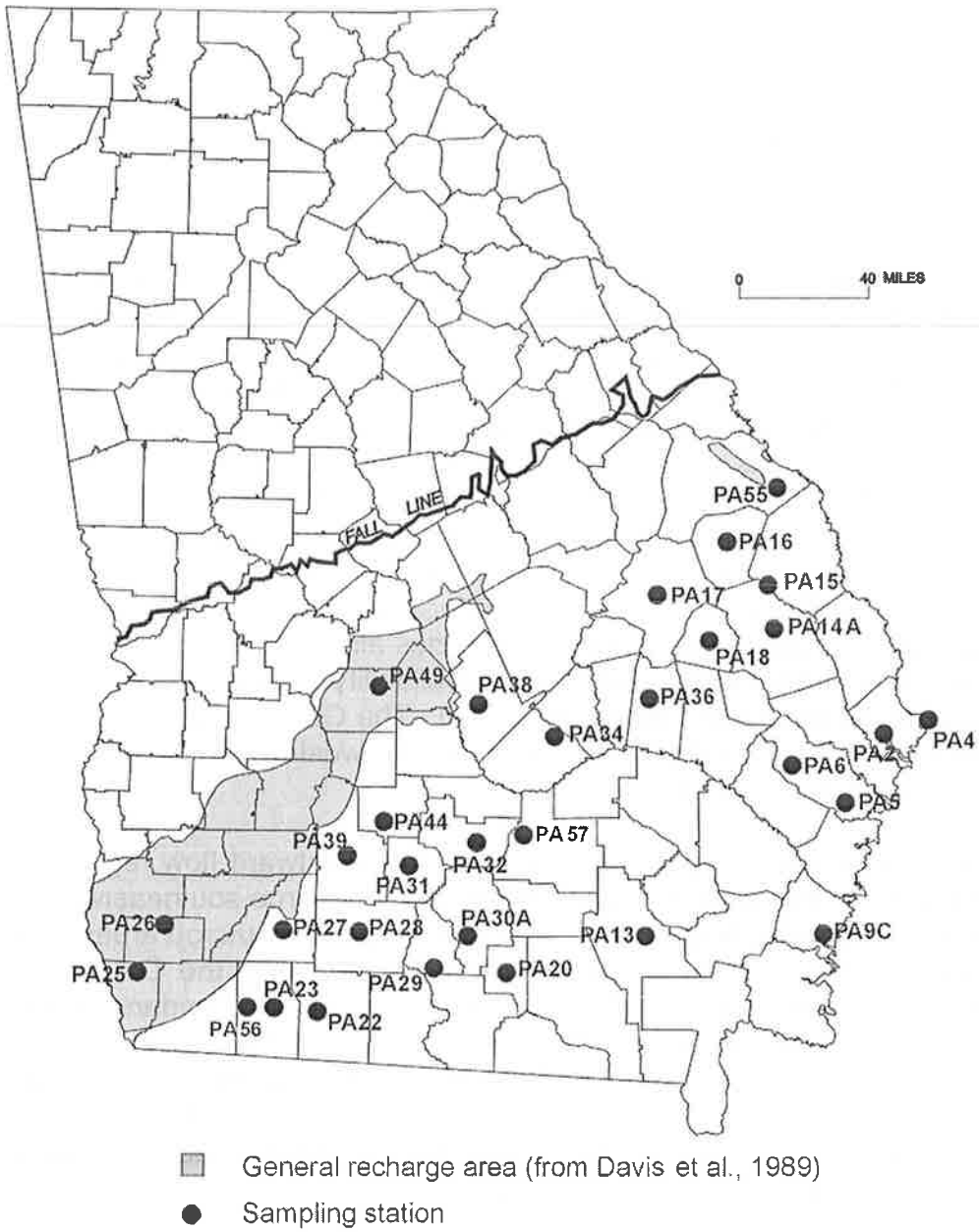


Figure 3-6. Locations of Stations Monitoring the Floridan Aquifer System.

3.6.1 Field parameters

Measurements of pH are available for all samples and ranged from 7.01 (PA39) to 8.49 (PA30). Conductivities are also available for all samples and ranged from 142 uS/cm (PA36) to 488 uS/cm (PA28). Temperatures are available for all sampling events and ranged from 20.3 °C for well PA27 to 28.1 °C for well PA9C. Well PA9C is the deepest of the Floridan wells at 1,211 feet, so the high temperature reflects the geothermal effect. Thirty seven dissolved oxygen measurements are available from 23 wells. At some stations, dissolved oxygen measurements were not taken because of equipment problems. At well PA14A, the raw water outlet is such that exposure of monitoring water and sampling water to air cannot be avoided.

3.6.2 Major Anions, Non-Metals, and Volatile Organic Compounds

Of the 10 wells scheduled for quarterly sampling, wells PA23, PA28, and PA56 gave eight samples with detectable chloride out of a total of nine samples collected. Levels ranged from undetected to 36 mg/L (PA56). Four wells (PA2, PA4, PA9C, PA13) of the 18 scheduled for annual sampling gave samples with detectable chloride, with concentrations ranging from 11 mg/L (PA2) to 730 mg/L (PA9C) (Secondary MCL of 250 mg/L). The 730 mg/L level occurred in well PA9C and is more than 16 times the next highest concentration of 44 mg/L in the sample from well PA4. Well PA9C derives water from the lower permeable zone of the Floridan aquifer. The remaining 21 wells and 39 samples contained no detectable chloride. Four of the 10 quarterly wells (PA23, PA28, PA29, PA56) gave 12 samples containing detectable sulfate, with concentrations ranging from 19 mg/L (PA6) to 170 mg/L (PA28). Eight of the 18 annual wells gave samples containing detectable sulfate. Levels ranged from 23 mg/L (PA6) to 170 mg/L (PA9C). The remaining six quarterly wells and 10 annual wells gave samples with no detectable sulfate. Wells PA23, PA25, PA28, PA44, and PA56 of the 10 quarterly sampled wells gave 13 samples with detectable nitrate/nitrite. Levels ranged from undetected to 1.7 mg/L (PA25) as nitrogen. Eight annually sampled wells gave samples with detectable nitrate/nitrite. Levels ranged from 0.02 mg/L as nitrogen (PA2) to 2.2 mg/L as nitrogen (PA49). The remaining 15 wells gave samples with no detectable nitrate/nitrite. There is some tendency for shallower wells to give samples with higher levels of nitrate/nitrite. Nitrate/nitrite levels in the samples from each quarterly well tend, as a rule, to be similar to one another. Phosphorus was detected in 41 of 48 samples from 26 of 28 wells. Fourteen of 16 annual wells gave samples with detectable phosphorus. All 10 quarterly wells gave samples with detectable phosphorus, with five giving one sample with no detectable phosphorus. Phosphorus levels ranged up to 0.07 mg/L (PA20, annual) as total phosphorus. Volatile organic compounds were detected in one sample each from wells PA28 (Moultrie #1) and PA44 (Sycamore #2) and in all three samples from well PA23 (Cairo #8). All VOCs detected were from the trihalomethane family of compounds.

3.6.3 Metals by Inductively-Coupled Plasma Spectrometry (ICP)

ICP analyses found detectable levels of potassium, aluminum, manganese, iron, calcium, magnesium, and sodium. Detectable potassium occurred in only one sample (PA9C). Failure to find detectable potassium in other samples results from the insensitivity of the testing procedure, as indicated by the high reporting limit (5,000 ug/L) for the metal. Detectable aluminum was found in three samples (PA6, PA13, PA20). The levels lie within the 50 ug/L to 200 ug/L Secondary MCL range. Detectable manganese occurred in 12 samples from six wells. Three of the six are sampled quarterly and all samples from each of the three contained detectable manganese. The manganese concentrations in the sample from one of the annually sampled wells (PA18) and in all three samples from one of the quarterly sampled wells (PA34A) exceeded the Secondary MCL of 50 ug/L. The manganese levels in the samples from each of the quarterly sampled wells vary within a restricted range. Iron was detected in 17 samples from nine wells, six of them quarterly wells and three annual wells. Two samples from two wells, annually sampled PA9C and quarterly sampled PA23, exceeded the Secondary MCL of 300 ug/L. The iron contents of samples from two quarterly wells (PA34A and PA36) varied within restricted ranges, while iron contents of samples from two other quarterly wells (PA23 and PA29) varied considerably, with order-of-magnitude differences. Detectable magnesium was found in 27 samples from the 10 quarterly sampled wells and in 17 samples from the 18 annually sampled wells. Magnesium concentrations ranged up to 76,000 ug/L. The three samples from quarterly well PA25 and the sample from annual well PA49 lacked detectable magnesium. Both wells are Floridan recharge area wells. Magnesium levels in samples from the quarterly wells seem to vary within relatively narrow limits. Calcium was detected in all samples from the 28 Floridan wells. Concentrations ranged from 22,000 ug/L (PA2) to 100,000 ug/L (PA9C). For samples from quarterly wells, calcium concentrations seem to fall within narrow ranges.

3.6.4 Metals by Inductively-Coupled Plasma Mass Spectrometry (ICPMS)

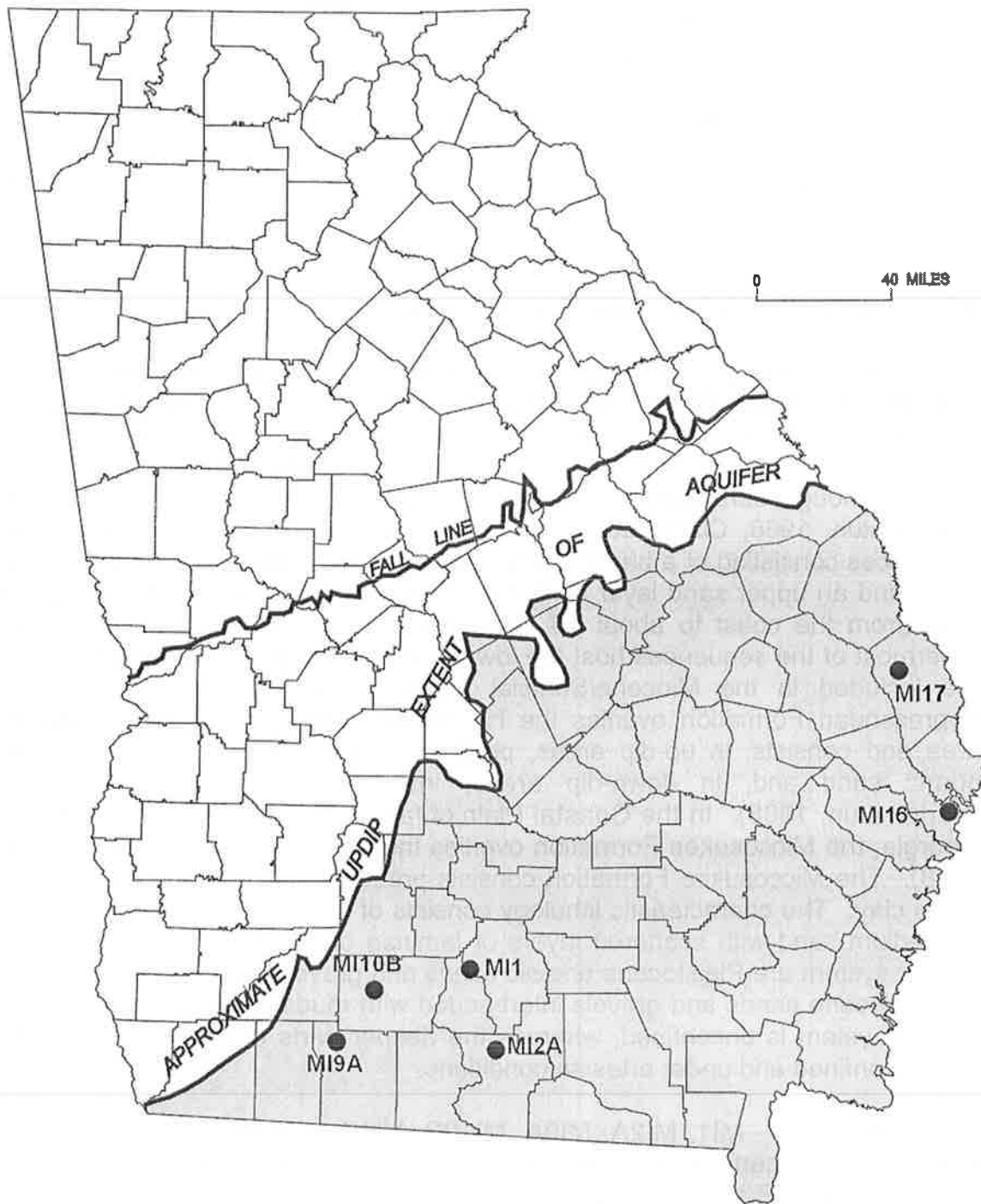
ICPMS analysis found detectable chromium, copper, zinc, arsenic, molybdenum, barium, and lead in the Floridan samples. The single chromium detection occurred in a sample taken shortly after quarterly well PA44 and its associated plumbing underwent maintenance. The sample also contained some trihalomethanes, presumably from post-maintenance disinfection of the well and its plumbing. Three samples contained detectable copper. Two were from quarterly wells PA14A and PA23, and, one from annual well PA9C. Wells PA9C and PA23 also gave the only two samples containing detectable zinc. Arsenic, at levels below the Primary MCL, was found in two samples from quarterly well PA23 but in no others. Molybdenum was detected in all six samples from two quarterly wells PA23 and PA56. Barium was detected in all samples from all wells and ranged in concentration from 3.9 ug/L to 200 ug/L. Barium seems to be

more abundant in samples from wells of a 400-foot to 700-foot depth range. Lead was detected in 10 samples from nine wells, with four of the wells being quarterly. All detections were below the action level of 15 ug/L. Eleven samples from seven wells contained detectable uranium. Quarterly wells PA44 and PA56 always gave samples with detectable uranium, while quarterly wells PA23 and PA29 did so occasionally. No samples exceeded the 30 ug/L Primary MCL for uranium.

3.7 MIOCENE/SURFICIAL AQUIFER SYSTEM

The Miocene/Surficial aquifer system is developed in sands of the Miocene Hawthorne Group and of the Pliocene Miccosukee and Cypresshead Formations of the Georgia Coastal Plain. The Hawthorne Group covers most of the Coastal Plain and consists predominantly of sand and clay (Huddleston, 1988), although carbonate rocks and phosphorites may locally be significant (Huddleston, 1988; Clarke et al., 1990). Clarke et al. (1990) note that three sequences consisting of a basal dense phosphatic limestone layer, a middle clay layer, and an upper sand layer typify the Miocene section in the Atlantic coastal area (from the coast to about 45 miles inland). The sand layers in the two lowermost of the sequences host the lower and upper Brunswick aquifers, which are included in the Miocene/Surficial aquifer system of this report. The Cypresshead Formation overlies the Hawthorne Group in the Atlantic coastal area and consists, in up-dip areas, predominantly of fine- to coarse- grained quartz sand and, in down-dip areas, interbedded fine sand and clay (Huddleston, 1988). In the Coastal Plain of far south central and southwestern Georgia, the Miccosukee Formation overlies the Hawthorne Group (Huddleston, 1988). The Miccosukee Formation consists predominantly of sand but contains some clay. The characteristic lithology consists of thin-bedded to laminated fine to medium sand with scattered layers or laminae of clay. Also included in the aquifer system are Pleistocene arkosic sands and gravels interbedded with clays and Holocene sands and gravels interbedded with muds. The upper part of the aquifer system is unconfined, whereas the deeper parts of the system may be locally confined and under artesian conditions.

Six wells -- MI1, MI2A, MI9A, MI10B, MI16, and MI17 -- were used to monitor the Miocene/Surficial aquifer system (Figure 3-7). Wells MI1, MI2A, MI9A, and MI10B are private domestic wells, with MI9A and MI10B no longer being used as drinking water sources. MI16 is used for general purposes at a fire station. MI17 originated as a geologic bore hole that became a flowing well. It is currently used both as a domestic water source and as an augmentation well for maintaining a pond. MI2A and MI9A are bored wells. The remainder are drilled wells. Depths are known for three wells, with MI9A at about 25 feet, MI17 at 120 feet, and MI16 at 400 feet. All wells are sampled yearly.



- General recharge area (from O'Connell and Davis, 1991)
- Sampling station

Figure 3-7. Locations of Stations Monitoring the Miocene/Surficial Aquifer System.

3.7.1 Field parameters

The pHs of the sample waters range from 4.44 to 8.05. MI2A and MI10B gave acidic water (MI2A at 4.44 and MI10B at 6.47). The remaining wells gave basic water (maximum is 8.05 for MI16). Conductivities ranged from 71 $\mu\text{S}/\text{cm}$ (MI10B) to 235 $\mu\text{S}/\text{cm}$ (MI1). Temperatures ranged from 19 $^{\circ}\text{C}$ (MI17) to 23.6 $^{\circ}\text{C}$ (MI16). The 23.6 $^{\circ}\text{C}$ temperature probably has a geothermal component; as well MI16 is 400 feet deep. Dissolved oxygen data are available for five wells and range from 0.04 (MI17) to 5.94 (MI2A). Valid dissolved oxygen measurements cannot be made on the sixth well, MI9A, since it must be sampled with a bailer.

3.7.2 Major Anions, Non-Metals, and Volatile Organic Compounds

Chloride was detected in samples from the two bored wells MI2A (15 mg/L) and MI9A (11 mg/L). The sample from the deepest Miocene well, MI16, provided the only sulfate detection, at 35 mg/L. Nitrate/nitrite was detected in sample waters from three wells. The two bored wells, MI2A and MI9A, gave samples with nitrate/nitrite levels in the human-influenced range (Daniels and Messner, 2010), respectively, 6.10 mg/L as nitrogen and 7.50 mg/L as nitrogen. The level in the sample from drilled well MI10B was within the natural range (not detected to 3 mg/L as nitrogen) at 0.02 mg/L as nitrogen. Detectable phosphorus was found in samples from all wells except bored well MI2A. The concentrations ranged from 0.02 mg/L to 0.45 mg/L. None of the samples contained detectable VOCs.

3.7.3 Metals by Inductively-Coupled Plasma Spectrometry (ICP)

Samples from all six wells contained calcium, magnesium, and sodium. Calcium levels ranged from 4,600 $\mu\text{g}/\text{L}$ (MI2A) to 52,000 $\mu\text{g}/\text{L}$ (MI16). The high calcium content (35,000 $\mu\text{g}/\text{L}$) of the sample from bored well MI9A may reflect recent repairs to the grout seal and concrete pad of a nearby drilled well. Magnesium levels ranged from 1,900 $\mu\text{g}/\text{L}$ (MI17) to 17,000 $\mu\text{g}/\text{L}$ (MI16). Sodium levels ranged from 4,500 $\mu\text{g}/\text{L}$ (MI2A) to 18,000 $\mu\text{g}/\text{L}$ (MI16). The highest concentrations of all three metals occurred in the sample from the deep drilled well MI16. The lowest levels of calcium and sodium occurred in the sample from the bored well MI2A. Iron was detected in samples from wells MI1 (25 $\mu\text{g}/\text{L}$), MI2A (22 $\mu\text{g}/\text{L}$), and MI10B (3,000 $\mu\text{g}/\text{L}$). This last value far exceeds the Secondary MCL for iron of 300 $\mu\text{g}/\text{L}$. Manganese was found in samples from two wells, MI2A (14 $\mu\text{g}/\text{L}$) and MI10B (97 $\mu\text{g}/\text{L}$). The 97 $\mu\text{g}/\text{L}$ level exceeds the Secondary MCL for manganese of 50 $\mu\text{g}/\text{L}$. The high iron and manganese levels in water from drilled well MI10B are the reason the residents ceased using the water for household purposes, i.e., cooking, drinking, and laundering. None of the samples contained detectable aluminum, beryllium, cobalt, titanium, or vanadium.

3.7.4 Metals by Inductively-Coupled Plasma Mass Spectrometry (ICPMS)

ICPMS analyses found detectable copper, zinc, selenium, barium, and lead in the Miocene aquifer samples. All six samples contained detectable barium, which ranged in concentration from 17 ug/L (MI16) to 190 ug/L (MI10B). Zinc was detected in samples from well MI1 (39 ug/L) and MI10B (96 ug/L). Detectable lead occurred in samples from bored well MI2A (11 ug/L) and MI10B (3.7 ug/L). The sample from bored well MI2A contained copper at a level of 7.1 ug/L. The sample from drilled well MI10B contained selenium at a level of 14 ug/L. The copper, lead, and zinc in the water samples were likely derived from plumbing. Selenium at detectable levels is rare in Georgia's ground water. None of these metals exceeded MCLs or action levels.

3.8 PIEDMONT/BLUE RIDGE AQUIFER SYSTEM

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

The regolith comprises a veneer of soil, or, in and near stream bottoms, alluvium, which is underlain by saprolite. Saprolite is bedrock that has undergone extensive chemical weathering in place. Downward percolating, typically acidic, ground water leaches alkali and alkaline earth and certain other metals from micas, feldspars, and other minerals composing the original rock, leaving behind a clay-rich residual material. Textures and structures of the original rock are usually well-preserved, with the saprolite appearing as a "rotten" version of the original rock. The regolith is characterized by high, mostly primary porosity (35% to 55%) (Daniel and Harned, 1997) and serves as the reservoir that feeds water into the underlying fractured bedrock. Saprolite grades downward through a transition zone consisting of saprolite and partially weathered bedrock with lumps of fresh bedrock into fresh bedrock.

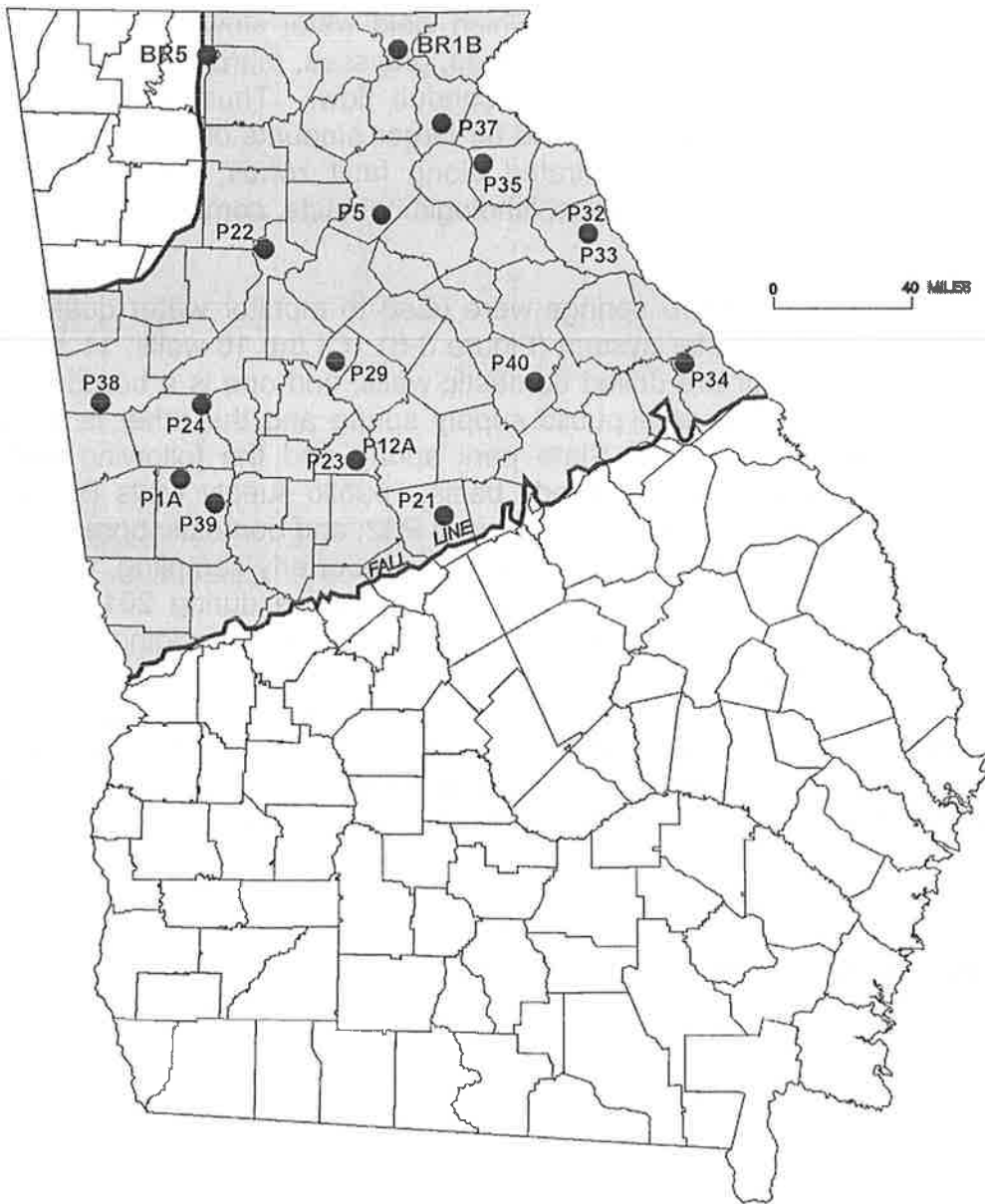
The fractured bedrock hydrologic unit is developed in igneous and metamorphic rocks. In contrast to the regolith, the porosity in such rocks is almost totally secondary, consisting of fractures and solution-enlarged voids. In the North Carolina Piedmont, Daniel and Harned (1997) found 1% to 3% porosity typical for bedrock. Fractures consist of faults, breaks in the rock with differential displacement between the broken sections, and joints, breaks in the rock with little or no differential displacement (Heath, 1980). Fractures tend to be wider and more numerous closer to the top of the bedrock; Daniel and Harned (1997) noted that at about 600 feet, pressure from the overlying rock column becomes too great and fractures are held shut. Fractures in schistose rocks consist mainly

of a network of fine, hair-line cracks which yield water slowly. Those in more massive rocks (e.g. granitic rocks, diabases, gneisses, marbles, quartzites) tend to be more open and are subject to conduit flow. Thus wells intersecting massive-rock fractures are able to yield far larger amounts of water than regolith wells. Fractures can be concentrated along fault zones, shear zones, late-generation fold axes, foliation planes, lithologic contacts, compositional layers, or intrusion boundaries.

Sixteen wells and two springs were used to monitor water quality in the Piedmont/Blue Ridge aquifer system (Figure 3-8). Of the 16 wells, 11 are drilled public supply wells, four are drilled domestic wells, and one is a bored domestic well. One of the springs is a public supply spring and the other is a mineral spring at a State park. The State park spring and the following wells are scheduled for sampling on a quarterly basis: public supply wells BR1B, P21, P23, P32, P33, and P34; domestic drilled well P32; and domestic bored well P33. Wells P32, P33, and P34, though scheduled for quarterly sampling, were recent additions to the network and were sampled only once during 2011. Stations BR1B, P12A, P21, and P23, were sampled twice. The remaining stations are sampled on a yearly basis. Where their depths are known, wells deriving water from the bedrock aquifer range in depth from 150 feet to 600 feet. Domestic bored well P33, the only regolith well, is 47 feet deep. While sample waters were supposed to be raw water, the sample from well P37 was probably taken inadvertently from a spigot downstream of a water softening unit.

3.8.1 Field parameters

Twenty two pH measurements from 18 stations are available for the Piedmont/Blue Ridge aquifer system. The pHs ranged from 4.70 to 8.31, with six samples being basic. Of the stations sampled twice, P12A was consistently basic and P21 consistently acidic, while P21 gave two divergent acidic samples and BR1B was consistently near neutral, giving a slightly basic sample and a slightly acidic one. The single regolith-derived sample (P33) was acidic. Conductivity measurements are available for 22 samples from 18 stations. Conductivities ranged from 17 uS/cm (P22) to 382 uS/cm (P32). Temperatures are available for all sampled waters and range from 14.9 °C (BR5) to 19.6 °C (P12A). The sample waters with the three coolest temperature readings are located in the Blue Ridge physiographic province; spring BR5 issues from the side of Fort Mountain east of Chatsworth. Most of the warmest sample water temperatures occur in the Piedmont, particularly the more southerly portions. Spring 12A is low-flow, 0.1 gallons per minute or less, which gives the water in the spring pool more time to interact with the atmosphere and warm up or cool off according to the air temperature. Geothermally elevated temperatures are not readily apparent for any sample waters. Dissolved oxygen measurements are available for 14 sample waters from 11 stations. Dissolved oxygen levels ranged from 0.77 mg/L (P21) to 10.69 mg/L (BR5). Springs BR5 and P12A gave samples



■ General recharge area (from O'Connell and Davis, 1991)

● Sampling station

Figure 3-8. Locations of Stations Monitoring the Piedmont/Blue Ridge Aquifer System.

with the two highest dissolved oxygen readings. The high readings were due atmospheric contact with water in the spring pools upstream of the sampling points and should not be considered valid measurements of the oxygen content of the water before it emerges into the spring pools.

3.8.2 Major Anions, Non-Metals, and Volatile Organic Compounds

All samples received testing for chloride, sulfate, nitrate/nitrite, total phosphorus, and VOCs. Samples from spring P12A and well P23, both located at Indian Springs State Park, received testing for fluoride. Detectable chloride was found in five samples from three stations. Four samples from two of these stations, spring P12A and well P21, each contained chloride in the 10 to 12 mg/L range. Well P37 gave the sample with the highest chloride level at 100 mg/L. As noted above, softening apparatus could have caused the high chloride content in sample water from P37. Fluoride levels for both samples from well P23 registered at 1.1 mg/L. Fluoride levels for the two samples from spring P12A slightly exceeded the Primary MCL of 4 mg/L. In the past, the spring has consistently given water with fluoride in the 4 mg/L to 5 mg/L range. Sulfate was detected in nine samples from six stations, with the highest concentration (220 mg/L) occurring in a sample from well P32. Twice-sampled wells BR1B and P21 and spring P12A accounted for six of the samples showing sulfate. Well BR1B and spring P12A each gave subsequent samples whose sulfate levels were similar to original samples from the same station. Well P21 gave samples with widely differing sulfate values. Nitrate/nitrite remained below detection in the sample from well P32 and in both samples from spring P12A. All other samples contained detectable nitrate/nitrite with levels ranging from 0.02 mg/L as nitrogen (P35) to 1.7 mg/L as nitrogen (P40). All samples except those from wells P32 and P38 and one sample from spring P12A contained detectable phosphorus. Concentrations ranged up to 0.16 mg/L for the sample from well P34. The sample from spring P12A that did contain detectable phosphorus did so at the reporting limit (0.02 mg/L). Well P37 gave the only sample to contain VOCs, chloroform at 0.77 ug/L (Primary MCL for total trihalomethanes is 80 ug/L).

3.8.3 Metals by Inductively-Coupled Plasma Spectrometry (ICP)

ICP analysis found detectable aluminum, calcium, iron, magnesium, manganese, and sodium. Aluminum was detected in two samples, one from bored well P33 and one from drilled well P38. The aluminum level (530 ug/L) in the sample from well P33 greatly exceeded the Secondary MCL range of 50 to 200 ug/L. The aluminum level in the sample from well P38 lay within that range. Calcium was found in all samples except for the ones from wells P22 and P37. The sample from P37 may have passed through a softener. The highest calcium level occurred in the sample from well P32 (160,000 ug/L). Magnesium was detected in 17 samples from 22 stations. Magnesium contents of sample waters ranged up to 9,500 ug/L (P21). The sample from well P37, which contained no

detectable magnesium, may have passed through a softener. Subsequent samples from multiply sampled stations P12A, P23, and BR1B had magnesium concentrations that were similar to those of the original samples. The subsequent sample from twice-sampled well P21 contained nearly three times the magnesium of the original sample. Four samples from three wells contained detectable iron. Iron in the sample from bored well P33 and in one of the samples from drilled well P23 exceeded the Secondary MCL of 300 ug/L. The other sample from drilled well P23 and the one from well P35 contained iron at levels below the MCL. Manganese was detected in 11 samples from nine stations, with a maximum concentration of 110 ug/L (P35). Well P21 (two samples) and well P35 yielded samples with concentrations above the Secondary MCL (50 ug/L). Spring P12A and well BR1B each gave subsequent samples with similar manganese concentrations to original samples from each station. Sodium was present in all samples and ranged from 2,100 ug/L in the sample from well P22 to 110,000 ug/L in the sample from well P37. Sample water from P37 may have travelled through a softener. The next highest sodium concentrations occurred in two samples from spring P12A, at 35,000 ug/L and 38,000 ug/L. For the five multiply sampled wells, sodium levels in subsequent samples from each well are similar to those of original samples.

3.8.4 Metals by Inductively-Coupled Plasma Mass Spectrometry (ICPMS)

ICPMS analysis found detectable copper, zinc, molybdenum, barium, lead, and uranium in the Piedmont/Blue Ridge samples. Copper occurred in four samples from four wells, with a maximum level of 28 ug/L in the sample from well P29. Testing found zinc in six samples from five wells, with a maximum of 170 ug/L in P29. Three samples from three wells (P29, P33, P34) containing detectable copper also contained detectable lead. Well P23 gave one sample of two that contained both detectable zinc and lead. A single sample, one from well P29, contained detectable molybdenum. Barium remained undetected in a sample from well P37 and in both samples from spring P12A. All other stations gave samples with detectable barium, with the maximum of 78 ug/L occurring in the sample from well BR1B. Sample water from P37 probably passed through a softener. Lead was detected in seven samples from seven wells. The maximum level was 14 ug/L found in the sample from well P29. The well is domestic but not used for drinking water. For two twice-sampled wells, P21 and P23, one sample contained detectable lead while the other did not. Testing found uranium in 12 samples from nine wells. The maximum level of 200 ug/L in the sample from well P29 exceeds the Primary MCL of 30 ug/L and far exceeds the second highest level, 13 ug/L in the sample from well P32. The sample water from well P29 contained visible fine sediment, so whether the uranium was in particulate form rather than in solution remains unknown.

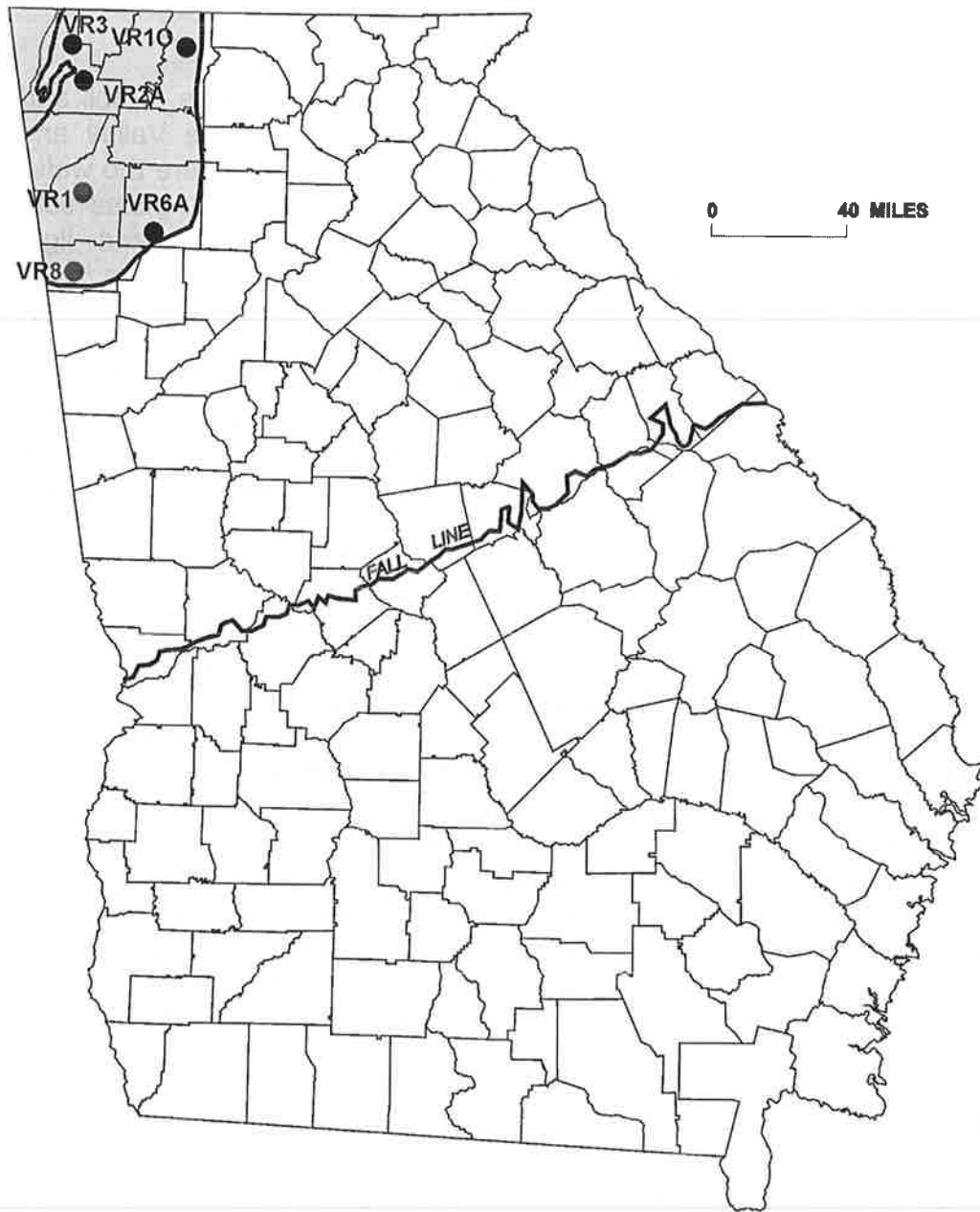
3.9 VALLEY AND RIDGE/APPALACHIAN PLATEAU AQUIFERS

As in the Piedmont/Blue Ridge Province, a regolithic mantle of soil and residuum derived from weathered bedrock blankets much of the Valley and Ridge/Appalachian Plateau Province of northwestern Georgia. Where the water table lies within the mantle above carbonate bedrock, the mantle yields soft, slightly acidic water ("freestone" water) sufficient for domestic and light agricultural use (Cressler et al., 1976; 1979). The mantle also acts as a reservoir, supplying water to the underlying bedrock. The bedrock, however, supplies most of the useful ground water in the provinces. Bedrock in the province is sedimentary, comprising limestones, dolostones, shales, siltstones, mudstones, cherts, and sandstones. Bedrock primary porosity in the province is very low, leaving fractures and solution-enlarged voids as the main water-bearing structures. The bedrock in the province has experienced extensive faulting and folding, particularly in the Valley and Ridge sector. Such tectonism has proliferated fracturing. Fractures in limestones and dolostones can become enlarged by dissolution, greatly increasing their ability to store water. Zones of intense fracturing in carbonate bedrock give rise to broad valleys with thick regolith and gentle slopes, and, bedrock beneath such valleys presents a copious source of ground water. The extensive faulting and folding has also served to prevent the development of areally extensive ground-water flow regimes that are characteristic of the sediments of the Coastal Plain.

Monitoring water quality in the Valley and Ridge/Appalachian Plateau aquifers made use of four springs and two drilled wells, all in the Valley and Ridge sector. (Figure 3-9). Springs VR2A, VR8, and VR 10 are public supply springs; and, spring VR3 is a former public supply spring. Well VR1 is a public supply well, and, well VR6A is an industrial process water source. Spring VR8 is scheduled for sampling on a quarterly basis and was sampled twice in 2011, while the other stations are sampled on a yearly basis.

3.9.1 Field parameters

Sample water pHs ranged from 6.85 for spring VR2A to 7.54 for spring VR8. All sample waters except for that from spring VR2A were slightly basic. The pHs of both sample waters from spring VR8 were similar. Conductivities ranged from 243 uS/cm (VR1) to 301 uS/cm (VR2A). Dissolved oxygen measurements are available for wells VR1 (7.29 mg/L) and VR6A (5.58 mg/L). Dissolved oxygen measurements were also taken at the springs; however, due to atmospheric exposure at the spring heads and in spring pools, these measurements do not validly represent oxygen levels in the water prior to discharge. The temperature of sample waters from well VR1 was 16.4 °C and from well VR6A was 17.8 °C. Temperatures are available for waters from the springs, however, these temperatures may have been altered from those at the spring heads by contact with the surface environment.



- General recharge area (from Davis et al., 1989)
- Sampling station

Figure 3-9. Locations of Stations Monitoring the Valley and Ridge/Appalachian Plateau Aquifers.

3.9.2 Major Anions, Non-Metals, and Volatile Organic Compounds (VOCs)

Neither chloride nor sulfate was detected in any of the sample waters. Nitrate/nitrite was present in all of the sample waters and ranged from 0.63 mg/L as nitrogen (VR1) to 1.70 mg/L as nitrogen (VR2A and VR10). Nitrate/nitrite levels in the two samples from VR8 were similar to each other. Phosphorus, at a level of 0.02 mg/L was detected in samples from well V6A and spring VR2A. The sample from well VR6A was the only one to contain VOCs. The compounds consisted of: 1,1-dichloroethylene at 2.0 ug/L (Primary MCL = 7 ug/L), tetrachloroethylene at 2.8 ug/L (Primary MCL = 5 ug/L), p-dichlorobenzene at 0.7 ug/L (Primary MCL = 75 ug/L), and o-dichlorobenzene at 2.7 ug/L (Primary MCL = 600 ug/L).

3.9.3 Metals by Inductively-Coupled Plasma Spectrometry (ICP)

ICP analysis found calcium, magnesium, and sodium in all samples. Detectable iron was present in samples from spring VR2A and spring VR10, both at levels below the Secondary MCL of 300 ug/L. The VR2A sample was the only one to contain detectable manganese, again, at a level below the Secondary MCL. Calcium levels ranged from 28,000 ug/L (VR1) to 41,000 ug/L (VR2A). Magnesium levels ranged from 12,000 ug/L (VR10) to 17,000 ug/L (VR6A). Sodium levels ranged from 1,100 ug/L (VR3) to 5,900 ug/L (VR6A).

3.9.4 Metals by Inductively-Coupled Plasma Mass Spectrometry (ICPMS)

ICPMS analysis found barium and lead. Detectable barium was present in all samples and ranged from 9.7 ug/L (VR1) to 500 ug/L (VR6A). All samples save the one from VR6A have barium levels below 100 ug/L. Well VR6A furnishes process water to a firm that manufactures barium and strontium compounds and is situated in an area that sees active barite mining. Lead at a level of 7.2 ug/L was found in the sample from spring VR10. Untreated water from the spring is currently drawn from a spigot in the treatment house, about 70 feet south of the spring head, thus plumbing may be responsible for the lead content.

CHAPTER 4 SUMMARY AND CONCLUSIONS

EPD personnel collected 99 water samples from 71 wells and six springs on the Ground-Water Monitoring Network during the calendar year 2011. The samples were analyzed for VOCs, chloride, sulfate, nitrate/nitrite, total phosphorus, 15 trace metals by ICPMS analysis, and 11 mostly major metals by ICP analysis. Waters from two neighboring stations in the central Piedmont received analyses for fluoride because one of the stations was known to produce water with excessive levels of that ion. These wells and springs monitor the water quality of eight major aquifers and aquifer systems in Georgia:

Cretaceous/Providence aquifer system

Clayton aquifer

Claiborne aquifer

Jacksonian aquifer

Floridan aquifer system

Miocene aquifer system

Piedmont/Blue Ridge aquifer system

Valley and Ridge/Appalachian Plateau aquifers

A review of the analyses of the water samples collected during calendar year 2011 indicates that the chemical quality of ground water obtained for most of the Ground-water Monitoring Network stations is quite good. Previous studies (Donahue et al., 2012; 2013) concerning uranium in Piedmont/Blue Ridge ground waters and arsenic in Floridan ground waters in the vicinity of the Gulf Trough indicate that each of these areas has an increased risk for encountering low quality ground water. Studies primarily by the USGS (Foyle et al., 2001; Krause and Clarke, 2001) point out saline water contamination in the coastal part of the Floridan. Table 4-1 lists the contaminants and pollutants detected at stations of the Network during the calendar year 2011.

4.1 PRIMARY MCL VIOLATIONS FOR 2011

The Primary MCL violations for the calendar year 2011 sampling involved uranium, lead, and fluoride (see Table 4-1). Station P29, a domestic non-potable well at Conyers, Rockdale County, gave a sample registering a uranium level of

200 ug/L. Purging the well stirred up much sediment, so how much of the uranium was dissolved and how much was particulate couldn't be determined. The area is underlain by metamorphic bedrock. Station K9A, a public well at Marshallville, Macon County, gave a water sample containing 330 ug/L of lead. The spigot used to draw the sample sees little use. Experience suggests that the lead originated from plumbing and did not represent the true lead level in ambient water at that station. Excessive fluoride, at 4.4 mg/L on one occasion and 4.6 mg/L on another, was detected in water from mineral spring P12A at Indian Springs State Park, Butts County. The fluoride is natural, and, the spring has a history of producing high-fluoride water. DNR staff typically warns people collecting water there about the risks of drinking it.

Various analytes were detected during the 2011 sampling which have Primary MCLs imposed on them, although they never exceeded such MCLs. These consist of nitrate/nitrite, various VOCs (see Table 4-2), barium, arsenic, and copper. Nitrate/nitrite has exceeded its Primary MCL in samples from past Circular 12 studies but not in the current one. Only three wells gave water with nitrate/nitrite concentrations outside the "natural" range of 3 mg/L or less as nitrogen (Daniels and Mesner, 2010). Wells J8 (nitrate/nitrite = 4.8 mgN/L), MI2A (nitrate/nitrite = 6.1 mgN/L), and MI9A (nitrate/nitrite = 7.5 mgN/L) are all shallow bored wells. Well J8 is in the Jacksonian recharge area, while the other two tap the Miocene.

VOCs were found in seven samples from five wells (see Table 4-2). None exceeded their respective Primary MCLs. The trihalomethanes (chloroform, bromodichloromethane, chlorodibromomethane, and bromoform) were the most widely occurring of the VOCs. These compounds result from halogen-bearing disinfectants reacting with organic matter naturally present in the water. Two scenarios accompany the occurrence of the compounds. The first involves disinfection of well and plumbing components incident to maintenance or repairs, as had happened in 2011 with Moultrie #1 and Sycamore #2. The second scenario involves leaking check valves or foot valves that allow disinfectant-treated water to flow back down the well when pumps are off. The Chemical Products Corporation South Well yielded sample water containing chlorinated ethylene and chlorinated benzene compounds. The former are used as solvents; the latter are used mainly as disinfectants, fumigants, pesticides, and starting compounds for agricultural chemicals (p-dichlorobenzene is familiar as mothballs and urinal cakes).

Owing to the sensitivity of analytical methods involving ICPMS, barium has been detected at low levels in nearly all of Georgia's ground water. Ground water containing barium approaching or exceeding the Primary MCL had been a problem only at the old in-town well field at Fitzgerald, Ben Hill County. The in-town well field has been closed since 1995.

Table 4-1. Pollution and Contaminant Incidents, Calendar Year 2011

Station	Contaminant/Pollutant	MCL	Type Source	Date Sampled
Primary MCL Violations				
P29	Uranium = 200 ug/L	30 ug/L	domestic non-potable	09/29/11
K9A	Lead = 330 ug/L	15 ug/L	public	09/28/11
P12A	Fluoride = 4.4 mg/L	4 mg/L	mineral spring	06/22/11
P12A	Fluoride = 4.6 mg/L	4 mg/L	mineral spring	09/28/11
Secondary MCL Violations				
P21	Manganese = 78 ug/L	50 ug/L	public	06/22/11
P21	Manganese = 93 ug/L	50 ug/L	public	09/28/11
P35	Manganese = 110 ug/L	50 ug/L	domestic	10/26/11
CL4A	Manganese = 69 ug/L	50 ug/L	public	12/14/11
CL8	Manganese = 56 ug/L	50 ug/L	domestic	04/27/11
J8	Manganese = 51 ug/L	50 ug/L	domestic	04/14/11
MI10B	Manganese = 97 ug/L	50 ug/L	domestic non-potable	08/09/11
PA18	Manganese = 55 ug/L	50 ug/L	public	05/11/11
PA34A	Manganese = 88 ug/L	50 ug/L	public	05/12/11
PA34A	Manganese = 98 ug/L	50 ug/L	public	08/09/11
PA34A	Manganese = 97 ug/L	50 ug/L	public	11/17/11
P23	Iron = 430 ug/L	300 ug/L	public	09/28/11
P33	Iron = 530 ug/L	300 ug/L	domestic non-potable	10/26/11
K6	Iron = 320 ug/L	300 ug/L	industrial	12/21/11
CL4A	Iron = 1900 ug/L	300 ug/L	public	12/14/11
CL8	Iron = 850 ug/L	300 ug/L	domestic	04/27/11
MI10B	Iron = 3,000 ug/L	300 ug/L	domestic non-potable	08/90/11
PA9C	Iron = 330 ug/L	300 ug/L	(former) test	05/25/11
PA23	Iron = 320 ug/L	300 ug/L	public	03/17/11
P33	Aluminum = 530 ug/L	50 – 200 ug/L	domestic non-potable	10/26/11
K11A	Aluminum = 290 ug/L	50 – 200 ug/L	public	04/27/11
K12	Aluminum = 460 ug/L	50 – 200 ug/L	public	04/27/11
J1B	Aluminum = 310 ug/L	50 – 200 ug/L	domestic	04/14/11
PA9C	Sulfate = 260 mg/L	250 mg/L	(former) test	05/25/11
PA9C	Chloride = 730 mg/L	250 mg/L	(former) test	05/25/11

The alphabetic prefix in a station number indicates the aquifer/aquifer system tapped: CL=Claiborne, J=Jacksonian, K=Cretaceous, P=Piedmont/Blue Ridge, PA=Floridan.

Arsenic was the subject of a study in South Georgia, resulting in the publication of Circular 12X (Donahue et al., 2013). City of Cairo Well #8 (station GA-2) was sampled for that study, producing sample water with an arsenic level of 6.7 ug/L. For the current study, The well (now station PA23) produced two samples during the calendar year 2011 that contained detectable arsenic. A third sample contained no detectable arsenic. .

Copper was found in sample waters from 15 stations, though not in excess of its action level. Three samples with detectable copper came from wells drawing from the Floridan aquifer. The sample waters' pHs were basic. Twelve samples with detectable copper came from the Miocene, Piedmont/Blue Ridge, Clayton, and Cretaceous/Providence aquifers and aquifer systems. The pHs of the sample waters were acidic. Like lead, copper in most samples is derived from plumbing; therefore the copper levels in those samples are not truly representative of those in the ambient ground water.

Chromium, nickel, and selenium were detected in one sample each and all were well below their Primary MCLs.

4.2 SECONDARY MCL VIOLATIONS FOR 2011

Manganese, iron, and aluminum were the analytes that were responsible for most of the Secondary MCL violations (see Table 4-1). Manganese was the most common offender, with 11 samples from eight wells containing the metal above its Secondary MCL. Iron was the next worst, with eight samples from eight wells registering excesses. Aluminum excesses occurred in four samples from four wells. Excessive chloride and excessive sulfate were the least common, with one sample from well PA9C containing both ions at levels above their respective Secondary MCLs. All of these contaminants are naturally occurring, although iron and, possibly, some manganese could be, in part, leached from plumbing. Well 9C, located in the Brunswick area, draws from the lower Floridan, which is subject to contamination from connate brines in that area. Zinc did not exceed its Secondary MCL in any samples. However, like copper and lead, zinc is, in most cases, likely leached from galvanized steel and brasses which see use in plumbing.

4.3 VOLATILE ORGANIC COMPOUNDS FOR 2011

Table 4-2 lists the stations experiencing contamination from volatile organic compounds (VOCs), all at levels below applicable Primary MCLs. Four of the five wells affected gave samples containing trihalomethanes which originate as disinfection byproducts. The four wells are all public supply wells. In the cases of wells PA44 and PA28, trihalomethane contamination probably resulted from well overhaul and maintenance, as halogen-bearing disinfectants

are typically used to perform the required cleaning of the well plumbing before placing the wells back in service. In the case of well PA23, trihalomethane contamination is ongoing, suggesting that a check valve or foot valve is not seating properly and is allowing treated water back down the well and into the aquifer.

The fifth well, industrial process water well VR6A, was contaminated with 1,1-dichloroethylene, perchloroethylene, o-dichlorobenzene, and p-dichlorobenzene. The facility is located in an industrial area and is within about two miles of former and current landfills. Cressler et al. (1979) had warned of the danger of using unlined worked-out barite pits for waste disposal in the Cartersville area because of the karstic bedrock. The source of the VOCs thus is uncertain.

4.4 pH

The pHs of the sample waters in the updip portions of the Jacksonian, Clayton, Claiborne, and, particularly, the Cretaceous/Providence are among the most acidic encountered in the current study. Such waters can be quite corrosive to metal plumbing and are probably responsible for detections of copper, lead, and zinc and for lead exceedances in sample waters from these areas.

Table 4-2. VOC Pollution Incidents, Calendar Year 2011

Station	Contaminant/Pollutant	Primary MCL	Type Source	Date Sampled
P37	chloroform = 0.77 ug/L	total	public	10/26/11
PA23	chloroform = 1.1 ug/L	trihalo-	public	03/17/11
	bromodichloromethane = 1.2 ug/L	methanes		
	chlorobibromomethane=1.4 ug/L	= 80 ug/L		
PA23	chloroform=1.3 ug/L	" "	public	08/10/11
	bromodichloromethane=1.0 ug/L			
	chlorobibromomethane=1.1 ug/L			
PA23	chloroform=2.3 ug/L	" "	public	10/27/11
	bromodichloromethane=1.4 ug/L			
	chlorodibromomethane=1.2 ug/L			
PA28	chloroform = 1.2 ug/L	" "	public	08/09/11
	bromoform = 1.8 ug/L			
	bromodichloromethane = 1.3 ug/L			
	chlorodibromomethane = 2.0 ug/L			
PA44	chloroform = 6.6 ug/L	" "	public	10/26/11
	bromoform = 0.62 ug/L			
	bromodichloromethane = 3.9 ug/L			
	chlorodibromomethane = 2.5 ug/L			
VR6A	1,1-dichloroethylene = 2.0 ug/L	7 ug/L	industrial	08/25/11
	tetrachloroethylene = 2.8 ug/L	5 ug/L		
	1,4-dichlorobenzene = 0.71 ug/L	75 ug/L		
	1,2-dichlorobenzene = 2.7 ug/L	600 ug/L		

The alphabetic prefix in a station number indicates the aquifer/aquifer system tapped: P = Piedmont/Blue Ridge, PA = Floridan, VR=Valley and Ridge/Appalachia Plateau.

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APPENDIX

LABORATORY AND STATION DATA

Tables A-1 through A-8 list the values for both laboratory parameters and field parameters for each well or spring. The following abbreviations are used on these tables:

Parameters and Units of Measure

Cl	= chloride	ND	= not detected
cond.	= conductivity	NG	= not given
diss O2	= dissolved oxygen	NOx	= nitrate/nitrite
F	= fluoride	P	= total phosphorus
ICP	= inductively coupled plasma (emission) spectroscopy	SO4	= sulfate
ICPMS	= inductively coupled plasma/mass spectrometry	Temp.	= temperature
mg/L	= milligrams per liter	ug/L	= micrograms per liter
mgN/L	= milligrams per liter as nitrogen	uS/cm	= microSiemenses per centimeter
NA	= not available; not analyzed	VOC	= volatile organic compound

Volatile Organic Compounds

1,1dce	= 1,1-dichloroethylene	odcb	= o-dichlorobenzene
bdcn	= bromodichloromethane	pdcn	= p-dichlorobenzene
dbcm	= dibromochloromethane	tbn	= bromoform
pce	= tetrachloroethylene	tcm	= chloroform

Metals

Ag = silver	Co = cobalt	Mo = molybdenum	Ti = titanium
Al = aluminum	Cr = chromium	Na = sodium	Tl = thallium
As = arsenic	Cu = copper	Ni = nickel	U = uranium
Ba = barium	Fe = iron	Pb = lead	V = vanadium
Be = beryllium	K = potassium	Sb = antimony	Zn = zinc
Ca = calcium	Mg = magnesium	Se = selenium	
Cd = cadmium	Mn = manganese	Sn = tin	

Table A-9 gives the reporting limits for the various analytes. The abbreviations used for Tables A-1 through A-8 also apply to Table A-9.

**Table A-1. Ground-Water Quality Analyses for Cretaceous/Providence Stations.
Part A: Station Identification, Date of Sampling, Field Parameters, VOCs, Anions, and Non-Metals.**

Station No. County	Well Name	Well Depth feet	Casing Depth feet	Well Size Inches	Date sampled	pH	cond. uS/cm	diss O2 mg/L	Temp °C	VOCs ug/L	Cl mg/L	SO4 mg/L	NOx mg N/L	P mg/L
GWN-K3 Washington	Sandersville Well #7B	697	NG	NG	5/26/2011	6.22	91	NA	20.8	ND	ND	13	0.28	0.99
GWN-K6 Twiggs	KaMin Well #6	400	NG	NG	12/21/2011	5.98	29	NA	19.8	ND	ND	ND	0.04	ND
GWN-K7 Jones	Jones County #4	128	NG	NG	5/25/2011	4.76	25	6.33	17.6	ND	ND	ND	0.4	ND
GWN-K9A Macon	Marshallville Well #2	560	NG	NG	9/28/2011	3.07	34	8.90	21.3	ND	ND	11	0.04	ND
GWN-K10B Peach	Fort Valley Well #6	600	NG	NG	5/25/2011	4.07	14	8.87	18.6	ND	ND	ND	0.69	ND
GWN-K11A Houston	Warner Robins Well #2	540	NG	NG	4/27/2011	4.72	18	6.78	19.3	ND	ND	ND	0.88	ND
GWN-K12 Houston	Perry/Holiday Inn Well	350	NG	NG	4/27/2011	4.05	47	0.71	20.0	ND	ND	10	ND	ND
GWN-K19 Richmond	Hephzibah/Murphy Street Well	484	NG	NG	5/26/2011	4.81	10	NA	20.2	ND	ND	ND	0.12	0.02
GWN-K20 Sumter	Plains Well #7	1000	NG	NG	12/14/2011	7.56	109	2.15	28.6	ND	ND	ND	ND	0.20
GWN-PD2A Webster	Preston Well #4	205	NG	NG	4/28/2011	5.26	34	6.09	19.8	ND	ND	ND	2.0	0.03
GWN-PD3 Clay	Fort Gaines Well #2	456	NG	NG	4/28/2011	8.37	362	0.59	21.6	ND	12	10	ND	0.03
GWN-PD6 Early	Blakely Well #4	1025	NG	NG	5/24/2011	8.40	338	NA	26.6	ND	ND	14	ND	0.03

Table A-1. Ground-Water Quality Analyses for Cretaceous/Providence Stations.

Part B: Metals.

Station No.	Cr ug/L	Ni ug/L	Cu ug/L	Zn ug/L	As ug/L	Se ug/L	Mo ug/L	Ag ug/L	Cd ug/L	Sn ug/L	Sb ug/L	Ba ug/L	Tl ug/L	Pb ug/L	U ug/L	Al ug/L	Be ug/L	Ca ug/L	Co ug/L	Fe ug/L	K ug/L	Mg ug/L	Mn ug/L	Na ug/L	Ti ug/L	V ug/L
GWN-K3 Washington	ND	ND	ND	ND	ND	ND	5.9	ND	ND	ND	ND	23	ND	ND	ND	73	ND	22,000	ND	190	ND	1,400	27	4,300	ND	19
GWN-K6 Twiggs	ND	ND	23	35	ND	ND	ND	ND	ND	ND	ND	18	ND	2.3	1.3	ND	ND	4,300	ND	320	ND	ND	ND	3,100	ND	ND
GWN-K7 Jones	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	19	ND	4.2	ND	64	ND	2,300	ND	ND	ND	ND	ND	1,900	ND	ND
GWN-K9A Macon	ND	ND	120	64	ND	ND	ND	ND	ND	ND	ND	8.8	ND	330	ND	170	ND	ND	ND	160	ND	ND	ND	1,000	ND	ND
GWN-K10B Peach	ND	ND	5.4	ND	ND	ND	ND	ND	ND	ND	ND	5.5	ND	2.6	ND	74	ND	ND	ND	ND	ND	ND	ND	1,200	ND	ND
GWN-K11A Houston	ND	ND	7.5	ND	ND	ND	ND	ND	ND	ND	ND	6.3	ND	3.2	ND	290	ND	1,200	ND	220	ND	ND	ND	1,800	ND	ND
GWN-K12 Houston	ND	ND	14	32	ND	ND	ND	ND	ND	ND	ND	5.2	ND	8.5	ND	460	ND	ND	ND	180	ND	ND	13	1,200	ND	ND
GWN-K19 Richmond	ND	ND	6.9	ND	ND	ND	ND	ND	ND	ND	ND	6.4	ND	1.5	ND	150	ND	ND	ND	ND	ND	ND	ND	1,300	ND	ND
GWN-K20 Sumter	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2,900	ND	22	ND	ND	ND	26,000	ND	ND
GWN-PD2A Webster	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	18	ND	ND	ND	75	ND	3,400	ND	ND	ND	1,100	ND	1,400	ND	ND
GWN-PD3 Clay	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.4	ND	ND	ND	ND	ND	6,200	ND	24	ND	1,100	ND	82,000	ND	ND
GWN-PD6 Early	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	7.2	ND	ND	ND	ND	ND	8,100	ND	ND	ND	3,800	ND	70,000	ND	ND

Table A-2. Ground-Water Quality Analyses for Clayton Stations.

Part A: Station Identification, Date of Sampling, Field Parameters, VOCs, Anions, and Non-Metals.

Station No.	Well Name	Well Depth feet	Casing Depth feet	Well Size Inches	Date sampled	pH	cond. uS/cm	diss O2 mg/L	Temp °C	VOCS ug/L	Cl mg/L	SO4 mg/L	NOx mg N/L	P mg/L
GWN-CT8 Schley	Weathersby house well	80	NG	NG	4/27/2011	4.22	41	8.00	18.0	ND	ND	ND	1.8	ND

**Table A-2. Ground-Water Quality Analyses for Clayton Stations.
Part B: Metals.**

Station No.	Cr ug/L	Ni ug/L	Cu ug/L	Zn ug/L	As ug/L	Se ug/L	Mo ug/L	Ag ug/L	Cd ug/L	Sn ug/L	Sb ug/L	Ba ug/L	Tl ug/L	Pb ug/L	U ug/L	Al ug/L	Be ug/L	Ca ug/L	Co ug/L	Fe ug/L	K ug/L	Mg ug/L	Mn ug/L	Na ug/L	Ti ug/L	V ug/L	
GWN-CT8 Schley	ND	ND	8.0	ND	ND	ND	ND	ND	ND	ND	ND	20	ND	ND	ND	100	ND	ND	ND	ND	1,100	ND	25	2,800	ND	ND	ND

Table A-3. Ground-Water Quality Analyses for Claiborne Stations.

Part A: Station Identification, Date of Sampling, Field Parameters, VOCs, Anions, and Non-Metals.

Station No. County	Well Name	Well Depth feet	Casing Depth feet	Well Size Inches	Date sampled	pH	cond. uS/cm	diss O2 mg/L	Temp °C	VOCs ug/L	Cl mg/L	SO4 mg/L	NOx mg N/L	P mg/L
GWN-CL2 Dooly	Unadilla Well #3	315	315	24	4/27/2011	7.29	200	3.18	20.2	ND	ND	ND	0.39	0.03
GWN-CL4A Sumter	Plains Well #8	230	NG	NG	12/14/2011	6.86	151	10.00	20.0	ND	ND	12	ND	0.35
GWN-CL8 Dooly	Flint River Nursery Office Well	NG	NG	NG	4/27/2011	5.96	84	0.58	21.4	ND	ND	10	ND	0.51

Table A-3. Ground-Water Quality Analyses for Claiborne Stations.

Part B: Metals.

Station No. County	Cr ug/L	Ni ug/L	Cu ug/L	Zn ug/L	As ug/L	Se ug/L	Mo ug/L	Ag ug/L	Cd ug/L	Sn ug/L	Sb ug/L	Ba ug/L	Tl ug/L	Pb ug/L	U ug/L	Al ug/L	Be ug/L	Ca ug/L	Co ug/L	Fe ug/L	K ug/L	Mg ug/L	Mn ug/L	Na ug/L	Ti ug/L	V ug/L	
GWN-CL2 Dooly	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	11	ND	ND	ND	60	ND	43,000	ND	ND	ND	ND	ND	ND	1,500	ND	ND
GWN-CL4A Sumter	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	15	ND	ND	ND	ND	ND	26,000	ND	1,900	ND	3,500	69	2,000	ND	ND	ND
GWN-CL8 Dooly	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	36	ND	ND	ND	ND	ND	12,000	ND	850	ND	1,300	56	1,900	ND	ND	ND

Table A-4. Ground-Water Quality Analyses for Jacksonian Stations.

Part A: Station Identification, Date of Sampling, Field Parameters, VOCs, Anions, and Non-Metals.

Station No. County	Well Name	Well Depth feet	Casing Depth feet	Well Size Inches	Date sampled	pH	cond. uS/cm	diss O2 mg/L	Temp °C	VOCs ug/L	Cl mg/L	SO4 mg/L	NOx mg N/L	P mg/L
GWN-J1B Burke	McNair House Well	100	NG	NG	4/14/2011	7.07	283	5.13	19.2	ND	11	ND	2.5	0.04
GWN-J6 Jefferson	Wrens Well #4	200	NG	8	4/14/2011	7.08	260	0.71	19.6	ND	ND	14	ND	0.15
GWN-J8 Jefferson	Kahn House Well	40	NG	30	4/14/2011	4.74	74	8.14	19.4	ND	10	ND	4.8	ND

**Table A-4. Ground-Water Quality Analyses for Jacksonian Stations.
Part B: Metals.**

Station No.	Cr ug/L	Ni ug/L	Cu ug/L	Zn ug/L	As ug/L	Se ug/L	Mo ug/L	Ag ug/L	Cd ug/L	Sn ug/L	Sb ug/L	Ba ug/L	Tl ug/L	Pb ug/L	U ug/L	Al ug/L	Be ug/L	Ca ug/L	Co ug/L	Fe ug/L	K ug/L	Mg ug/L	Mn ug/L	Na ug/L	Ti ug/L	V ug/L	
GWN-J1B Burke	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	23	ND	ND	ND	310	ND	54,000	ND	ND	ND	ND	ND	4,200	ND	ND	ND
GWN-J6 Jefferson	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8.5	ND	ND	ND	67	ND	47,000	ND	76	ND	1,400	ND	1,800	ND	ND	ND
GWN-J8 Jefferson	ND	11	ND	36	ND	ND	ND	0.96	ND	ND	ND	30	ND	2.9	ND	110	ND	6,800	ND	ND	1,200	51	3,700	ND	ND	ND	

Table A-5. Ground-Water Quality Analyses for Miocene Stations.

Part A: Station Identification , Date of Sampling, Field Parameters, VOCs, Anions, and Non-Metals.

Station No. County	Well Name	Well Depth feet	Casing Depth feet	Well Size Inches	Date sampled	pH	cond. uS/cm	diss O2 mg/L	Temp °C	VOCs ug/L	Cl mg/L	SO4 mg/L	NOx mg N/L	P mg/L
GWN-MI1 Cook	Adel/McMillan	NG	NG	NG	3/16/2011	7.73	235	1.61	22.5	ND	ND	ND	ND	0.03
GWN-MI2A Lowndes	Boutwell House well	NG	NG	NG	3/30/2011	4.44	115	5.94	20.4	ND	15	ND	6.10	ND
GWN-MI9A Thomas	Murphy garden well	25	NG	NG	12/20/2011	7.62	147	NA	21.1	ND	11	ND	7.50	0.12
GWN-MI10B Colquitt	Calhoun house well	NG	NG	NG	8/9/2011	6.47	71	0.54	22.3	ND	ND	ND	0.02	0.45
GWN-MI16 Liberty	Liberty County East District Fire Station deep well.	400'	NG	NG	12/15/2011	8.05	197	0.81	23.6	ND	ND	35	ND	0.03
GWN-MI 17 Effingham	Springfield Egypt Road Test Well	120'	NG	NG	12/15/2011	7.88	162	0.04	19.0	ND	ND	ND	ND	0.02

Table A-5. Ground-Water Quality Analyses for Miocene Stations.

Part B: Metals.

Station No. County	Cr ug/L	Ni ug/L	Cu ug/L	Zn ug/L	As ug/L	Se ug/L	Mo ug/L	Ag ug/L	Cd ug/L	Sn ug/L	Sb ug/L	Ba ug/L	Tl ug/L	Pb ug/L	U ug/L	Al ug/L	Be ug/L	Ca ug/L	Co ug/L	Fe ug/L	K ug/L	Mg ug/L	Mn ug/L	Na ug/L	Ti ug/L	V ug/L	
GWN-MI1 Cook	ND	ND	ND	39	ND	ND	ND	ND	ND	ND	ND	20	ND	ND	ND	ND	ND	25,000	ND	25	ND	15,000	ND	6,800	ND	ND	ND
GWN-MI2A Lowndes	ND	ND	7.1	ND	ND	ND	ND	ND	ND	ND	ND	29	ND	11	ND	200	ND	4,600	ND	22	ND	3,500	14	4,500	ND	ND	ND
GWN-MI9A Thomas	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	62	ND	ND	ND	ND	ND	35,000	ND	ND	ND	3,900	ND	5,200	ND	ND	ND
GWN-MI10B Colquitt	ND	ND	ND	96	ND	14	ND	ND	ND	ND	ND	190	ND	3.7	ND	ND	ND	8,600	ND	3,000	ND	5,700	97	6,700	ND	ND	ND
GWN-MI16 Liberty	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	17	ND	ND	ND	ND	ND	31,000	ND	ND	ND	17,000	ND	18,000	ND	ND	ND
GWN-MI 17 Effingham	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	24	ND	ND	ND	ND	ND	52,000	ND	ND	ND	1,900	14	8,800	ND	ND	ND

Table A-6. Ground-Water Quality Analyses for Floridan Stations.

Part A: Station Identification , Date of Sampling, Field Parameters, VOCs, Anions, and Non-Metals.

Station No. County	Well Name	Well Depth feet	Casing Depth feet	Well Size Inches	Date sampled	pH	cond. uS/cm	diss O2 mg/L	Temp °C	VOCs ug/L	Cl mg/L	SO4 mg/L	NOx mg N/L	P mg/L
GWN-PA2 Chatham	Savannah Well #13	1004	NG	NG	5/10/2011	7.94	237	0.57	23.2	ND	11	ND	0.02	0.02
GWN-PA4 Chatham	Tybee Island Well #1	402	NG	NG	8/24/2011	8.09	407	NA	22.9	ND	44	120	ND	0.03
GWN-PA5 Liberty	Interstate Paper Well #1	810	NG	NG	5/10/2011	7.82	310	0.52	24.4	ND	ND	33	ND	0.04
GWN-PA6 Liberty	Hinesville Well #5	806	NG	NG	5/25/2011	7.79	176	NA	24.7	ND	ND	23	ND	0.03
GWN-PA9C Glynn	Miller Ball Park North East Well	1211	NG	NG	5/25/2011	8.15	307	NA	28.1	ND	730	260	ND	0.03
GWN-PA13 Ware	Waycross Well #3	775	NG	NG	4/13/2011	7.55	391	0.58	25.2	ND	15	50	ND	ND
GWN-PA14A Bulloch	Statesboro Well #4	413	NG	NG	5/11/2011 8/24/2011 11/17/2011	7.82 8.21 8.06	250 154 153	NA NA NA	23.5 23.9 22.9	ND ND ND	ND ND ND	ND ND ND	ND ND ND	0.02 0.03 0.04
GWN-PA16 Jenkins	Millen Well #1	500	NG	NG	5/11/2011	7.12	284	0.59	21.5	ND	ND	ND	ND	0.03
GWN-PA17 Emanuel	Swainsboro Well #7	260	NG	NG	5/11/2011	7.15	257	3.83	21.0	ND	ND	ND	0.04	ND
GWN-PA18 Candler	Meffer Well #2	540	NG	NG	5/11/2011	7.89	217	0.58	21.9	ND	ND	ND	ND	0.03
GWN-PA20 Lanier	Lakeland Well #2	340	NG	NG	4/13/2011	7.65	349	0.66	22.3	ND	ND	64	ND	0.07
GWN-PA22 Thomas	Thomasville Well #6	400	NG	NG	3/31/2011	7.67	401	4.05	21.9	ND	ND	67	0.18	0.03

**Table A-6. Ground-Water Quality Analyses for Floridan Stations.
Part B: Metals.**

Station No. County	Cr ug/L	Ni ug/L	Cu ug/L	Zn ug/L	As ug/L	Se ug/L	Mo ug/L	Ag ug/L	Cd ug/L	Sn ug/L	Sb ug/L	Ba ug/L	Tl ug/L	Pb ug/L	U ug/L	Al ug/L	Be ug/L	Ca ug/L	Co ug/L	Fe ug/L	K ug/L	Mg ug/L	Mn ug/L	Na ug/L	Ti ug/L	V ug/L
GWN-PA2 Chatham	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	11	ND	ND	ND	ND	ND	22,000	ND	ND	ND	8,300	ND	15,000	ND	ND
GWN-PA4 Chatham	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	ND	ND	ND	ND	ND	35,000	ND	ND	ND	28,000	ND	55,000	ND	ND
GWN-PA5 Liberty	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	31.0	ND	ND	ND	ND	ND	24,000	ND	ND	ND	14,000	ND	16,000	ND	ND
GWN-PA6 Liberty	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	23.0	ND	ND	ND	65	ND	26,000	ND	ND	ND	13,000	ND	16,000	ND	ND
GWN-PA9C Glynn	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	56	ND	ND	ND	ND	ND	100,000	ND	330	8,400	76,000	ND	400,000	ND	ND
GWN-PA13 Ware	ND	ND	17	17	ND	ND	ND	ND	ND	ND	ND	71	ND	1.2	ND	72	ND	41,000	ND	ND	ND	18,000	ND	16,000	ND	ND
GWN-PA14A Bulloch	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.9	ND	ND	ND	ND	ND	30,000	ND	ND	ND	5,700	ND	6,700	ND	ND
	ND	ND	12	ND	ND	ND	ND	ND	ND	ND	ND	4.3	ND	ND	ND	ND	ND	33,000	ND	ND	ND	6,200	ND	7,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.8	ND	ND	ND	ND	ND	34,000	ND	ND	ND	6,500	ND	7,300	ND	ND
GWN-PA16 Jenkins	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.5	ND	ND	ND	ND	ND	45,000	ND	ND	ND	3,200	45	4,900	ND	ND
GWN-PA17 Emanuel	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	160	ND	ND	ND	ND	ND	45,000	ND	ND	ND	2,000	ND	2,900	ND	ND
GWN-PA18 Candler	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	25	ND	ND	ND	ND	ND	27,000	ND	ND	ND	3,000	55	9,500	ND	ND
GWN-PA20 Lanier	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	28	ND	ND	ND	69	ND	43,000	ND	ND	ND	17,000	ND	4,600	ND	ND
GWN-PA22 Thomas	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	24	ND	1.3	ND	ND	ND	43,000	ND	ND	ND	21,000	ND	6,900	ND	ND

Part A: Station Identification, Date of Sampling, Field Parameters, VOCs, Anions, and Non-Metals.

Station No.	Well Name	Well Depth feet	Casing Depth feet	Well Size Inches	Date sampled	pH	cond. uS/cm	diss O2 mg/L	Temp °C	VOCs ug/L	Cl mg/L	SO4 mg/L	NOx mg N/L	P mg/L
GWN-PA23 Grady	Cairo #8	465'	NG	NG	3/17/2011	7.66	375	2.05	22.9	tcm=1.1 bdbcm=1.2	11	49	0.02	0.02
					8/10/2011	7.82	224	1.49	23.0	dbcm=1.4 tcm=1.3 bdbcm=1.0	10	43	ND	0.02
					10/27/2011	7.62	347	2.78	23.1	dbcm=1.1 tcm=2.3 bdbcm=1.4 bdbcm=1.2	ND	41	0.03	ND
GWN-PA25 Seminole	Donalsonville / 7th Street Well	174	NG	NG	3/31/2011	7.35	290	5.05	21.1	ND	ND	ND	1.70	0.03
					8/10/2011	7.55	186	5.00	21.1	ND	ND	ND	1.70	0.02
					11/16/2011	7.59	287	NA	21.1	ND	ND	ND	1.60	ND
GWN-PA27 Mitchell	Camilla Industrial Park Well	360	NG	NG	3/31/2011	7.58	238	3.49	20.3	ND	ND	ND	0.49	0.03
GWN-PA28 Colquitt	Moultrie Well #1	750	NG	NG	3/17/2011	7.84	438	0.53	23.4	ND	11	96	ND	0.03
					8/9/2011	7.43	388	0.59	25.3	tcm=1.2 tbrm=1.8 bdbcm=1.3 bdbcm=2.0	16	170	ND	0.03
GWN-PA29 Cook	Adel Well #6	405	NG	NG	10/27/2011	7.76	488	8.20	22.9	ND	12	120	0.02	ND
					3/16/2011	7.34	353	0.67	22.1	ND	ND	64	ND	0.05
					8/9/2011	8.38	223	0.01	22.1	ND	ND	60	ND	0.05
					10/26/2011	7.54	347	0.63	22.1	ND	ND	62	ND	0.05
GWN-PA30 Berrien	Propex/Nashville Mills Well #2	410'	NG	NG	8/9/2011	8.49	218	0.04	23.6	ND	ND	62	ND	0.03
GWN-PA31 Tift	Tifton Well #6	652	NG	NG	3/16/2011	7.36	270	1.15	22.0	ND	ND	ND	0.02	0.03
GWN-PA32 Irwin	Ocilla Well #3	637	NG	NG	3/30/2011	7.82	195	3.25	20.9	ND	ND	ND	ND	0.04

Table A-6. Ground-Water Quality Analyses for Floridan Stations.

Part B: Metals.

Station No.	Cr ug/L	Ni ug/L	Cu ug/L	Zn ug/L	As ug/L	Se ug/L	Mo ug/L	Ag ug/L	Cd ug/L	Sn ug/L	Sb ug/L	Ba ug/L	Tl ug/L	Pb ug/L	U ug/L	Al ug/L	Be ug/L	Ca ug/L	Co ug/L	Fe ug/L	K ug/L	Mg ug/L	Mn ug/L	Na ug/L	Ti ug/L	V ug/L	
GWN-PA23 Grady	ND	ND	ND	ND	ND	ND	20	ND	ND	ND	ND	110	ND	ND	ND	ND	ND	38,000	ND	320	ND	18,000	ND	15,000	ND	ND	ND
GWN-PA25 Seminole	ND	ND	ND	ND	5.2	ND	20	ND	ND	ND	ND	120	ND	ND	ND	ND	ND	33,000	ND	41	ND	16,000	ND	14,000	ND	ND	ND
GWN-PA27 Mitchell	ND	ND	25	22	5.0	ND	26	ND	ND	ND	ND	110	ND	ND	1.8	ND	ND	37,000	ND	120	ND	18,000	ND	14,000	ND	ND	ND
GWN-PA28 Colquitt	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8.2	ND	ND	ND	ND	ND	57,000	ND	ND	ND	ND	ND	3,100	ND	ND	ND
GWN-PA29 Cook	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8.5	ND	ND	ND	ND	ND	59,000	ND	ND	ND	ND	ND	3,700	ND	ND	ND
GWN-PA30 Berrien	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8.6	ND	ND	ND	ND	ND	57,000	ND	73	ND	ND	ND	3,500	ND	ND	ND
GWN-PA31 Tift	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	12	ND	ND	ND	ND	ND	46,000	ND	ND	ND	1,400	ND	1,300	ND	ND	ND
GWN-PA32 Irwin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	96	ND	ND	ND	ND	ND	36,000	ND	ND	ND	20,000	ND	27,000	ND	ND	ND
	ND	ND	ND	ND	ND	ND	19	ND	ND	ND	ND	83	ND	ND	ND	ND	ND	58,000	ND	65	ND	28,000	ND	28,000	ND	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	83	ND	ND	ND	ND	ND	38,000	ND	ND	ND	22,000	ND	26,000	ND	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	12	ND	ND	ND	ND	ND	52,000	ND	100	ND	18,000	23	3,900	ND	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	13	ND	1.1	1.5	ND	ND	46,000	ND	39	ND	16,000	17	3,300	ND	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	11	ND	ND	ND	ND	ND	45,000	ND	34	ND	16,000	16	3,100	ND	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	58	ND	3.2	1.4	ND	ND	43,000	ND	110	ND	17,000	ND	5,100	ND	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	69	ND	1.1	1.6	ND	ND	47,000	ND	ND	ND	8,900	ND	2,500	ND	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	76	ND	ND	ND	ND	ND	33,000	ND	92	ND	6,000	29	1,900	ND	ND	ND

**Table A-6, Continued. Ground-Water Quality Analyses for Floridan Stations.
Part A: Station Identification, Date of Sampling, Field Parameters, VOCs, Anions, and Non-Metals.**

Station No. County	Well Name	Well Depth feet	Casing Depth feet	Well Size Inches	Date sampled	pH	cond. uS/cm	diss O2 mg/L	Temp °C	VOCs ug/L	Cl mg/L	SO4 mg/L	NOx mg N/L	P mg/L
GWN-PA34A Telfair	McRae Well #3	600	NG	NG	5/12/2011 8/9/2011 11/17/2011	7.45 7.37 7.64	318 315 206	0.57 0.54 NA	22.4 22.6 22.3	ND ND ND	ND ND ND	ND ND ND	ND ND ND	ND 0.03 0.02
GWN-PA36 Toombs	Vidalia #1	808	NG	NG	5/26/2011 8/9/2011 11/17/2011	7.98 7.54 8.17	142 215 142	NA 0.53 NA	23.2 23.9 22.9	ND ND ND	ND ND ND	ND ND ND	ND ND ND	0.03 0.03 0.02
GWN-PA38 Dodge	Eastman Well #4	410	NG	NG	5/12/2011	7.61	225	4.73	20.7	ND	ND	ND	0.28	0.03
GWN-PA39 Worth	SylvesterWell #1	196	NG	NG	5/24/2011	7.01	278	1.57	22.0	ND	ND	ND	0.04	0.02
GWN-PA44 Turner	Sycamore Well #2	501	NG	NG	4/13/2011 8/9/2011 10/26/2011	7.81 7.75 7.35	187 185 208	4.78 4.25 8.67	21.3 22.0 23.3	ND ND tcm=6.6 tbn=0.62	ND ND ND	ND ND ND	0.2 0.2 0.04	ND 0.02 0.02
GWN-PA49 Dooly	Harmony Church Well	97	NG	NG	5/12/2011	7.55	204	8.02	20.9	ND	ND	ND	2.2	0.03
GWN-PA56 Grady	Whigham / Davis Avenue Well	604'	NG	NG	3/17/2011 8/10/2011 11/16/2011	7.70 7.84 8.06	380 254 250	1.07 0.51 NA	22.9 22.8 22.8	ND ND ND	31 36 34	19 21 20	0.05 0.07 0.05	0.02 0.03 0.02
GWN-PA57 Coffee	Ambrose Well #2	600	465	10	3/30/2011 8/9/2011 10/26/2011	7.89 7.79 7.54	231 237 237	6.57 0.70 0.60	22.1 22.8 21.6	ND ND ND	ND ND ND	ND ND ND	ND ND ND	0.03 0.02 0.02

**Table A-6. Ground-Water Quality Analyses for Floridan Stations.
Part B: Metals.**

Station No. County	Cr ug/L	Ni ug/L	Cu ug/L	Zn ug/L	As ug/L	Se ug/L	Mo ug/L	Ag ug/L	Cd ug/L	Sn ug/L	Sb ug/L	Ba ug/L	Tl ug/L	Pb ug/L	U ug/L	Al ug/L	Be ug/L	Ca ug/L	Co ug/L	Fe ug/L	K ug/L	Mg ug/L	Mn ug/L	Na ug/L	Ti ug/L	V ug/L	
GWN-PA34A Telfair	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	180	ND	ND	ND	ND	ND	ND	44,000	ND	220	ND	9,800	88	4,200	ND	ND
GWN-PA36 Toombs	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	180	ND	1.3	ND	ND	ND	47,000	ND	240	ND	10,000	98	4,300	ND	ND	
GWN-PA38 Dodge	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	180	ND	ND	ND	ND	ND	49,000	ND	240	ND	11,000	97	4,600	ND	ND	
GWN-PA39 Worth	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	140	ND	ND	ND	ND	ND	28,000	ND	32	ND	5,700	38	12,000	ND	ND	
GWN-PA44 Turner	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	130	ND	ND	ND	ND	ND	28,000	ND	24	ND	5,500	38	11,000	ND	ND	
GWN-PA49 Dooley	7.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	130	ND	ND	ND	ND	ND	29,000	ND	25	ND	5,800	39	12,000	ND	ND	
GWN-PA56 Grady	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	100	ND	ND	ND	ND	ND	41,000	ND	ND	ND	1,300	ND	1,800	ND	ND	
GWN-PA57 Coffee	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	200	ND	1.7	2.4	ND	ND	48,000	ND	ND	ND	7,000	ND	3,800	ND	ND	
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	150	ND	ND	1.4	ND	ND	28,000	ND	ND	ND	4,100	ND	2,400	ND	ND	
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	140	ND	3.0	1.3	ND	ND	30,000	ND	ND	ND	4,300	ND	2,400	ND	ND	
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	140	ND	ND	1.2	ND	ND	34,000	ND	ND	ND	5,200	ND	3,500	ND	ND	
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	17.0	ND	ND	ND	ND	ND	37,000	ND	ND	ND	ND	ND	1,600	ND	ND	
	ND	ND	ND	ND	ND	ND	8.1	ND	ND	ND	ND	150	ND	ND	2.8	ND	ND	31,000	ND	23	ND	19,000	ND	21,000	ND	ND	
	ND	ND	ND	ND	ND	ND	9.3	ND	ND	ND	ND	150	ND	ND	4.1	ND	ND	32,000	ND	ND	ND	20,000	ND	24,000	ND	ND	
	ND	ND	ND	ND	ND	ND	9.3	ND	ND	ND	ND	160	ND	ND	3.1	ND	ND	31,000	ND	ND	ND	19,000	ND	22,000	ND	ND	
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	190	ND	ND	ND	ND	ND	25,000	ND	ND	ND	16,000	ND	7,300	ND	ND	
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	180	ND	1.0	ND	ND	ND	25,000	ND	ND	ND	14,000	ND	7,100	ND	ND	
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	160	ND	1.0	ND	ND	ND	25,000	ND	ND	ND	15,000	ND	7,400	ND	ND	

**Table A-7. Ground-Water Quality Analyses for Piedmont-Blue Ridge Stations.
Part A: Station Identification, Date of Sampling, Field Parameters, VOCs, Anions, and Non-Metals.**

Station No. County	Well Name	Well Depth feet	Casing Depth feet	Well Size Inches	Date sampled	pH	cond. uS/cm	diss O2 mg/L	Temp °C	VOCs ug/L	Cl mg/L	SO4 mg/L	NOx mg N/L	P mg/L	F mg/L
GWN-P1A Meriwether	Luthersville Well #3	185	NG	NG	9/29/2011	6.47	52	NA	17.5	ND	ND	ND	1.00	0.07	NA
GWN-P5 Hall	Flowers Branch Well #1	161	NG	NG	9/28/2011	6.50	105	5.06	16.5	ND	ND	ND	0.91	0.03	NA
GWN-P12A Butts	Indian Spring	0	NG	NG	6/22/2011 9/28/2011	7.27 7.27	162 264	NA 10.50	18.3 19.6	ND ND	12 12	26 25	ND ND	0.03 ND	4.4 4.6
GWN-P21 Jones	Gray/Bragg Well	405	NG	NG	6/22/2011 9/28/2011	6.49 5.81	197 335	5.33 0.77	19.4 19.1	ND ND	10 11	36 50	0.14 0.20	0.04 0.03	NA NA
GWN-P22 Fulton	Rahbar well	200	NG	NG	6/23/2011	4.71	17	6.39	16.7	ND	ND	ND	0.86	0.02	NA
GWN-P23 Butts	Indian Springs State Parl New Main Well	NG	NG	NG	6/22/2011 9/28/2011	6.03 6.07	92 140	1.64 3.36	18.3 18.4	ND ND	ND ND	ND ND	0.23 0.28	0.09 0.09	1.1 1.1
GWN-P24 Coweta	The Gates Well #1	705	NG	NG	6/23/2011	7.44	132	2.66	18.7	ND	ND	15	0.22	0.06	NA
GWN-P29 Rockdale	Cook well	310	NG	NG	9/29/2011	6.10	90	NA	17.9	ND	ND	ND	1.3	0.06	NA
GWN-P32 Elbert	Cecchini deep well	400	NG	NG	10/26/2011	8.31	382	NA	18.0	ND	ND	220	ND	ND	NA
GWN-P33 Elbert	Cecchini bored well	47	NG	NG	10/26/2011	6.29	52	NA	17.8	ND	ND	ND	0.23	0.04	NA
GWN-P34 Columbia	Mistletoe State Park Cottage Area Well	NG	NG	NG	11/30/2011	5.69	91	8.46	18.6	ND	ND	ND	0.65	0.16	NA
GWN-P35 Franklin	O'Connor well	150	NG	NG	10/26/2011	7.65	113	NA	17.1	ND	ND	ND	0.02	0.02	NA

**Table A-7. Ground-Water Quality Analyses for Piedmont-Blue Ridge Stations.
Part B: Metals.**

Station No.	County	Cr ug/L	Ni ug/L	Cu ug/L	Zn ug/L	As ug/L	Se ug/L	Mo ug/L	Ag ug/L	Cd ug/L	Sn ug/L	Sb ug/L	Ba ug/L	Tl ug/L	Pb ug/L	U ug/L	Al ug/L	Be ug/L	Ca ug/L	Co ug/L	Fe ug/L	K ug/L	Mg ug/L	Mn ug/L	Na ug/L	Ti ug/L	V ug/L
GWN-P1A	Meriwether	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	44	ND	ND	ND	ND	ND	9,200	ND	ND	ND	1,900	ND	4,300	ND	ND
GWN-P5	Hall	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	35	ND	ND	ND	ND	ND	25,000	ND	ND	ND	4,700	ND	2,400	ND	ND
GWN-P12A	Butts	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	15,000	ND	ND	2,300	19	35,000	ND	ND	
GWN-P21	Jones	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	14	ND	ND	7.1	ND	ND	37,000	ND	ND	3,200	78	15,000	ND	ND	
GWN-P22	Fulton	ND	ND	12	ND	ND	ND	ND	ND	ND	ND	ND	11	ND	3.7	12	ND	ND	36,000	ND	ND	9,500	93	14,000	ND	ND	
GWN-P23	Butts	ND	ND	ND	47	ND	ND	ND	ND	ND	ND	ND	4.3	ND	ND	2.1	ND	ND	12,000	ND	130	3,600	ND	13,000	ND	ND	
GWN-P24	Coweta	ND	ND	ND	100	ND	ND	ND	ND	ND	ND	ND	7.1	ND	7.5	2.1	ND	ND	11,000	ND	430	3,400	ND	13,000	ND	ND	
GWN-P29	Rockdale	ND	ND	28	170	ND	ND	18	ND	ND	ND	ND	4.1	ND	14	200	ND	ND	13,000	ND	ND	1,400	23	11,000	ND	ND	
GWN-P32	Elbert	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.4	ND	ND	13.0	ND	ND	160,000	ND	ND	1,900	14	23,000	ND	ND	
GWN-P33	Elbert	ND	ND	23	40	ND	ND	ND	ND	ND	ND	ND	25	ND	1.5	ND	530	ND	13,000	ND	530	ND	35	3,800	ND	ND	
GWN-P34	Columbia	ND	ND	19	35	ND	ND	ND	ND	ND	ND	ND	20	ND	2.8	9.1	ND	ND	5,800	ND	ND	3,000	ND	8,000	ND	ND	
GWN-P35	Franklin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	38	ND	ND	2.6	ND	ND	19,000	ND	130	6,000	110	7,300	ND	ND	

**Table A-7, Continued. Ground-Water Quality Analyses for Piedmont-Blue Ridge Stations.
Part A: Station Identification, Date of Sampling, Field Parameters, VOCs, Anions, and Non-Metals.**

Station No.	Well Name	Well Depth feet	Casing Depth feet	Well Size Inches	Date sampled	pH	cond. uS/cm	diss O2 mg/L	Temp °C	VOCs ug/L	Cl mg/L	SO4 mg/L	NOx mg N/L	P mg/L	F mg/L
GWN-P37 Habersham	Mt. Airy/City Hall Well	500	NG	NG	10/26/2011	6.85	326	1.08	16.6	tcm = 0.77	100	24	0.22	0.02	NA
GWN-P38 Carroll	Roopville Well #1	230	NG	NG	12/01/2011	4.70	26	NA	18.0	ND	ND	ND	1.60	ND	NA
GWN-P39 Meriwether	Gay Well #1	600	NG	NG	12/01/2011	6.07	46	NA	17.4	ND	ND	ND	1.00	0.07	NA
GWN-P40 Greene	Siloam Well #2	300+	NG	NG	11/30/2011	5.46	84	7.85	19.3	ND	ND	ND	1.70	0.09	NA
GWN-BR1B Towns	Young Harris/ Swanson Road Well	265	NG	NG	8/10/2011 11/16/2011	6.97 7.04	158 160	1.50 1.01	15.7 15.7	ND ND	ND ND	22 21	0.04 0.03	0.02 0.02	NA NA
GWN-BR5 Murray	Chatsworth / Nix Spring	0	NG	NG	11/15/2011	6.90	49	10.69	14.9	ND	ND	ND	0.58	0.10	NA

**Table A-7. Ground-Water Quality Analyses for Piedmont-Blue Ridge Stations.
Part B: Metals.**

Station No. County	Cr ug/L	Ni ug/L	Cu ug/L	Zn ug/L	As ug/L	Se ug/L	Mo ug/L	Ag ug/L	Cd ug/L	Sn ug/L	Sb ug/L	Ba ug/L	Tl ug/L	Pb ug/L	U ug/L	Al ug/L	Be ug/L	Ca ug/L	Co ug/L	Fe ug/L	K ug/L	Mg ug/L	Mn ug/L	Na ug/L	Ti ug/L	V ug/L	
GWN-P37 Habersham	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	110,000	ND	ND	ND
GWN-P38 Carroll	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	30	ND	1.1	ND	62	ND	1,100	ND	ND	ND	ND	ND	24	4,900	ND	ND
GWN-P39 Meriwether	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	39	ND	ND	ND	ND	ND	4,700	ND	ND	ND	1,100	ND	8,400	ND	ND	
GWN-P40 Greene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	17	ND	1.2	7.5	ND	ND	7,000	ND	ND	ND	1,400	ND	9,400	ND	ND	
GWN-BR1B Towns	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	74	ND	ND	8.7	ND	ND	21,000	ND	ND	ND	4,600	21	3,900	ND	ND	
GWN-BR5 Murray	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	78	ND	ND	8.6	ND	ND	20,000	ND	ND	ND	4,400	22	3,800	ND	ND	
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	13	ND	ND	ND	ND	ND	4,200	ND	ND	ND	ND	ND	4,200	ND	ND	

**Table A-8. Ground-Water Quality Analyses for Valley and Ridge/Appalachian Plateau Stations.
Part A: Station Identification, Date of Sampling, Field Parameters, VOCs, Anions, and Non-Metals.**

Station No. County	Well Name	Well Depth feet	Casing Depth feet	Well Size Inches	Date sampled	pH	cond. uS/cm	diss O2 mg/L	Temp °C	VOCs ug/L	Cl mg/L	SO4 mg/L	NOx mg N/L	P mg/L
GWN-VR1 Floyd	Floyd County / Kingston Rd. Well	280	NG	NG	8/25/2011	7.13	243	7.29	16.4	ND	ND	ND	0.63	ND
GWN-VR2A Walker	LaFayette / Lower Big Spring	0	NG	NG	11/15/2011	6.85	301	6.50	15.7	ND	ND	ND	1.70	0.02
GWN-VR3 Walker	Chickamauga / Crawfish Spring	0	NG	NG	8/10/2011	7.10	253	8.81	15.7	ND	ND	ND	0.79	ND
GWN-VR6A Bartow	Chemical Products Corp. South Well	300	NG	NG	8/25/2011	7.15	280	5.58	17.8	1,1dce=2.0 pce=2.8 pdcb=0.71 odcb=2.7	ND	ND	0.90	0.02
GWN-VR8 Polk	Cedartown Spring	0	NG	NG	8/25/2011 11/15/2011	7.52 7.54	262 255	NA 7.75	16.9 16.7	ND ND	ND ND	ND ND	0.67 0.69	ND ND
GWN-VR10 Murray	Eton Spring	0	NG	NG	11/15/2011	7.20	250	4.76	16.3	ND	ND	ND	1.70	ND

**Table A-8. Ground-Water Quality Analyses for Valley-and-Ridge Stations.
Part B: Metals.**

Station No. County	Cr ug/L	Ni ug/L	Cu ug/L	Zn ug/L	As ug/L	Se ug/L	Mo ug/L	Ag ug/L	Cd ug/L	Sn ug/L	Sb ug/L	Ba ug/L	Tl ug/L	Pb ug/L	U ug/L	Al ug/L	Be ug/L	Ca ug/L	Co ug/L	Fe ug/L	K ug/L	Mg ug/L	Mn ug/L	Na ug/L	Ti ug/L	V ug/L	
GWN-VR1 Floyd	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9.7	ND	ND	ND	ND	ND	28,000	ND	ND	ND	16,000	ND	1,600	ND	ND	ND
GWN-VR2A Walker	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	93	ND	ND	ND	100	ND	41,000	ND	130	ND	14,000	11	1,500	ND	ND	ND
GWN-VR3 Walker	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	80	ND	ND	ND	ND	ND	32,000	ND	ND	ND	14,000	ND	1,100	ND	ND	ND
GWN-VR6A Bartow	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	500	ND	ND	ND	ND	ND	29,000	ND	ND	ND	17,000	ND	5,900	ND	ND	ND
GWN-VR8 Polk	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	14	ND	ND	ND	ND	ND	34,000	ND	ND	ND	16,000	ND	1,400	ND	ND	ND
GWN-VR10 Murray	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	12	ND	ND	ND	ND	ND	31,000	ND	ND	ND	15,000	ND	1,300	ND	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	45	ND	7.2	ND	ND	ND	30,000	ND	120	ND	12,000	ND	2,300	ND	ND	ND

Table A-9. Analytes, EPA Analytical Methods, and Reporting Limits.

Analyte	Reporting Limit/ EPA Method	Analyte	Reporting Limit/ EPA Method
Vinyl Chloride	0.5 ug/L / 524.2	Dichlorodifluoro- methane	0.5 ug/L / 524.2
1,1-Dichloro- ethylene	0.5 ug/L / 524.2	Chloromethane	0.5 ug/L / 524.2
Dichloromethane	0.5 ug/L / 524.2	Bromomethane	0.5 ug/L / 524.2
Trans-1,2- Dichloroethylene	0.5 ug/L / 524.2	Chloroethane	0.5 ug/L / 524.2
Cis-1,2- Dichloroethylene	0.5 ug/L / 524.2	Fluorotrichloro- methane	0.5 ug/L / 524.2
1,1,1-Trichloro- ethane	0.5 ug/L / 524.2	1,1-Dichloroethane	0.5 ug/L / 524.2
Carbon Tetrachloride	0.5 ug/L / 524.2	2,2-Dichloropropane	0.5 ug/L / 524.2
Benzene	0.5 ug/L / 524.2	Bromochloro- methane	0.5 ug/L / 524.2
1,2-Dichloroethane	0.5 ug/L / 524.2	Chloroform	0.5 ug/L / 524.2
Trichloroethylene	0.5 ug/L / 524.2	1,1-Dichloropropene	0.5 ug/L / 524.2
1,2-Dichloropropane	0.5 ug/L / 524.2	Dibromomethane	0.5 ug/L / 524.2
Toluene	0.5 ug/L / 524.2	Bromodichloro- methane	0.5 ug/L / 524.2
1,1,2-Trichloro- ethane	0.5 ug/L / 524.2	Cis-1,3-Dichloropro- pene	0.5 ug/L / 524.2
Tetrachloroethylene	0.5 ug/L / 524.2	Trans-1,3- Dichloropropene	0.5 ug/L / 524.2
Chlorobenzene	0.5 ug/L / 524.2	1,3-Dichloropropane	0.5 ug/L / 524.2
Ethylbenzene	0.5 ug/L / 524.2	Chlorodibromo- methane	0.5 ug/L / 524.2
Total Xylenes	0.5 ug/L / 524.2	1,2-Dibromoethane	0.5 ug/L / 524.2
Styrene	0.5 ug/L / 524.2	1,1,1,2- Tetrachloroethane	0.5 ug/L / 524.2
p-Dichlorobenzene	0.5 ug/L / 524.2	Bromoform	0.5 ug/L / 524.2
o-Dichlorobenzene	0.5 ug/L / 524.2	Isopropylbenzene	0.5 ug/L / 524.2
1,2,4-Trichloro- benzene	0.5 ug/L / 524.2	1,1,2,2- Tetrachloroethane	0.5 ug/L / 524.2

Table A-9, Continued. Analytes, EPA Analytical Methods, and Reporting Limits.

Analyte	Reporting Limit/ EPA Method	Analyte	Reporting Limit/ EPA Method
Bromobenzene	0.5 ug/L / 524.2	Total Phosphorus	0.02 mg/L / 365.1
1,2,3-Trichloro- propane	0.5 ug/L / 524.2	Fluoride	0.20 mg/L / 300.0
n-Propylbenzene	0.5 ug/L / 524.2	Silver	10 ug/L / 200.7 (ICP)
o-Chlorotoluene	0.5 ug/L / 524.2	Aluminum	60 ug/L / 200.7
1,3,5-Trimethyl- benzene	0.5 ug/L / 524.2	Arsenic	80 ug/L / 200.7
p-Chlorotoluene	0.5 ug/L / 524.2	Barium	10 ug/L / 200.7
Tert-Butylbenzene	0.5 ug/L / 524.2	Beryllium	10 ug/L / 200.7
1,2,4-Trimethyl- benzene	0.5 ug/L / 524.2	Calcium	2000 ug/L / 200.7
Sec-Butylbenzene	0.5 ug/L / 524.2	Cobalt	10 ug/L / 200.7
p-Isopropyltoluene	0.5 ug/L / 524.2	Chromium	20 ug/L / 200.7
m-Dichlorobenzene	0.5 ug/L / 524.2	Copper	20 ug/L / 200.7
n-Butylbenzene	0.5 ug/L / 524.2	Iron	20 ug/L / 200.7
1,2-Dibromo-3- chloropropane	0.5 ug/L / 524.2	Potassium	5000 ug/L / 200.7
Hexachlorobutadi- ene	0.5 ug/L / 524.2	Magnesium	1000 ug/L / 200.7
Naphthalene	0.5 ug/L / 524.2	Manganese	10 ug/L / 200.7
1,2,3-Trichloro- benzene	0.5 ug/L / 524.2	Sodium	1000 ug/L / 200.7
Methyl-tert-butyl ether (MTBE)	0.5 ug/L / 524.2	Nickel	20 ug/L / 200.7
Chloride	10 mg/L / 300.0	Lead	90 ug/L / 200.7
Sulfate*	10 mg/L / 300.0	Antimony	120 ug/L / 200.7
Nitrate/nitrite*	0.02 mg/L as Nitrogen / 353.2	Selenium	190 ug/L / 200.7

Table A-9, Continued. Analytes and Reporting Limits.

Analyte	Reporting Limit/ EPA Method	Analyte	Reporting Limit/ EPA Method
Titanium	10 ug/L / 200.7	Molybdenum	5 ug/L / 200.8
Thallium	200 ug/L / 200.7	Silver	5 ug/L / 200.8
Vanadium	10 ug/L / 200.7	Cadmium	0.7 ug/L / 200.8
Zinc	20 ug/L / 200.7	Tin	30 ug/L / 200.8
Chromium	5 ug/L / 200.8 (ICPMS)	Antimony	5 ug/L / 200.8
Nickel	10 ug/L / 200.8	Barium	2 ug/L / 200.8
Copper	5 ug/L / 200.8	Thallium	1 ug/L / 200.8
Zinc	10 ug/L / 200.8	Lead	1 ug/L / 200.8
Arsenic	5 ug/L / 200.8	Uranium	1 ug/L / 200.8
Selenium	5 ug/L / 200.8		

* **Note:** Reporting limits for sulfate and nitrate/nitrite are subject to change. A sample with a concentration of either analyte greater than certain ranges may need to be diluted to bring the concentration within the analytical ranges of the testing instruments. This dilution results in a proportional increase in the reporting limit.

Table A-10. Analytes, Primary MCLs*, and Secondary MCLs*.

Analyte	Primary MCL	Secondary MCL	Analyte	Primary MCL	Secondary MCL
Vinyl Chloride	2 ug/L	None	p-Dichlorobenzene	75 ug/L	None
1,1-Dichloroethylene	7 ug/L	None	o-Dichlorobenzene	600 ug/L	None
Dichloromethane	5 ug/L	None	1,2,4-Trichlorobenzene	70 ug/L	None
Trans-1,2-Dichloroethylene	100 ug/L	None	Chloroform (1)	Total 1,2,3,4 = 80 ug/L	None
Cis-1,2-Dichloroethylene	70 ug/L	None	Bromodichloromethane (2)	Total 1,2,3,4 = 80 ug/L	None
1,1,1-Trichloroethane	200 ug/L	None	Chlorodibromomethane (3)	Total 1,2,3,4 = 80 ug/L	None
Carbon Tetrachloride	5 ug/L	None	Bromoform (4)	Total 1,2,3,4 = 80 ug/L	None
Benzene	5 ug/L	None	Chloride	None	250 mg/L
1,2-Dichloroethane	5 ug/L	None	Sulfate	None	250 mg/L
Trichloroethylene	5 ug/L	None	Nitrate/nitrite	10 mg/L as Nitrogen	None
1,2-Dichloro-propane	5 ug/L	None	Fluoride	4 mg/L	2 mg/L
Toluene	1,000 ug/L	None	Aluminum	None	50 -200 ug/L
1,1,2-Trichloroethane	5 ug/L	None	Antimony	6 ug/L	None
Tetrachloroethylene	5 ug/L	None	Arsenic	10 ug/L	None
Chlorobenzene	100 ug/L	None	Barium	2000 ug/L	None
Ethylbenzene	700 ug/L	None	Beryllium	4 ug/L	None
Total Xylenes	10,000 ug/L	None	Cadmium	5 ug/L	None
Styrene	100 ug/L	None	Chromium	100 ug/L	None

Table A-10, Continued. Analytes, Primary MCLs*, and Secondary MCLs*.

Analyte	Primary MCL	Secondary MCL	Analyte	Primary MCL	Secondary MCL
Copper	Action level = 1,300 ug/L	1000 ug/L	Selenium	50 ug/L	None
Iron	None	300 ug/L	Silver	None	100 ug/L
Lead	Action level = 15 ug/L	None	Thallium	2 ug/L	None
Manganese	None	50 ug/L	Zinc	None	5,000 ug/L
Nickel	100 ug/L	None			

*Primary MCL = Primary Maximum Contaminant Level, a maximum concentration of a substance allowed in public drinking water due to adverse health effects.

*Secondary MCL = Secondary Maximum Contaminant Level, a maximum concentration of a substance suggested for public drinking water due solely to unpleasant characteristics such as bad flavor or stain-causing ability.

mg/L = milligrams per liter.

ug/L = micrograms per liter.

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