GROUND-WATER QUALITY IN GEORGIA
FOR 2013

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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 2013, is the twenty-seventh 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 an 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 Georgia. With this report and its predecessors, Circular 12Y and 12Z, monitoring the chemical quality of ground water continues using a static array of periodically sampled stations.

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. 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, Resource Conservation Recovery Act (RCRA) facilities, 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 1-1Georgia 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 January 2013 through December 2013 and from previous years form the database for this summary. The Georgia Ground-Water Monitoring Network is presently comprised of 83 stations, both wells and springs. Twenty-one of the stations are scheduled for quarterly sampling; the remainder are 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 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 January 2013 through December 2013 period, Ground-Water Monitoring staff collected 145 samples from 77 wells and 6 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 83 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 and in areas of leakage from adjacent geologic units. 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 casings, through compositional breakdown, can contribute metals (e.g., iron from steel casings) 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 Provinces 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 overlying or underlying aquifers. Most

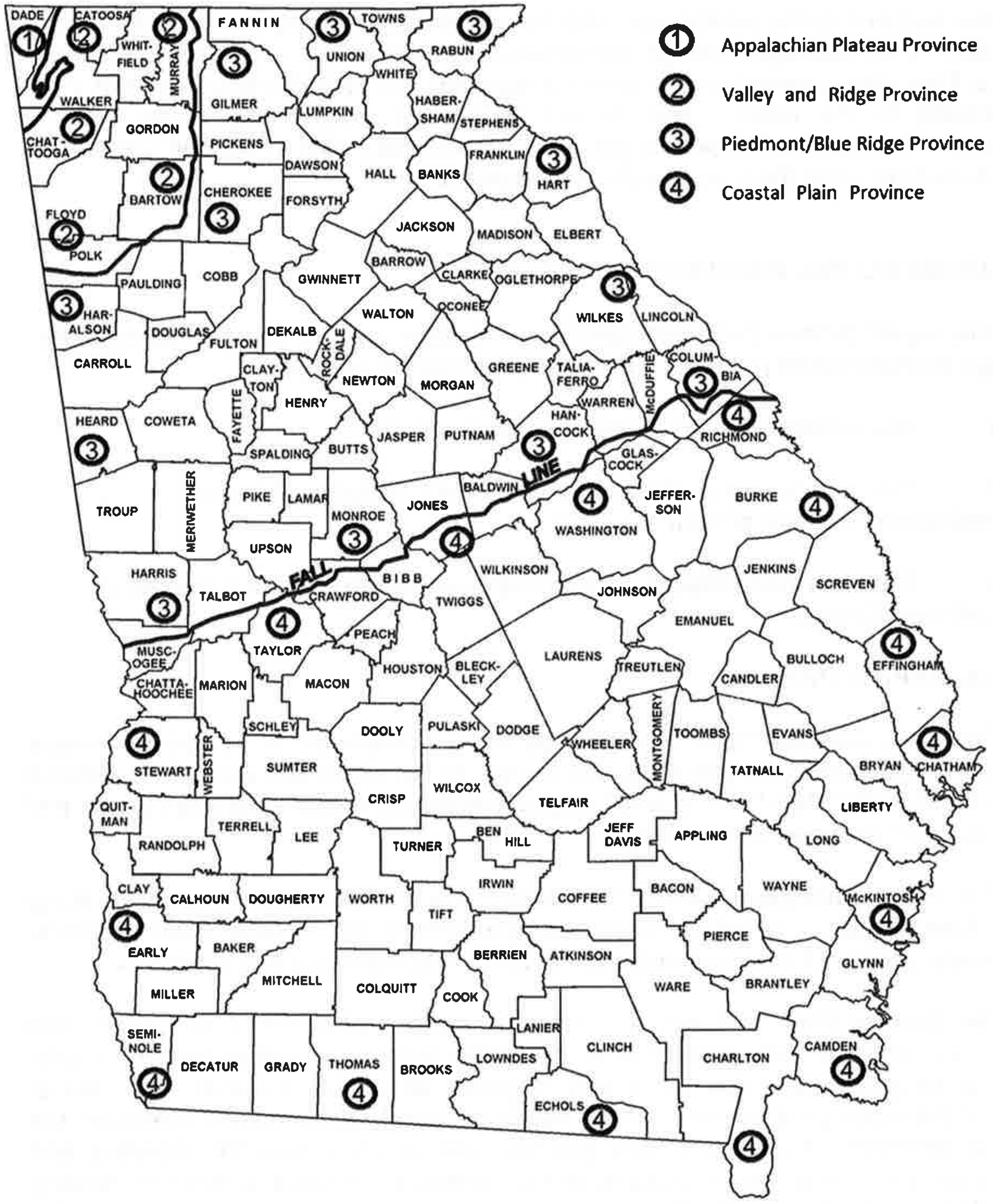


Figure 1-1. The Hydrogeologic Provinces of Georgia

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 through confined Coastal Plain aquifers 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 in part 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); the water resides in fractures and, in the case of specialized rocks such as marbles, solution-enlarged voids (secondary porosity). 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 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 in fold axes at the centers 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, and sediments tend to be flatter lying and more continuous areally. 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 Georgia, at the State's far northwest corner (Dade County and parts of Chattooga and Walker Counties). Due to 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 combined Valley and Ridge/ Appalachian Plateau 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, requiring 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 south of the Fall Line typically yield acidic water that may 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 system. The first is the karstic Dougherty Plain of southwestern Georgia. The second is the Gulf Trough area. The third is in the coastal area of east Georgia.

In the Dougherty Plain, as with the carbonate terranes of northwestern Georgia, surface waters and the contaminants they entrain can directly access the aquifer through sink holes.

The Gulf Trough is a linear geologic feature extending from southwestern Decatur County through northern Effingham County and probably represents a filled-in marine current channel way (Huddleston, 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).

In the Coastal area of east Georgia, the influx of water with high dissolved solids contents can dramatically raise levels of sodium, calcium, magnesium, sulfate, and chloride. In the Brunswick part of the Coastal area, ground-water withdrawal from the upper Floridan results in the upwelling of ground water with high dissolved solids content from the deeper parts of the aquifer system (Krause and Clarke, 2001). In the Savannah portion of the Coastal area, heavy pumping in and around Savannah has caused a cone of depression which has induced seawater to enter the Floridan aquifer system and to flow down-gradient toward Savannah. The seawater enters the aquifer system 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 (Foyle et al., 2001; Krause and Clarke, 2001).

CHAPTER 2 GEORGIA GROUND-WATER MONITORING NETWORK

2.1 MONITORING STATIONS

For the period January 2013 through December 2013, attempts were made to place sampling stations in the Coastal Plain Province's six major aquifer systems, in the Piedmont/Blue Ridge Province, and in the Valley and Ridge/ Appalachian Plateau Province (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 and 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 83 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 2013.

Aquifer or Aquifer System	Number of Stations Visited (Samples Taken)	Primary Stratigraphic Equivalents	Age of Aquifer Host Rocks
Cretaceous	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	5 stations (5 samples)	Barnwell Group	Late Eocene
Floridan	29 stations (59 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	21 stations (50 samples)	Various igneous and metamorphic complexes	Precambrian and Paleozoic
Valley and Ridge/ Appalachian Plateau	6 stations (9 samples)	Shady Dolomite, Knox Group, Conasauga Group	Paleozoic, mainly Cambrian, Ordovician

Stations of the Ground-Water Monitoring Network are intentionally located away from known point sources of pollution. The stations 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 the future drinking-water resource for down-flow areas. 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 145 water samples collected from 83 stations (77 wells and 6 springs) during the period January 2013 through December 2013. 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, a variety of metals, and VOCs. Water from stations P12A and P23 also receive testing for fluoride. Appendix Table A-9 lists the EPA methods used to test for these analytes along with a reporting limit for each analyte. The results of the chemical tests are reported in this Circular. Before collecting a sample, EPD personnel also observe certain field measurements – pH, conductivity, dissolved oxygen, and temperature. This Circular also reports these measurements.

Testing for aluminum, beryllium, calcium, cobalt, iron, potassium, magnesium, manganese, sodium, titanium, and vanadium was undertaken using the inductively-coupled plasma (ICP) method (EPA method 200.7 in Table A-9). This method works well for the mostly major metals listed above. This method was also used to test for arsenic, barium, cadmium, chromium, copper, nickel, lead, antimony, selenium, thallium, and zinc. The inductively-coupled plasma mass spectrometry (ICPMS) method (EPA method 200.8 in Table A-9) was also used to test for the metals mentioned in the previous sentence as well as for molybdenum, silver, tin, and uranium. The ICPMS method generally gives better results for trace metals.

Pursuant to the Georgia Safe Drinking Water Act of 1977, EPD has established Maximum Contaminant Levels (MCLs) for certain analytes and other parameters, certain of which are included in analyses performed on Ground-Water Monitoring samples (EPD, 2009). Primary MCLs pertain to analytes that can adversely affect human health if the maximum concentration for an analyte is exceeded for drinking water. 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 ability to cause stains are examples of such properties. MCLs apply only to treated water offered for public consumption; nevertheless, they constitute 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 analytes.

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, the Miller Ball Park North East Well (PA9C) and the Springfield Egypt Road Test Well (MI17), are flowing, which dispenses altogether with pumps and lessens the effects of the pump-well system on sample water. The pump on the Murphy Garden 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 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 readings of pH, conductivity, temperature, and dissolved oxygen to stabilize and to allow 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 a 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. Sample waters do not pass through a filter before collection. 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 the area. For deeper wells geothermal heating may become apparent.

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 Table A-1 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.

Station numbering assigns each station a two-part alphanumeric designation, the first part consisting of an alphabetic abbreviation for the aquifer being sampled and the second part consisting of a serial numeral, sometimes with an alphabetic suffix, the two parts separated by a dash. In order for the ground-water database to be compatible with a Watershed Protection Branch-wide water database, the stations were also assigned a three-part alphanumeric designation, the first part being an alphabetic abbreviation "GW" (for ground water), the second part representing the local river basin and the third part being numeric.

CHAPTER 3 CHEMICAL 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, the Piedmont/Blue Ridge Province, and the Valley and Ridge/Appalachian Plateau Province.

The Coastal Plain Province comprises six major aquifer systems that are restricted to specific regions and depths within the Province (Figure 3-1). These major aquifer systems commonly incorporate smaller aquifers that can be 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 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 from 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, in contrast to those of the Coastal Plain.

Paleozoic sedimentary formations characterize the combined 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. Also in contrast to the Coastal Plain Province, the faulting and folding has resulted in the creation of numerous, small-scale localized flow systems in the Valley and Ridge/Appalachian Plateau Province. The major water-bearing units in the province are carbonate rocks. Faulting and fracturing of the carbonates has led to the widespread development of karst features, which significantly enhance porosity and permeability and exert a strong influence on local flow patterns.

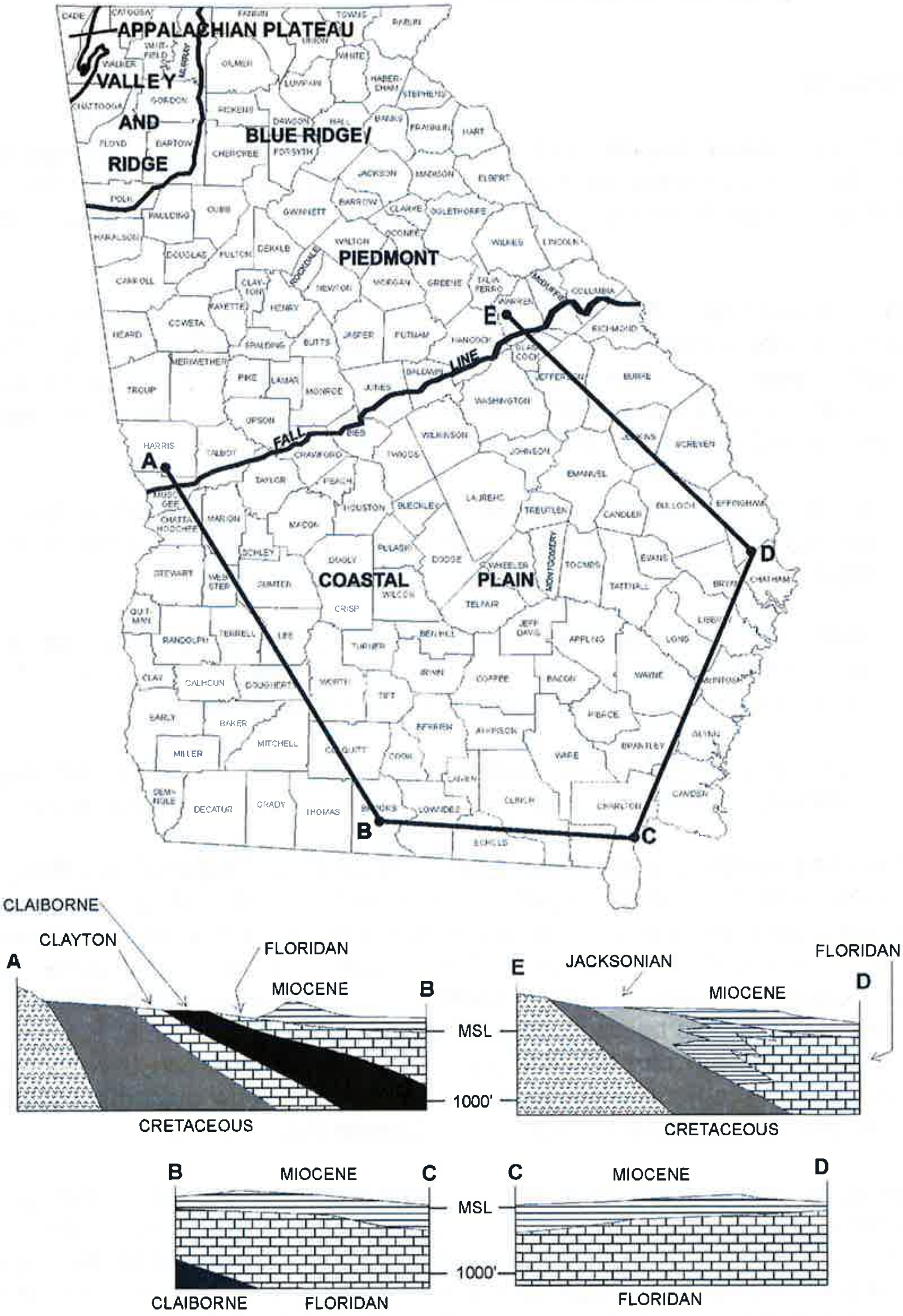


Figure 3-1. The Major Aquifers and Aquifer Systems of the Coastal Plain Province (after Davis, 1990).

3.2 CRETACEOUS AQUIFER SYSTEM

3.2.1 Aquifer System Description

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, are recognized west of the Ocmulgee River (Pollard and Vorhis, 1980). These merge into three subsystems to the east (Clarke et al, 1985; Huddlestun 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). This report treats the Providence aquifer as a part of the Cretaceous aquifer system.

EPD used 12 wells to monitor the Cretaceous 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.

3.2.2 Field Parameters

The pHs of sample waters from all 12 wells ranged from 3.85 (K12) to 8.18 (PD6), with a median of 4.84. 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. Its sampling pH of 8.17 would be expected for a well about twice its reported depth of 456 feet.

Conductivities are available for all 12 wells and ranged from 18 uS/cm (K19) to 379 uS/cm (PD3), with a median of 50 uS/cm. As a rule, the deeper wells gave water with the higher conductivities.

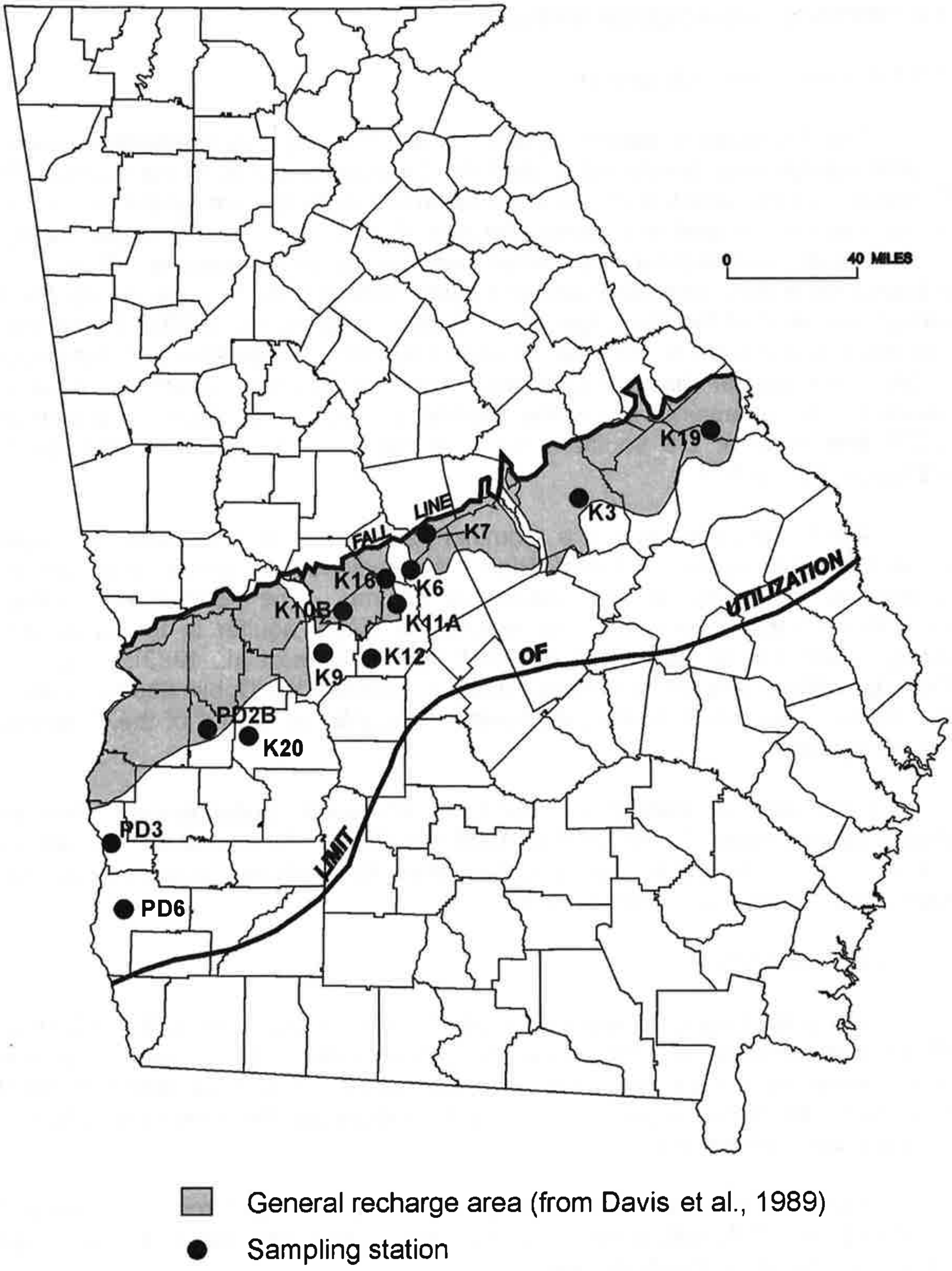


Figure 3-2. Locations of Stations Monitoring the Cretaceous Aquifer System.

The temperatures measured should be viewed as approximations of the temperature of the water in the aquifer. Temperatures over all 12 well samples ranged from 17.95 degrees C (K3) to 28.78 degrees C (K20). Comparing well depths with sample water temperatures shows that the deeper wells generally tend to yield water with higher temperatures. The water temperature can also depend somewhat on the time of year measured, since sample water must traverse a zone influenced by surface temperature on its way from the aquifer to the measurement point.

Dissolved oxygen measurements are available for nine of the 12 wells. Concentrations ranged from 0.62 mg/L (PD3) up to 10.45 mg/L (PD2A). Generally, the dissolved oxygen content of ground water decreases with depth. Dissolved oxygen measurements can suffer from various interferences, processes that can expose the ground water to air. An inadequately purged well may deliver water that has been in contact with air in the well bore. Pumping a well's water level down near the pump intake can entrain air in the pumped water. Also, pumping the water level in the well below a recharging horizon allows water to "cascade" or fall freely down the well bore and splash, thereby becoming aerated.

3.2.3 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 10 mg/L, occurred solely in a sample from well (PD3). Sulfate was detected in samples from five wells, with concentrations all at or below 13 mg/L. Nitrate/nitrite, detected in eight samples from eight wells ranged up to 2.0 mg/L (PD2A). Samples from three wells contained detectable phosphorus, with concentrations ranging up to 3.8 mg/L (K3). No VOCs were detected.

3.2.4 Metals by Inductively-Coupled Plasma Spectrometry (ICP)

All 12 samples contained detectable sodium, which ranged from 1,000 ug/L (K9A and K12) to 78,000 ug/L (PD3). The current high reporting limit for analyzing potassium accounts for the lack of potassium detections.

Two wells gave samples with detectable aluminum, with well K12 registering at 430 ug/L and well K9A 300 ug/L. Seven wells yielded samples containing detectable calcium and, six wells gave samples containing detectable iron. Calcium levels ranged from undetected to 25,000 ug/L (K3). Iron levels ranged up to 1,800 ug/L (K20), with samples from two wells exceeding the Secondary MCL of 300 ug/L. Four samples contained detectable magnesium, with a maximum value of 3,800 ug/L (PD6). Four wells gave samples with detectable manganese. None exceeded the Secondary MCL of 50 ug/L. Beryllium, cobalt, potassium, vanadium, and titanium remained undetected.

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

ICPMS analysis found detectable levels only of copper, zinc, lead, barium and uranium. Barium was detected in samples from all 12 wells, with a maximum concentration of 23 ug/L (K3). Copper was detected in samples from six wells with the maximum level at 28 ug/L; zinc was detected in samples from two wells, with the maximum level at 36 ug/L; lead was detected in samples from five wells, with the maximum level at 2.4 ug/L. The copper and lead levels fell below their respective action levels of 1,300 ug/L and15 ug/L. The highest concentrations for these three metals occurred in the sample from well K12, the sample with the lowest pH. These three metals commonly leach into sample water from plumbing and are not necessarily present naturally. Uranium was detected in one sample (K6) at a level of 1.0 ug/L.

3.3 CLAYTON AQUIFER

The Clayton aquifer system of southwestern Georgia is developed mainly in the middle limestone unit of the Paleocene Clayton Formation. Limestones and calcareous sands of the Clayton aquifer system 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). Both the Flint River to the east and the Chattahoochee River, to the west are the areas of discharge for the aquifer in its updip extent. 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. The well is sampled yearly. The sample water had a pH of 4.34, an electrical conductivity of 49 uS/cm, and a temperature of 19.69 degrees C. Dissolved oxygen was 7.44 mg/L and nitrate/nitrite registered at 1.8 mg/L as nitrogen. The water contained sodium at a level of 4,100 ug/L, magnesium at a level of 1,100 ug/L, aluminum at a level of 67 ug/L, and manganese at a level of 26 ug/L. Copper at a concentration of 15 ug/L and barium at a concentration of 21 ug/L were the trace metals detected. Copper was probably leached from plumbing. Any calcium present was below detection.

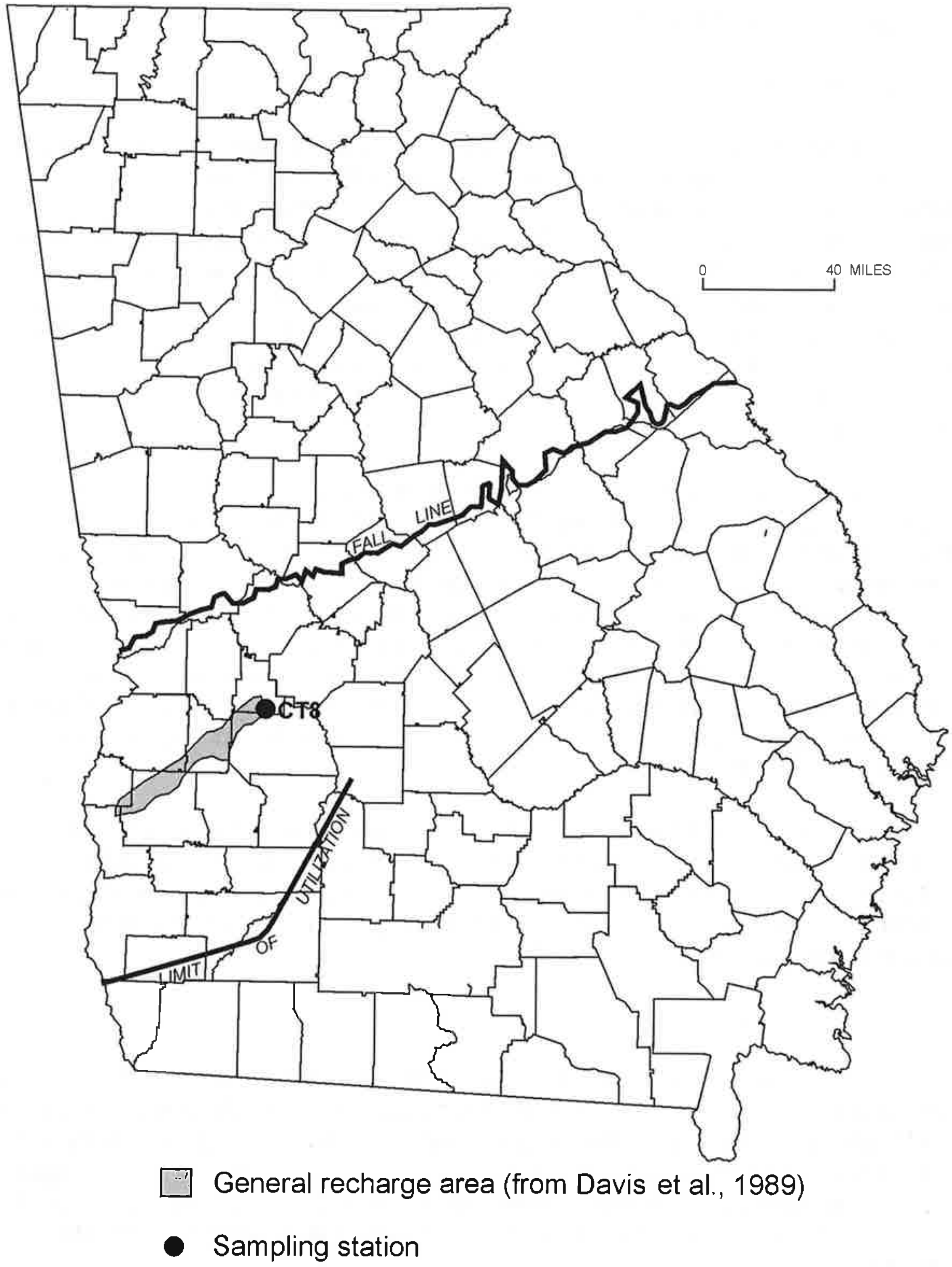


Figure 3-3. Location of the Station Monitoring the Clayton Aquifer.

3.4 CLAIBORNE AQUIFER

3.4.1 Aquifer Description

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 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 generally thickens to the southeast and is more than 350 feet thick near its downdip limit of utilization (Figure 3-4) (Tuohy, 1984).

The clay-rich upper unit of the Claiborne Group, the Lisbon Formation, acts as a confining layer and separates the Claiborne aquifer 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. 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, CL4A is 230 feet deep, and CL8 is not known precisely, but is about 90 feet deep.

3.4.2 Field parameters

The pHs of sample waters from two wells was mildly acidic (CL8 at 6.06 and CL4A at 6.07), while the third was mildly basic (CL2 at 7.29). Conductivities registered at 117 uS/cm (CL8), 278 uS/cm (CL4A), and 313 uS/cm (CL2); and, temperatures registered at 17.81 degrees C (CL4A), 20.53 degrees C (CL2), and 22.12 degrees C (CL8). Dissolved oxygen contents measured at 1.26 mg/L (CL8) and 3.26 mg/L (CL2). Since well CL4A exposes water to air, the 9.08 mg/L measurement for the water there may be inaccurate.

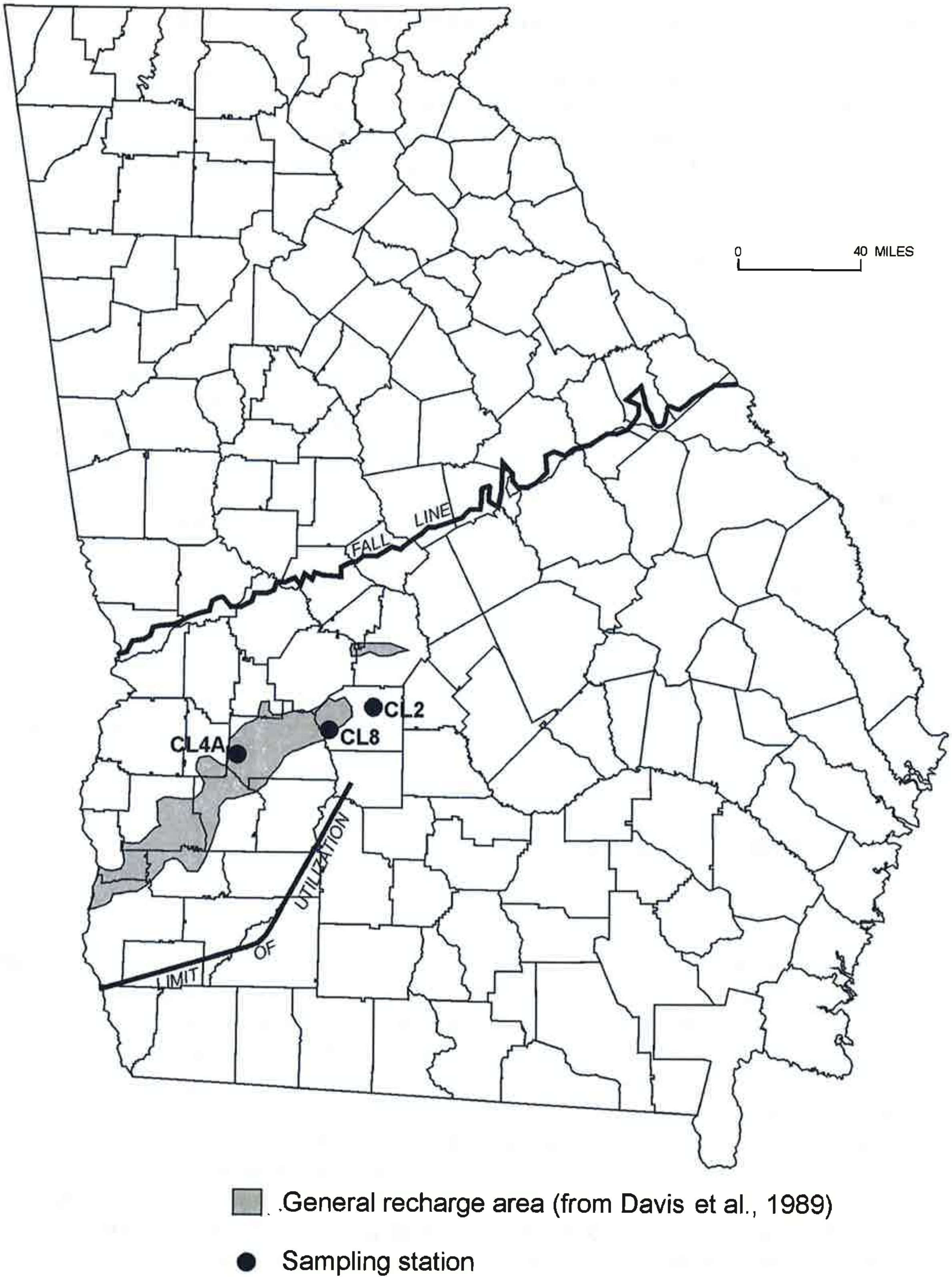


Figure 3-4. Locations of Stations Monitoring the Claiborne Aquifer.

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

Well CL2 was the only station to give a sample with detectable nitrate/nitrite (0.44 mg/L as nitrogen). A sample from well CL4A contained detectable sulfate at 12 mg/L. Samples from two wells contained detectable phosphorus (CL4A at 0.34 mg/L and CL8 at 0.47 mg/L). None of the samples contained detectable chloride or VOCs.

3.4.4 Metals by Inductively-Coupled Plasma Spectrometry (ICP)

Calcium and sodium were detected in samples from all three wells. The maximum and minimum calcium concentrations were 39,000 ug/L (CL2) and 12,000 ug/L (CL8). The maximum and minimum sodium concentrations were 2,000 ug/L (CL8) and 1,400 ug/L (CL2). Detectable magnesium occurred only in the samples from well CL8 (1,300 ug/L) and CL4A (3,100 ug/L). Wells CL4A and CL8 gave samples with detectable iron at 1,800 ug/L and 300 ug/L respectively and manganese at 61 ug/L and 57 ug/L respectively. Both samples exceeded the iron and manganese Secondary MCLs of 300 ug/L and 50 ug/L respectively.

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

ICPMS analyses found barium in all three samples. The maximum and minimum barium concentrations were 27 ug/L (CL8) and 10 ug/L (CL2). The sample from well CL8 also contained copper at 8.7 ug/L, zinc at 190 ug/L, and lead at 1.4 ug/L, all below any applicable MCLs or action levels. The same well registered the lowest pH.

3.5 JACKSONIAN AQUIFER

3.5.1 Aquifer Description

The Jacksonian aquifer system (Vincent, 1982) 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 extent and 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 Flint River are the eastern and western discharge boundaries for the updip parts of the Jacksonian aquifer system. The Jacksonian aquifer system is equivalent to the Upper Three Runs aquifer, as discussed by Summerour et al. (1994), page 2, and Williams (2007), "General Hydrogeology" table.

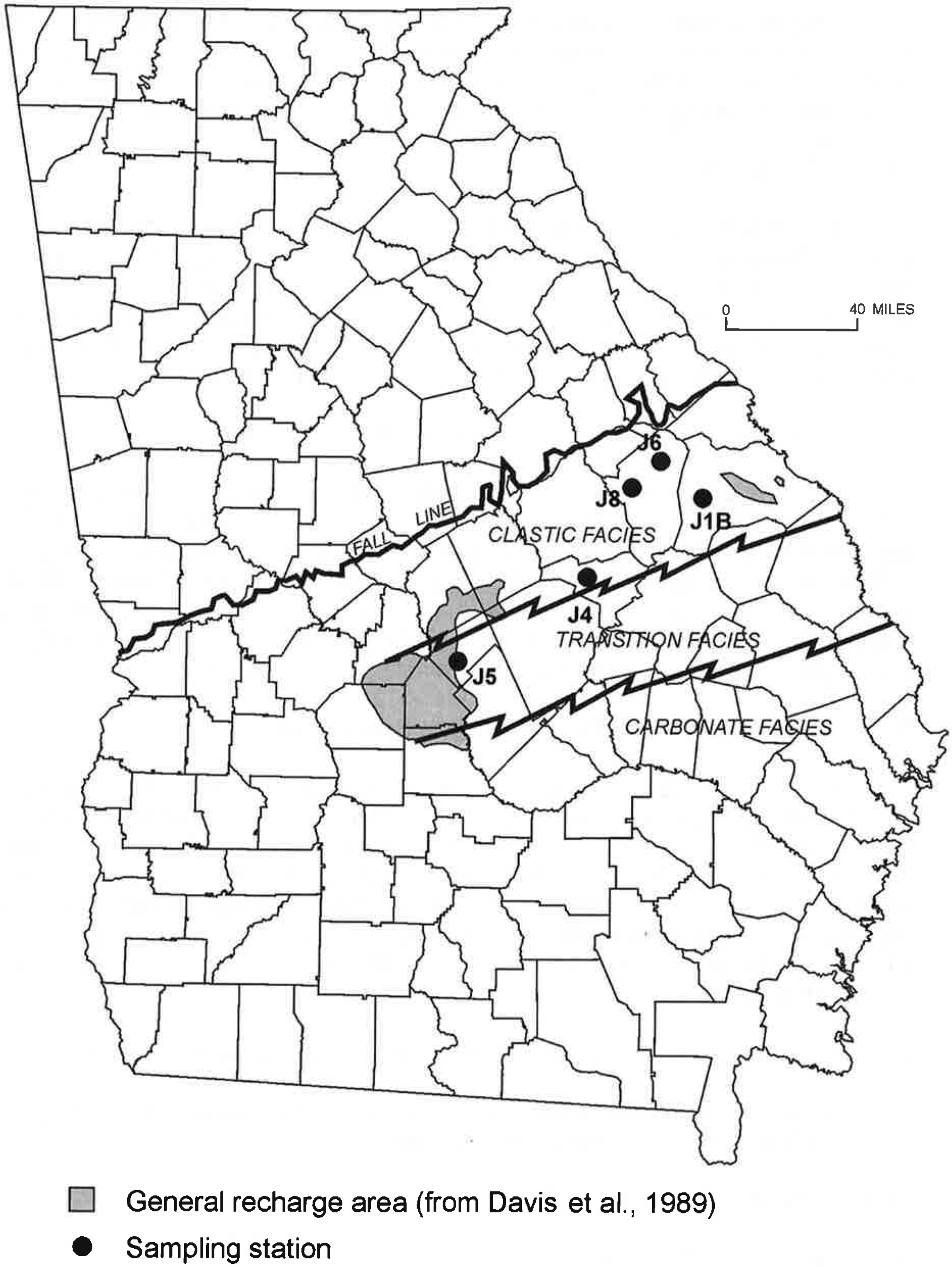


Figure 3-5. Locations of Stations Monitoring the Jacksonian Aquifer.

Five wells were available to monitor the Jacksonian aquifer system. Wells J1B and J8A are domestic wells, while wells J4, J5 and J6 are public supply wells. All are drilled wells, and each is scheduled for yearly sampling. Well J8A serves as a substitute, replacing a nearby well while it is down for maintenance.

3.5.2 Field parameters

The pHs for wells J4, J5, and J8A were basic and wells J1B and J6 were acidic. The pHs range from 6.76 (J1B) to 7.48 (J4). Conductivities ranged from 268 uS/cm (J6) to 348 uS/cm (J5). Temperatures ranged from 17.13 degrees C for well J8A to 20.69 degrees C for well J4, with water from the deeper wells registering higher temperatures. Dissolved oxygen concentrations ranged from 0.88 mg/L for well J6 to 5.93 mg/L for well J1B and were lowest in the deeper wells.

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

Chloride was detected in sample water only from well J1B (10 mg/L). Sample waters from wells J5 and J6 contained detectable sulfate (both 13 mg/L). Nitrate/nitrite was detected in samples from wells J1B (2.7 mg/L as nitrogen), J4 (0.20 mg/L as nitrogen), and J8A (0.14 mg/L as nitrogen), all measurements below the human-influenced range of greater than 3 mg/L as nitrogen. Phosphorus was detected in water from all wells and ranged from 0.03 mg/L (J4) to 0.16 mg/L (J6). No sample waters contained detectable volatile organic compounds.

3.5.4 Metals by Inductively-Coupled Plasma Spectrometry (ICP)

All five wells gave waters with detectable calcium, with a rather tight range from 51,000 ug/L (J4) to 66,000 ug/L (J5). Magnesium ranged from undetected (J1B) to 2,500 ug/L (J4 and J5). Detectable sodium occurred in each well sample and ranged from 2,000 ug/L (J6) to 4,500 ug/L (J1B). Well J6 gave a sample containing 170 ug/L iron; and well J5 and J8A gave a sample containing 13 ug/L manganese. According to Kellam and Gorday (1990), the high calcium /magnesium ratios for these wells signifies that they derive most of their recharge from local surface water.

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

All five wells yielded waters containing detectable barium, with a range from 8.1 ug/L (J5 and J6) to 21 ug/L (J1B). Analysis found no other trace metals.

3.6 FLORIDAN AQUIFER SYSTEM

3.6.1 Aquifer System Characteristics

The Floridan aquifer system is developed predominantly in Eocene and Oligocene limestones and dolostones that underlie most of the Coastal Plain Province (Figure 3-6). 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 and dolostones 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 portions of the Floridan are restricted to units of Eocene age (Clarke et al., 1990). The lower parts of the Floridan consist mainly of dolomitic limestone of middle and early Eocene age and pelletal, vuggy, dolomitic limestone of Paleocene age, but extend into the late Cretaceous in Glynn County. The lower portions of the Floridan are hydrologically connected with the upper parts but are deeply buried and not widely used except for some municipal and industrial wells in the Savannah area. From its updip limit, defined by clays of the Barnwell Group, the aquifer system thickens to well over 700 feet in coastal Georgia.

A dense limestone facies occupying the Gulf Trough locally limits ground-water quality and availability (Kellam and Gorday, 1990; Applied Coastal Research Laboratory, 2001). The Gulf Trough is a likely marine-current channel extending across Georgia from southwestern Decatur County through northern Effingham County. The trough, active beginning in the early Eocene, had ceased operating and filled with sediment in the Miocene.

A ground-water divide separates a smaller southwestward flow regime in the Floridan aquifer system in the Dougherty Plain in southwestern Georgia from the larger southeastward flow regime characteristic for the aquifer system under the remaining part of Georgia's Coastal Plain. 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, lying to the east, is recharged by leakage from Jacksonian aquifer 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 29 wells, with 19 scheduled for sampling on a yearly basis and 10 on a quarterly basis. The total number of samples collected from the wells was 59. All 29 wells are drilled wells. Twenty five wells are local-government-owned public supply wells. Two wells supply industrial process water. One remaining well is a domestic-type well supplying a church and a pastorium, and the other well is a former USGS test well. Depths range from 97 feet (PA49 church well) to 1,211 feet (PA9C test well).

3.6.2 Field parameters

Measurements of pH are available for all samples and ranged from 7.02 (PA25) to 8.04 (PA2). The median pH is 7.65 and the mean is 7.62. Conductivities

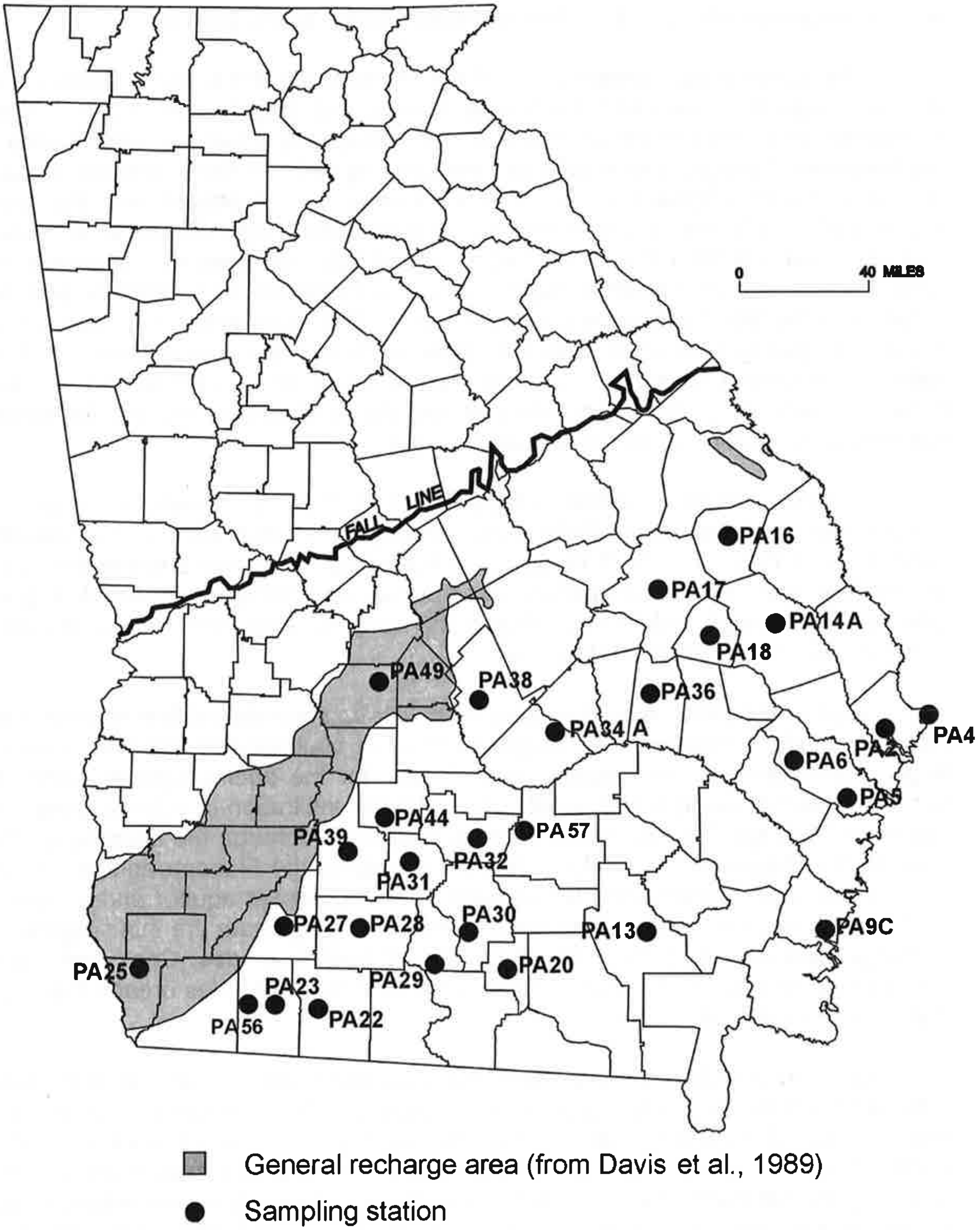


Figure 3-6. Locations of Stations Monitoring the Floridan Aquifer System.

are also available for all samples and ranged from 161 uS/cm (PA41A) to 1580 uS/cm (PA9C), with a median of 310 uS/cm and a mean of 336 uS/cm. Temperatures are available for all sampling events and ranged from 18.38 degrees C for well PA17 to 27.68 degrees C for well PA9C. Well PA9C is the deepest of the Floridan wells at 1211 feet, so the high temperature reflects the geothermal effect. Fifty-five dissolved oxygen measurements are available from 28 wells. The available measurements range from 0.45 mg/L (PA57) to 8.70 mg/L (PA25). No measurement was taken at well PA14A because the raw water outlet will not permit the attachment of the usual sampling apparatus and exposes sample water to air.

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

Five Floridan wells yielded 10 samples containing detectable chloride. Chloride concentrations ranged from undetected to 650 mg/L (PA9C). The measurement for well PA9C is more than 14 times the next highest concentration of 46 mg/L for well PA4. Well PA9C derives water from the lower part of the Floridan aquifer.

Twenty four samples from 12 wells gave samples containing detectable sulfate. Levels ranged from undetected to 240 mg/L (PA9C).

Twenty water samples from 11 wells contained detectable nitrate/nitrite. Concentrations ranged from undetected to 2.2 mg/L as nitrogen (PA49). There is a general tendency for shallower wells to give samples with higher levels of nitrate/nitrite. Nitrate/nitrite levels in the samples from each quarterly sampled well tend, as a rule, to be similar to one another.

Phosphorus was detected in 33 samples from 20 wells. Phosphorus levels ranged up to 0.07 mg/L (PA17) as total phosphorus.

Volatile organic compounds (VOCs), consisting entirely of trihalomethane compounds, were detected in seven samples from four wells (PA17, PA23, PA28, and PA57). The compounds typically arise as byproducts from disinfection and their presence can indicate the reflux of treated water back down a well or result from sterilizing well plumbing following maintenance. For well PA23, samples regularly register detectable trihalomethanes, suggestive of leaky valves allowing treated water back down the well. For the remaining three wells, the occasional nature of trihalomethane detections suggests a maintenance related origin.

3.6.4 Metals by Inductively-Coupled Plasma Spectrometry (ICP)

ICP analyses found detectable levels of potassium, manganese, iron, calcium, magnesium, and sodium. Detectable potassium occurred in only one sample from one well (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 manganese occurred in 17 samples from eight wells. The maximum concentration of 100 ug/L occurred in two samples from well PA34A. All four samples from quarterly-sampled well PA34A and samples from annually sampled wells PA16 and PA18 exceeded the Secondary MCL of 50ug/L. The manganese levels in the samples from each of the quarterly sampled wells vary within a restricted range. Wells giving samples with manganese detections seem clustered in two areas: one in the Cook-Irwin-Lanier County area and the other in the Candler-Emanuel-Jenkins-Telfair-Toombs County area.

Iron was detected in 21 samples from 11 wells. Of these, only the sample from annual well PA9C, with an iron level of 680 ug/L, exceeded the Secondary MCL (300 ug/L). The iron contents of samples from three quarterly wells (PA29, PA34A and PA36) seemed to vary within restricted ranges.

Detectable magnesium was found in all samples from all wells except for those from quarterly well PA25 and annual well PA49. Magnesium concentrations ranged up to 72,000 ug/L (well PA9C), with a mean of 12,134 ug/L and a median of 11,000 ug/L. Non-detections were assigned a level of 500 ug/L. Wells PA25 and PA49 are both Floridan recharge area wells. Kellam and Gorday (1990) have noted that Ca/Mg ratios are higher in ground waters from Floridan recharge areas, as is the case with these two wells. Magnesium levels in samples from each quarterly well seem to vary within relatively narrow ranges.

Calcium was detected in all samples from the 29 Floridan wells. Concentrations ranged from 20,000 ug/L (PA41A) to 100,000 ug/L (PA9C), with a mean of 37,746 ug/L and a median of 34,000 ug/L. For samples from quarterly wells, calcium concentrations seem to fall within a narrow range for each well. Ca/Mg ratios in Floridan well waters have already been mentioned.

Sodium was also found in all sample waters from all 29 wells and ranged in concentration from 1800 ug/L (PA49) to 370,000 ug/L (PA9C), with a mean of 16,347 ug/L and a median of 7,400 ug/L. Sodium concentrations generally increase with depth.

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

ICPMS analysis found the following detectable metals in the Floridan samples: chromium, copper, zinc, lead, arsenic, selenium, molybdenum, barium, uranium.

Annual well PA49 gave one sample with detectable chromium below the Primary MCL (100 ug/L). One sample from quarterly well PA23 registered arsenic detection below the Primary MCL (10 ug/L). The well has given intermittent samples with detectable arsenic before. Annual well PA9C gave a sample showing detectable selenium below the Primary MCL (50 ug/L).

Two samples contained detectable copper, one from annual well PA17 and one from quarterly well PA23. Unlike most other wells, quarterly well PA14A furnishes sample water through a small diameter copper tube. Annual well PA49 and quarterly well PA14A gave samples with detectable zinc. Quarterly well PA14A and annual well PA17 contained detectable lead. Copper and lead detections were below the action levels of 1,300 ug/L for copper and 15 ug/L for lead. The zinc concentration fell below the Secondary MCL of 5,000 ug/L.

Twelve samples drawn from quarterly wells PA23, PA28 and PA56 contained detectable molybdenum. Well PA23 produced the sample with the highest concentration, 27 ug/L. All three wells are in the Gulf Trough area.

Uranium was detected in 11 samples from two quarterly wells (PA44 and PA56) and three annual wells (PA39, PA31 and PA22). The maximum concentration was 3.0 ug/L for well PA56, below the Primary MCL of 30 ug/L.

Barium was detected in all samples from all wells and ranged in concentration from 3.4 ug/L to 220 ug/L, all below the Primary MCL of 2,000 ug/L. The mean concentration was 84.53 ug/L and the median was 84 ug/L. Barium seems to be more abundant in samples from wells of 400 foot to 700 foot depth range.

3.7 MIOCENE/SURFICIAL AQUIFER SYSTEM

3.7.1 Aquifer System Characteristics

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 (Figure 3-7).

The Hawthorne Group covers most of the Coastal Plain and consists predominantly of sand and clay (Huddlestun, 1988), although carbonate rocks and phosphorites may locally be significant (Huddlestun, 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 coastal area. 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 Coastal area (from the Atlantic coast to about 45 miles inland) and consists, in updip areas, predominantly of fine to coarse- grained quartz sand and, in downdip areas, interbedded fine sand and clay (Huddlestun, 1988). In the Coastal Plain of far south central and southwestern Georgia, the Miccosukee Formation overlies the Hawthorne Group (Huddlestun, 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 annually sampled wells were used to monitor the Miocene/Surficial aquifer system. Wells MI1, MI2A, MI9A and MI10B are private domestic wells, with MI9A and MI10B no longer being used as drinking water sources. Well MI16 is used for general purposes at a fire station. Well MI17 originated as a geologic bore hole -- a hole drilled for investigating bedrock -- that became a flowing well. It is currently used both as a domestic water source and as an augmentation well for maintaining a pond. Wells MI2A and MI9A are bored wells. The remainder are drilled wells. Depths, actual or approximate, have been determined for all six wells.

3.7.2 Field parameters

The pHs of the sample waters from the six wells used to monitor the Miocene/Surficial aquifer system ranged from 4.16 (well MI2A) to 7.47 (well MI1). Three of the six wells sampled (MI2A, MI10B and MI9A) produced acidic water. The remaining three gave basic water. The acidic water-yielding wells included the two shallowest, while the basic water-producing wells included the two deepest. Conductivities ranged from 104 uS/cm (MI2A) to 251 uS/cm (MI17). Water temperatures ranged from 19.2 degrees C (MI17) to 23.95 degrees C (MI16). The 23.95 degrees C temperature probably has a geothermal component, since well MI16 is 400 feet deep. Dissolved oxygen data are available for four wells and range from 1.22 (MI16) to 6.81 (MI1). Valid dissolved oxygen measurements cannot be made on well MI9A since it must be sampled with a bailer.

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

Chloride registered at 12 mg/L in samples from the two bored wells MI2A and MI9A. 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 the bored wells MI2A and MI9A, lying in the range of likely human influence ($\geq$ 3.1 mg/L as nitrogen) (Madison and Brunett, 1984). The former well registered 5.3 mg/L as nitrogen and the latter 17 mg/L, the maximum found. The nitrate/nitrite level for well MI9A also exceeded the Primary MCL of 10 mg/L as nitrogen. Detectable phosphorus was found in samples from all wells except bored well MI2A and drilled well MI17. The concentrations ranged up to 0.28 mg/L (MI10B). None of the samples contained detectable VOCs.

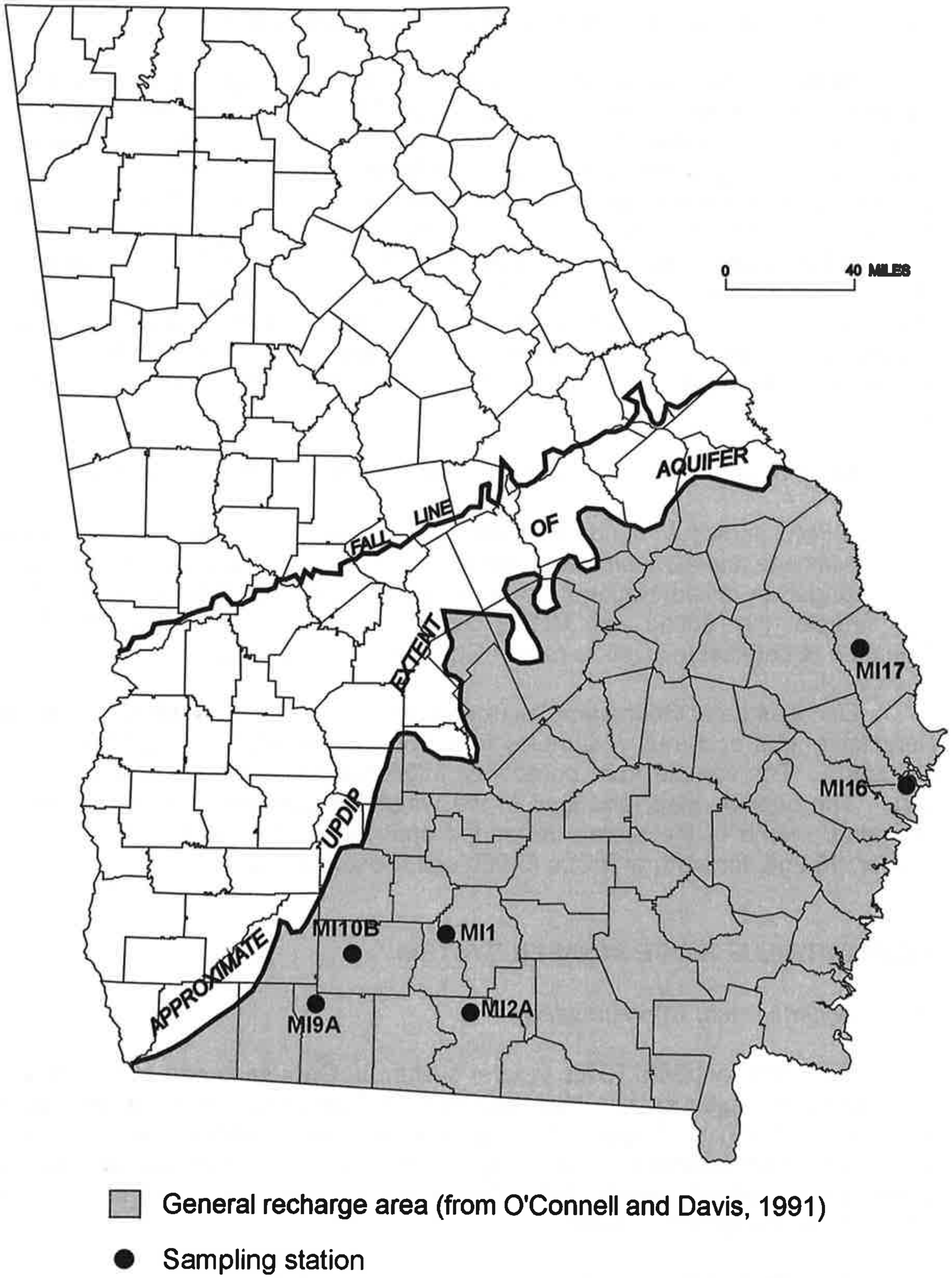


Figure 3-7. Locations of Stations Monitoring the Miocene/Surficial Aquifer System.

3.7.4 Metals by Inductively-Coupled Plasma Spectrometry (ICP)

Samples from all six wells contained calcium, magnesium, and sodium. Calcium levels ranged from 4,000 ug/L (well MI2A) to 42,000 ug/L (well MI17). Magnesium levels ranged from 1,800 ug/L (well MI17) to 15,000 ug/L (well MI16). Sodium levels ranged from 2,500 ug/L (well MI9A) to 17,000 ug/L (well MI16). Iron was detected in the sample from well MI10B at 2,400 ug/L. This last value far exceeds the Secondary MCL for iron of 300 ug/L. Manganese was found in samples from three wells: MI1 (12 ug/L), MI10B (89 ug/L) and MI17 (12 ug/L). The 89 ug/L level exceeds the Secondary MCL for manganese of 50 ug/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. Aluminum was detected in two wells, MI2A (140 ug/L) and MI9A (83 ug/L).

3.7.5 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 20 ug/L (well MI17) to 150 ug/L (well MI10B). The sample from drilled well MI10B contained selenium at a level of 14 ug/L. Selenium at detectable levels is rare in Georgia's ground water.

Zinc was detected in samples from well MI1 (33 ug/L) and MI10B (130 ug/L). Detectable lead occurred in samples from bored wells MI2A (12 ug/L) and MI10B (1.7 ug/L). The sample from bored well MI2A contained copper at a level of 7.3 ug/L. The copper, lead, and zinc in the water samples were likely derived from plumbing. None of the metals exceeded applicable action levels (1,300 ug/L for copper, 15 ug/L for lead) or MCLs (5,000 ug/L Secondary for zinc).

3.8 PIEDMONT/BLUE RIDGE AQUIFER SYSTEM

3.8.1 Aquifer System Characteristics

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: a) regolith and b) fractured igneous and metamorphic bedrock (Heath, 1980; Daniel and Harned, 1997). Figure 3-8 shows the extent of the system in Georgia.

Regolith hydrologic unit comprises a mantle of soil or, in and near stream bottoms, alluvium, and underlying saprolite. Saprolite is bedrock that has undergone extensive chemical weathering in place. Downward percolating, typically acidic, ground water leaches alkali, alkaline earth and certain other divalent 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 unit is characterized by high, mostly primary porosity (35% to 55%) (Daniel and Harned, 1998) and serves as the reservoir that feeds water into the underlying fractured bedrock. Though it can store a great deal of water, saprolite, owing to its clay content, does not give up its water very rapidly. Saprolite grades downward through a transition zone consisting of saprolite and partially weathered bedrock with some 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 a depth of about 600 feet, pressure from the overlying rock column becomes too great and holds fractures shut. Fracturing in schistose rocks consists mainly of a network of fine, hair-line cracks which yield water slowly. Fractures in more massive rocks (e.g. granitic rocks, diabases, gneisses, marbles, quartzites) are mostly open and are subject to conduit flow. Thus wells intersecting massive-rock fractures are able to yield far larger amounts of water than wells in schistose rocks or even wells in regolith. Fractures can be concentrated along fault zones, shear zones, late-generation fold axes, foliation planes, lithologic contacts, compositional layers, or intrusion boundaries.

Fifty samples from 19 wells and two springs were used to monitor water quality in the Piedmont/Blue Ridge aquifer system. Eighteen of these wells are drilled. Thirteen of the 19 wells are public supply wells, and the remaining six are domestic. One of the 19 wells is bored (P33) and is in domestic use. Of the two springs, one (P12A) is a mineral spring at a State park, and the other spring (BR5) is a public supply source. The State park mineral spring and the following wells are scheduled for sampling on a quarterly basis: P21, P23, P25, P32, P33, P34, P35, P37 and BR1B. Well P25, newly added to the network on a quarterly basis, was sampled only twice during the year. Per agreement with the State Park manager, an annual filtered sample is to be collected in addition to the quarterly unfiltered ones. 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 well drawing from the regolith aquifer, is 47 feet deep.

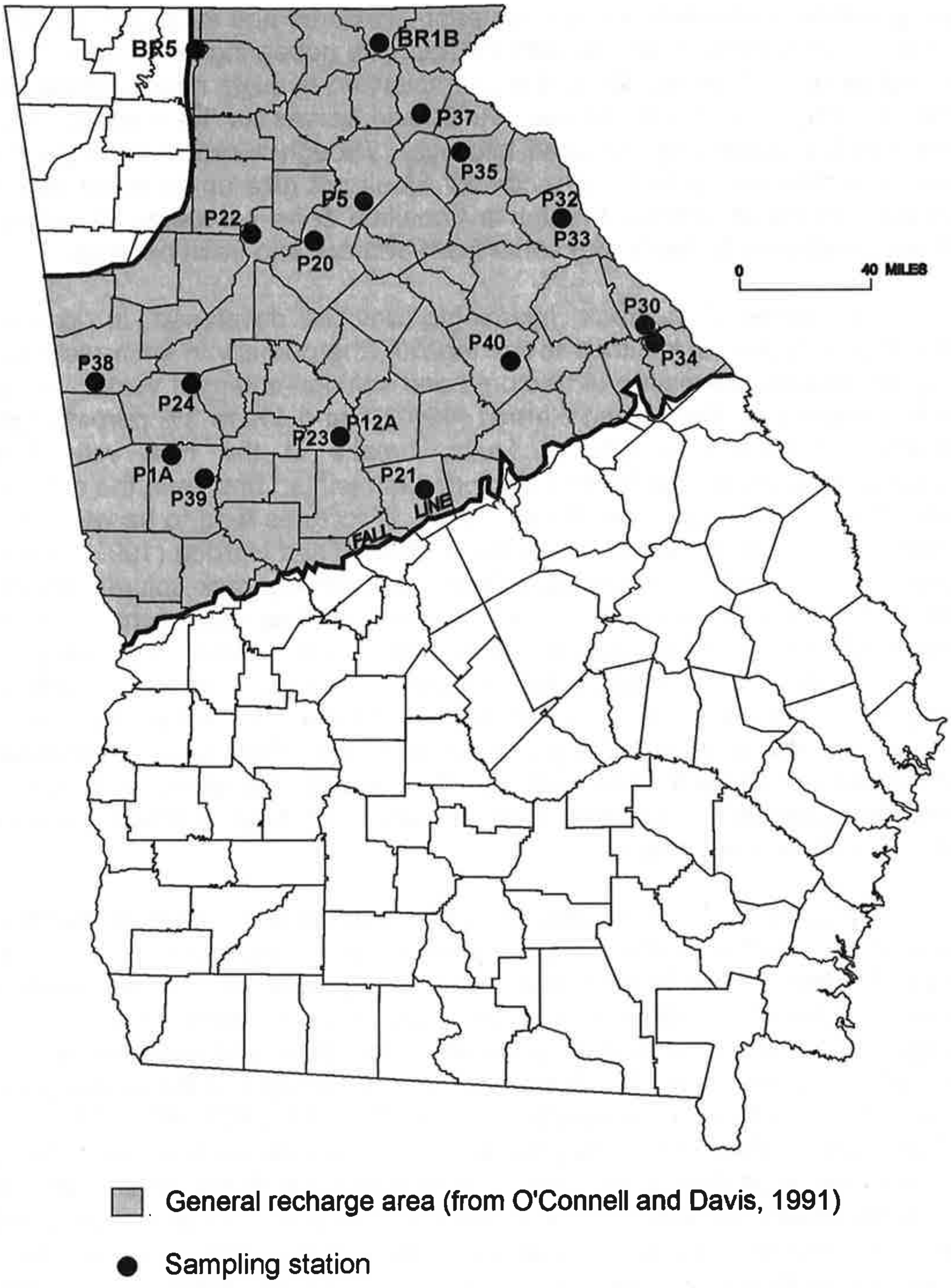


Figure 3-8. Locations of Stations Monitoring the Piedmont/Blue Ridge Aquifer System.

3.8.2 Field parameters

Fifty pH measurements from all 21 stations are available for the Piedmont/Blue Ridge aquifer system. The pHs ranged from 4.49 to 7.56. Nine samples; all samples from quarterly well P32, three samples from quarterly spring P12A, one sample from quarterly well P35 and the sample from annual well P20 were basic. The sample from annual well P24 was neutral. The remaining samples were acidic, including all samples from quarterly regolith well P33. The mean pH was 6.45 and the median 6.48.

Conductivity measurements are available for all 50 samples. Conductivities range from 32 uS/cm (well P22) to 1,120 uS/cm (well P32). Samples with the higher pHs generally tended to have higher conductivities and vice versa.

Temperatures were available for all sampled waters and range from 13.29 degrees C (spring BR5) to 23.84 degrees C (well P25). Geothermally elevated temperatures are not readily apparent for the Piedmont/Blue Ridge. Latitude, ground elevation, and season appear to have more influence on the sampling temperature.

Dissolved oxygen measurements are available for 47 samples from 21 stations. One dissolved oxygen measurement was made on a sample from quarterly spring P12A and one on a sample from annual spring BR5, but both are of doubtful accuracy since water at each spring is well exposed to air before measurements can be performed. The remaining three samples from quarterly spring P12A receive no dissolved oxygen measurements since exposure of the sample water to air can render the measurement inaccurate. Dissolved oxygen levels ranged from 0.62 mg/L for quarterly well P32 to 10.26 mg/L for quarterly well P34. The 10.26 mg/L reading lies above the oxygen saturation level for the temperature at sampling (18.34 degrees C). This reading suggests free-falling (cascading) water in the well or entrainment of air at the pump intake due to a low pumping water level and does not reflect the actual oxygen level in the ground water.

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

All samples received testing for chloride, sulfate, nitrate/nitrite, total phosphorus, and VOCs. Three samples each from spring P12A and well P23, both located at Indian Springs State Park, received testing for fluoride.

Three stations yielded seven samples with detectable chloride: quarterly well P37 with all four samples; quarterly spring P12A with two samples; annual well P30 with one sample. Well P37 gave the sample with the highest level at 110 mg/L

Two stations, quarterly spring P12A and quarterly well P23, receive testing for fluoride. Detectable fluoride occurred in all four samples from well P23 at levels of 1.0 mg/L to 1.1 mg/L. Detectable fluoride also occurred in all four samples from quarterly spring P12A at levels ranging from 4.6 mg/L to 4.9 mg/L. This last range of levels exceeds the Primary MCL of 4 mg/L for fluoride; the spring water from this station has consistently done so in the past. Historical fluoride levels have ranged from slightly above 4 mg/L to slightly above 5 mg/L.

Sulfate was detected in 26 samples from six quarterly and three annual stations, with the highest concentration (370 mg/L) occurring in a sample from quarterly well P32. Apparatus difficulties prevented sulfate analysis of a fourth sample from that well. Spring P12A and wells P21 and BR1B each have sulfate values that vary within narrow ranges.

All samples from quarterly spring P12A and from quarterly wells P32 and P35 lacked detectable nitrate/nitrite. All samples from all other stations contained some, with a high concentration of 2.3 mg/L as nitrogen for annual well P28. This level is well below the Primary MCL of 10 mg/L as nitrogen.

Detectable phosphorus occurred in 34 samples from 13 wells and 2 springs, with the highest concentration of 0.22 mg/L being found for quarterly well P34. Phosphorus concentrations vary within narrow ranges within the quartets of samples from quarterly spring P12A and from quarterly wells P34, P21 and P23.

No detectable VOCs occurred in any Piedmont/Blue Ridge samples.

3.8.4 Metals by Inductively-Coupled Plasma Spectrometry (ICP)

ICP analysis found detectable aluminum, calcium, iron, potassium, magnesium, manganese, and sodium. No beryllium, cobalt, titanium, or vanadium were detected.

Calcium was found in all samples except for the one from annual well P38. A sample from quarterly well P35 also contained no detectable calcium, however this lack of calcium arose because sample water was inadvertently directed through a water softener prior to sampling. The highest calcium levels (140,000 ug/L, 130,000 ug/L, 120,000 ug/L, 120,000 ug/L) occurred in the quarterly samples from well P32. Omitting the spurious sample from well P35 and assigning a value of 500 ug/L to the below-detection level for well P38, the mean calcium concentration was 29,333 ug/L and the median concentration 18,000 ug/L. As a rule, calcium levels of samples from each quarterly station tend to cluster closely.

Magnesium was detected in 43 samples from 18 stations. Magnesium contents of sample waters ranged up to 27,000 ug/L (well P30). As with calcium, magnesium levels in samples from each quarterly well generally tend to cluster. All samples from the quarterly regolith well P33 and samples from annual bedrock well P38 and annual spring BR5 contained no detectable magnesium. A sample from quarterly well P35 registered no magnesium due to a water softener that was mistakenly left engaged.

Sodium was present in all samples and ranged from 2,100 ug/L in the sample from well P22 to 41,000 ug/L in a sample from spring P12A. Sodium levels for each quarterly well have a general tendency to cluster. The mean sodium concentration is 14,264 ug/L and the median is 13,000 ug/L.

Detectable potassium was found in three samples from one station (well P35). Potassium was not detected in one sample from P35 due to interference from a water softener. The low sensitivity of the current laboratory testing procedure for potassium probably accounts for the apparent scarcity of this metal.

Aluminum was detected in seven samples from wells P33, P21, P22 and BR1B. Well P21 registered the highest level at 360 ug/L. The sample from that well and two samples from well P33 equaled or exceeded the high limit of 200 ug/L for the Secondary MCL range for aluminum. Aluminum levels in the remaining samples exceeded the low limit of 50 ug/L for the Secondary MCL range but not the upper limit.

Iron was detected in 20 samples from 9 wells, with a range up to 1,100 ug/L (well P37). This concentration exceeds the Secondary MCL for iron of 300 ug/L. Well P37 produced another sample with an iron level equal to the Seconndary MCL. Wells P23 and P33 also gave samples with excessive iron. For well P25, the filtered sample contained no detectable iron in contrast to the raw samples.

Manganese was detected in 30 samples from ten wells and one spring, with a maximum concentration of 220 ug/L (well P37). All samples from quarterly wells P37, the sample from annual well P20, and three samples from quarterly wells P21 and P35 exceeded the Secondary MCL of 50 ug/L. The fourth sample from well P35 lacked detectable manganese due to inadvertent passage through a water softener. For well P25, filtration seemed to have little effect on the manganese level.

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

ICPMS analysis of water samples detected the following metals: copper, zinc, barium, lead, uranium. None of the following metals were found in detectable amounts: nickel, chromium, arsenic, selenium, molybdenum, silver, cadmium, tin, antimony, and thallium.

Copper occurred in 11 samples from 5 wells, with a maximum level of 43 ug/L in the sample from well P22. This sample also had the lowest pH. All copper detections occurred in acidic waters, with the highest pH for a sample containing detectable copper registering at 6.52. No detectable copper occurred in neutral or basic waters.

Zinc was detected in 19 samples from eight wells, with the maximum level at 60 ug/L for well P24. All zinc detections except for two (wells P24 and P20) occurred in acidic waters. The pH of the sample from P24 (the well with the maximum level) was neutral, and the pH of the sample from P20 was basic.

Lead was detected in 12 samples from six wells and one spring. All lead detections except one in the spring P12A sample, occurred in acidic water. Only two lead detections occurred without zinc or copper detections.

Barium, as elsewhere in the State's ground water, was a nearly ubiquitous trace metal, being detected in 41 samples from 18 wells and one spring. All four samples from quarterly spring P12A and quarterly well P32 and one sample from quarterly well P35 contained no detectable barium. The sample from well P35 lacking detectable barium had inadvertently been passed through a water softener. The maximum concentration was 200 ug/L from a sample from annual well P20. No samples exceeded the Primary MCL of 2,000 ug/L.

Uranium was detected in 31 samples from 11 wells. Uranium concentrations ranged up to 27 ug/L, found in a sample from well P34. Granitic bedrock is present where four of the wells are drilled and is the most common bedrock type to host uraniferous water.

3.9 VALLEY AND RIDGE/APPALACHIAN PLATEAU AQUIFER SYSTEM

3.9.1 Aquifer System Characteristics

Since Georgia's portion of the Appalachian Plateau Province extends over such a small area of the State, i.e., its northwestern corner, this report includes that province with the Valley and Ridge Province for purposes of discussion. Bedrock in the combined province is sedimentary, comprising limestones, dolostones, shales, siltstones, mudstones, conglomerates and sandstones (Figure 3-9).

Primary porosity in the province's bedrock is low, leaving fractures and solution-enlarged voids as the main water-bearing structures. The bedrock in the province is extensively faulted and folded, conditions that have served to proliferate fracturing and to segment water-bearing strata into numerous local flow systems, in contrast to the expansive regional flow regimes characteristic of the Coastal Plain sediments. Fractures in limestones and dolostones can become much enlarged by solution, greatly increasing their ability to store water.

Zones of intense fracturing commonly occur in carbonate bedrock along such structures as fold axes and fault planes and are especially prone to weathering. Such zones of intense fracturing give rise to broad valleys with gently sloping sides and bottoms covered with thick regolith. The carbonate bedrock beneath such valleys presents a voluminous source of typically hard ground water.

As in the Piedmont/Blue Ridge Province, the regolithic mantle of soil and residuum derived from weathered bedrock blankets much of the Valley and Ridge/ Appalachian Plateau Province. Where the water table lies within the mantle, the mantle yields soft water ("freestone" water) sufficient for domestic and light agricultural use (Cressler et al., 1976; 1979). The mantle also acts as a reservoir, furnishing water to the underlying bedrock, which supplies most of the useful ground water in the province.

Monitoring water quality in the Valley and Ridge/Appalachian Plateau aquifers made use of four springs and two drilled wells (Figure 3-9). Springs VR2A, VR8 and VR10 are public supply springs. Spring VR3 is a former public supply spring now serving ornamental purposes in a public park. Well VR1 is a public supply well, and well VR6A is an industrial process water source. Spring VR8 is scheduled for quarterly sampling, while all the other stations are sampled on a annual basis. All stations tap carbonate bedrock aquifers.

3.9.2 Field parameters

Sample water pHs ranged from 6.70 for spring VR10 to 7.59 for well VR6A. Quarterly spring VR8 and annual spring VR10 returned slightly acidic pHs for February sampling.

Conductivities ranged from 255 uS/cm (well VR1) to 309 uS/cm (spring VR8).

Dissolved oxygen measurements are available for wells VR1 (7.52 mg/L) and VR6A (6.91 mg/L). Dissolved oxygen measurements were made on spring waters at or downstream of spring heads; however, due to atmospheric exposure at the spring heads, these measurements may not validly represent oxygen levels in the water prior to discharge.

The temperature of sample waters from well VR1 was 17.54 degrees C and from well VR6A was 18.97 degrees C. For spring waters, contact with the surface environment may have altered actual water temperatures present at the spring heads, since water temperatures were measured downstream from the springheads.

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

Neither chloride nor sulfate was detected in any of the sample waters. Phosphorus (0.02 mg/L) was detected in the sample from well VR6A. Detectable nitrate/nitrite was present in all of the sample waters and ranged from 0.66 mg/L as nitrogen in well VR1 to 1.70 mg/L as nitrogen in spring VR2A.

The sample from well VR6A was the only one to contain detectable VOCs. The compounds consisted of: 1,1-dichloroethylene at 1.5 ug/L (Primary MCL = 7 ug/L), tetrachloroethylene at 2.7 ug/L (Primary MCL = 5 ug/L), m-dichlorobenzene at 0.58 ug/L (no Primary MCL), and o-dichlorobenzene at 1.5 ug/L (Primary MCL = 600 ug/L). The compounds, particularly the chlorinated ethylenes are used primarily as solvents. O-dichlorobenzene is additionally used as a starting material for some agricultural chemicals. The owner/user of well VR6A manufactures barium and strontium compounds and anthraquinone.

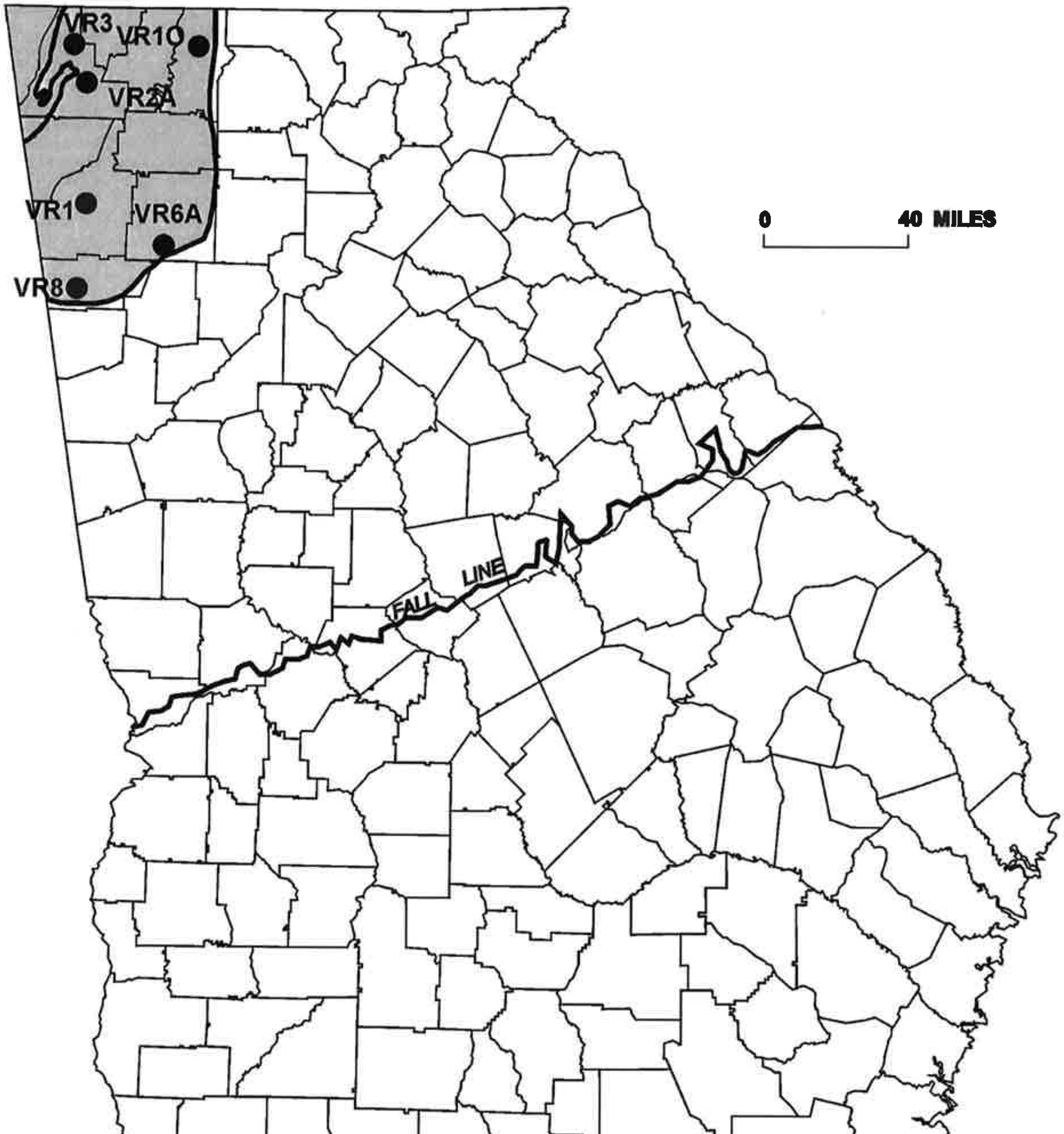
3.9.4 Metals by Inductively-Coupled Plasma Spectrometry (ICP)

ICP analysis found calcium, magnesium, and sodium in all samples. Detectable iron was present in two out of four samples from spring VR8 and in the sample from spring VR10, all at levels below the Secondary MCL of 300 ug/L. Neither manganese nor aluminum was detected in any of the samples. Calcium levels ranged from 29,000 ug/L from well VR1 and spring VR3 to 38,000 ug/L from spring VR2A. Magnesium levels ranged from 13,000 ug/L from spring VR2A to 18,000 ug/L from well VR6A. Sodium levels ranged from 1,300 ug/L from spring VR3 to 5,100 ug/L from well VR6A.

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

ICPMS analysis found barium and zinc. Detectable barium was present in all samples and ranged from 9.6 ug/L from well VR1 to 540 ug/L from well 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 the mining and processing of barite.

Zinc at a level of 11 ug/L was found in the sample from spring VR10. A spigot in the treatment house near the spring head or related plumbing may have contributed the zinc. This spigot is the only source of untreated water from the spring.



▨ General recharge area (from Davis et al., 1989)

● Sampling station

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

CHAPTER 4 SUMMARY AND CONCLUSIONS

EPD personnel collected 145 water samples from 77 wells and six springs on the Ground-Water Monitoring Network during the calendar year 2013. The samples were analyzed for VOCs, chloride, sulfate, nitrate/nitrite, total phosphorus, 15 trace metals by ICPMS analysis, and 11 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 as considered for this report in Georgia:

Cretaceous/Providence aquifer system,

Clayton aquifer,

Claiborne aquifer,

Jacksonian aquifer

Floridan aquifer system,

Miocene/Recent aquifer system,

Piedmont/Blue Ridge aquifer system,

Valley and Ridge/Appalachian Plateau aquifer system.

4.1 PHYSICAL PARAMETERS AND pH

4.1.1 pH

The Cretaceous/Providence aquifer system, developed in Coastal Plain sands, furnished waters with the overall lowest pHs as well as the lowest pH measurement (well K12) of the study. Even though this aquifer system featured only three wells yielding waters with basic pHs, one of these three wells also produced waters with the highest pH (well PD6). The Floridan aquifer system, as might be expected for carbonate-rock aquifers, gave waters with mildly basic pHs. Waters from the Floridan are the most basic in pH of any in the study.

Not many stations were available to sample wells tapping the Clayton, Claiborne, or Jacksonian aquifers. However, the results are these: 1) Clayton – acidic – as expected for updip portions of the aquifer, downdip portions should be basic; 2) Claiborne – one basic, two acidic – one acidic-yielding well is shallow and updip in sands; basic-yielding well is deeper and probably penetrates some limey sand or limestone; 3) Jacksonian – three basic, two acidic – basic waters should be expected from limey sands.

A few more stations were available to sample the Miocene and Valley-and-Ridge/Appalachian Plateau aquifer systems. The Valley-and-Ridge/Appalachian Plateau sampling stations are all located in the Valley-and-Ridge sector. With carbonate rocks being the major aquifer media, samples from the sector would be expected to be mildly basic. Of the nine samples taken in the sector, two were acidic: one from one of the two annually sampled springs and one from a quarterly sampled spring. Two of six stations, thus, gave acidic water, in contrast to the Floridan aquifer, where all 29 stations yielded basic samples. The seeming unusual high incidence of acidic water may be due to a larger amount of typically acidic precipitation entering the springs' flow systems than the carbonate bedrock can neutralize.

The Miocene aquifer system is developed in sands. However, these may include shelly detritus in some places (evident at surface excavations near well MI17). Dissolution of such detritus is capable of raising the pHs of ground waters in such areas, giving water from this well a mildly basic pH. In places where such shelly matter is not available, waters emerge with low pHs, as at well MI2A.

Sample-water pHs in the Piedmont/Blue Ridge are general mildly acidic, with nine out of 50 sample measurements exceeding a pH of 7.00.

The very acidic pHs of the sample waters in the updip portions of the Jacksonian, Clayton, Claiborne, and, particularly, the Cretaceous/Providence can face metal plumbing with leaching and corrosion problems. Such waters may contain elevated or excessive, but not naturally occurring, levels of lead, copper, and zinc.

4.1.2 Conductivity

Conductivity in ground waters from the sandy Cretaceous/ Providence aquifer system seems to be highest for the deeper wells near the Chattahoochee River. Overall, conductivities are relatively low, in the range of lower tens of microsiemenses.

Similar conductivities can be found in waters from the updip portions of the Clayton and Claiborne aquifers, where the media consist mostly of sand. For the Piedmont/Blue Ridge aquifer system, low conductivities could be associated with ground waters hosted by quartzites or quartz veins. High conductivities may arise in waters in deep flow regimes where waters are long in contact with granitic and other reactive host rocks.

Conductivities of ground waters in the Floridan and other carbonate rock aquifers are generally higher than those in siliceous rocks. This condition results from the dissolution of carbonate minerals, in cases augmented by dissolution of intergranular sulfate, where dissolved sulfate will also be present in the water.

4.1.3 Temperature

Ground-water temperatures measured under the current sampling procedure are only approximations of the actual ground-water temperature, as some heating can result from the action of pumping and heating or cooling can result from exposure to ambient surface conditions. Nevertheless, ground waters from shallower wells in the northern part of the State are overall somewhat cooler than those from the southern part; and those from wells much deeper than about 400 to 500 feet show effects from geothermal warming.

4.2 ANIONS, NON-METALS AND VOCS

4.2.1 Chloride and Fluoride

Water samples receive testing for fluoride only at Piedmont/Blue Ridge stations P12A, a mineral spring and well P23, a nearby well. Testing more stations for fluoride could provide a better base level assessment of fluoride contents in the State's ambient ground waters.

Chloride at currently detectable levels is not too common in ambient ground waters. Abundance seems to be largest in the Miocene/Surficial, with two stations of less than 100 feet depth giving water with detectable chloride. Chloride is also relatively abundant in Piedmont/Blue Ridge waters, detected at three out of 21 stations, and in deeper Floridan waters, detected at five out of 29 stations. The Floridan occurrences seem restricted to the Gulf Trough and Coastal areas, with Coastal area sample from well PA9C giving the study's only Secondary MCL exceedance for chloride.

4.2.2 Sulfate

Sulfate is more widespread than chloride. Sulfate is more abundant in deeper waters, with the shallowest occurrence, aside from Piedmont/Blue Ridge mineral spring P12A, being 200 feet-deep well J6. The substance seems more abundant in the Piedmont/Blue Ridge, occurring in detectable amounts in waters from nine of 21 stations. Sulfate also has considerable presence in Floridan sample waters (detectable at 12 out of 29 stations), and in Jacksonian sample waters (2 out of 5 stations). The sample from Piedmont well P32 yielded the study's highest overall sulfate content and a Secondary MCL exceedance. The lowest incidences of detectable sulfate were in the Miocene/Surficial (at one of six stations) and in the sole Clayton station sample.

4.2.3 Nitrate/Nitrite

Eighty-two samples from 50 of the 83 stations sampled for this project contained detectable nitrate/nitrite. At least one sampling station drawing from each of the aquifers and aquifer systems discussed in this report gave a sample with detectable nitrate/nitrite. The combined substances are most widespread among the Valley and Ridge/Appalachian Plateau samples, where all stations gave samples containing detectable amounts. The combined substances are also widespread in Piedmont/Blue Ridge and Floridan waters. The two highest concentrations of nitrate/nitrite (17 mg/L at well MI9A, 5.3 mg/L at well MI2A) occurred at Miocene/Surficial stations. The first sample exceeded Primary MCL of 10 mg/L as nitrogen, and, the second exceeded the 3 mg/L (as nitrogen) level generally considered to indicate human influence (Madison and Brunett, 1984; Gaskin et al., 2003).

Since nitrate/nitrite, an oxidant, becomes depleted the farther water travels away from oxidizing, near-surface environments and into reducing ones, a rude inverse relation exists between the concentration of the combined substances and well depths. The nitrate/nitrite concentrations in Floridan samples illustrate this: the combined substances are undetected in wells deeper than about 650 feet and reach a maximum concentration of 2.2 mg/L at well PA49, 97 feet deep. The situation in the Piedmont/Blue Ridge is less straightforward, as mineral spring P12A lacks detectable nitrate/nitrite and well P24 at 700 feet gives water with a concentration of 0.24 mg/L.

4.2.4 Phosphorus

Analyses determine only total phosphorus; the method used (EPA Method 365.1) for testing cannot determine how the element is bound. Arithmetic means cited for the following aquifers use a value of 0.01 mg/L where a phosphorus value of “not detected” is reported. Only three samples from three stations were collected for the Claiborne, however, the aquifer registered the highest phosphorus content encountered (0.47 mg/L) as well as a mean phosphorus content of 0.22 mg/L. Of the more extensively sampled Piedmont/Blue Ridge and Floridan aquifer systems, the former registered a mean phosphorus content of 0.05 mg/L and the latter a content of 0.02 mg/L. The high phosphorus value for the Piedmont/Blue Ridge was 0.22 mg/L and the high for the Floridan was 0.07 mg/L. The apparent low phosphorus content occurred for the Valley and Ridge/Appalachian Plateau aquifer system with no phosphorus detections.

4.2.5 Dissolved Oxygen

The measurement of dissolved oxygen contents is beset with some difficulties that can cause spurious values: instrument malfunction; aeration of well water due to cascading or to a pump’s entraining air at low pumping water levels; measuring at spring pools or at sampling points that cannot be isolated from atmosphere. Nevertheless, measured dissolved oxygen generally decreases with well depth.

4.2.6 Volatile Organic Compounds

Volatile organic compounds (VOCs) were found in eight samples from five wells (see Table 4-3). 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 took place in 2012 with well PA44. 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, as apparently happened with well PA23.

Well VR6A yielded water containing chlorinated ethylene compounds. Sample water from VR6A also contained detectable chlorinated benzene compounds. The former are used as solvents; in addition to solvent uses, the latter can be used as disinfectants, fumigants, pesticides, and starters for manufacturing other compounds. The owner of well VR6A, Chemical Products Corporation, manufactures barium and strontium compounds.

4.3 ICP METALS

Analysis using inductively coupled plasma spectrometry (ICP) works well for metals that occur in larger concentrations in ground water samples. Samples in this study were not filtered, so the method measured analytes that occurred in fine suspended matter as well as those occurring as solutes. The laboratory used the technique to test for aluminum, beryllium, calcium, cobalt, iron, magnesium, manganese, potassium, sodium, titanium, and vanadium. No beryllium, cobalt, titanium, or vanadium occurred in any samples at detectable levels.

4.3.1 Aluminum

Aluminum, a common naturally occurring contaminant in the State's ground water may be present in particulate form or as a solute. Current sampling procedures do not allow separate analyses of particulates and solutes. For its Secondary MCL, aluminum is subject to a range of concentrations from 50 ug/L to 200 ug/L, depending on the ability of a water system to remove the metal from water undergoing treatment. The EPD laboratory's reporting level for the metal, 60 ug/L lies within the Secondary MCL range, placing any sample with detectable aluminum within the MCL range.

The metal appears to be most abundant in water samples with acidic pHs and, as a rule, is more concentrated the higher the acidity. The Miocene/Recent aquifer system, updip portions of the Cretaceous/Providence aquifer system, and updip terrigenous clastic-rich portions of the Clayton aquifer are examples. Aquifers giving mildly basic samples such as the carbonate-hosted Floridan aquifer and carbonate portions of the Valley and Ridge/Appalachian Plateau aquifers produce few sample waters containing any detectable aluminum. The metal's abundance in bedrock waters from the Piedmont Blue Ridge aquifer system seems also low. Samples from deeper wells with more strongly basic pHs (approaching 8.00) may contain some detectable aluminum.

4.3.2 Iron and Manganese

Iron and manganese, also, are two naturally occurring contaminants in Georgia's ground water. Both, like aluminum, may occur as fine particulates or as solutes. Both seem more abundant in acidic waters. Manganese also seems more abundant in waters with low dissolved oxygen contents. Sand units (e.g., the Cretaceous and updip Clayton) and shallower igneous /metamorphic bedrock give waters with the highest iron or manganese concentrations. Waters with the lowest concentrations are drawn from carbonate units (e.g., the Floridan and the carbonates in the Valley and Ridge/ Appalachian Plateau province), which also usually have the higher pH waters.

4.3.3 Calcium, Magnesium, Sodium, and Potassium

Calcium is most abundant in sample waters from the Jacksonian aquifer. Sample waters from the Floridan and the Piedmont/Blue Ridge aquifer systems also contain high calcium levels. The metal could be considered least abundant in samples from the Cretaceous/ Providence aquifer system. Only a single, updip sample is available from the Clayton aquifer, making this lowest average calcium content hardly representative.

Magnesium appears most abundant in the Valley and Ridge/Appalachian Plateau aquifer system and least abundant in the Cretaceous/Providence system. Again, the average magnesium value for the Clayton aquifer depends on a single sample and is not representative for the aquifer.

Detectable sodium is nearly ubiquitous. The metal is most abundant in waters from the Floridan and the Piedmont/Blue Ridge and least so in waters from the more updip Cretaceous.

The testing method used by the EPD laboratory to analyze for potassium is not very sensitive (reporting limit 5,000 ug/L), therefore, detectable potassium was found in only five samples from three stations – one each from the Floridan, Miocene and Piedmont/Blue Ridge.

Kellam and Gorday (1990) observed that Ca/Mg ratios are highest in the Floridan where recharge areas are closest. Their observation also applies to the Floridan in this study, and a wide range of Ca/Mg ratios from indefinitely large (division by zero or a very small number) to 1.25 exists. However, for carbonate or carbonate-bearing aquifer media in the Valley and Ridge/Appalachian Plateau, the Jacksonian, the Claiborne, the Miocene/Surficial aquifers and aquifer systems the rule does not seem to apply. The ratios seem to cluster around 2.00 for the Valley and Ridge/Appalachian Plateau samples, and to range from 20.4 up to indefinitely large for the Jacksonian. The low number of sampling stations situated in these other aquifers or aquifer systems might cause the differences between Floridan Ca/Mg ratios and ratios for the other aquifers and aquifer systems to be apparent.

4.4 ICPMS METALS

The ICPMS method works well for most trace metals. Sample waters undergoing testing by this method, as with the samples subject to ICP testing, were unfiltered. The EPD laboratory tested for the following trace metals: chromium, nickel, copper, zinc, arsenic, selenium, molybdenum, silver, cadmium, tin, antimony, barium, thallium, lead and uranium. Silver, cadmium, tin, antimony, and thallium remained below detection in all samples. Of the remaining metals, only lead registered any levels above the action level.

4.4.1 Chromium and Nickel

Detectable chromium occurred in one sample from one Floridan station. The station, well PA49, is shallow at a 97-foot depth. As the metal ordinarily does not accumulate in marine carbonate bedrock; outside pollution is a likely source.

4.4.2 Arsenic, Selenium, Uranium, and Molybdenum

Arsenic was detected in a sample from the Floridan (quarterly well PA23). The Floridan sample came from the Gulf Trough area of Grady County, the scene of other ground-water arsenic detections, some above the Primary MCL (10 ug/L) (Donahue et al., 2012). Selenium was found in a sample from the Miocene/Surficial (Well MI10B) and the Floridan aquifer system (PA9C). The element may accompany uranium in deposits formed from the reduction of oxic ground waters.

Twelve samples from three Floridan stations are the only samples containing detectable molybdenum. The stations – PA23, PA28, and PA56 – are all Gulf Trough area wells. Like selenium, molybdenum can be associated with uranium in deposits formed through the reduction of oxic ground waters (Turner-Peterson and Hodges, 1986).

Uranium appears to be most abundant in Piedmont/Blue Ridge, with 11 of 20 stations giving 31 of 50 samples containing detectable uranium. The remaining uranium detections were divided between the Floridan, with samples from five stations containing detectable uranium, and the Cretaceous/Providence, with one station. Uranium minerals, sometimes accompanied by molybdenum and selenium minerals, can precipitate from oxic ground waters subjected to strong reduction.

4.4.3 Copper, Lead, and Zinc

Copper, lead, and zinc detections are more numerous in acidic samples. Copper did not exceed its action level nor zinc its Secondary MCL in any samples. Out of a total of 145 samples taken for the study, 31 samples with pHs below 7.00 contained detectable amounts of at least one of these metals. In contrast, only seven samples with basic pHs and one sample with a neutral pH contained detectable amounts of any of these metals. Past experiences where two samples, each drawn from a different spigot, had different copper, zinc, and lead values, suggest that these metals are, at least in part, derived from plumbing. Therefore, the copper, lead, and zinc levels in the samples are not necessarily representative of those in the ambient ground water.

4.4.4 Barium

A possible effect of the sensitivity of the testing method, barium detections occur in almost every sample. Because, perhaps, nearby barite deposits and associated mining and processing activities greatly increased the barium level in ground water at station VR6A, a sample from that station has caused the Valley and Ridge/Appalachian Plateau samples to have the highest average barium level. Samples from the Floridan and Miocene/Surficial aquifer systems also have elevated average barium levels. Ground water containing excessive barium (Primary MCL of 2,000 ug/L) has not been a problem since the in-town public well field, drawing from the Floridan at Fitzgerald, Ben Hill County, closed in 1995.

4.5 CONTAMINATION OCCURENCES

According to the Safe Drinking Water Act (Public Law 93-523, section 1401, Dec. 16, 1974) a "contaminant" is any "physical, chemical, biological, or radiological substance in water" – almost anything except water itself. Some contaminants can be innocuous or even beneficial; others can be undesirable or harmful.

Modeled after limits USEPA has established concerning the quality of water offered for public consumption, the State established limits on certain contaminants in water for public use (Table 4-2). Some contaminants may endanger health, if present in sufficient concentrations. Two types of limits apply to such contaminants. The first, the Primary MCL, imposes mandatory limits applying to treated water at the point of its production. The second, the action level, sets forth mandatory limits that regulate copper and lead contents and apply to water at the point where the consumer can partake of it.

Secondary MCLs (Table 4-2) are suggested limits established for substances imparting only unpleasant qualities to water. The unpleasant qualities include bad taste and staining ability -- such as with iron and manganese -- and cosmetic effects – such as with silver.

4.5.1 Primary MCL and Action Level Exceedances

One well and one spring produced samples with substances that exceeded Primary MCLs or action levels (Table 4-2). Mineral spring P12A gave four samples that exceeded the Primary MCL for fluoride (4 mg/L). The spring has, in the past, regularly given samples that fall in a range from 4 mg/L to a little above 5 ug/L fluoride. The fluoride is almost certainly natural.

Nitrate/nitrite exceeded its Primary MCL of 10 mg/L as nitrogen in well MI9A. The well, a former garden well, 22 feet deep and located adjacent to a row-crop field, has yielded water with excessive nitrate/nitrite before.

4.5.2 Secondary MCL Exceedances

Substances occurring in excess of Secondary MCLs (Table 4-2) consisted of manganese, iron, aluminum, sulfate, and chloride. Manganese, aluminum, and iron are common natural contaminants in Georgia's ground water.

Manganese exceeded its MCL in 20 samples from 10 wells. Four of the wells were quarterly (P21, P35, P37, PA34A) and two gave four samples and two gave three of four samples with excessive manganese.

The Secondary MCL for aluminum is established as a range, varying from 50 ug/L to 200 ug/L. The range is designed to accommodate varying ability of water treatment facilities at removing aluminum from treated water. This is a consequence of a tradeoff between introducing into treated water coagulants, which contain soluble aluminum, versus impaired removal of suspended aluminum-bearing contaminants. The aluminum present in waters covered by this study is naturally occurring rather than introduced. Of additional note, water in shallow wells may experience an increase in suspended matter (turbidity) during prolonged rain events, which may result in an increased aluminum value because of suspended material. Aluminum excesses, those which exceeded the 50 ug/L level (most ground water used for public consumption lacks measureable suspended matter), were found in 12 samples from nine wells. Aluminum excesses were the most consistent in the domestic bored Piedmont regolith well P33.

Iron exceeded its Secondary MCL in seven samples from seven wells. Iron is another common naturally occurring contaminant in Georgia's ground water. Two of the wells are quarterly (P33 and P37) but gave only one sample each that exceeded the MCL.

Table 4-1. Contaminant Exceedances, Calendar Year 2013.

Station	Contaminant	MCL	Type Source	Date Sampled
Primary MCL and Copper/Lead Action Level Exceedances				
MI9A	Nitrate/nitrite = 17 mg/L as N	10 mg/L	domestic well	06/26/13
P12A	Fluoride = 4.9 mg/L	4 mg/L	mineral spring	09/11/13
P12A	Fluoride = 4.7 mg/L	4 mg/L	mineral spring	01/09/13
P12A	Fluoride = 4.7 mg/L	4 mg/L	mineral spring	04/04/13
P12A	Fluoride = 4.6 mg/L	4 mg/L	mineral spring	07/24/13
Secondary MCL Exceedances				
P37	Manganese = 220 ug/L	50 ug/L	public well	01/08/13
P37	Manganese = 160 ug/L	50 ug/L	public well	04/03/13
P37	Manganese = 130 ug/L	50 ug/L	public well	07/10/13
P35	Manganese = 120 ug/L	50 ug/L	domestic well	04/03/13
P35	Manganese = 120 ug/L	50 ug/L	domestic well	07/10/13
P35	Manganese = 120 ug/L	50 ug/L	domestic well	10/09/13
PA34A	Manganese = 100 ug/L	50 ug/L	public well	02/06/13
PA34A	Manganese = 100 ug/L	50 ug/L	public well	06/12/13
PA34A	Manganese = 96 ug/L	50 ug/L	public well	08/07/13
PA34A	Manganese = 92 ug/L	50 ug/L	public well	11/06/13
P37	Manganese = 90 ug/L	50 ug/L	public well	10/09/13
MI10B	Manganese = 89 ug/L	50 ug/L	domestic well	06/26/13
P20	Manganese = 81 ug/L	50 ug/L	public well	02/07/13
P21	Manganese = 68 ug/L	50 ug/L	public well	11/07/13
PA18	Manganese = 63 ug/L	50 ug/L	public well	03/20/13
K20	Manganese = 61 ug/L	50 ug/L	public well	01/23/13
CL8	Manganese = 57 ug/L	50 ug/L	domestic well	01/23/13

Table 4-1 Continued. Contaminant Exceedances, Calendar Year 2013

Station	Contaminant	MCL	Type Source	Date Sampled
Secondary MCL Exceedances Continued				
P21	Manganese = 56 ug/L	50 ug/L	public well	06/13/13
P21	Manganese = 55 ug/L	50 ug/L	public well	08/07/13
PA16	Manganese = 52 ug/L	50 ug/L	public well	06/12/13
K12	Aluminum = 430 ug/L	50-200 ug/L	public well	02/20/13
P21	Aluminum = 360 ug/L	50-200 ug/L	public well	08/07/13
P33	Aluminum = 350 ug/L	50-200 ug/L	domestic well	07/10/13
K9A	Aluminum = 300 ug/L	50-200 ug/L	public well	02/21/13
P33	Aluminum = 200 ug/L	50-200 ug/L	domestic well	01/08/13
MI2A	Aluminum = 140 ug/L	50-200 ug/L	domestic well	03/06/13
P33	Aluminum = 130 ug/L	50-200 ug/L	domestic well	04/03/13
P33	Aluminum = 120 ug/L	50-200 ug/L	domestic well	10/09/13
BR1B	Aluminum = 90 ug/L	50-200 ug/L	public well	06/27/13
MI9A	Aluminum = 83 ug/L	50-200 ug/L	domestic well	06/26/13
P22	Aluminum = 75 ug/L	50-200 ug/L	domestic well	07/24/13
CT8	Aluminum = 67 ug/L	50-200 ug/L	domestic well	02/21/13
MI10B	Iron = 2,400 ug/L	300 ug/L	domestic well	06/26/13
K20	Iron = 1,800 ug/L	300 ug/L	public well	01/23/13
K3	Iron = 1,400 ug/L	300 ug/L	public well	03/20/13
P37	Iron = 1,100 ug/L	300 ug/L	public well	01/08/13
PA9C	Iron = 680 ug/L	300 ug/L	former test	03/20/13
P23	Iron = 320 ug/L	300 ug/L	public well	06/13/13
P33	Iron = 320 ug/L	300 ug/L	domestic well	07/10/13
P32	Sulfate = 370 mg/L	250 mg/L	domestic well	10/09/13
P32	Sulfate = 350 mg/L	250 mg/L	domestic well	01/08/13

Table 4-1 Continued. Contaminant Exceedances, Calendar Year 2013

Station	Contaminant	MCL	Type Source	Date Sampled
Secondary MCL Exceedances Continued				
P32	Sulfate = 314 mg/L	250 mg/L	domestic well	04/03/13
P32	Sulfate = 300 mg/L	250 mg/L	domestic well	07/10/13
PA9C	Chloride = 650 mg/L	250 mg/L	former test	03/20/13

(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, CT=Clayton, VR=Valley and Ridge, M=Miocene)

One well (P32) gave four samples with excessive sulfate.

Well PA9C was the only well that contained excessive chloride.

4.5.3 Volatile Organic Compounds

Trihalomethanes are the most common of the VOCs detected (Table 4-3). Chloroform, the most commonly detected of VOCs, was present in seven samples from four stations. Bromodichloromethane and chlorodibromomethane are next, with six detections apiece in three stations. Detectable bromoform occurred in one sample from one station. In ground water, these compounds originate as by-products when halogenous disinfectants react with naturally-occurring organic matter present in the water. The disinfectants are introduced to the water through cleaning processes incident to well maintenance or through leaky check valves or foot valves allowing treated water down a well during normal operation.

One station (VR6A) gave a sample containing detectable tetrachloroethylene, 1,1-dichloroethylene, m-dichlorobenzene, and o-dichlorobenzene. Well VR6A, an industrial process water well, is in an industrial area and is within about two miles of former and current landfills. The former landfills utilized unlined exhausted barite pits. Cressler et al. (1979) had warned of the danger of using these sorts of pits for waste disposal in the Cartersville area because of the karstic bedrock. The source of the VOCs at station VR6A thus is uncertain.

Table 4-2. VOC Contamination Incidents, Calendar Year 2013.				
Station	**Constituents**	**Primary MCL**	**Type Source**	**Date Sampled**
GWN-PA57	chloroform = 0.62 ug/L	See note	public	07/11/13
GWN-PA17	chloroform = 1.10 ug/L bromodichloromethane = 0.97 ug/L chlorobibromomethane = 0.89 ug/L	See note	public	02/06/13
GWN-PA23	chloroform = 1.00 ug/L bromodichloromethane = 0.99 ug/L chlorobibromomethane = 1.00 ug/L	See note	public	01/09/13
GWN-PA23	chloroform = 0.69 ug/L bromodichloromethane = 0.58 ug/L chlorobibromomethane = 0.65 ug/L	See note	public	04/03/13
GWN-PA23	chloroform = 1.70 ug/L bromodichloromethane = 1.50 ug/L chlorobibromomethane = 1.80 ug/L bromoform = 0.60 ug/L	See note	public	07/24/13
GWN-PA23	chloroform = 1.90 ug/L bromodichloromethane = 1.20 ug/L chlorobibromomethane = 1.20 ug/L	See note	public	10/09/13
GWN-PA28	chloroform = 0.62 ug/L bromodichloromethane = 0.73 ug/L chlorobibromomethane = 0.92 ug/L	See note	public	10/09/13
GWN-VR6A	1,1 dichloroethylene = 1.50 ug/L	7 ug/L	public	06/13/13
	tetrachloroethylene = 2.70 ug/L	5 ug/L		
	o - dichlorobenzene = 1.50 ug/L	600 ug/L		
	m - dichlorobenzene = 0.58 ug/L	No MCL		

4.6 GENERAL QUALITY

A review of the analyses of the water samples collected during calendar year 2013 indicates that the chemical quality of ground water sampled for most of the Ground-Water Monitoring Network stations is quite good.

However, as mentioned in Chapter 1, areas of elevated risk for low-quality ground water exist:

1) Valley and Ridge/Appalachian Plateau Province – surface influence;
2) Piedmont/Blue Ridge Province – in areas excluding the eastern metavolcanic terranes - uranium:
3) Coastal Plain agricultural areas – high nitrate/nitrite;
4) Coastal Plain, Dougherty Plain – surface influence;
5) Coastal Plain, Gulf Trough – high total dissolved solids, especially sulfate – high radionuclides, high barium, high arsenic;
6) Coastal Plain, Atlantic coast area – saline water influx.

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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
bdcm	= bromodichloromethane	pdcb	= p-dichlorobenzene
dbcm	= dibromochloromethane	tbm	= bromoform
pce	= tetrachloroethylene	tcm	= chloroform

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	03/20/13	6.36	175	5.23	17.95	ND	ND	11	0.89	3.8
GWN-K6 **Twiggs**	KaMin Well #6	400	NG	NG	08/07/13	6.05	44	NA	21.47	ND	ND	ND	0.03	ND
GWN-K7 **Jones**	Jones County #4	128	NG	NG	06/26/13	4.86	30	8.20	18.49	ND	ND	ND	0.55	ND
GWN-K9A **Macon**	Marshallville Well #1	550	NG	NG	02/21/13	3.95	47	NA	19.40	ND	ND	10	0.06	ND
GWN-K10B **Peach**	Fort Valley Well #6	600	NG	NG	01/23/13	4.76	30	9.14	18.91	ND	ND	ND	0.72	ND
GWN-K11A **Houston**	Warner Robins Well #2	540	NG	NG	02/20/13	4.48	25	6.31	19.80	ND	ND	ND	0.88	ND
GWN-K12 **Houston**	Perry/Holiday Inn Well	550	NG	NG	02/20/13	3.85	53	0.76	20.34	ND	ND	11	ND	ND
GWN-K19 **Richmond**	Hephzibah/Murphy Street Well	484	NG	NG	06/12/13	4.81	18	7.78	21.00	ND	ND	ND	0.14	ND
GWN-K20 **Sumter**	Plains Well #7	1000	NG	NG	01/23/13	7.10	209	1.81	28.78	ND	ND	ND	0.17	ND
GWN-PD2A **Webster**	Preston Well #4	205	NG	NG	01/23/13	4.57	60	10.45	19.00	ND	ND	ND	2.0	0.02
GWN-PD3 **Clay**	Fort Gaines Well #2	456	NG	NG	03/06/13	8.17	379	0.62	22.15	ND	10	ND	ND	ND
GWN-PD6 **Early**	Blakely Well #4	1025	NG	NG	03/06/13	8.18	352	NA	22.58	ND	ND	13	ND	ND

Table A-1. Ground-Water Quality Analyses for Cretaceous Stations.
Part B: Metals.

Station No. County	Chromium ug/L	Nickel ug/L	Copper ug/L	Zinc ppb ug/L	Arsenic ug/L	Selenium ug/L	Molybdenum ug/L	Silver ppb ug/L	Cadmium ug/L	Tin ppb ug/L	Antimony ug/L	Barium ppb ug/L	Thallium ug/L	Lead ppb ug/L	Uranium ug/L	Aluminum ug/L	Beryllium ug/L	Calcium ug/L	Cobalt ug/L	Iron ug/L	Potassium ug/L	Magnesium ug/L	Manganese ug/L	Sodium ug/L	Titanium ug/L	Vanadium ug/L
GWN-K3 **Washington**	ND	ND	6.7	12	ND	ND	ND	ND	ND	ND	ND	23	ND	1.9	ND	ND	ND	25,000	ND	1,400	ND	1,300	48	11,000	ND	ND
GWN-K6 **Twiggs**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	14	ND	ND	1.0	ND	ND	4,000	ND	22	ND	ND	ND	3,000	ND	ND
GWN-K7 **Jones**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	17	ND	ND	ND	ND	ND	2,100	ND	ND	ND	ND	ND	1,900	ND	ND
GWN-K9 **Macon**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.3	ND	1.5	ND	300	ND	ND	ND	150	ND	ND	ND	1,000	ND	ND
GWN-K10B **Peach**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1,200	ND	ND
GWN-K11A **Houston**	ND	ND	7.0	ND	ND	ND	ND	ND	ND	ND	ND	7.3	ND	1.3	ND	ND	ND	ND	ND	220	ND	ND	11	1,800	ND	ND
GWN-K12 **Houston**	ND	ND	28	36	ND	ND	ND	ND	ND	ND	ND	5.5	ND	2.4	ND	430	ND	ND	ND	210	ND	ND	13	1,000	ND	ND
GWN-K19 **Richmond**	ND	ND	6.6	ND	ND	ND	ND	ND	ND	ND	ND	5.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1,200	ND	ND
GWN-K20 **Sumter**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3,700	ND	ND	ND	ND	ND	25,000	ND	ND
GWN-PD2A **Webster**	ND	ND	5.8	ND	ND	ND	ND	ND	ND	ND	ND	18	ND	1.3	ND	ND	ND	2,200	ND	ND	ND	1,100	ND	1,700	ND	ND
GWN-PD3 **Clay**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.7	ND	ND	ND	ND	ND	5,500	ND	ND	ND	1,000	ND	78,000	ND	ND
GWN-PD6 **Early**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	7.0	ND	ND	ND	ND	ND	7,700	ND	ND	ND	3,800	ND	68,000	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. 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-CT8 **Schley**	Weathersby House Well	80	NG	NG	02/21/13	4.34	49	7.44	19.69	ND	ND	ND	1.8	ND

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

Station No. County	Chromium ug/L	Nickel ug/L	Copper ug/L	Zinc ppb ug/L	Arsenic ug/L	Selenium ug/L	Molybdenum ug/L	Silver ppb ug/L	Cadmium ug/L	Tin ppb ug/L	Antimony ug/L	Barium ppb ug/L	Thallium ug/L	Lead ppb ug/L	Uranium ug/L	Aluminum ug/L	Beryllium ug/L	Calcium ug/L	Cobalt ug/L	Iron ug/L	Potassium ug/L	Magnesium ug/L	Manganese ug/L	Sodium ug/L	Titanium ug/L	Vanadium ug/L
GWN-CT8 **Schley**	ND	ND	15	ND	ND	ND	ND	ND	ND	ND	ND	21	ND	ND	ND	67	ND	ND	ND	ND	ND	1,100	26	4,100	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	01/23/13	7.29	313	3.26	20.53	ND	ND	ND	0.44	ND
GWN-CL4A **Sumter**	Plains Well #8	230	NG	NG	01/23/13	6.07	278	9.08	17.81	ND	ND	12	ND	0.34
GWN-CL8 **Dooly**	Flint River Nursery Office Well	90	NG	NG	01/23/13	6.06	117	1.26	22.12	ND	ND	ND	ND	0.47

Table A-3. Ground-Water Quality Analyses for Claiborne Stations.
Part B: Metals.

Station No. County	Chromium ug/L	Nickel ug/L	Copper ug/L	Zinc ppb ug/L	Arsenic ug/L	Selenium ug/L	Molybdenum ug/L	Silver ppb ug/L	Cadmium ug/L	Tin ppb ug/L	Antimony ug/L	Barium ppb ug/L	Thallium ug/L	Lead ppb ug/L	Uranium ug/L	Aluminum ug/L	Beryllium ug/L	Calcium ug/L	Cobalt ug/L	Iron ug/L	Potassium ug/L	Magnesium ug/L	Manganese ug/L	Sodium ug/L	Titanium ug/L	Vanadium ug/L
GWN-CL2 **Dooly**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	10	ND	ND	ND	ND	ND	39,000	ND	ND	ND	ND	ND	1,400	ND	ND
GWN-CL4A **Sumter**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	11.0	ND	ND	ND	ND	ND	22,000	ND	1,800	ND	3,100	61	1,800	ND	ND
GWN-CL8 **Dooly**	ND	ND	8.7	190	ND	ND	ND	ND	ND	ND	ND	27	ND	1.4	ND	ND	ND	12,000	ND	300	ND	1,300	57	2,000	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 **Jefferson**	McNair House Well	~90	NG	NG	02/06/13	6.76	277	5.93	18.89	ND	10	ND	2.7	0.06
GWN-J4 **Johnson**	Wrightsville #4	520	NG	8	02/06/13	7.48	274	2.14	20.69	ND	ND	ND	0.20	0.03
GWN-J5 **Bleckley**	Cochran #3	307	NG	NG	03/21/13	7.37	348	1.38	20.03	ND	ND	13	ND	0.04
GWN-J6 **Jefferson**	Wrens #4	200	NG	NG	02/06/13	6.81	268	0.88	19.40	ND	ND	13	ND	0.16
GWN-J8A **Jefferson**	Kahn House Well II	100	NG	NG	02/06/13	7.08	307	2.33	17.13	ND	ND	ND	0.14	0.04

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

Station No. County	Chromium ug/L	Nickel ug/L	Copper ug/L	Zinc ppb ug/L	Arsenic ug/L	Selenium ug/L	Molybdenum ug/L	Silver ppb ug/L	Cadmium ug/L	Tin ppb ug/L	Antimony ug/L	Barium ppb ug/L	Thallium ug/L	Lead ppb ug/L	Uranium ug/L	Aluminum ug/L	Beryllium ug/L	Calcium ug/L	Cobalt ug/L	Iron ug/L	Potassium ug/L	Magnesium ug/L	Manganese ug/L	Sodium ug/L	Titanium ug/L	Vanadium ug/L
GWN-J1B **Jefferson**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	21	ND	ND	ND	ND	ND	54,000	ND	ND	ND	ND	ND	4,500	ND	ND
GWN-J4 **Johnson**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	13	ND	ND	ND	ND	ND	51,000	ND	ND	ND	2,500	ND	3,400	ND	ND
GWN-J5 **Bleckley**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8.1	ND	ND	ND	ND	ND	66,000	ND	ND	ND	2,500	13	3,400	ND	ND
GWN-J6 **Jefferson**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8.1	ND	ND	ND	ND	ND	55,000	ND	170	ND	1,600	ND	2,000	ND	ND
GWN-J8A **Jefferson**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9.6	ND	ND	ND	ND	ND	62,000	ND	ND	ND	1,100	13	2,600	ND	ND

Table A-5. 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 ^{0}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	06/27/13	8.04	252	1.29	24.15	ND	ND	ND	ND	0.03
GWN-PA4 **Chatham**	Tybee Island Well #1	402	NG	NG	06/27/13	7.97	678	1.82	24.04	ND	46	140	ND	0.02
GWN-PA5 **Liberty**	Interstate Paper Well #1	810	NG	NG	03/20/13	7.98	325	0.66	24.89	ND	ND	34	ND	0.03
GWN-PA6 **Liberty**	Hinesville Well #5	806	NG	NG	03/20/13	7.92	287	0.63	25.29	ND	ND	23	ND	0.03
GWN-PA9C **Glynn**	Miller Ball Park North East Well	1211	NG	NG	03/20/13	7.81	1,580	0.86	27.68	ND	650	240	ND	0.03
GWN-PA13 **Ware**	Waycross Well #3	775	NG	NG	03/06/13	7.25	415	1.10	24.25	ND	14	50	ND	0.02
GWN-PA14A **Bulloch**	Statesboro Well #4	413	NG	NG	03/20/13	7.78	247	NA	20.87	ND	ND	ND	ND	0.05
					06/12/13	7.62	253	NA	24.16	ND	ND	ND	ND	0.03
					09/12/13	7.75	243	NA	23.53	ND	ND	ND	0.10	0.03
					12/11/13	7.44	255	NA	21.82	ND	ND	ND	ND	0.03
GWN-PA16 **Jenkins**	Millen Well #1	500	NG	NG	06/12/13	7.28	284	5.25	21.71	ND	ND	ND	ND	0.02
GWN-PA17 **Emanuel**	Swainsboro Well #7	260	NG	NG	02/06/13	7.43	256	3.58	18.38	tcm=1.1 bdcm=0.97 dbcm=0.89	ND	ND	0.04	0.07
GWN-PA18 **Candler**	Metter Well #2	540	NG	NG	03/20/13	7.83	219	0.68	21.61	ND	ND	ND	ND	0.03
GWN-PA20 **Lanier**	Lakeland Well #2	340	NG	NG	03/06/13	7.28	372	1.34	21.84	ND	ND	65	ND	0.06
GWN-PA22 **Thomas**	Thomasville Well #6	400	NG	NG	04/03/13	7.54	399	4.07	22.63	ND	ND	62	0.14	0.02

Table A-5. Ground-Water Quality Analyses for Floridan Stations.
Part B: Metals.

Station No. County	Chromium ug/L	Nickel ug/L	Copper ug/L	Zinc ppb ug/L	Arsenic ug/L	Selenium ug/L	Molybdenum ug/L	Silver ppb ug/L	Cadmium ug/L	Tin ppb ug/L	Antimony ug/L	Barium ppb ug/L	Thallium ug/L	Lead ppb ug/L	Uranium ug/L	Aluminum ug/L	Beryllium ug/L	Calcium ug/L	Cobalt ug/L	Iron ug/L	Potassium ug/L	Magnesium ug/L	Manganese ug/L	Sodium ug/L	Titanium ug/L	Vanadium ug/L
GWN-PA2 **Chatham**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9.9	ND	ND	ND	ND	ND	22,000	ND	ND	ND	8,500	ND	15,000	ND	ND
GWN-PA4 **Chatham**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8.1	ND	ND	ND	ND	ND	32,000	ND	ND	ND	27,000	ND	54,000	ND	ND
GWN-PA5 **Liberty**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	31	ND	ND	ND	ND	ND	28,000	ND	ND	ND	16,000	ND	18,000	ND	ND
GWN-PA6 **Liberty**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	23	ND	ND	ND	ND	ND	26,000	ND	ND	ND	14,000	ND	16,000	ND	ND
GWN-PA9C **Glynn**	ND	ND	ND	34	ND	6.0	ND	ND	ND	ND	ND	53	ND	ND	ND	ND	ND	100,000	ND	680	7,800	72,000	ND	370,000	ND	ND
GWN-PA13 **Ware**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	76	ND	ND	ND	ND	ND	40,000	ND	ND	ND	18,000	ND	17,000	ND	ND
GWN-PA14A **Bulloch**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5.8	ND	ND	ND	ND	ND	36,000	ND	ND	ND	6,900	ND	7,900	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.1	ND	ND	ND	ND	ND	34,000	ND	ND	ND	6,700	ND	7,600	ND	ND
	ND	ND	69	60	ND	ND	ND	ND	ND	ND	ND	3.4	ND	2.5	ND	ND	ND	33,000	ND	ND	ND	6,600	ND	7,400	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.9	ND	ND	ND	ND	ND	34,000	ND	ND	ND	6,600	ND	7,700	ND	ND
GWN-PA16 **Jenkins**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.1	ND	ND	ND	ND	ND	47,000	ND	ND	ND	3,400	52	5,200	ND	ND
GWN-PA17 **Emanuel**	ND	ND	9.5	ND	ND	ND	ND	ND	ND	ND	ND	160	ND	4.0	ND	ND	ND	51,000	ND	81	ND	2,200	11	3,400	ND	ND
GWN-PA18 **Candler**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	23	ND	ND	ND	ND	ND	30,000	ND	ND	ND	3,500	63	11,000	ND	ND
GWN-PA20 **Lanier**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	28	ND	ND	ND	ND	ND	42,000	ND	ND	ND	17,000	14	4,800	ND	ND
GWN-PA22 **Thomas**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	22	ND	ND	1.3	ND	ND	41,000	ND	ND	ND	19,000	ND	6,600	ND	ND

Table A-5, 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-PA23 **Grady**	Cairo #8	465'	NG	NG	01/09/13	7.74	363	1.79	23.20	tcm=1.0 bdcm=0.99 dbcm=1.0	ND	41	0.02	ND
					04/03/13	7.56	362	1.75	23.35	tcm=0.69 bdcm=0.58 dbcm=0.65	ND	40	ND	ND
					07/24/13	7.77	365	3.03	23.76	tcm=1.7 bdcm=1.5 dbcm=1.8 tbm=0.6	ND	43	ND	ND
					10/09/13	7.73	366	2.04	23.56	tcm=1.9 bdcm=1.2 dbcm=1.2	ND	44	ND	ND
GWN-PA25 **Seminole**	Donalsonville / 7th Street Well	174	NG	NG	03/06/13	7.29	312	4.69	21.85	ND	ND	ND	1.7	ND
					06/26/13	7.17	310	7.47	21.39	ND	ND	ND	1.6	ND
					09/11/13	7.02	289	8.70	21.33	ND	ND	ND	1.7	ND
					12/11/13	7.32	292	5.53	21.05	ND	ND	ND	1.7	0.02
GWN-PA27 **Mitchell**	Camilla Industrial Park Well	360	NG	NG	03/07/13	7.31	265	4.37	19.91	ND	ND	ND	0.64	ND
GWN-PA28 **Colquitt**	Moultrie Well #1	750	NG	NG	01/09/13	7.87	494	1.05	24.09	ND	11	120	ND	ND
					04/03/13	7.70	493	0.88	24.26	ND	12	110	ND	ND
					07/10/13	7.88	463	1.32	24.48	ND	ND	100	ND	ND
					10/09/13	7.87	485	1.35	24.46	tcm=0.62 bdcm=0.73 dbcm=0.92	11	110	ND	ND
GWN-PA29 **Cook**	Adel Well #6	405	NG	NG	01/09/13	7.73	336	4.75	22.81	ND	ND	48	ND	0.05
					04/03/13	7.55	351	0.66	22.73	ND	ND	51	ND	0.05
					07/10/13	7.65	365	1.06	22.80	ND	ND	61	ND	0.04
					10/09/13	7.71	379	0.71	22.88	ND	ND	70	ND	0.05

Table A-5, Continued. Ground-Water Quality Analyses for Floridan Stations.
Part B: Metals.

Station No. County	Chromium ug/L	Nickel ug/L	Copper ug/L	Zinc ppb ug/L	Arsenic ug/L	Selenium ug/L	Molybdenum ug/L	Silver ppb ug/L	Cadmium ug/L	Tin ppb ug/L	Antimony ug/L	Barium ppb ug/L	Thallium ug/L	Lead ppb ug/L	Uranium ug/L	Aluminum ug/L	Beryllium ug/L	Calcium ug/L	Cobalt ug/L	Iron ug/L	Potassium ug/L	Magnesium ug/L	Manganese ug/L	Sodium ug/L	Titanium ug/L	Vanadium ug/L
GWN-PA23 **Grady**	ND	ND	9.6	ND	ND	ND	14	ND	ND	ND	ND	120	ND	ND	ND	ND	ND	33,000	ND	45	ND	17,000	ND	15,000	ND	ND
	ND	ND	ND	ND	ND	ND	14	ND	ND	ND	ND	120	ND	ND	ND	ND	ND	33,000	ND	ND	ND	16,000	ND	15,000	ND	ND
	ND	ND	ND	ND	ND	ND	17	ND	ND	ND	ND	120	ND	ND	ND	ND	ND	34,000	ND	ND	ND	17,000	ND	15,000	ND	ND
	ND	ND	ND	ND	5.2	ND	27	ND	ND	ND	ND	120	ND	ND	ND	ND	ND	36,000	ND	ND	ND	17,000	ND	14,000	ND	ND
GWN-PA25 **Seminole**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	7.3	ND	ND	ND	ND	ND	56,000	ND	ND	ND	ND	ND	3,600	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	7.1	ND	ND	ND	ND	ND	52,000	ND	ND	ND	ND	ND	3,400	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	6.6	ND	ND	ND	ND	ND	55,000	ND	ND	ND	ND	ND	3,500	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	6.7	ND	ND	ND	ND	ND	55,000	ND	ND	ND	ND	ND	3,600	ND	ND
GWN-PA27 **Mitchell**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	13	ND	ND	ND	ND	ND	45,000	ND	ND	ND	1,400	ND	2,000	ND	ND
GWN-PA28 **Colquitt**	ND	ND	ND	ND	ND	ND	7.0	ND	ND	ND	ND	88	ND	ND	ND	ND	ND	38,000	ND	ND	ND	24,000	ND	28,000	ND	ND
	ND	ND	ND	ND	ND	ND	13	ND	ND	ND	ND	83	ND	ND	ND	ND	ND	35,000	ND	ND	ND	21,000	ND	27,000	ND	ND
	ND	ND	ND	ND	ND	ND	24	ND	ND	ND	ND	89	ND	ND	ND	ND	ND	34,000	ND	ND	ND	21,000	ND	27,000	ND	ND
	ND	ND	ND	ND	ND	ND	23	ND	ND	ND	ND	84	ND	ND	ND	ND	ND	37,000	ND	ND	ND	22,000	ND	29,000	ND	ND
GWN-PA29 **Cook**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	11	ND	ND	ND	ND	ND	43,000	ND	ND	ND	16,000	15	3,200	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	11	ND	ND	ND	ND	ND	41,000	ND	24	ND	15,000	17	3,300	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	11	ND	ND	ND	ND	ND	45,000	ND	26	ND	16,000	14	3,500	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	12	ND	ND	ND	ND	ND	48,000	ND	32	ND	17,000	15	3,600	ND	ND

Table A-5, 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=PA30 **Berrien**	Propex/Nashville Mills Well #2	410	NG	NG	03/21/13	7.57	361	0.53	25.37	ND	ND	62	ND	ND
GWN-PA31 **Tift**	Tifton Well #6	652	NG	NG	01/09/13	7.58	281	1.19	22.51	ND	ND	ND	ND	ND
GWN-PA32 **Irwin**	Ocilla Well #3	637	NG	NG	03/21/13	7.62	213	0.95	21.41	ND	ND	ND	ND	ND
GWN-PA34A **Telfair**	McRae Well #3	600	NG	NG	02/06/13	7.25	335	0.64	23.05	ND	ND	ND	ND	0.02
					06/12/13	7.21	334	2.83	22.44	ND	ND	ND	ND	ND
					08/07/13	7.14	319	7.31	22.36	ND	ND	ND	ND	0.02
					11/06/13	7.53	327	0.58	23.22	ND	ND	ND	ND	0.02
GWN-PA36 **Toombs**	Vidalia Well #1	808	NG	NG	02/06/13	7.79	233	0.57	23.88	ND	ND	ND	ND	0.03
					06/12/13	7.79	234	1.08	23.57	ND	ND	ND	ND	0.02
					08/07/13	7.51	229	5.09	23.17	ND	ND	ND	ND	0.02
					11/06/13	7.95	226	0.71	23.61	ND	ND	ND	ND	0.02
GWN-PA38 **Dodge**	Eastman Well #4	410	NG	NG	02/20/13	7.21	232	4.57	21.33	ND	ND	ND	0.26	0.03
GWN-PA39 **Worth**	SylvesterWell #1	196	NG	NG	03/07/13	7.30	314	1.35	22.33	ND	ND	ND	0.04	ND
GWN-PA41A **Turner**	Ashburn #4	600	NG	NG	12/11/13	8.02	161	2.89	23.18	ND	ND	ND	ND	ND
GWN-PA44 **Turner**	Sycamore Well #2	501	NG	NG	01/10/13	7.87	191	3.45	22.03	ND	ND	ND	0.23	ND
					04/04/13	7.61	199	5.66	22.03	ND	ND	ND	0.22	0.02
					07/11/13	7.83	200	4.29	22.08	ND	ND	ND	0.22	0.02
					10/10/13	7.72	196	3.09	21.97	ND	ND	ND	0.23	0.02
GWN-PA49 **Dooly**	Harmony Church Well	97	NG	NG	03/21/13	7.79	202	7.90	20.02	ND	ND	ND	2.2	0.02

Table A-5, Continued. Ground-Water Quality Analyses for Floridan Stations.
Part B: Metals.

Station No. County	Chro-mium ug/L	Nick-el ug/L	Cop-per ug/L	Zinc ppb ug/L	Arsen-ic ug/L	Selen-ium ug/L	Molyb-denum ug/L	Silver ppb ug/L	Cad-mium ug/L	Tin ppb ug/L	Anti-mony ug/L	Barium ppb ug/L	Thal-lium ug/L	Lead ppb ug/L	Ura-nium ug/L	Alumi-num ug/L	Beryl-lium ug/L	Calcium ug/L	Co-balt ug/L	Iron ug/L	Potas-sium ug/L	Magne-sium ug/L	Manga-nese ug/L	Sodium ug/L	Tita-nium ug/L	Vana-dium ug/L
GWN-PA30 **Berrien**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	55	ND	ND	ND	ND	ND	43,000	ND	170	ND	18,000	ND	5,400	ND	ND
GWN-PA31 **Tift**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	67	ND	ND	1.6	ND	ND	44,000	ND	ND	ND	8,900	ND	2,500	ND	ND
GWN-PA32 **Irwin**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	71	ND	ND	ND	ND	ND	33,000	ND	130	ND	5,700	29	2,700	ND	ND
GWN-PA34A **Telfair**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	180	ND	ND	ND	ND	ND	49,000	ND	250	ND	11,000	100	4,800	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	190	ND	ND	ND	ND	ND	50,000	ND	260	ND	11,000	100	4,800	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	180	ND	ND	ND	ND	ND	48,000	ND	250	ND	11,000	96	4,700	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	160	ND	ND	ND	ND	ND	45,000	ND	240	ND	11,000	92	4,400	ND	ND
GWN-PA36 **Toombs**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	130	ND	ND	ND	ND	ND	29,000	ND	27	ND	5,900	40	12,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	150	ND	ND	ND	ND	ND	27,000	ND	25	ND	5,500	36	11,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	140	ND	ND	ND	ND	ND	29,000	ND	26	ND	5,400	40	11,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	120	ND	ND	ND	ND	ND	28,000	ND	26	ND	5,500	38	11,000	ND	ND
GWN-PA38 **Dodge**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	110	ND	ND	ND	ND	ND	44,000	ND	27	ND	1,400	ND	1,900	ND	ND
GWN-PA39 **Worth**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	220	ND	ND	2.4	ND	ND	44,000	ND	ND	ND	6,900	ND	3,600	ND	ND
GWN-41A **Turner**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	62	ND	ND	ND	ND	ND	20,000	ND	ND	ND	7,000	ND	1,900	ND	ND
GWN-PA44 **Turner**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	150	ND	ND	1.4	ND	ND	31,000	ND	ND	ND	4,500	ND	2,200	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	130	ND	ND	1.4	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	130	ND	ND	1.2	ND	ND	29,000	ND	ND	ND	4,200	ND	2,400	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	130	ND	ND	1.4	ND	ND	31,000	ND	ND	ND	4,400	ND	2,400	ND	ND
GWN-PA49 **Dooly**	6.4	ND	ND	11	ND	ND	ND	ND	ND	ND	ND	17	ND	ND	ND	ND	ND	38,000	ND	ND	ND	ND	ND	1,800	ND	ND

Table A-5, 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-PA56	Whigham / Davis Avenue	604	NG	NG	03/06/13	7.63	429	1.07	23.34	ND	34	20	0.06	ND
Grady	Well				06/26/13	7.48	418	7.87	23.12	ND	33	19	0.05	ND
					09/11/13	7.60	390	1.58	22.85	ND	36	20	0.07	ND
					12/11/13	7.58	412	1.65	22.72	ND	37	22	0.08	0.03
GWN-PA57	Ambrose Well #2	600	465	10	01/10/13	7.93	253	0.67	23.20	ND	ND	ND	ND	ND
Coffee					04/04/13	7.71	250	0.45	23.14	ND	ND	ND	ND	ND
					07/11/13	7.84	263	1.54	23.43	tcm=0.62	ND	ND	ND	ND
					11/06/13	7.85	248	1.26	23.99	ND	ND	ND	ND	ND

Table A-5, Continued. Ground-Water Quality Analyses for Floridan Stations.
Part B: Metals.

Station No. County	Chro-mium ug/L	Nick-el ug/L	Cop-per ug/L	Zinc ppb ug/L	Arsen-ic ug/L	Selen-ium ug/L	Molyb-denum ug/L	Silver ppb ug/L	Cad-mium ug/L	Tin ppb ug/L	Anti-mony ug/L	Barium ppb ug/L	Thal-lium ug/L	Lead ppb ug/L	Ura-nium ug/L	Alumi-num ug/L	Beryl-lium ug/L	Calcium ug/L	Co-balt ug/L	Iron ug/L	Potas-sium ug/L	Magne-sium ug/L	Manga-nese ug/L	Sodium ug/L	Tita-nium ug/L	Vana-dium ug/L
GWN-PA56	ND	ND	ND	ND	ND	ND	9.3	ND	ND	ND	ND	150	ND	ND	2.9	ND	ND	31,000	ND	ND	ND	19,000	ND	23,000	ND	ND
Grady	ND	ND	ND	ND	ND	ND	8.2	ND	ND	ND	ND	140	ND	ND	2.5	ND	ND	30,000	ND	42	ND	19,000	ND	22,000	ND	ND
	ND	ND	ND	ND	ND	ND	8.5	ND	ND	ND	ND	140	ND	ND	2.7	ND	ND	32,000	ND	ND	ND	20,000	ND	23,000	ND	ND
	ND	ND	ND	ND	ND	ND	7.9	ND	ND	ND	ND	130	ND	ND	3.0	ND	ND	29,000	ND	ND	ND	19,000	ND	22,000	ND	ND
GWN-PA57	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	160	ND	ND	ND	ND	ND	25,000	ND	ND	ND	15,000	ND	7,700	ND	ND
Coffee	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	160	ND	ND	ND	ND	ND	23,000	ND	ND	ND	13,000	ND	7,400	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	170	ND	ND	ND	ND	ND	25,000	ND	ND	ND	15,000	ND	7,600	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	160	ND	ND	ND	ND	ND	24,000	ND	ND	ND	14,000	ND	7,600	ND	ND

Table A-6. 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	220	NG	NG	03/06/13	7.47	247	6.81	21.46	ND	ND	ND	ND	0.02
GWN-MI2A **Lowndes**	Boutwell House Well	70	NG	NG	03/06/13	4.16	104	6.80	20.88	ND	12	ND	5.3	ND
GWN-MI9A **Thomas**	Murphy Garden Well	22	NG	NG	06/26/13	6.25	243	NA	23.42	ND	12	ND	17	0.03
GWN-MI10B **Colquitt**	Calhoun House Well	150	NG	NG	06/26/13	6.32	114	2.02	22.58	ND	ND	ND	ND	0.28
GWN-MI16 **Liberty**	Liberty County East District Fire Station Deep Well	400	NG	NG	03/20/13	8.01	314	1.22	23.95	ND	ND	35	ND	0.03
GWN-MI17 **Effingham**	Springfield Egypt Road Test Well	120	NG	NG	06/27/13	7.65	251	1.74	19.86	ND	ND	ND	ND	ND

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

Station No. County	Chromium ug/L	Nickel ug/L	Copper ug/L	Zinc ppb ug/L	Arsenic ug/L	Selenium ug/L	Molybdenum ug/L	Silver ppb ug/L	Cadmium ug/L	Tin ppb ug/L	Antimony ug/L	Barium ppb ug/L	Thallium ug/L	Lead ppb ug/L	Uranium ug/L	Aluminum ug/L	Beryllium ug/L	Calcium ug/L	Cobalt ug/L	Iron ug/L	Potassium ug/L	Magnesium ug/L	Manganese ug/L	Sodium ug/L	Titanium ug/L	Vanadium ug/L
GWN-MI1 **Cook**	ND	ND	ND	39	ND	ND	ND	ND	ND	ND	ND	21	ND	ND	ND	ND	ND	22,000	ND	ND	ND	14,000	12	7,000	ND	ND
GWN-MI2A **Lowndes**	ND	ND	7.3	ND	ND	ND	ND	ND	ND	ND	ND	27	ND	4.6	ND	140	ND	4,000	ND	ND	ND	2,700	ND	4,000	ND	ND
GWN-MI9A **Thomas**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	140	ND	ND	ND	83	ND	20,000	ND	ND	8,500	7,500	ND	2,500	ND	ND
GWN-MI10B **Colquitt**	ND	ND	ND	33	ND	17	ND	ND	ND	ND	ND	150	ND	1.2	ND	ND	ND	7,300	ND	2,400	ND	5,200	89	6,500	ND	ND
GWN-MI16 **Liberty**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	23	ND	ND	ND	ND	ND	27,000	ND	ND	ND	15,000	ND	17,000	ND	ND
GWN-MI17 **Effingham**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	20	ND	ND	ND	ND	ND	42,000	ND	ND	ND	1,800	12	8,000	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	F mg/L	Cl mg/L	SO4 mg/L	NOx mg N/L	P mg/L
GWN-P1A	Luthersville Well #3		185	NG	NG	03/07/13	6.11	88	8.91	17.18	ND	NA	ND	ND	0.99	0.07
Meriwether																
GWN-P5	Flowery Branch Well #1		240	NG	NG	02/07/13	6.42	178	6.74	16.00	ND	NA	ND	ND	0.88	0.03
Hall																
GWN-P12A	Indian Spring		0	NG	NG	01/09/13	6.70	466	4.85	15.36	ND	4.7	11	26	ND	0.02
Butts						04/04/13	7.25	264	NA	14.60	ND	4.7	11	25	ND	0.02
						07/24/13	7.25	271	NA	20.46	ND	4.6	ND	27	ND	0.02
						09/11/13	7.20	265	NA	20.77	ND	4.9	ND	27	ND	0.02
GWN-P20	Suwanee #1		600	NG	NG	02/07/13	7.21	324	0.87	17.26	ND	NA	ND	14	0.04	ND
Gwinnett																
GWN-P21	Gray/Bragg Well		405	NG	NG	02/21/13	6.38	326	3.28	16.35	ND	NA	ND	30	0.07	0.03
Jones						06/13/13	6.66	292	4.31	19.96	ND	NA	ND	32	0.08	0.03
						08/07/13	6.02	281	3.24	21.14	ND	NA	ND	28	0.08	0.03
						11/07/13	6.64	269	7.91	20.20	ND	NA	ND	29	0.08	0.03
GWN-P22	Rahbar Well		200	NG	NG	07/24/13	4.49	32	8.80	17.10	ND	NA	ND	ND	0.88	ND
Fulton																
GWN-P23	Indian Springs State		NG	NG	NG	01/09/13	6.43	252	6.74	18.09	ND	1.1	ND	ND	0.22	0.07
Butts	Park New Main Well					06/13/13	6.48	145	2.10	18.32	ND	1.1	ND	ND	0.25	0.08
						07/24/13	5.83	144	2.38	18.30	ND	1.0	ND	ND	0.25	0.07
						09/11/13	6.31	142	2.81	19.17	ND	1.1	ND	ND	0.30	0.07
GWN-P24	The Gates Well #1		705	NG	NG	01/24/13	7.00	396	3.08	18.52	ND	NA	ND	14	0.24	0.04
Coweta																
GWN-P25	Jarrell Plantation	**raw**	NG	NG	NG	07/24/13	5.93	186	8.36	22.76	ND	NA	ND	ND	0.26	0.10
Jones	Staff House Well	**filtered**				07/24/13	6.10	169	10.17	22.78	ND	NA	ND	ND	0.28	0.10
		raw				09/11/13	6.26	177	7.22	23.84	ND	NA	ND	ND	0.26	0.10
GWN-P28	Willow Court Well		NG	NG	NG	10/10/13	6.63	122	9.45	15.81	ND	NA	ND	ND	2.3	0.08
Coweta																
GWN-P30	Fizer House Well		220	NG	NG	06/12/13	6.83	432	2.49	20.26	ND	NA	21	27	1.8	0.04
Lincoln																

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

Station No. County	Chromium ug/L	Nickel ug/L	Copper ug/L	Zinc ppb ug/L	Arsenic ug/L	Selenium ug/L	Molybdenum ug/L	Silver ppb ug/L	Cadmium ug/L	Tin ppb ug/L	Antimony ug/L	Barium ppb ug/L	Thallium ug/L	Lead ppb ug/L	Uranium ug/L	Aluminum ug/L	Beryllium ug/L	Calcium ug/L	Cobalt ug/L	Iron ug/L	Potassium ug/L	Magnesium ug/L	Manganese ug/L	Sodium ug/L	Titanium ug/L	Vanadium ug/L
GWN-P1A **Meriwether**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	45	ND	ND	ND	ND	ND	10,000	ND	ND	ND	2,000	ND	4,600	ND	ND
GWN-P5 **Hall**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	35	ND	ND	ND	ND	ND	27,000	ND	ND	ND	5,100	ND	2,600	ND	ND
GWN-P12A	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	16,000	ND	ND	ND	2,600	20	41,000	ND	ND
Butts	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	14,000	ND	ND	ND	2,300	19	37,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.4	ND	ND	ND	15,000	ND	ND	ND	2,500	19	38,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	16,000	ND	ND	ND	2,700	19	39,000	ND	ND
GWN-P20 **Gwinnett**	ND	ND	ND	48	ND	ND	ND	ND	ND	ND	ND	200	ND	ND	4.0	ND	ND	49,000	ND	ND	ND	11,000	81	13,000	ND	ND
GWN-P21	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	15	ND	1.0	6.8	ND	ND	35,000	ND	ND	ND	7,900	46	16,000	ND	ND
Jones	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	14	ND	ND	6.1	ND	ND	37,000	ND	ND	ND	8,000	56	16,000	ND	ND
	ND	ND	5.4	ND	ND	ND	ND	ND	ND	ND	ND	15	ND	1.5	6.6	360	ND	37,000	ND	37	ND	8,000	55	16,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	15	ND	ND	6.3	ND	ND	35,000	ND	ND	ND	7,500	68	15,000	ND	ND
GWN-P22 **Fulton**	ND	ND	43	ND	ND	ND	ND	ND	ND	ND	ND	19	ND	2.0	ND	75	ND	1,100	ND	ND	ND	1,000	ND	2,100	ND	ND
GWN-P23	ND	ND	ND	16	ND	ND	ND	ND	ND	ND	ND	4.5	ND	ND	1.6	ND	ND	12,000	ND	85	ND	3,900	ND	15,000	ND	ND
Butts	ND	ND	ND	51	ND	ND	ND	ND	ND	ND	ND	5.5	ND	ND	2.0	ND	ND	11,000	ND	320	ND	3,600	11	14,000	ND	ND
	ND	ND	ND	22	ND	ND	ND	ND	ND	ND	ND	5.0	ND	ND	2.0	ND	ND	11,000	ND	260	ND	3,700	ND	14,000	ND	ND
	ND	ND	ND	14	ND	ND	ND	ND	ND	ND	ND	4.7	ND	ND	1.7	ND	ND	11,000	ND	38	ND	3,600	ND	13,000	ND	ND
GWN-P24 **Coweta**	ND	ND	ND	60	ND	ND	ND	ND	ND	ND	ND	3.8	ND	ND	1.7	ND	ND	28,000	ND	ND	ND	4,400	ND	12,000	ND	ND
GWN-P25	ND	ND	11	30	ND	ND	ND	ND	ND	ND	ND	20	ND	1.0	24	ND	ND	12,000	ND	140	ND	5,200	29	16,000	ND	ND
Jones (Filter)	ND	ND	ND	27	ND	ND	ND	ND	ND	ND	ND	20	ND	ND	1.3	ND	ND	12,000	ND	ND	ND	5,300	27	16,000	ND	ND
	ND	ND	10	25	ND	ND	ND	ND	ND	ND	ND	17	ND	ND	23	ND	ND	12,000	ND	58	ND	5,100	30	15,000	ND	ND
GWN-P28 **Coweta**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	35	ND	ND	ND	ND	ND	46,000	ND	37	ND	17,000	15	4,000	ND	ND
GWN-P30 **Lincoln**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.0	ND	ND	ND	ND	ND	36,000	ND	ND	ND	27,000	ND	17,000	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	Casing Depth	Well Size	Date	pH	cond.	diss O2	Temp	VOCS	Cl	SO4	NOx	P
County		feet	feet	Inches	sampled		uS/cm	mg/L	°C	ug/L	mg/L	mg/L	mg N/L	mg/L
GWN-P32	Cecchini Deep Well	400	NG	NG	01/08/13	7.56	1120	2.26	15.48	ND	ND	350	ND	ND
Elbert					04/03/13	7.51	942	0.69	16.42	ND	ND	314	ND	ND
					07/10/13	7.49	812	0.62	20.26	ND	ND	NA	ND	ND
					10/09/13	7.48	808	1.63	18.94	ND	ND	370	ND	ND
GWN-P33	Cecchini Bored Well	47	NG	NG	01/08/13	6.47	201	7.33	17.41	ND	ND	ND	1.7	0.04
Elbert					04/03/13	6.52	109	8.05	17.39	ND	ND	ND	0.88	0.06
					07/10/13	5.85	105	7.98	18.13	ND	ND	ND	1.6	0.08
					10/09/13	5.54	78	7.73	18.05	ND	ND	ND	0.55	0.02
GWN-P34	Mistletoe State Park	NG	NG	NG	02/06/13	5.87	134	7.11	18.60	ND	ND	11	0.58	0.22
Columbia	Cottage Area Well				06/12/13	6.18	194	7.43	19.59	ND	ND	28	0.33	0.20
					08/08/13	5.64	123	7.54	19.59	ND	ND	12	0.38	0.13
					11/07/13	6.44	200	10.26	18.34	ND	ND	24	0.34	0.19
GWN-P35	O'Connor Well	150	NG	NG	01/08/13	7.11	325	5.63	16.57	ND	ND	ND	ND	0.02
Franklin					04/03/13	6.96	198	0.91	16.82	ND	ND	ND	ND	ND
					07/10/13	6.81	192	0.70	17.21	ND	ND	ND	ND	0.02
					10/09/13	6.67	193	5.91	16.99	ND	ND	ND	ND	0.02
GWN-P37	Mt. Airy/City Hall Well	500	NG	NG	01/08/13	6.58	549	7.13	16.55	ND	27	20	0.06	ND
Habersham					04/03/13	6.31	450	7.97	16.62	ND	69	25	0.35	ND
					07/10/13	5.90	574	5.71	16.79	ND	110	25	0.86	ND
					10/09/13	5.72	468	3.39	16.82	ND	91	35	1.2	ND
GWN-P38	Roopville Well #1	230	NG	NG	06/26/13	4.88	42	7.52	19.01	ND	ND	ND	1.4	ND
Carroll														
GWN-P39	Gay Well #1	600	NG	NG	03/07/13	6.01	72	7.25	12.86	ND	ND	ND	1.0	0.08
Meriwether														
GWN-P40	Siloam Well #2	300	NG	NG	08/08/13	6.36	123	4.11	20.97	ND	ND	ND	1.3	0.08
Greene														

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

Station No. County	Chromium ug/L	Nickel ug/L	Copper ug/L	Zinc ppb ug/L	Arsenic ug/L	Selenium ug/L	Molybdenum ug/L	Silver ppb ug/L	Cadmium ug/L	Tin ppb ug/L	Antimony ug/L	Barium ppb ug/L	Thallium ug/L	Lead ppb ug/L	Uranium ug/L	Aluminum ug/L	Beryllium ug/L	Calcium ug/L	Cobalt ug/L	Iron ug/L	Potassium ug/L	Magnesium ug/L	Manganese ug/L	Sodium ug/L	Titanium ug/L	Vanadium ug/L
GWN-P32	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	14	ND	ND	120,000	ND	68	ND	2,200	15	22,000	ND	ND
Elbert	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	17	ND	ND	130,000	ND	ND	ND	2,200	18	23,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	16	ND	ND	120,000	ND	ND	ND	2,300	16	22,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	16	ND	ND	140,000	ND	ND	ND	2,300	19	23,000	ND	ND
GWN-P33	ND	ND	19	29	ND	ND	ND	ND	ND	ND	ND	21	ND	1.7	ND	200	ND	18,000	ND	270	ND	ND	ND	4,300	ND	ND
Elbert	ND	ND	23	22	ND	ND	ND	ND	ND	ND	ND	20	ND	3.3	ND	130	ND	16,000	ND	180	ND	ND	ND	3,300	ND	ND
	ND	ND	25	43	ND	ND	ND	ND	ND	ND	ND	32	ND	5.3	ND	350	ND	15,000	ND	320	ND	ND	ND	2,900	ND	ND
	ND	ND	8.4	26	ND	ND	ND	ND	ND	ND	ND	25	ND	1.0	ND	120	ND	9,700	ND	160	ND	ND	ND	3,400	ND	ND
GWN-P34	ND	ND	12	26	ND	ND	ND	ND	ND	ND	ND	13	ND	ND	13	ND	ND	9,500	ND	ND	ND	4,700	ND	12,000	ND	ND
Columbia	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	10	ND	ND	27	ND	ND	15,000	ND	ND	ND	7,100	ND	14,000	ND	ND
	ND	ND	6.4	26	ND	ND	ND	ND	ND	ND	ND	23	ND	1.2	13	ND	ND	7,600	ND	ND	ND	4,200	ND	9,100	ND	ND
	ND	ND	6.1	13	ND	ND	ND	ND	ND	ND	ND	11	ND	ND	23	ND	ND	14,000	ND	ND	ND	6,500	ND	13,000	ND	ND
GWN-P35	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	49,000	ND	ND
Franklin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	30	ND	ND	3.5	ND	ND	19,000	ND	ND	6,100	5,900	120	6,900	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	34	ND	ND	3.2	ND	ND	19,000	ND	24	6,200	5,900	120	7,100	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	32	ND	ND	3.9	ND	ND	19,000	ND	43	6,300	6,100	120	7,200	ND	ND
GWN-P37	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	23	ND	ND	1.4	ND	ND	41,000	ND	1,100	ND	7,000	220	9,800	ND	ND
Habersham	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	40	ND	ND	1.4	ND	ND	46,000	ND	300	ND	10,000	160	17,000	ND	ND
	ND	ND	ND	22	ND	ND	ND	ND	ND	ND	ND	91	ND	1.4	ND	ND	ND	50,000	ND	44	ND	13,000	130	29,000	ND	ND
	ND	ND	ND	36	ND	ND	ND	ND	ND	ND	ND	59	ND	1.5	ND	ND	ND	47,000	ND	210	ND	13,000	90	17,000	ND	ND
GWN-P38	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	25	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	22	4,400	ND	ND
Carroll																										
GWN-P39	ND	ND	ND	19	ND	ND	ND	ND	ND	ND	ND	38	ND	ND	ND	ND	ND	4,600	ND	ND	ND	1,100	ND	6,800	ND	ND
Meriwether																										
GWN-P40	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	18	ND	ND	16	ND	ND	9,600	ND	ND	ND	1,900	ND	12,000	ND	ND
Greene																										

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	Casing Depth	Well Size	Date	pH	cond.	diss O2	Temp	VOCS	Cl	SO4	NOx	P
County		feet	feet	Inches	sampled		uS/cm	mg/L	°C	ug/L	mg/L	mg/L	mg N/L	mg/L
GWN-BR1B	Young Harris/	265	NG	NG	02/20/13	6.71	179	1.54	15.19	ND	ND	21	0.04	ND
Towns	Swanson Road Well				06/27/13	6.84	169	1.79	15.61	ND	ND	19	0.09	ND
					08/07/13	6.88	164	1.71	17.16	ND	ND	20	0.05	ND
					11/06/13	6.77	179	1.08	15.60	ND	ND	21	0.04	ND
GWN-BR5	Chatsworth/	0	NG	NG	02/20/13	5.44	42	8.08	13.29	ND	ND	ND	0.39	0.04
Murray	Nix Spring													

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

Station No. County	Chromium ug/L	Nickel ug/L	Copper ug/L	Zinc ppb ug/L	Arsenic ug/L	Selenium ug/L	Molybdenum ug/L	Silver ppb ug/L	Cadmium ug/L	Tin ppb ug/L	Antimony ug/L	Barium ppb ug/L	Thallium ug/L	Lead ppb ug/L	Uranium ug/L	Aluminum ug/L	Beryllium ug/L	Calcium ug/L	Cobalt ug/L	Iron ug/L	Potassium ug/L	Magnesium ug/L	Manganese ug/L	Sodium ug/L	Titanium ug/L	Vanadium ug/L
GWN-BR1B	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	79	ND	ND	8.1	ND	ND	20,000	ND	45	ND	4,700	24	4,000	ND	ND
Towns	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	77	ND	ND	6.9	90	ND	19,000	ND	ND	ND	4,500	18	3,900	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	73	ND	ND	8.5	ND	ND	21,000	ND	ND	ND	4,800	23	4,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	76	ND	ND	7.5	ND	ND	21,000	ND	ND	ND	4,700	22	4,100	ND	ND
GWN-BR5 **Murray**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	15	ND	ND	ND	ND	ND	2,700	ND	ND	ND	ND	ND	2,700	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 Road Well	280	NG	NG	06/13/13	7.43	255	7.52	17.54	ND	ND	ND	0.66	ND
GWN-VR2A **Walker p**	LaFayette Lower Big Spring	0	NG	NG	07/25/13	7.51	281	NA	24.00	ND	ND	ND	1.70	ND
GWN-VR3 **Walker**	Chickamauga Crawfish Spring	0	NG	NG	07/25/13	7.11	261	NA	16.05	ND	ND	ND	0.81	ND
GWN-VR6A **Bartow**	Chemical Products Corp. South Well	300	NG	NG	06/13/13	7.59	285	6.91	18.97	1,1dce=1.5 pce=2.7 odcb=1.5 mdcb=0.58	ND	ND	0.87	0.02
GWN-VR8 **Polk**	Cedartown Spring	0	NG	NG	02/20/13	6.89	309	8.60	16.42	ND	ND	ND	0.94	ND
					06/13/13	7.44	271	NA	17.47	ND	ND	ND	0.79	ND
					08/21/13	7.19	275	NA	17.52	ND	ND	ND	0.73	ND
					11/06/13	7.34	271	8.77	16.85	ND	ND	ND	0.71	ND
GWN-VR10 **Murray**	Eton Spring	0	NG	NG	02/20/13	6.70	281	7.59	15.77	ND	ND	ND	1.5	ND

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

Station No. County	Chromium ug/L	Nickel ug/L	Copper ug/L	Zinc ppb ug/L	Arsenic ug/L	Selenium ug/L	Molybdenum ug/L	Silver ppb ug/L	Cadmium ug/L	Tin ppb ug/L	Antimony ug/L	Barium ppb ug/L	Thallium ug/L	Lead ppb ug/L	Uranium ug/L	Aluminum ug/L	Beryllium ug/L	Calcium ug/L	Cobalt ug/L	Iron ug/L	Potassium ug/L	Magnesium ug/L	Manganese ug/L	Sodium ug/L	Titanium ug/L	Vanadium ug/L
GWN-VR1 **Floyd**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9.6	ND	ND	ND	ND	ND	29,000	ND	ND	ND	17,000	ND	1,700	ND	ND
GWN-VR2A **Walker**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	88	ND	ND	ND	ND	ND	38,000	ND	ND	ND	13,000	ND	1,900	ND	ND
GWN-VR3 **Walker**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	79	ND	ND	ND	ND	ND	32,000	ND	ND	ND	14,000	ND	1,300	ND	ND
GWN-VR6A **Bartow**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	540	ND	ND	ND	ND	ND	29,000	ND	ND	ND	18,000	ND	5,100	ND	ND
GWN-VR8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	16	ND	ND	ND	ND	ND	37,000	ND	21	ND	17,000	ND	2,300	ND	ND
Polk	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	13	ND	ND	ND	ND	ND	33,000	ND	ND	ND	16,000	ND	1,900	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	13	ND	ND	ND	ND	ND	35,000	ND	20	ND	16,000	ND	1,900	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	12	ND	ND	ND	ND	ND	32,000	ND	ND	ND	15,000	ND	1,500	ND	ND
GWN-VR10 **Murray**	ND	ND	ND	11	ND	ND	ND	ND	ND	ND	ND	51	ND	ND	ND	ND	ND	32,000	ND	29	ND	15,000	ND	2,300	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	Dichlorodifluoromethane	0.5 ug/L / 524.2
1,1-Dichloroethylene	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	Fluorotrichloromethane	0.5 ug/L / 524.2
1,1,1-Trichloroethane	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	Bromochloromethane	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	Bromodichloromethane	0.5 ug/L / 524.2
1,1,2-Trichloroethane	0.5 ug/L / 524.2	Cis-1,3-Dichloropropene	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	Chlorodibromomethane	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-Trichlorobenzene	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	1000 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
Hexachlorobutadiene	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. EPA Analytical Methods, and Reporting Limits. 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$^{(A)}$, and Secondary MCLs$^{(B)}$.

Analyte	Primary MCL	Second-ary MCL	Analyte	Primary MCL	Second-ary 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$^{(C)}$	1000 ug/L	Selenium	50 ug/L	None
Iron	None	300 ug/L	Silver	None	100 ug/L
Lead	Action level = 15 ug/L$^{(C)}$	None	Thallium	2 ug/L	None
Manganese	None	50 ug/L	Zinc	None	5,000 ug/L
Nickel	100 ug/L	None			

Notes:

(A) Primary MCL = Primary Maximum Contaminant Level, a maximum concentration of a substance (other than lead or copper) allowed in public drinking water due to adverse health effects.

(B) 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.

(C) Action Level = the maximum concentrations of lead or copper permitted for public drinking water as measured at the user's end of the system. Water issuing from at least ninety percent of a representative sample of user's end outlets must contain copper or lead concentrations at or below their respective action levels.

mg/L = milligrams per liter.

ug/L = micrograms per liter.