GROUNDWATER QUALITY IN GEORGIA FOR 2016

John C. Donahue and Anthony W. Chumbley

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

ATLANTA
2019

CIRCULAR 12AD

GROUNDWATER QUALITY IN GEORGIA FOR 2016

John C. Donahue and Anthony W. Chumbley

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

GEORGIA DEPARTMENT OF NATURAL RESOURCES
Mark Williams, Commissioner

ENVIRONMENTAL PROTECTION DIVISION
Richard E. Dunn, Director

WATERSHED PROTECTION BRANCH
James A. Capp, Branch Chief

ATLANTA
2019

CIRCULAR 12AD

TABLE OF CONTENTS

APPENDIX

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1 INTRODUCTION

1.1 PURPOSE AND SCOPE

This report, covering the calendar year 2016, is the thirtieth of the Circular 12 series. The first 19 reports, Circulars 12A through 12S, summarized the chemical quality of groundwater statewide across Georgia and utilized a static array of sampling stations that were sampled periodically, typically on a semiannual, annual, or biennial basis. The next five reports, Circulars 12T through 12X, dealt with specialized chemical groundwater 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, groundwater uranium in Georgia, and groundwater arsenic in Georgia. With this report and its predecessors, Circular 12Y, 12Z, 12AA, 12AB and 12AC, monitoring the chemical quality of groundwater 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 groundwater resources. EPD is the State organization with regulatory responsibility for maintaining and where possible, improving groundwater quality and availability. EPD has implemented a comprehensive statewide groundwater management policy of anti-degradation (EPD, 1991; 1998). Four components comprise EPD's current groundwater quality assessment program:

1. The Georgia Groundwater Monitoring Network. EPD's Watershed Protection Branch, Source Water Assessment Program, took over the Georgia Groundwater Monitoring Network from the Regulatory Support Program when that program disbanded in 2012. The Monitoring Network is designed to evaluate the ambient groundwater quality of eight aquifer systems present in the State of Georgia. The data collected from sampling of the Groundwater 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 groundwater that the residents of Georgia are using.

3. Groundwater 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 United States Environmental Protection Agency (EPA) approved Georgia's WHP Plan on September 30, 1992. The WHP Plan became a part of the Georgia Safe Drinking Water Rules, effective July 1, 1993. The protection of public supply wells from contaminants is important not only for maintaining groundwater quality, but also for ensuring that public water supplies meet health standards.

Analyses of water samples collected for the Georgia Groundwater Monitoring Network during the period January 2016 through December 2016 and from previous years form the database for this summary. The Georgia Groundwater Monitoring Network is presently comprised of 124 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 2016 through December 2016 period, Groundwater Monitoring staff collected 187 samples from 115 wells and 9 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 groundwater quality at most of the 124 stations has remained good.

1.2 FACTORS AFFECTING CHEMICAL GROUNDWATER QUALITY

The chemical quality of groundwater is the result of complex physical, chemical, and biological processes. Among the more significant controls are the chemical quality of the water entering the groundwater 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 groundwater 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 groundwater in recharge areas. Chemical interactions between the water and the aquifer host rocks have an increasing significance with longer residence times. As a result, groundwater from discharge areas tends to be more highly mineralized than groundwater 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 groundwater 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. Groundwater 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 several 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 Coastal Plain aquifers are unconfined in their updip outcrop areas, but become confined 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. Groundwater flow through confined Coastal Plain aquifers is generally to the south and southeast, in the direction of dip of the sedimentary layers.

Figure 1-1. The Hydrogeologic Provinces of Georgia

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. However, the aquifer systems do extend downdip of the band. A well has been planned to test the Cretaceous aquifer along the Atlantic Coast for water supply development. 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 in central and eastern Georgia. The system is unconfined over most of its inland extent, but becomes partly 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 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 and the bedrock itself offering local confinement to the fractures and voids. The regolith aquifer also serves as the reservoir that recharges the bedrock aquifer.

1.3.3 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 in the carbonate rocks; intergranular porosity may be important in some places. Locally, groundwater 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 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 GROUNDWATER PROBLEMS

Data from groundwater investigations in Georgia, including those from the Groundwater Monitoring Network, indicate that virtually all of Georgia has shallow groundwater 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 groundwater 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 may contain 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. Groundwater from the Cretaceous along the coast is typically brackish.

Nitrate/nitrite concentrations in shallow groundwater 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 groundwater 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 may represent a filled-in marine current channel (Huddleston, 1993). Floridan groundwater in and near the trough may be 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, groundwater withdrawal from the upper permeable zone of the Floridan aquifer system results in the upwelling of groundwater 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 and Hilton Head, South Carolina has caused a cone of depression which has induced seawater to enter the Floridan aquifer system in South Carolina and to flow down-gradient toward Savannah. The seawater has not yet reached Savannah and may not reach Savannah for many years. 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 in what is referred to as the Beaufort Arch; where the top of the Floridan aquifer system is closer to the ocean water (Foyle et al., 2001; Krause and Clarke, 2001).

CHAPTER 2 GEORGIA GROUNDWATER MONITORING NETWORK

2.1 MONITORING STATIONS

For the period January 2016 through December 2016, 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 hydrogeologic settings (e.g., granitic intrusions, the Dougherty Plain, and the Gulf Trough);
3. areas of significant groundwater 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 Groundwater Monitoring Network permits analysis of groundwater 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 groundwater quality. Temporal trends permit an assessment of the effects of rainfall and drought periods on groundwater 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 Groundwater Monitoring Network represent water quality in only limited areas of Georgia. Monitoring water quality at the 124 sites located throughout Georgia provides an indication of groundwater 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 groundwaters that are not being monitored.

Table 2-1. Georgia Groundwater Monitoring Network, Calendar Year 2016.

Aquifer or Aquifer System	Number of Stations Visited (Samples Taken)	Primary Stratigraphic Equivalents	Age of Aquifer Host Rocks
Cretaceous	22 stations (22 samples)	Ripley Formation, Cusseta Sand, Blufftown Formation, Eutaw Formation, Tuscaloosa Formation, Providence Sand, Steel Creek Formation, Gaillard Formation, Pio Nono Formation	Late Cretaceous
Clayton	3 stations (3 sample)	Clayton Formation	Paleocene
Claiborne	3 stations (3 samples)	Claiborne Group	Middle Eocene
Jacksonian	8 stations (8 samples)	Barnwell Group	Late Eocene
Floridan	35 stations (65 samples)	Ocala Group, Suwanee Limestone	Middle Eocene to Early Oligocene
Miocene/Surficial	7 stations (7 samples)	Hawthorne Group, Miccosukee Formation, Cypresshead Formation	Miocene to Recent
Piedmont/Blue Ridge	39 stations (69 samples)	Various igneous and metamorphic complexes	Precambrian and Paleozoic
Valley and Ridge/ Appalachian Plateau	7 stations (10 samples)	Shady Dolomite, Knox Group, Conasauga Group	Paleozoic, mainly Cambrian, Ordovician

Stations of the Groundwater 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 groundwater 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.

Groundwater 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 groundwater in the vicinity of the stations. Groundwater in the recharge areas of the Coastal Plain aquifer systems is one of the future drinking-water resources for down-flow areas. Monitoring stations in these recharge areas, in effect, constitute an early warning system of potential future water quality problems in confined portions of the Coastal Plain aquifer systems.

2.3 ANALYSES AND DATA RETENTION

Analyses are available for 187 water samples collected from 124 stations (115 wells and 9 springs) during the period January 2016 through December 2016. In 1984, the first year of the Groundwater 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 124 stations situated in all three hydrogeologic provinces, with most of the stations being in the Coastal Plain Province.

Groundwater from all monitoring stations is tested for chloride, sulfate, nitrate/nitrite, total phosphorus, a variety of metals, and volatile organic compounds (VOCs). Water from stations P12A and P23 also receive testing for fluoride. Testing for the VOCs was done using the Gas Chromatography / Mass Spectrometry (GC/MS) method (EPA method 524.2). Testing for anions chloride, fluoride and sulfate was done using the Ion Chromatography method (EPA method 300.0). Testing for nitrite / nitrate as total nitrogen was done using the Automated Colorimetry method (EPA method 353.2). Testing for phosphorus was done using the Semi-Automated Colorimetry method (EPA method 365.1). 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 and record 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 most of the 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 Groundwater 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 guidelines for evaluating the quality of untreated (raw) water. Table A-10 in the Appendix lists the Primary and Secondary MCLs for Groundwater 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. Pumped wells also may affect VOC concentrations. 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 United States Geologic Survey (USGS) and EPA. 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. Some wells were also added from previous sampling and monitoring programs that were previously labeled with a County alphabetic abbreviation instead of an aquifer. In this case the previous identification number was retained for cross reference with previous samples. In order for the groundwater database to be compatible with the Georgia Environmental Monitoring and Assessment System (GOMAS), 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 groundwater), the second part representing the local river basin and the third part being numeric.

CHAPTER 3 CHEMICAL GROUNDWATER 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. Groundwater 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 is secondary and consists of discontinuous fractures, but can be very permeable as fractures can locally 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 have led to the widespread development of karst features, which significantly enhance porosity and permeability and exert a strong influence on local flow patterns.

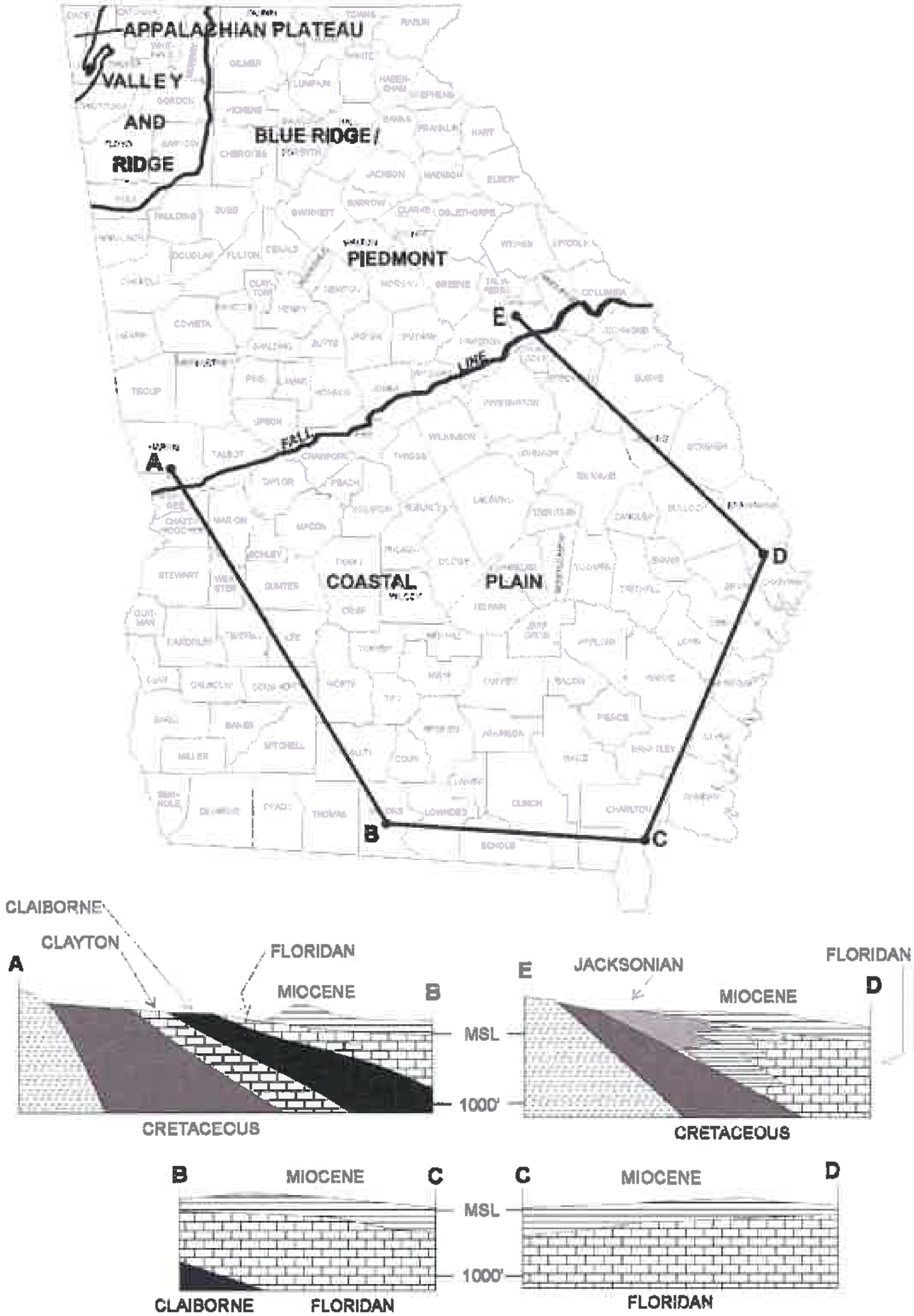


Figure 3-1. The Major Aquifers and Aquifer Systems of the Coastal Plain Province (after Davis, 1990).

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). Below the limit of utilization some Cretaceous wells have reached depths of 4,000 feet.

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 22 wells to monitor the Cretaceous aquifer system. Reported depths ranged from 128 feet (K7) to 1025 feet (PD6). All except well MAC1, MAR1 and K6 are local government owned public supply wells. Well MAC1 provides water for a park, well MAR1 produces process water for a sand mining operation and 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 22 wells ranged from 3.99 (K9A) to 8.83 (TAL1), with a median of 5.29. As a rule, pHs of waters from the deeper wells are basic, while those from shallower wells are acidic. Well PD3 and TAL1 seem to be the exceptions. Their sampling pH of 8.72 (PD3) and 8.83 (TAL1) would be expected for a well about twice their reported depth of 456 feet (PD3) and 300 feet (TAL1). Conductivities are available for all 22 wells and ranged from 14 uS/cm (BUR2) to 387 uS/cm (PD3), with a median of 49 uS/cm. As a rule, the deeper wells gave water with the higher conductivities. The temperatures measured should be viewed as approximations of the temperature of the water in the aquifer. Temperatures over all 22 well samples ranged from 16.38 degrees C (K12) to 28.94 degrees C (K20). Comparing well depths with sample water temperatures shows that the deeper wells generally tend to yield water with higher temperatures. The

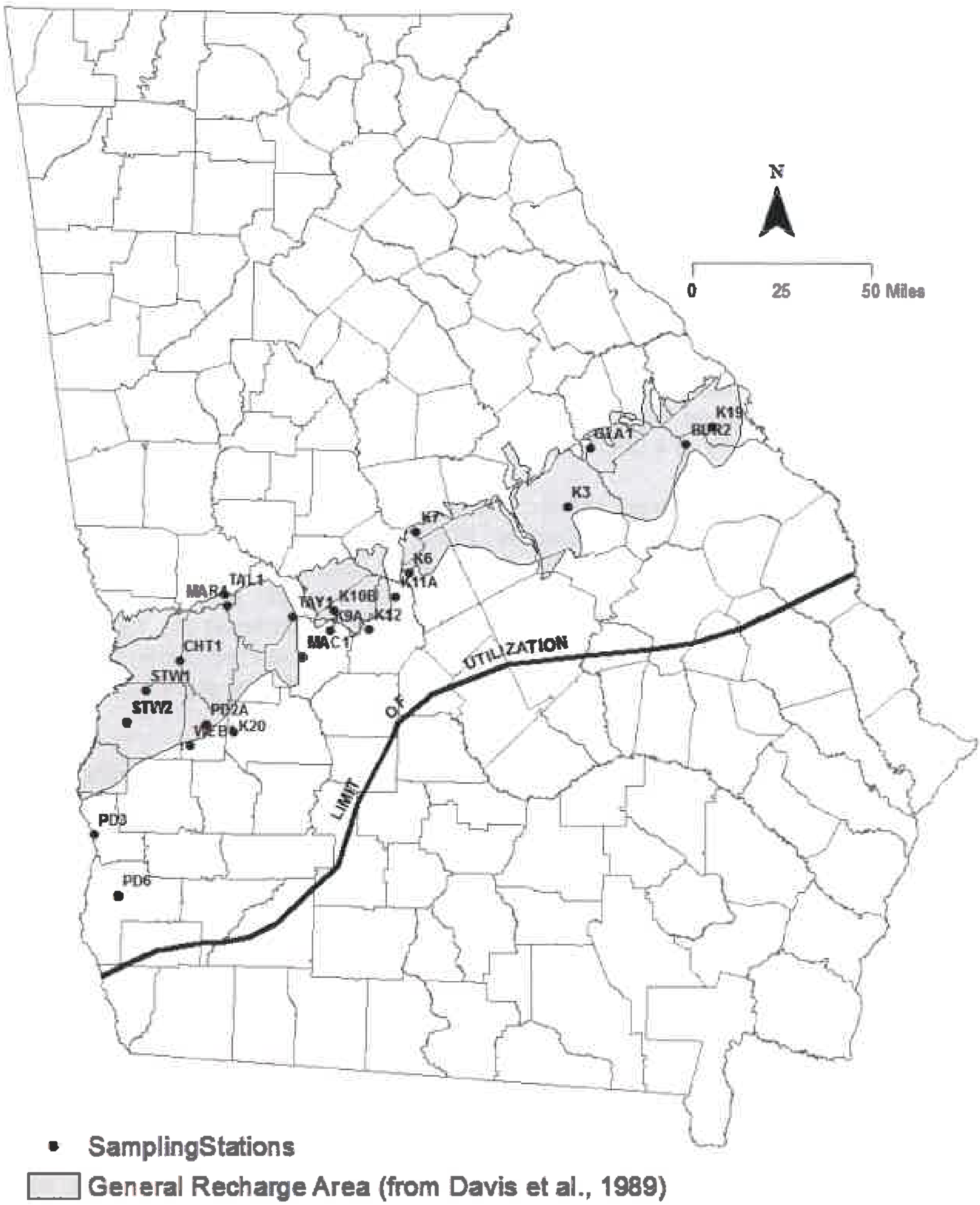


Figure 3-2. Locations of Stations Monitoring the Cretaceous Aquifer System.

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 20 of the 22 wells. Concentrations ranged from 0.85 mg/L (K20) up to 9.81 mg/L (BUR2). Generally, the dissolved oxygen content of groundwater decreases with depth. Dissolved oxygen measurements can suffer from various interferences, processes that can expose the groundwater 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 22 wells. None of the 22 samples contained detectable chloride or VOCs. Sulfate was detected in samples from seven wells, with all concentrations at or below 37 mg/L. Nitrate/nitrite was detected in 13 samples and ranged up to 2.10 mg/L (GLA1). Samples from ten wells contained detectable phosphorus, with concentrations ranging up to 2.6 mg/L (K3).

3.2.4 Metals by Inductively-Coupled Plasma Spectrometry (ICP)

All 22 samples contained detectable sodium, which ranged from 1,100 ug/L (K9A) and (MAC1) to 83,000 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 ranging up to 350 ug/L (K12). Fourteen wells yielded samples containing detectable calcium, and 14 wells gave samples containing detectable iron. Calcium levels ranged from undetected to 63,000 ug/L (WEB1). Iron levels ranged up to 1,500 ug/L (STW1), with samples from five wells exceeding the Secondary MCL of 300 ug/L. Seven samples contained detectable magnesium, with a maximum value of 4,200 ug/L (PD6). Seven 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 chromium, copper, zinc, selenium, barium and lead. Barium was detected in all 22 samples with a maximum concentration of 20 ug/L (K7). Copper was detected in samples from three wells with the maximum level at 9.3 ug/L (K11A); zinc was detected in samples from three wells, with the maximum level at 210 ug/L (STW2); lead was detected in samples from two wells, with the maximum level at 1.5 ug/L (K9A). The copper and lead levels fell below their respective action levels of 1,300 ug/L and 15 ug/L and zinc below its secondary MCL of 5,000 ug/L. The highest concentrations for these three metals tend to occur in samples with the lowest pHs. These three metals commonly leach into sample water from plumbing and are not necessarily present naturally. Chromium was detected at a concentration of 7.0 ug/L and selenium was detected at a concentration of 14 ug/L, both from well K7.

3.3 CLAYTON AQUIFER

3.3.1 Aquifer System Description

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.

3.3.2 Field Parameters

EPD sampled three wells annually to monitor the Clayton aquifer system. Wells SUM1 and SUM2 are public supply wells and well CT8 is a private well. These wells vary in depth from 80 feet (CT8) to 230 feet (SUM2). The sample waters had a pH range of 3.69 (SUM2) to 5.20 (SUM1), an electrical conductivity range of 47 uS/cm (CT8) to 220 uS/cm (SUM2), a temperature range of 17.93 degrees C (CT8) to 19.61 degrees C (SUM1) and a dissolved oxygen range of 1.42 mg/L (SUM2) to 9.71 mg/L (SUM1).

3.3.3 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 three wells. One sample contained detectable chloride at a concentration of 10 mg/L (SUM1). Sulfate was detected in one sample with a concentration of 72 mg/L (SUM2). Nitrate/nitrite was detected in all three samples and ranged up to 2.0 mg/L (SUM1). No Samples contained detectable phosphorus.

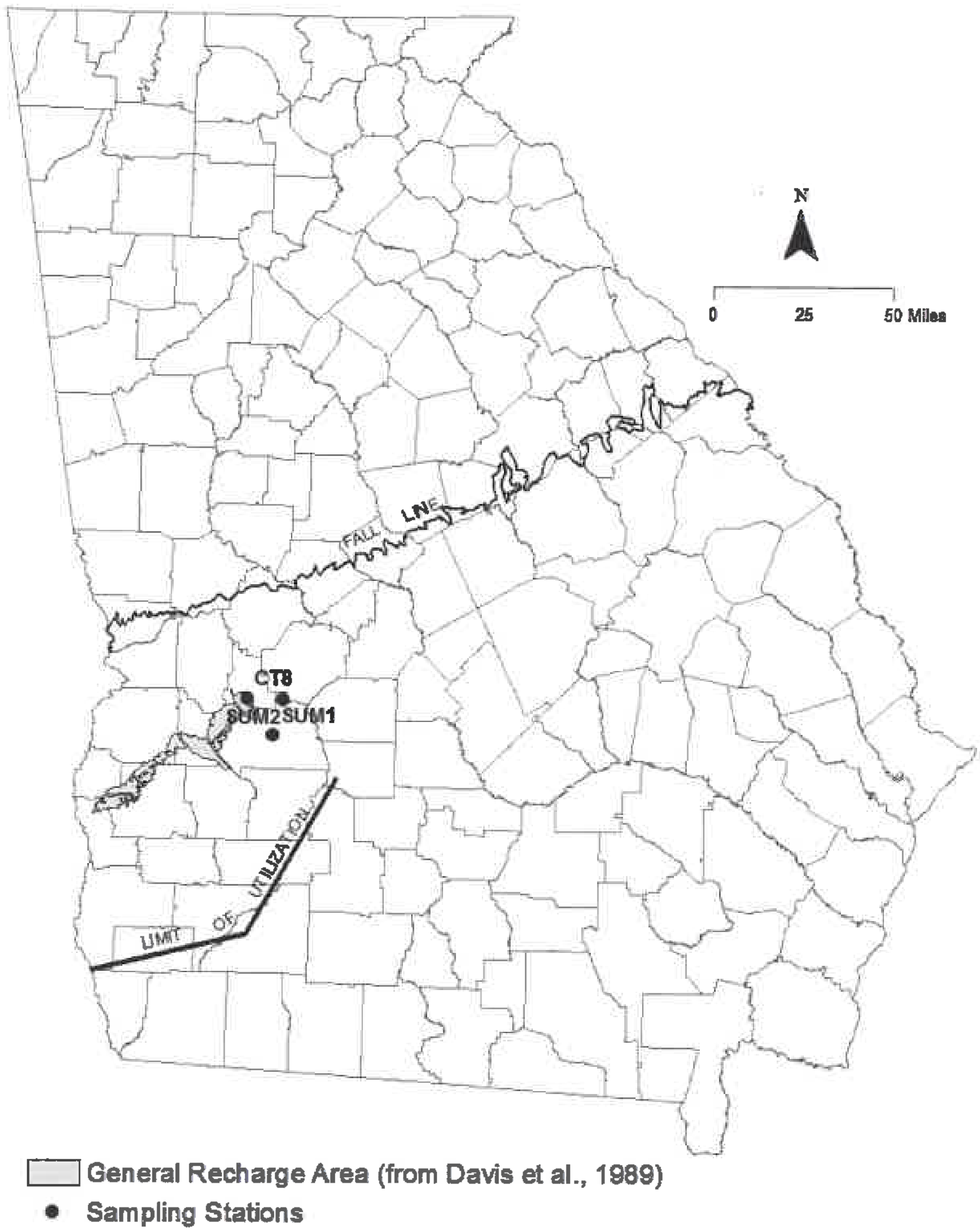


Figure 3-3. Location of the Stations Monitoring the Clayton Aquifer.

3.3.4 Metals by Inductively-Coupled Plasma Spectrometry (ICP)

All three samples contained detectable sodium, which ranged from 2,700 ug/L (SUM2) to 9,200 ug/L (SUM1). The current high reporting limit for analyzing potassium accounts for the lack of potassium detections. Two wells gave samples with detectable aluminum ranging up to 1,200 ug/L (SUM2). One well yielded a sample containing detectable calcium and two wells gave samples containing detectable iron. Calcium levels ranged from undetected to 17,000 ug/L (SUM2). Iron levels ranged up to 230 ug/L (SUM2). One sample contained detectable magnesium at a value of 8,600 ug/L (SUM2). All three wells gave samples with detectable manganese with one well (SUM2) exceeding the Secondary MCL of 50 ug/L. Beryllium, cobalt, potassium, vanadium, and titanium remained undetected.

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

ICPMS analysis found detectable levels only of copper, zinc, lead and barium. Barium was detected in all three samples with a maximum concentration of 100 ug/L (SUM2). Copper was detected in three samples with the maximum level at 18 ug/L (SUM1); zinc was detected in samples from two wells, with the maximum level at 36 ug/L (SUM2); and lead was detected in samples from two wells, with the maximum level at 4.6 ug/L (SUM2). The copper and lead levels of all three wells fell below their respective action levels of 1,300 ug/L and 15 ug/L.

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 pH of sample water from one well was mildly acidic (CL8 6.07), while the other two were mildly basic (CL2 at 7.34 and CL4A at 7.20). Conductivities registered at 88 uS/cm (CL8), 154 uS/cm (CL4A), and 208 uS/cm (CL2); and temperatures registered at 19.65 degrees C (CL4A), 19.66 degrees C (CL2), and 19.81 degrees C (CL8). Dissolved oxygen contents measured at 0.65 mg/L (CL8) and 6.84 mg/L (CL2). Since well CL4A exposes water to air, there was no measurement for dissolved oxygen for the water at this well.

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

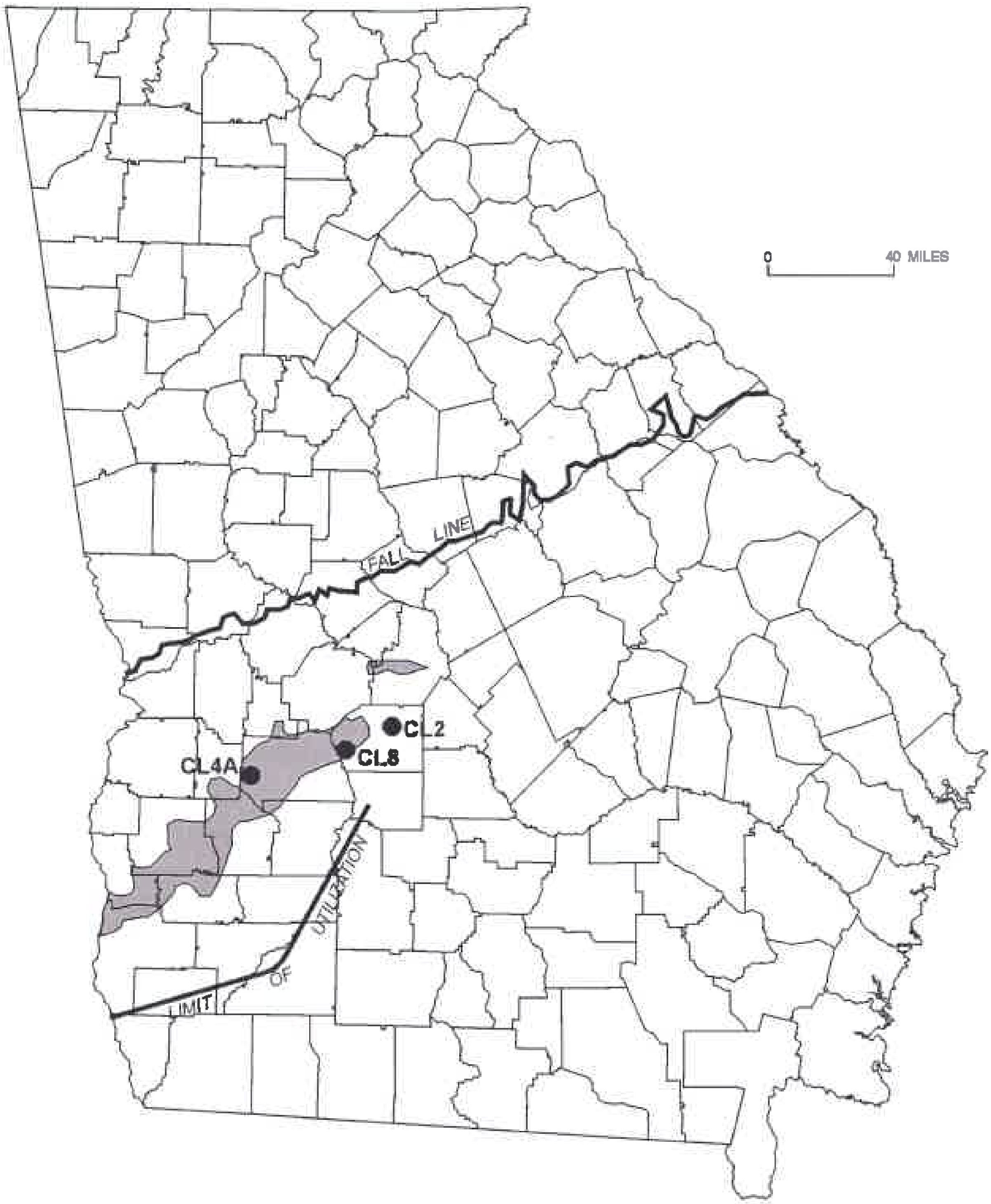
Well CL2 was the only station to give a sample with detectable nitrate/nitrite (0.47 mg/L as nitrogen). A sample from well CL4A contained detectable sulfate at 11 mg/L. Samples from two wells contained detectable phosphorus (CL4A at 0.37 mg/L and CL8 at 0.53 mg/L). None of the samples contained detectable 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 42,000 ug/L (CL2) and 12,000 ug/L (CL8). The maximum and minimum sodium concentrations were 1,900 ug/L (CL8) and 1,400 ug/L (CL2). Detectable magnesium occurred only in the samples from well CL8 (1,400 ug/L) and CL4A (3,300 ug/L). Wells CL4A and CL8 gave samples with detectable iron at 2,000 ug/L and 570 ug/L respectively and manganese at 54 ug/L and 52 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 40 ug/L (CL8) and 11 ug/L (CL2 and CL4A). The sample from well CL8 contained zinc at 11 ug/L, which was below any applicable MCLs or action levels. Well CL8 also registered the lowest pH.



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

Sampling station

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

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.

Eight wells were available to monitor the Jacksonian aquifer system. Wells J1B and J8A are domestic wells, while all the other wells are public supply wells. All are drilled wells, and each is scheduled for annual sampling.

3.5.2 Field Parameters

The pHs for all the wells were near neutral. The pHs range from 7.13 (J1B) to 7.81 (J4). Conductivities ranged from 221 uS/cm (J6) to 351 uS/cm (J5). Temperatures ranged from 18.12 degrees C for well J8A to 20.37 degrees C for well J5, with water from the deeper wells registering higher temperatures. Dissolved oxygen concentrations ranged from 0.88 mg/L for well J6 to 9.98 mg/L for well WAS2 and are usually lowest in the deeper wells.

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

Sample waters from wells J5 and J6 contained detectable sulfate of 12 mg/L and 13 mg/L respectively. Nitrate/nitrite was detected in four of the eight samples ranging from undetected to 2.3 mg/L as nitrogen (J1B), and all measurements were below the Primary MCL of 10 mg/L as nitrogen. Phosphorus was detected in water from all eight wells and ranged from 0.02 mg/L (WAS2) to 0.15 mg/L (J6). No sample waters contained detectable chloride. The sample water from well J4 had detectable trihalomethanes (disinfectant by-products possibly from leaky check valve) in the following concentrations: chloroform 1.1 ug/L; bromodichloromethane 1.1 ug/L; dibromochloromethane 0.97 mg/L.

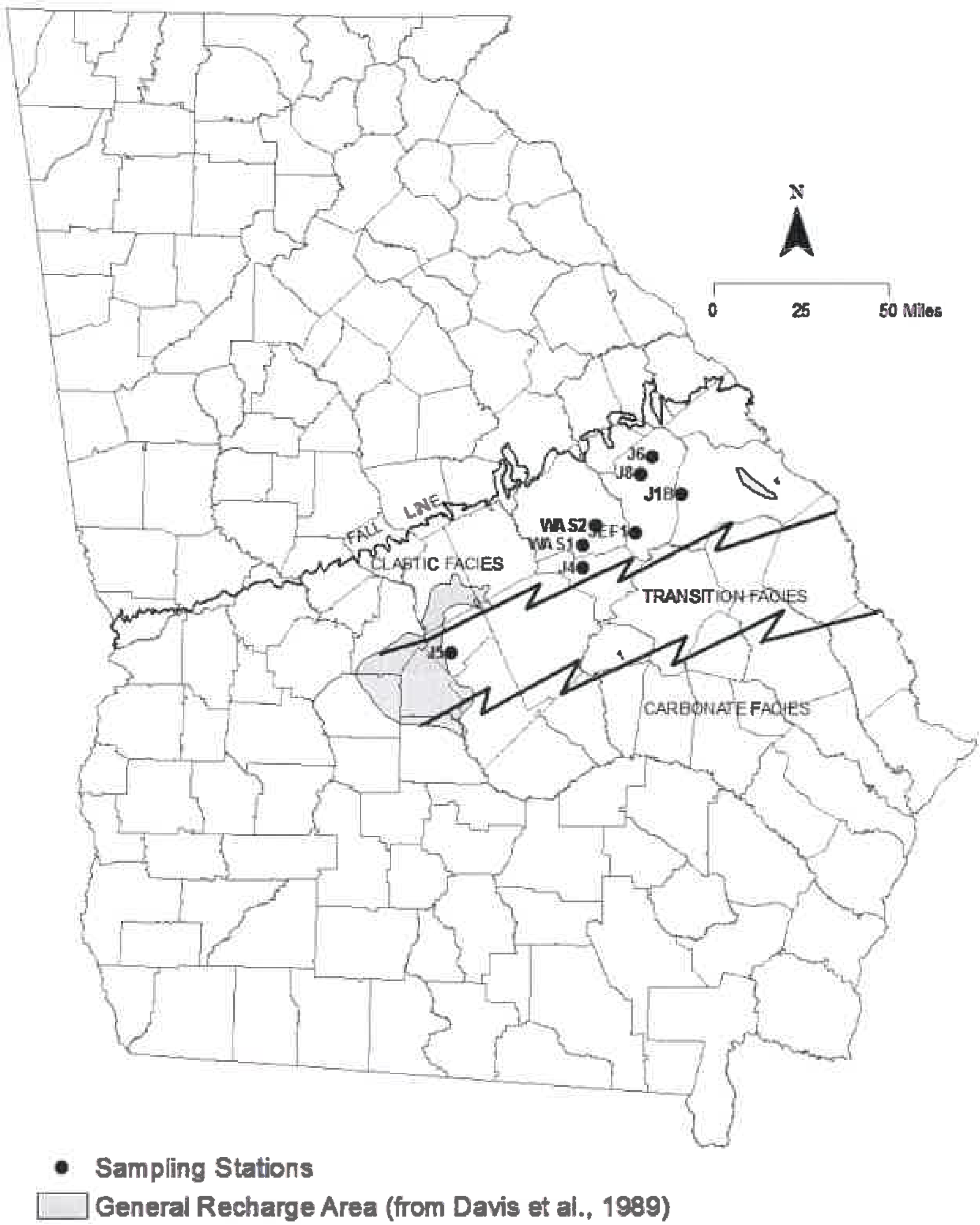


Figure 3-5. Locations of Stations Monitoring the Jacksonian Aquifer.

3.5.4 Metals by Inductively-Coupled Plasma Spectrometry (ICP)

All eight wells gave waters with detectable calcium from 45,000 ug/L (J1B) to 68,000 ug/L (J8A). Magnesium was detected in seven of the eight wells and ranged from undetected in J1B to 2,600 ug/L (J5). Detectable sodium occurred in each well sample and ranged from 2,100 ug/L (J6) to 3,300 ug/L (J1B and J4). Iron was detected in three of the eight wells and ranged from undetected to 170 ug/L (J6). Well J5, J8A and JEF1 gave a sample containing 62 ug/L, 13 ug/L and 67 ug/L manganese respectively. The sample from well J5 and JEF1 exceeded the manganese Secondary MCL of 50 ug/L. 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)

Seven of the eight wells yielded waters containing detectable barium, with a range from undetected (JEF1) to 88 ug/L (WAS1). Well J5 yielded sample water containing detectable zinc at a concentration of 53 ug/L. 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 groundwater 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 groundwater quality and availability (Kellam and Gorday, 1990; Applied Coastal Research Laboratory, 2001). The Gulf Trough may be a filled 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 groundwater 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 34 wells and one spring, with 25 scheduled for sampling on a yearly basis and 10 on a quarterly basis. The total number of samples collected was 65. All 34 wells are drilled wells. Thirty wells are local-government-owned public supply wells. One well supplies industrial process water, one well is a former USGS test well, one a private residence well and the remaining well supplies water for a coastal marina. Depths range from 174 feet (PA25 municipal well) to 1,211 feet (PA9C test well). The one remaining site is Radium Spring in Albany.

3.6.2 Field Parameters

Measurements of pH are available for all samples from all 35 locations and ranged from 7.33 (PA25) to 8.35 (PA41A). The median pH is 7.90 and the mean is 7.88. Conductivities are also available for all the samples from all sites and ranged from 164 uS/cm (PA41A) to 1900 uS/cm (PA9C) with a median of 316 uS/cm and a mean of 344 uS/cm. Temperatures are available for all sampling events and ranged from 20.23 degrees C for well PA27 to 25.67 degrees C for well GLY4 with a median of 22.55 degrees C and a mean of 22.61 degrees C. The high temperatures reflect the geothermal effect of the deeper wells. Sixty dissolved oxygen measurements are available from 32 wells and the one spring. The available measurements range from 0.52 mg/L (LIB2) to 9.11 mg/L (PA23) with a median of 3.54 mg/L and a mean of 3.93 mg/L. No measurements were taken at well GLY3 and 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

Nine Floridan wells yielded 14 samples containing detectable chloride. Chloride concentrations ranged from undetected to 860 mg/L (PA9C). The measurement for well PA9C is more than 20 times the next highest concentration of 41 mg/L for well PA4. Well PA9C derives water from the lower part of the Floridan aquifer. Twenty-eight samples from 16 wells gave samples containing detectable sulfate. Levels ranged from undetected to 270 mg/L (PA9C). Twenty-two water samples from 12 wells and one spring contained detectable nitrate/nitrite. Concentrations ranged from undetected to 2.2 mg/L as nitrogen (PA59). 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 24 wells and one spring. Phosphorus levels ranged up to 0.17 mg/L (PA14A) as total phosphorus. Volatile organic compounds (VOCs), consisting entirely of trihalomethane compounds, were detected in six samples from four wells (PA17, PA23 PA28 and PA39). These 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 wells, the occasional nature of trihalomethane detections suggests a maintenance related origin. Radium spring also yielded a water sample with a VOC detection. This VOC was trichloroethylene a degreaser commonly used in factories and dry cleaners. Springs are subject to surface contaminations more so than deeper wells.

3.6.4 Metals by Inductively-Coupled Plasma Spectrometry (ICP)

ICP analyses found detectable levels of potassium, manganese, iron, calcium, magnesium, aluminum, titanium and sodium. Detectable potassium occurred in only two samples from two wells (PA4 and 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 14 samples from seven 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 well PA16 and PA18 exceeded the Secondary MCL of 50 ug/L. The manganese levels in the samples from each of the quarterly sampled wells vary within a restricted range. 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 26 samples from 15 wells. Of these, two samples exceeded the Secondary MCL of 300 ug/L; annual wells PA9C (1,000 ug/L) and GLY2 (1,200 ug/L). The iron contents of samples from three quarterly wells (PA34A and PA36) seemed to vary within restricted ranges. Detectable magnesium was found in all samples from all wells and spring except for those from quarterly well PA25. Magnesium concentrations ranged up to 85,000 ug/L (well PA9C), with a mean of 13,805 ug/L and a median of 14,000 ug/L.

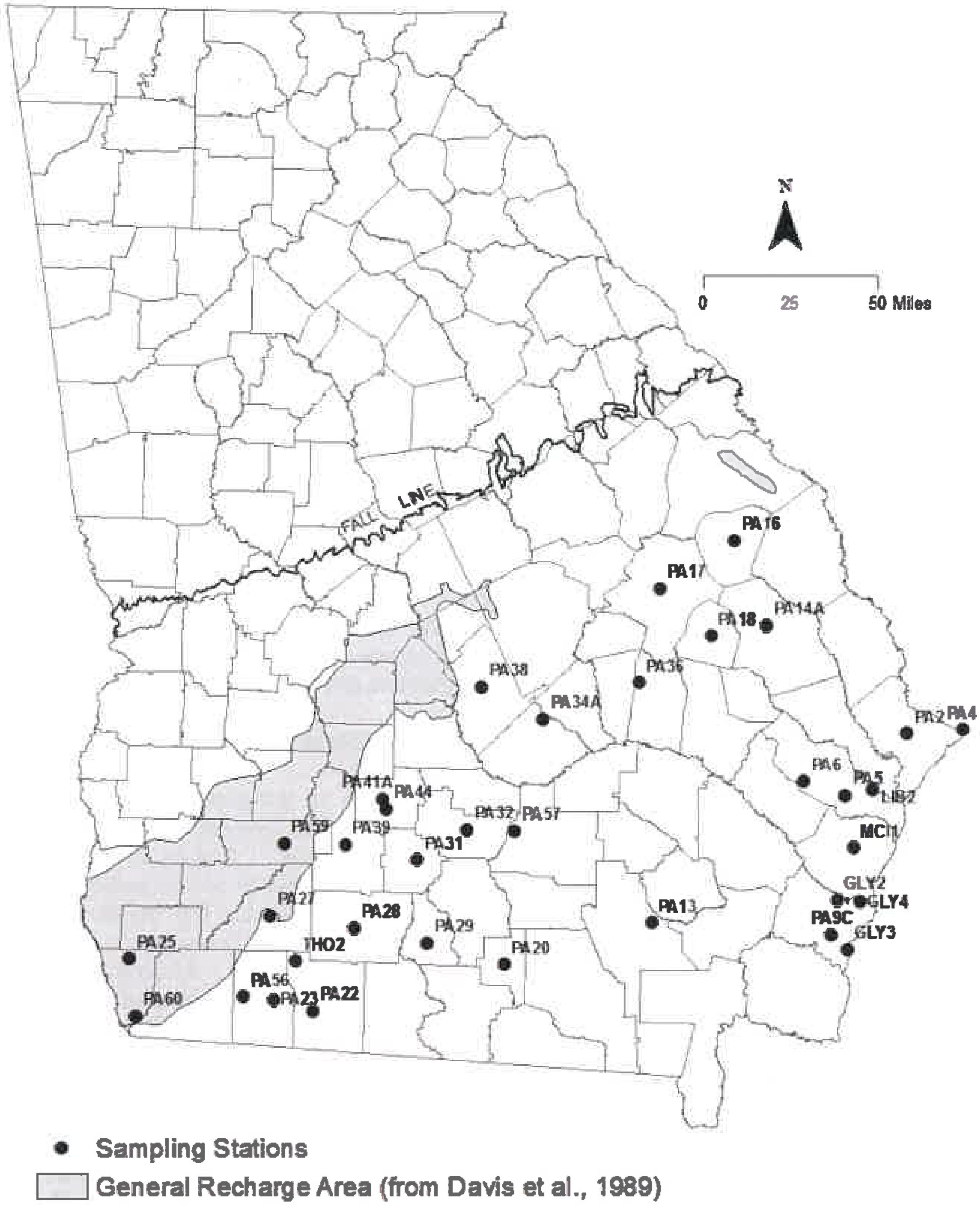


Figure 3-6. Locations of Stations Monitoring the Floridan Aquifer System.

Well PA25 is a Floridan recharge area well. Kellam and Gorday (1990) have noted that Ca/Mg ratios are higher in groundwaters from Floridan recharge areas, as is the case with this well. Magnesium levels in samples from each quarterly well seem to vary within relatively narrow ranges. Calcium was detected in all samples from the 35 Floridan wells and spring. Concentrations ranged from 18,000 ug/L (PA41A) to 110,000 ug/L (PA9C), with a mean of 39,338 ug/L and a median of 36,000 ug/L. For samples from quarterly wells, calcium concentrations seem to fall within a narrow range for each well. Aluminum was detected above the Secondary MCL of 50-200 ug/L in one sample from one well, PA38 (130 ug/L). Sodium was also found in all sample waters from all 35 wells and spring and ranged in concentration from 1,500 ug/L (PA41A) to 460,000 ug/L (PA9C), with a mean of 18,026 ug/L and a median of 7,900 ug/L. Sodium concentrations generally increase with depth. Titanium was detected in one sample from one well (PA56) at a concentration of 11 ug/L.

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

ICPMS analysis found the following detectable metals in the Floridan samples: copper, zinc, lead, arsenic, selenium, molybdenum, thallium and barium. Four samples from quarterly well PA23 and one sample from well PA28 registered arsenic detection below the Primary MCL (10 ug/L). Well PA23 has given intermittent samples with detectable arsenic before. Annual well PA9C and PA18 gave samples showing detectable selenium below the Primary MCL (50 ug/L). One sample from well PA27 registered detectable thallium below the Primary MCL (2.0 ug/L). Three samples contained detectable copper, one from annual well PA17 and two from quarterly well PA14A. Unlike most other wells, quarterly well PA14A furnishes sample water through a small diameter copper tube. Annual well PA9C and PA60 along with quarterly well PA14A gave samples with detectable zinc. Quarterly wells PA14A and PA36, along with 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 PA28 produced the sample with the highest concentration of 41 ug/L. All three wells are in the Gulf Trough area. Barium was detected in all samples from all wells and spring and ranged in concentration from 3.3 ug/L (PA60) to 190 ug/L (PA39), all below the Primary MCL of 2,000 ug/L. The mean concentration of barium was 78.6 ug/L and the median was 72 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.

Seven annually sampled wells were used to monitor the Miocene/Surficial aquifer system. Wells MI1, MI2A, MI9A and MI10B are private domestic wells, well WAY1 is a public supply well for a mobile home park and MI9A and MI10B are 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 seven wells.

3.7.2 Field Parameters

The pHs of the sample waters from the seven wells used to monitor the Miocene/Surficial aquifer system ranged from 3.93 (MI2A) to 7.94 (MI16). Three of the seven wells sampled (MI2A, MI9A and MI10B) produced acidic water. The remaining five wells 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 108 uS/cm (MI10B) to 309 uS/cm (MI16). Water temperatures ranged from 19.06 degrees C (MI17) to 23.92 degrees C (MI9A). Dissolved oxygen data are available for five of the seven wells and range from 1.03 mg/L (MI16) to 4.67 mg/L (MI2A). Valid dissolved oxygen measurements cannot be made on well MI9A and MI17 since one must be sampled with a bailer and the other is exposed to air before sampling.

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

Chloride registered at 13 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 33 mg/L. Nitrate/nitrite was detected in sample waters from the bored wells MI2A and MI9A, both wells lying in the range of likely human influence ($\geq$ 3.1 mg/L as nitrogen) (Madison and Brunett, 1984). The former well registered 7.8 mg/L as nitrogen and the latter 20.0 mg/L. Detectable phosphorus was found in samples from five of the seven wells. The concentrations ranged from 0.02 mg/L (MI16) to 0.91 mg/L (MI10B). None of the samples contained detectable VOCs.

3.7.4 Metals by Inductively-Coupled Plasma Spectrometry (ICP)

Samples from all seven wells contained calcium, magnesium, and sodium. Calcium levels ranged from 4,700 ug/L (well MI2A) to 43,000 ug/L (well MI17). Magnesium levels ranged from 1,900 ug/L (well MI17) to 17,000 ug/L (well MI16). Sodium levels ranged from 3,300 ug/L (well MI9A) to 18,000 ug/L (well MI16). Potassium was detected in well MI2A (6,800 ug/L) and well MI9A (7,900 ug/L). Iron was detected in the sample from well MI2A at 20 ug/L, well MI9A at 23 ug/L and well MI10B at 11,000 ug/L. This last value far exceeds the Secondary MCL for iron of 300 ug/L. Manganese was found in samples from five wells: MI1 (12 ug/L), MI2A (11 ug/L), MI10B (190 ug/L), MI17 (12 ug/L) and WAY1 (93 ug/L). The 93 ug/L and 190 ug/L levels exceed 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 well MI2A at a concentration of 190 ug/L and well MI9A at a level of 65 ug/L, both above the Secondary MCL range of 50-200 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 seven samples contained detectable barium, which ranged in concentration from 18 ug/L (MI1 and MI17) to 210 ug/L (MI10B). The sample from drilled well MI10B contained selenium at a level of 23 ug/L. Selenium at detectable levels is rare in Georgia's groundwater. Zinc was detected in samples from well MI1 (42 ug/L), MI2A (14 ug/L), MI10B (100 ug/L) and MI16 (41 ug/L). Detectable lead occurred in the sample from bored well MI2A (3.1 ug/L) and

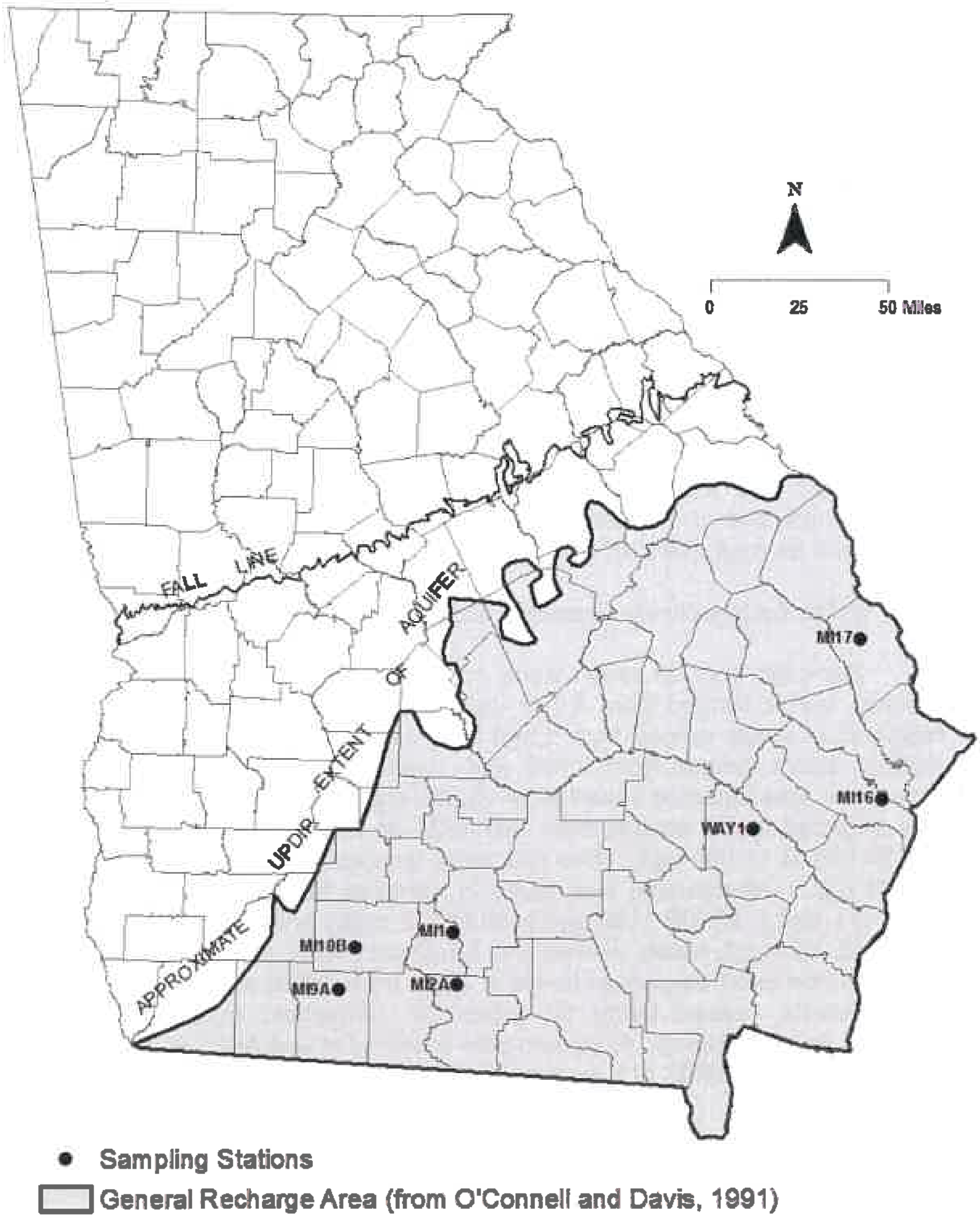


Figure 3-7. Locations of Stations Monitoring the Miocene/Surficial Aquifer System.

well MI10B (4.3 ug/L). The samples from wells MI2A and MI10B also contained copper at levels of 9.6 ug/L and 27 ug/L respectively. 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 and 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.

The regolith hydrologic unit is comprised of a mantle of soil, alluvium in and near stream bottoms and underlying saprolite. Saprolite is bedrock that has undergone extensive chemical weathering in place. Downward percolating, typically acidic, groundwater 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 highly weathered 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, is relatively impermeable. 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

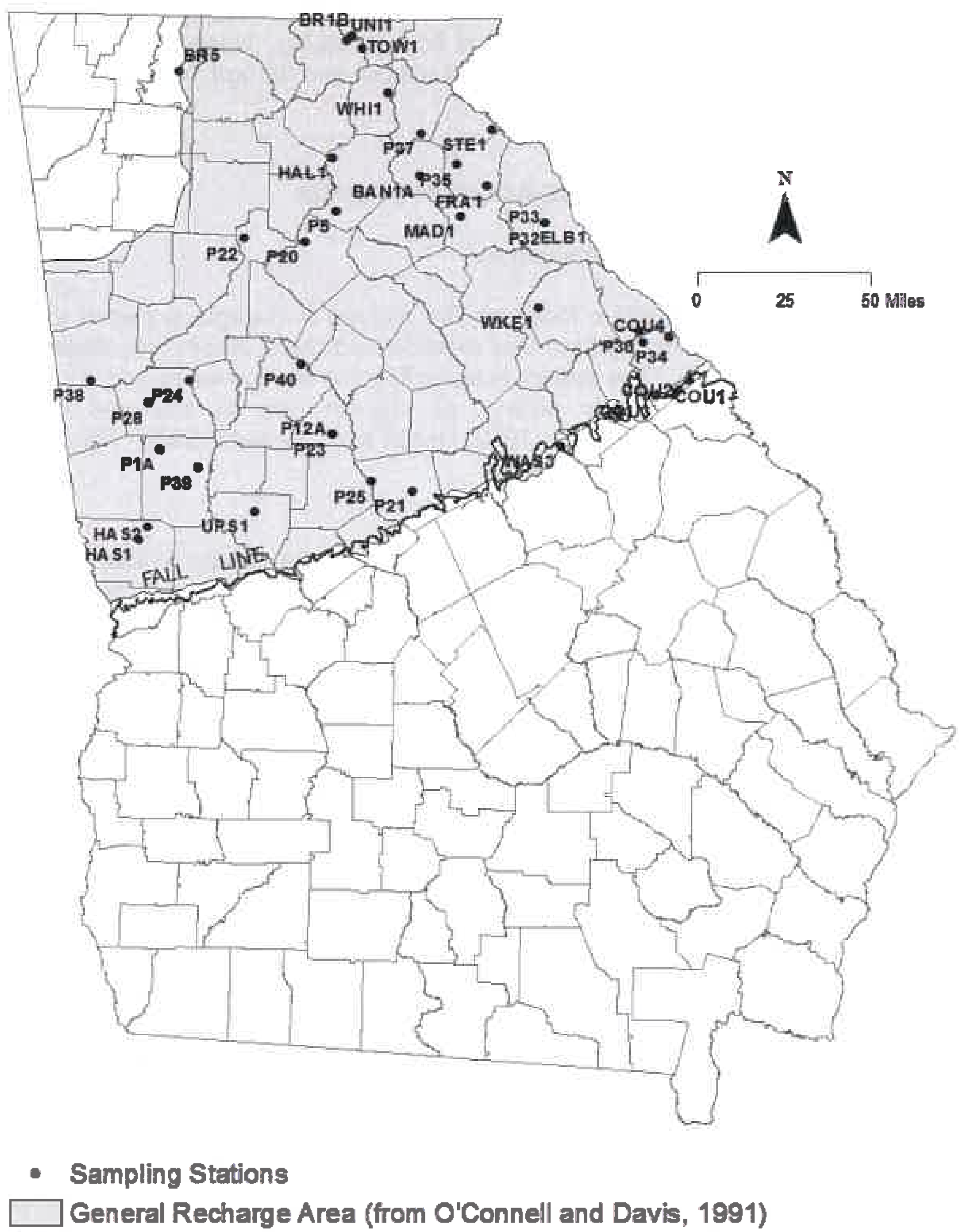


Figure 3-8. Locations of Stations Monitoring the Piedmont/Blue Ridge Aquifer System.

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.

Sixty-nine samples from 35 wells and four springs were used to monitor water quality in the Piedmont/Blue Ridge aquifer system. Thirty-four of these wells are drilled. Thirty of the 35 wells are public supply wells, and the remaining five are domestic. One of the 35 wells is bored (P33) and is in domestic use. Of the four springs, three (P12A, HAS2 and TOW1) are mineral springs at State parks, and the other spring (BR5) is a public supply source. The State park mineral spring P12A and the following wells are scheduled for sampling on a quarterly basis: P21, P23, P25, P32, P33, P34, P35, P37 and BR1B. Well P25 was added to the network on a quarterly basis, and 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 705 feet. Domestic bored well P33, the only well drawing from the regolith aquifer, is 47 feet deep.

3.8.2 Field Parameters

Sixty-nine pH measurements from all 39 stations are available for the Piedmont/Blue Ridge aquifer system. The pHs ranged from 4.75 (HAS2) to 8.21 (BAN1A). Twenty-four total samples were basic; all four samples from quarterly well P32, four samples from quarterly spring P12A, three samples from quarterly well P35 and BR1B, and one sample from annual wells P20, P24, BAN1A, COU1, COU2, COU3, HAL1, MAD1, UPS1 and WAS3. The remaining samples were acidic, including all samples from quarterly regolith well P33. The mean pH was 6.71 and the median 6.67. Conductivity measurements are available for all 69 samples. Conductivities range from 13 uS/cm (HAS2) to 1060 uS/cm (well P32). The mean conductivity was 235 uS/cm and the median was 180 uS/cm. Samples with the higher pHs generally tended to have higher conductivities and vice versa. Temperatures were available for all sampled waters and range from 11.82 degrees C (spring TOW1) to 21.06 degrees C (well COU2). The mean temperature was 17.65 degrees C and the median was 17.74 degrees C. 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 59 of the 69 samples from 32 of 39 stations. The samples from quarterly spring P12A and annual springs HAS2, BR5, and TOW1 and wells P39, COU2 and FRA1 received no dissolved oxygen measurements since exposure of the sample water to air can render the measurement inaccurate. Dissolved oxygen levels ranged from 0.60 mg/L for quarterly well P35 to 9.58 mg/L for quarterly well P37. The 9.58 mg/L reading lies just under the oxygen saturation level for the temperature at sampling (16.40 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 groundwater.

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

All samples received testing for chloride, sulfate, nitrate/nitrite, total phosphorus, and VOCs. Four samples each from spring P12A and well P23, both located at Indian Springs State Park, received testing for fluoride. Five stations yielded 10 samples with detectable chloride: quarterly well P37 with all four samples; quarterly spring P12A with three samples; and annual wells P30, COU4 and WAS3 with one sample each. Well P37 gave the sample with the highest level at 120 mg/L. Detectable fluoride occurred in all four samples from well P23 at levels of 1.1 mg/L. Detectable fluoride also occurred in all four samples from quarterly spring P12A at levels ranging from 4.5 mg/L to 4.7 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 33 samples from seven quarterly and eight annual stations, with the highest concentration (620 mg/L) occurring in a sample from quarterly well P32. Spring P12A and quarterly wells P32, P37, P34, P21 and BR1B each have sulfate values that vary within narrow ranges. Nitrate/nitrite was detected in 51 of 69 samples from 30 stations with a high concentration of 3.5 mg/L as nitrogen for annual well WKE1. This level is well below the Primary MCL of 10 mg/L as nitrogen. Detectable phosphorus occurred in 48 samples from 30 stations, with the highest concentration of 0.18 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 P21, P23, P25, P33, P34 and P35. Detectable VOCs occurred in samples from wells COU4 (chloroform 0.69 ug/L and methyl tert-butyl ether 1.1 ug/L) and UPS1 (chloroform 1.0 ug/L). Chloroform is a disinfectant by-product.

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 was detected. Calcium was found in all samples except springs HAS2 and TOW1. These two springs are located in FD Roosevelt State Park (HAS2) and Brasstown Bald Recreation Area (TOW1). The reason for no detectable calcium in these two springs is probably because these two springs flow through a homogeneous quartzite rock. The highest calcium levels (260,000 ug/L, 120,000 ug/L, 200,000 ug/L and 160,000 ug/L) occurred in the quarterly samples from well P32. The mean calcium concentration was 29,104 ug/L and the median concentration was 19,000 ug/L. As a rule, calcium levels of samples from each quarterly station tend to cluster closely. Magnesium was detected in 60 samples from 33 stations. Magnesium contents of sample waters ranged from not detected up to 39,000 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 wells P38 and BAN1A and annual springs BR5, HAS2 and TOW1 contained no detectable magnesium. Sodium was present in all samples and ranged from 1,100 ug/L in the samples from springs HAS2 and TOW1 to 42,000 ug/L in a sample from well P12A. Sodium levels for each quarterly well have a general tendency to cluster. The mean sodium concentration was 13,286 ug/L and the median was 11,000 ug/L. Detectable potassium was found in all four samples from one station (well P35) in a range of 6,600 ug/L to 7,300 ug/L. 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 P30, P33, P37, P38 and TOW1. Well P33 registered the highest level at 470 ug/L. Aluminum levels exceeded the Secondary MCL range of 50-200 ug/L. Iron was detected in 35 samples from 20 wells and one spring, with a range from not detected up to 1,700 ug/L (well COU3). This concentration exceeds the Secondary MCL for iron of 300 ug/L. Five other wells produced samples with an iron level equal to or greater than the Secondary MCL; P30 (510 ug/L), P33 (360 ug/L and 570 ug/L), COU1 (970 ug/L), FRA1 (350 ug/L), and MAD1 (590 ug/L). Manganese was detected in 39 samples from 18 wells and one spring, with a maximum concentration of 340 ug/L (well COU3). Twenty-three samples from wells P20, P21, P25, P33, P35, P37, COU1, COU2, COU3, COU4, FRA1, HAS1, MAD1 and WAS3 equaled or exceeded the Secondary MCL of 50 ug/L.

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

ICPMS analysis of water samples detected the following metals: chromium, copper, zinc, selenium, molybdenum, barium, thallium, lead and uranium. None of the following metals were found in detectable amounts: nickel, arsenic, silver, cadmium, tin and antimony. Chromium and selenium were both detected in only one sample from the same well (P28). Molybdenum was detected in only one sample from well BAN1A. Thallium was detected in only one sample from well UPS1. Copper occurred in 13 samples from 8 wells, with a maximum level of 110 ug/L in the sample from well P22. This sample also had one of the lowest pHs. All copper detections occurred in acidic waters, with the highest pH for a sample containing detectable copper registering at 6.90. No detectable copper occurred in neutral or basic waters. Zinc was detected in 23 samples from 15 wells, with the maximum level at 300 ug/L from well WKE1. All zinc detections except for wells P20 (pH 7.79), P24 (pH 7.28), COU1 (pH 7.05) and COU3 (pH 7.09) occurred in acidic waters. Lead was detected in four samples from four wells. All lead detections occurred in acidic water. All lead detections occurred with zinc or copper detections. Again, these three metals commonly leach into sample water from plumbing and are not necessarily present naturally. Barium, as elsewhere in the State's groundwater, was a nearly ubiquitous trace metal, being detected in 64 samples from 35 wells and three springs. Four samples from quarterly spring P12A and one sample from quarterly well P32 contained no detectable barium. The maximum concentration was 230 ug/L from a sample from annual well P20. No samples exceeded the Primary MCL of 2,000 ug/L. Uranium was detected in five samples from four wells. Uranium detections were down from previous years due to the reporting limit of the lab going from the previous 1.0 ug/L to 10 ug/L. Uranium concentrations ranged from not detected up to 13.5 ug/L found in a sample from well P25. Granitic bedrock is present where these 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 groundwater.

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. The water table lying within the regolithic mantle yields soft water ("freestone" water) sufficient for domestic and light agricultural use (Cressler et al., 1976; 1979). The regolithic mantle also acts as a reservoir, furnishing water to the underlying bedrock, which supplies most of the useful groundwater in the province.

Monitoring water quality in the Valley and Ridge/Appalachian Plateau aquifers made use of four springs and three 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, well VR6A is an industrial process water source and well VR11 is a private domestic well. Spring VR8 is scheduled for quarterly sampling, while all the other stations are sampled on an annual basis. All stations tap carbonate bedrock aquifers.

3.9.2 Field Parameters

Sample water pHs ranged from 7.08 for well VR11 to 7.87 for well VR1. Conductivities ranged from 220 uS/cm (spring VR10) to 454 uS/cm (well VR11). Dissolved oxygen measurements are available for well VR1 (7.24 mg/L) and well VR11 (1.87 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 16.17 degrees C, 17.91 degrees C from well VR6A and 17.14 degrees C from well VR11. 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, sulfate nor phosphorus was detected in any of the sample waters. Detectable nitrate/nitrite was present in all of the sample waters and ranged from 0.68 mg/L as nitrogen in spring VR8 to 2.60 mg/L as nitrogen in well VR11. The sample from well VR6A was the only one to contain detectable VOCs. The compounds consisted of: 1,1-dichloroethylene at 1.8 ug/L (Primary MCL = 7 ug/L) and tetrachloroethylene at 2.1 ug/L (Primary MCL = 5 ug/L). These compounds, particularly the chlorinated ethylenes, are used primarily as solvents. 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, aluminum in one sample and iron in four samples. Aluminum was detected in one sample from spring VR8 at a level of 110 ug/L. This aluminum level exceeded the Secondary MCL range of 50-200 ug/L. Detectable iron was present in the sample from well VR6A (29 ug/L), one of the four samples from spring VR8 (29 ug/L), from spring VR10 (35 ug/L) and from well VR11 (70 ug/L), all at levels below the Secondary MCL of 300 ug/L. Neither manganese nor potassium was detected in any of the samples. Calcium levels ranged from 28,000 ug/L from well VR1 to 65,000 ug/L from well VR11. Magnesium levels ranged from 14,000 ug/L from well VR11 to 18,000 ug/L from well VR6A. Sodium levels ranged from 1,400 ug/L from springs VR3 and VR8 to 8,700 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 10.0 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 levels of 18.0 ug/L and 16.0 ug/L was detected in two samples from well VR6A and spring VR10 respectively. A spigot in the treatment house near the spring head or related plumbing may have contributed the zinc at spring VR10. This spigot is the only source of untreated water from the spring.

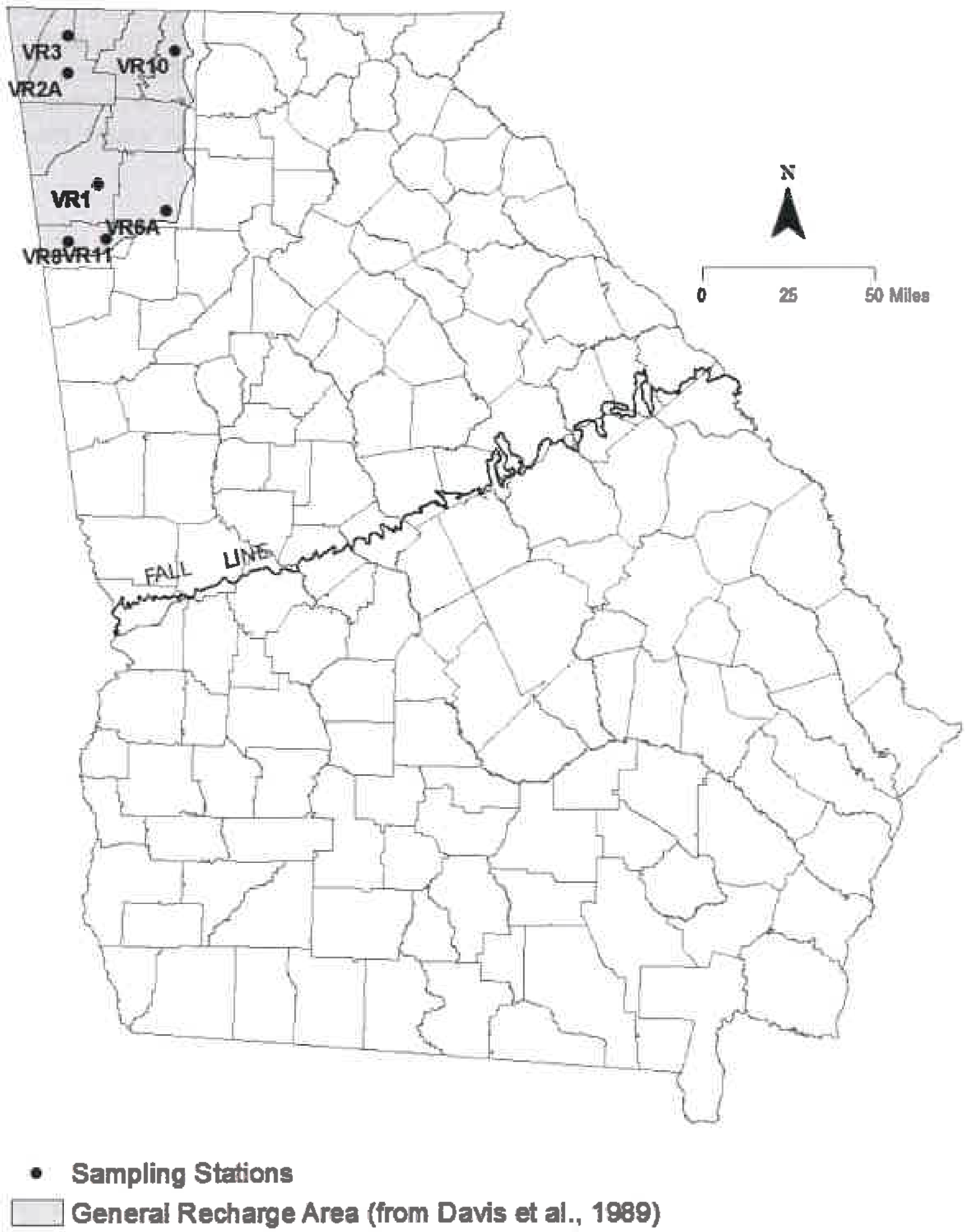


Figure 3-9. Locations of Stations Monitoring the Valley-and-Ridge/Appalachian Plateau Aquifer System.

CHAPTER 4 SUMMARY AND CONCLUSIONS

EPD personnel collected 187 water samples from 115 wells and nine springs on the Groundwater Monitoring Network during the calendar year 2016. 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 fluoride. 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. This aquifer system featured only five of 22 wells yielding waters with basic pHs.

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 – two basic, one acidic – one acidic-yielding well is shallow and updip in sands; the two basic-yielding wells are deeper and probably penetrate some limey sand or limestone; 3) Jacksonian – all eight wells were basic – basic and neutral waters should be expected from limey sands.

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.

The Miocene aquifer system is developed in sands. However, these may include shelly detritus in some places (evident at surface excavations near well MI17 and at coastal well MI16). Dissolution of such detritus can raise the pHs of groundwaters 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 generally mildly acidic, with 24 out of 69 sample measurements exceeding or equaling a pH of 7.00.

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, which all ten samples taken in the sector were found to be basic with some samples close to neutral. In the past, some of these samples were found to be slightly acidic instead of all samples being basic. The seeming incidence of past acidic waters was probably due to a larger amount of typically acidic precipitation entering the springs' flow systems than the carbonate bedrock can neutralize.

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 groundwaters 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 microsiemens.

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 groundwaters 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 groundwaters 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

Groundwater temperatures measured under the current sampling procedure are only approximations of the actual groundwater temperature, as some heating can result from the action of pumping and heating or cooling can result from exposure to ambient surface conditions. Nevertheless, groundwaters 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. All four samples from spring P12A exceeded the Primary MCL for fluoride. Testing more stations for fluoride could provide a better base level assessment of fluoride contents in the State's ambient groundwaters.

Chloride at currently detectable levels is not too common in ambient groundwaters. Abundance seems to be largest in the deeper Floridan waters, which had detections at nine out of 39 stations. The Floridan occurrences seem restricted to the Gulf Trough and Coastal areas, with the Coastal area sample from well PA9C giving the study's only Secondary MCL exceedance for chloride. The Miocene/Surficial aquifer is the next most abundant with two of seven stations of less than 100 feet depth giving water with detectable chloride. Chloride is also relatively abundant in Piedmont/Blue Ridge waters, detected at five out of 39 stations.

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 150 feet-deep well MAR1 in the Cretaceous aquifer. Sulfate seems more abundant in Floridan sample waters, detectable at 15 out of 35 stations. Sulfate is also abundant in the Piedmont/Blue Ridge, occurring in detectable amounts in waters from 15 of 39 stations. The Cretaceous aquifer yielded samples containing detectable sulfate in seven out of 22 stations. Jacksonian sample waters yielded two out of eight stations with detectable sulfate. 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 seven stations.

4.2.3 Nitrate/Nitrite

Ninety-six (96) samples from 66 of the 124 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 three highest concentrations of nitrate/nitrite (20.0 mg/L at well MI9A, 7.8 mg/L at well MI2A and 3.3 mg/L at well P30) occurred at Miocene/Surficial and Piedmont stations. All three samples exceeded the naturally occurring maximum level of 3 mg/L (as nitrogen), a 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 crude 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 1.8 mg/L in four of four samples from well PA25, 174 feet deep. The situation in the Piedmont/Blue Ridge is less straightforward, as mineral spring P12A lacks detectable nitrate/nitrite in three of four quarterly samples 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. There were only three samples from three stations collected for the Claiborne, however this aquifer registered the highest mean phosphorus content of 0.30 mg/L. Of the more extensively sampled Piedmont/Blue Ridge and Floridan aquifer systems, the former registered a mean phosphorus content of 0.047 mg/L and the latter a content of 0.018 mg/L. The high phosphorus value for the Floridan was .17 mg/L and the high for the Piedmont/Blue Ridge was 0.18 mg/L. The highest value for all the aquifers was in the Cretaceous aquifer system at a level of 2.60 mg/L detected in the sample from station K3. However, the Cretaceous still only registered a mean phosphorus content of 0.16 mg/L. The apparent low phosphorus content occurred for the Valley and Ridge/Appalachian Plateau aquifer system with no 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 11 samples from 10 wells and one spring (see Table 4-2). None exceeded their respective Primary MCLs. The trihalomethanes -- chloroform, bromodichloromethane, chlorodibromomethane, and bromoform -- were the most widely occurring of the VOCs. These compounds result from halogen-bearing disinfectants reacting with organic matter naturally present in the water. Two scenarios accompany the occurrence of the compounds. The first involves disinfection of the 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 and spring PA59 yielded water containing chlorinated ethylene compounds. Sample water from VR6A has also contained detectable chlorinated benzene compounds in the past. 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.

Well COU4 yielded water containing methyl tert-butyl ether (MTBE; 2-methoxy-2-methyl-propane), which has no MCL. An advisory range of 20 ug/L to 40 ug/L has preliminarily been set due to offensive taste and smell. The compound has been added to motor fuels as an oxygenate (promotes cleaner burning). That use is being curtailed due to the greater water solubility of the compound compared to other fuel components thus its heightened ability to contaminate groundwater. Data on the long-term health effects of the compound are sparse.

4.3 ICP METALS

Analysis using inductively coupled plasma spectrometry (ICP) works well for metals that occur in larger concentrations in groundwater 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, potassium, magnesium, manganese, sodium, titanium, and vanadium. No beryllium, cobalt or vanadium occurred in any samples at detectable levels.

4.3.1 Aluminum

Aluminum, a common naturally occurring metal in the State's groundwater 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 are also two more naturally occurring metals in Georgia's groundwater. 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 three, updip samples are 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 three samples 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 eight samples from five stations – two samples from two stations in the Miocene, two samples from two stations in the Floridan and four samples from one station in the 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 1.2 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 21.6 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 and lead; uranium testing was performed by the Soil, Plant and Water Analysis Laboratory at the University of Georgia. Silver, cadmium, tin, and antimony remained below detection in all samples. No metals analyzed under the ICPMS method registered any levels above the Primary or Secondary MCLs or action levels.

4.4.1 Chromium and Nickel

Detectable chromium occurred in one sample from one Cretaceous station and one sample from one Piedmont station. Nickel occurred in one sample from one Clayton station. These metals do occur naturally occasionally in the sedimentary rocks of the Floridan aquifer sysytem. However, in this study the chromium and nickel occurrences were in the Cretaceous, Piedmont and Clayton aquifer systems and not the Floridan.

4.4.2 Arsenic, Selenium, Uranium, and Molybdenum

Arsenic was detected in two samples from the Floridan (quarterly well PA23 and PA28). The Floridan samples came from the Gulf Trough area of Grady County, the scene of other groundwater arsenic detections, some above the Primary MCL (10 ug/L) (Donahue et al., 2012). Selenium was found in samples from the Piedmont, Cretaceous, Miocene and Floridan aquifer systems (wells P28, K7, MI10B, PA9C and PA18). The element may accompany uranium in deposits formed from the reduction of oxic groundwaters. Twelve samples from three Floridan stations and one sample from one Piedmont station contained detectable molybdenum. The stations – PA23, PA28, and PA56 – are all Gulf Trough area wells. The lone sample to contain molybdenum in the Piedmont was from well BAN1A, which is a well that has had detectable uranium in the past. Like selenium, molybdenum can be associated with uranium in deposits formed through the reduction of oxic groundwaters (Turner-Peterson and Hodges, 1986). Uranium appears to be most abundant in the Piedmont/Blue Ridge, with four stations giving five samples containing detectable uranium. Uranium detections were down from previous years due to the reporting limit of the lab going from the previous 1.0 ug/L to 10 ug/L. Uranium minerals, sometimes accompanied by molybdenum and selenium minerals, can precipitate from oxic groundwaters subjected to strong reduction.

4.4.3 Copper, Lead, and Zinc

Copper, lead, and zinc detections are more numerous in acidic samples. Copper and lead did not exceed their action level nor zinc its Secondary MCL in any samples. Out of a total of 187 samples taken for the study, 33 samples with pHs below 7.00 contained detectable amounts of at least one of these metals. In contrast, only 14 samples with basic pHs 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 groundwater.

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 groundwater at station VR6A, a sample from that station has caused the Valley and Ridge/Appalachian Plateau samples to have one of the highest average barium levels along with samples from the Floridan and Miocene/Surficial aquifer systems. Groundwater 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 4-1). 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 4-1) 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 4-1). 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 4-1) consisted of manganese, aluminum, iron, sulfate, and chloride. Manganese, aluminum, and iron are common naturally occurring metals in Georgia's groundwater.

Manganese exceeded its MCL in 36 samples from 24 wells. Five of the wells were quarterly (P21, P25, P33, P35, P37 and PA34A); four gave four samples and two gave one 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 groundwater used for public consumption lacks measureable suspended matter), were found in 15 samples from 13 wells. Aluminum excesses were the most consistent in the domestic bored Piedmont regolith well P33.

Iron equaled or exceeded its Secondary MCL in 17 samples from 16 wells. Iron is another common naturally occurring contaminant in Georgia's groundwater. One of the wells was quarterly well P33 which had detectable iron in two of the quarterly samples. Well P33 is a shallow bored well and sample water from this well is typically murky with suspended particulates.

Well P32 gave four samples with excessive sulfate and well PA9C gave a sample with excessive sulfate and excessive chloride.

4.5.3 Volatile Organic Compounds

Trihalomethanes are the most common of the VOCs detected (Table 4-2). Chloroform, the most commonly detected of the VOCs, was present in nine samples from seven stations. Bromodichloromethane and dibromochloromethane were the next most common with each having five detections from four stations and bromoform with three detections from two stations. In groundwater, 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 and 1,1-dichloroethylene. 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. However, the source of the VOCs at station VR6A is uncertain.

Well COU4 also gave a sample with a detection of MTBE, a fuel additive, and spring PA59 gave a sample with a trichloroethylene detection. Trichloroethylene is commonly used as a solvent or degreaser for metals parts, as a dry-cleaning solvent and in the manufacturing of a range of fluorocarbon refrigerants.

Table 4-1. Contaminant Exceedances, Calendar Year 2016.				
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	09/13/16
P12A	Fluoride = 4.7 mg/L	4 mg/L	mineral spring	02/10/16
P12A	Fluoride = 4.5 mg/L	4 mg/L	mineral spring	05/04/16
P12A	Fluoride = 4.5 mg/L	4 mg/L	mineral spring	08/23/16
P12A	Fluoride = 4.5 mg/L	4 mg/L	mineral spring	11/02/16
Secondary MCL Exceedances				
COU3	Manganese = 340 ug/L	50 ug/L	public well	02/24/16
WAS3	Manganese = 270 ug/L	50 ug/L	public well	03/09/16
COU4	Manganese = 260 ug/L	50 ug/L	public well	08/22/16
MI10B	Manganese = 190 ug/L	50 ug/L	domestic well	09/13/16
COU1	Manganese = 160 ug/L	50 ug/L	public well	05/03/16
HAS1	Manganese = 150 ug/L	50 ug/L	public well	04/20/16
MAD1	Manganese = 140 ug/L	50 ug/L	public well	05/17/16
P35	Manganese = 140 ug/L	50 ug/L	domestic well	01/20/16
P35	Manganese = 130 ug/L	50 ug/L	domestic well	07/13/16
P35	Manganese = 130 ug/L	50 ug/L	domestic well	10/18/16
P35	Manganese = 120 ug/L	50 ug/L	domestic well	04/06/16
P37	Manganese = 120 ug/L	50 ug/L	public well	01/20/16
P37	Manganese = 120 ug/L	50 ug/L	public well	10/18/16
SUM2	Manganese = 110 ug/L	50 ug/L	public well	01/26/16
PA34A	Manganese = 100 ug/L	50 ug/L	public well	09/07/16
PA34A	Manganese = 100 ug/L	50 ug/L	public well	12/07/16
PA34A	Manganese = 97 ug/L	50 ug/L	public well	03/22/16
PA34A	Manganese = 96 ug/L	50 ug/L	public well	06/14/16

Table 4-1. Contaminant Exceedances, Calendar Year 2016.				
Station	**Contaminant**	**MCL**	**Type Source**	**Date Sampled**
Secondary MCL Exceedances Continued				
P37	Manganese = 96 ug/L	50 ug/L	public well	07/13/16
P25	Manganese = 95 ug/L	50 ug/L	public well	08/23/16
WAY1	Manganese = 93 ug/L	50 ug/L	public well	07/27/16
P25	Manganese = 89 ug/L	50 ug/L	public well	11/02/16
P20	Manganese = 82 ug/L	50 ug/L	public well	07/22/16
P25	Manganese = 77 ug/L	50 ug/L	public well	05/04/16
P33	Manganese = 72 ug/L	50 ug/L	public well	10/18/16
JEF1	Manganese = 67 ug/L	50 ug/L	domestic well	06/02/16
PA18	Manganese = 64 ug/L	50 ug/L	public well	06/02/16
J5	Manganese = 62 ug/L	50 ug/L	public well	03/22/16
COU2	Manganese = 62 ug/L	50 ug/L	public well	05/03/16
P25	Manganese = 58 ug/L	50 ug/L	public well	02/10/16
P37	Manganese = 57 ug/L	50 ug/L	public well	04/06/16
P21	Manganese = 55 ug/L	50 ug/L	public well	05/04/16
FRA1	Manganese = 54 ug/L	50 ug/L	public well	01/20/16
CL4A	Manganese = 54 ug/L	50 ug/L	public well	01/26/16
CL8	Manganese = 52 ug/L	50 ug/L	public well	01/27/16
PA16	Manganese = 51 ug/L	50 ug/L	public well	06/02/16
SUM2	Aluminum=1,200ug/L	50-200 ug/L	public well	01/26/16
P33	Aluminum = 470 ug/L	50-200 ug/L	domestic well	01/20/16
P30	Aluminum = 380 ug/L	50-200 ug/L	domestic well	02/09/16
K12	Aluminum = 350 ug/L	50-200 ug/L	public well	01/27/16
K9A	Aluminum = 330 ug/L	50-200 ug/L	public well	01/27/16
P33	Aluminum = 280 ug/L	50-200 ug/L	domestic well	04/06/16
MI2A	Aluminum = 190 ug/L	50-200 ug/L	domestic well	09/13/16

Table 4-1 Continued. Contaminant Exceedances, Calendar Year 2016.				
Station	**Contaminant**	**MCL**	**Type Source**	**Date Sampled**
Secondary MCL Exceedances Continued				
VR8	Aluminum = 110 ug/L	50-200 ug/L	spring	05/16/16
TOW1	Aluminum = 99 ug/L	50-200 ug/L	spring	08/09/16
CT8	Aluminum = 90 ug/L	50-200 ug/L	domestic well	04/20/16
P33	Aluminum = 81 ug/L	50-200 ug/L	domestic well	07/13/16
P38	Aluminum = 76 ug/L	50-200 ug/L	public well	08/10/16
P37	Aluminum = 69 ug/L	50-200 ug/L	public well	01/20/16
MI9A	Aluminum = 65 ug/L	50-200 ug/L	domestic well	09/13/16
PA25	Aluminum = 65 ug/L	50-200 ug/L	public well	06/28/16
MI10B	Iron = 11,000 ug/L	300 ug/L	domesic well	09/13/16
CL4A	Iron = 2,000 ug/L	300 ug/L	public well	01/26/16
COU3	Iron = 1,700 ug/L	300 ug/L	public well	02/24/16
STW1	Iron = 1,500 ug/L	300 ug/L	public well	03/08/16
CHT1	Iron = 1,400 ug/L	300 ug/L	public well	09/27/16
STW2	Iron = 1,300 ug/L	300 ug/L	public well	06/28/16
GLY2	Iron = 1,200 ug/L	300 ug/L	public well	06/15/16
K3	Iron = 1,100 ug/L	300 ug/L	public well	03/09/16
PA9C	Iron = 1,000 ug/L	300 ug/L	former test	06/15/16
COU1	Iron = 970 ug/L	300 ug/L	public well	05/03/16
MAC1	Iron = 940 ug/L	300 ug/L	public well	03/23/16
MAD1	Iron = 590 ug/L	300 ug/L	public well	05/17/16
CL8	Iron = 570 ug/L	300 ug/L	public well	01/27/16
P33	Iron = 570 ug/L	300 ug/L	domesic well	10/18/16
P30	Iron = 510 ug/L	300 ug/L	domesic well	02/09/16
P33	Iron = 360 ug/L	300 ug/L	domesic well	01/20/16
FRA1	Iron = 350 ug/L	300 ug/L	public well	01/20/16

Table 4-1 Continued. Contaminant Exceedances, Calendar Year 2016.				
Station	**Contaminant**	**MCL**	**Type Source**	**Date Sampled**
Secondary MCL Exceedances Continued				
P32	Sulfate = 620 mg/L	250 mg/L	domestic well	01/20/16
P32	Sulfate = 460 mg/L	250 mg/L	domestic well	07/13/16
P32	Sulfate = 430 mg/L	250 mg/L	domestic well	10/18/16
PA9C	Sulfate = 270 mg/L	250 mg/L	former test	06/15/16
P32	Sulfate = 260 mg/L	250 mg/L	domestic well	04/06/16
PA9C	Chloride = 860 mg/L	250 mg/L	former test	06/15/16

(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)

Table 4-2. VOC Detection Incidents, Calendar Year 2016.				
Station	Constituents	Primary MCL	Type Source	Date Sampled
GWN-J4	chloroform = 1.1 ug/L bromodichloromethane = 1.1 ug/L dibromochloromethane = 0.97 ug/L	See note	public	03/09/16
GWN-PA17	chloroform = 0.67 ug/L bromodichloromethane = 0.64 ug/L dibromochloromethane = 0.68 ug/L	See note	public	06/02/16
GWN-PA23	chloroform = 2.2 ug/L bromodichloromethane = 1.2 ug/L dibromochloromethane = 1.3 ug/L bromoform = 0.62 ug/L	See note	public	01/12/16
GWN-PA23	chloroform = 3.0 ug/L bromodichloromethane = 1.7 ug/L dibromochloromethane = 1.8 ug/L bromoform = 0.50 ug/L	See note	public	04/05/16
GWN-PA23	chloroform = 0.82 ug/L	See note	public	07/12/16
GWN-PA28	chloroform = 1.9 ug/L bromodichloromethane = 1.6 ug/L dibromochloromethane = 2.0 ug/L bromoform = 1.1 ug/L	See note	public	04/05/16
GWN-PA39	chloroform = 0.61ug/L	See note	public	05/19/16
GWN-PA59	trichloroethylene = 0.63 ug/L	See note	public	05/19/16
GWN-COU4	chloroform = 0.69 ug/L MTBE = 1.1 ug/L	See note	public	08/22/16
GWN-UPS1	chloroform = 1.0 ug/L	See note	public	06/01/16
GWN-VR6A	1,1 dichloroethylene = 1.8 ug/L tetrachloroethylene = 2.1 ug/L	7 ug/L 5 ug/L	public	06/29/16

4.6 GENERAL QUALITY

A review of the analyses of the water samples collected during calendar year 2016 indicates that the chemical quality of groundwater sampled for most of the Groundwater Monitoring Network stations is quite good.

However, as mentioned in Chapter 1, areas of elevated risk for low-quality groundwater 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.

CHAPTER 5 LIST OF REFERENCES

Applied Coastal Research Laboratory, Georgia Southern University, 2002, Gulf Trough and Satilla Line Data Analysis, Georgia Geologic Survey Project Report 48, 14 p., 1 pl.

Brooks, R., Clarke, J.S. and Faye, R.E., 1985, Hydrology of the Gordon Aquifer System of East-Central Georgia: Georgia Geologic Survey Information Circular 75, 41 p., 2 pl.

Clarke, J.S., Faye, R.E., and Brooks, R., 1983, Hydrogeology of the Providence Aquifer of Southwest Georgia: Georgia Geologic Survey Hydrologic Atlas 11, 5 pl.

Clarke, J.S., Faye, R.E., and Brooks, R., 1984, Hydrogeology of the Clayton Aquifer of Southwest Georgia: Georgia Geologic Survey Hydrologic Atlas 13, 6 pl. Midville Aquifer Systems of East Central Georgia: Georgia Geologic Survey Information Circular 74, 62p., 2 pl.

Clarke, J.S., Brooks, R., and Faye, R.E., 1985, Hydrogeology of the Dublin and Midville Aquifer Systems of East Central Georgia: Georgia Geologic Survey Information Circular 74, 62 p., 2 pl.

Clarke, J.S., Hacke, C.M., and Peck, M.F., 1990, Geology and Ground-Water Resources of the Coastal Plain of Georgia: Georgia Geologic Survey Bulletin 113, 116 p., 12 pl.

Clarke, J.S., Falls, W.F., Edwards, L.E., Fredriksen, N.O., Bybell, L.M., Gibson, T.G., Gohn, G.S., and Fleming, F., 1996, Hydrogeologic Data and Aquifer Interconnection in a Multi-Aquifer System in Coastal Plain Sediments Near Millhaven, Screven County, Georgia: Georgia Geologic Survey Information Circular 99, 49 p., 1 pl.

Cressler, C.W., Franklin, M.A., and Hester, W.G., 1976, Availability of Water Supplies in Northwest Georgia: Georgia Geologic Survey Bulletin 91, 140 p.

Cressler, C.W., Blanchard, Jr., H.E., and Hester, W.G., 1979, Geohydrology of Bartow, Cherokee, and Forsyth Counties, Georgia: Georgia Geologic Survey Information Circular 50, 45 p., 5 pl.

Crews, P.A. and Huddlestun, P.F., 1984, Geologic Sections of the Principal Artesian Aquifer System, in Hydrogeologic Evaluation for Underground Injection Control in the Coastal Plain of Georgia: Georgia Geologic Survey Hydrologic Atlas 10, 41 pl.

Davis, K.R., Donahue, J.C., Hutcheson, R.H., and Waldrop, D.L., 1989, Most Significant Ground-Water Recharge Areas of Georgia: Georgia Geologic Survey Hydrologic Atlas 19, 1 pl.

Davis, K.R., 1990, Water Quality in Georgia for 1988: Georgia Geologic Survey Circular 12E, 99 p.

Daniel III, C.C., and Harned, D., 1997: Ground-Water Recharge to and Storage in the Regolith-Crystalline Rock Aquifer System, Guilford County, North Carolina: USGS Water Resources Investigations Report 97-4140, 65 p.

Donahue, J.C., Kibler, S.R., and Chumbley, A.W., 2012, An Investigation of the Occurrence of Uranium in Ground Water in Georgia: Watershed Protection Branch Circular 12W, 105 p.

Donahue, J.C., Kibler, S.R., and Chumbley, A.W.,2013, An Investigation of the Occurrence of Arsenic in Ground Water in the Gulf Trough Area of Georgia: Watershed Protection Branch Circular 12X, 69 p.

EPD, 1991, A Ground-Water Management Plan for Georgia: Georgia Geologic Survey Circular 11 (1991 edition).

EPD, 1998, A Ground-Water Management Plan for Georgia: Georgia Geologic Survey Circular 11 (1998 edition).

EPD, 2009, State of Georgia Environmental Rule 391-3-5: Rules for Safe Drinking Water.

Foyle, A.M., Henry, V.J., and Alexander, C.R., 2001, The Miocene Aquitard and the Floridan Aquifer of the Georgia/South Carolina Coast: Geophysical Mapping of Potential Seawater Intrusion Sites: Georgia Geologic Survey Bulletin 132, 61 p., 4 pl.

Gaskin, J., Vendrell, P. F., and Atiles, J. H., 2003, Your Household Water Quality: Nitrate in Water. Univ. of Georgia Cooperative Extension Service Circular 858-5, 1 p.

Gorday, L.L., Lineback, J.A., Long, A.F., and McLemore, W.H., 1997, A Digital Model Approach to Water-Supply Management of the Claiborn,Clayton, and Providence Aquifers in Southwestern Georgia, Georgia Geologic Survey Bulletin 118, 31 p., Appendix, Supplements and II.

Hayes, L.R., Maslia, M.L., and Meeks, W.C, 1983, Hydrology and Model Evaluation of the Principal Artesian Aquifer, Dougherty Plain, Southwest Georgia: Georgia Geologic Survey Bulletin 97, 93 p.

Heath, R.C., 1980, Basic Elements of Ground-Water Hydrology with Reference to Conditions in North Carolina: USGS Open File Report 80-44, 87 p.

Hetrick, J.H., 1990, Geologic Atlas of the Fort Valley Area: Georgia Geologic Survey Geologic Atlas 7, 2 pl.

Hetrick, J.H., 1992, Geologic Atlas of the Wrens-Augusta Area: Georgia Geologic Survey Geologic Atlas 8, 3 pl.

Hicks, D.W., Krause, Clarke, J.S., 1981, Geohydrology of the Albany Area, Georgia: Georgia Geologic Survey Information Circular 57, 31 p.

Huddlestun, 1988, A Revision of the Lithostratigraphic Units of the Coastal Plain of Georgia: The Miocene through Holocene, Georgia Geologic Survey Bulletin 104, 162 p., 3 pl.

Huddlestun, P.F., 1993, A Revision of the Lithostratigraphic Units of the Coastal Plain of Georgia: the Oligocene: Georgia Geologic Survey Bulletin 104, 152 p. 5 pl.

Huddlestun, P.F., and Summerour, J., H., 1996, The Lithostratigraphic Framework of the Uppermost Cretaceous and Lower Tertiary of Burke County, Georgia: Georgia Geologic Survey Bulletin 127, 94 p., 1 pl.

Kellam, M.F., and Gorday, L.L., 1990, Hydrogeology of the Gulf Trough- Apalachicola Embayment Area, Georgia: Georgia Geologic Survey Bulletin 94, 74 p., 15 pl.

Krause, R.E., 1979, Geohydrology of Brooks, Lowndes, and Western Echols Counties, Georgia: United States Geological Survey Water-Resources Investigations 78-117, 48 p., 8 pl.

Krause, R.E., and Clarke, J.S., 2001, Coastal Ground Water at Risk – Saltwater Contamination at Brunswick, Georgia, and Hilton Head Island, South Carolina: United States Geological Survey Water-Resources Investigations Report 01-4107, 1 pl.

Long, A.F., 1989, Hydrogeology of the Clayton and Claiborne Aquifer Systems: Georgia Geologic Survey Hydrologic Atlas 19, 6 pl.

McFadden, S.S., and Perriello, P.D., 1983, Hydrogeology of the Clayton and Claiborne Aquifers of Southwestern Georgia: Georgia Geologic Survey Information Circular 55, 59 p., 2 pl.

Madison, R.J., and Brunett, J.O., 1984, Overview of the Occurrence of Nitrate in Ground Water of the United States in National Water Summary 1984 - Hydrologic Events, Selected Water-Quality Trends, and Ground-Water Resources:, United States Geological Survey Water Supply Paper 2275, p. 93-105.

O'Connell, D.B., and Davis, K.R., 1991, Ground-Water Quality in Georgia for 1989: Georgia Geologic Survey Circular 12F, 115 p.

Turner-Peterson, C.E. and Hodges, C. A.,1986, Descriptive Model of Sandstone U, Model 30c, in Mineral Deposit Models: Deposits in Clastic Sedimentary Rocks, Cox, D.P. and Singer, D. E., eds., USGS Bulletin 1693, on-line pdf. publication.

Pollard, L.D., and Vorhis, R.C., 1980, The Geology of the Cretaceous Aquifer System in Georgia: Georgia Geologic Survey Hydrologic Atlas 3, 5 pl.

Summerour, J.H., Shapiro, E.A., Lineback, J.A., Huddlestun, P.F., and Hughes, A.C., 1994, An Investigation of Tritium in the Gordon and Other Aquifers in Burke County, Georgia: Georgia Geologic Survey Information Circular 95, 93 p.

Tuohy, M. A., 1984, Isopach Map of the Claiborne Aquifer , in Hydrogeologic Evaluation for Underground Injection Control in the Coastal Plain of Georgia: Georgia Geologic Survey Hydrologic Atlas 10, 41 pl.

Vincent, R.H., 1982, Geohydrology of the Jacksonian Aquifer in Central and East Central Georgia: Georgia Geologic Survey Hydrologic Atlas 8, 3 pl.

Williams, L.J., 2007, Hydrology and Potentiometric Surface of the Dublin and Midville Aquifer Systems in Richmond County, Georgia, January 2007: U.S. Geological Survey Scientific Investigations Map 2983, 1 sheet.

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	mdcb	= m-dichlorobenzene
bdcm	= bromodichloromethane	odcb	= o-dichlorobenzene
dbcm	= dibromochloromethane	pdcb	= p-dichlorobenzene
pce	= tetrachloroethylene	tbm	= bromoform
cb	= chlorobenzene	tcm	= chloroform
MTBE	= methyl tert-butyl ether	tce	= trichloroethylene

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. Groundwater 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	03/09/16	6.39	164	9.53	18.61	ND	ND	11	0.52	2.60
GWN-K6 Twiggs	Kaolin Well #6	400	NG	NG	06/01/16	5.32	48	7.34	20.20	ND	ND	ND	0.03	ND
GWN-K7 Jones	Jones County #4	128	NG	NG	06/01/16	4.88	33	5.87	17.84	ND	ND	ND	0.60	ND
GWN-K9A Macon	Marshallville Well #2	550	NG	NG	01/27/16	3.99	49	NA	18.49	ND	ND	10	0.04	ND
GWN-K10B Peach	Fort Valley Well #6	600	NG	NG	01/27/16	4.89	20	8.07	18.07	ND	ND	ND	0.73	ND
GWN-K11A Houston	Warner Robins Well #2	540	NG	NG	06/01/16	4.19	25	7.01	19.75	ND	ND	ND	0.84	ND
GWN-K12 Houston	Perry/Holiday Inn Well	550	NG	NG	01/27/16	5.25	45	8.13	16.38	ND	ND	ND	ND	0.08
GWN-K19 Richmond	Hephzibah/Murphy Street Well	484	NG	NG	05/03/16	4.81	16	7.97	19.96	ND	ND	ND	0.13	ND
GWN-K20 Sumter	Plains Well #7	1000	NG	NG	01/26/16	7.89	120	0.85	28.94	ND	ND	ND	ND	0.18
GWN-BUR2 Burke	Keysville #1	NG	NG	NG	05/03/16	4.76	14	9.81	20.47	ND	ND	ND	0.08	ND
GWN-CHT1 Chattahoochee	Camp Darby Well	NG	NG	NG	09/27/16	6.08	55	1.86	21.70	ND	ND	10	ND	0.05
GWN-GLA1 Glascock	Mitchell #3	NG	NG	NG	02/24/16	4.58	35	8.61	19.48	ND	ND	ND	2.10	ND
GWN-MAC1 Macon	Whitewater Creek PK #1	NG	NG	NG	03/23/16	6.09	60	NA	18.64	ND	ND	ND	ND	0.26
GWN-MAR1 Marion	Unimin #1	150	NG	NG	04/20/16	5.31	134	3.52	20.03	ND	ND	35	0.37	ND
GWN-STW1 Stewart	Louvale Community Well	NG	NG	NG	03/08/16	4.74	35	7.36	18.38	ND	ND	ND	ND	ND
GWN-TAL1 Talbot	Junction City Well #2	300	NG	NG	03/23/16	8.83	219	1.02	21.14	ND	ND	37	ND	ND
GWN-TAY1 Taylor	Potterville Community Well	310	NG	NG	03/23/16	4.57	26	9.58	18.72	ND	ND	ND	0.38	ND

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

Station No. / County	Chromium ug/L	Nickel ug/L	Copper ug/L	Zinc ug/L	Arsenic ug/L	Selenium ug/L	Molybdenum ug/L	Silver ug/L	Cadmium ug/L	Tin ug/L	Antimony ug/L	Barium ug/L	Thallium ug/L	Lead 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	ND	ND	ND	ND	ND	ND	ND	ND	ND	19	ND	ND	NA	ND	ND	21,000	ND	1,100	ND	1,400	37	6,900	ND	ND
GWN-K6 Twiggs	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	16	ND	ND	NA	ND	ND	4,300	ND	60	ND	ND	ND	3,300	ND	ND
GWN-K7 Jones	7.0	ND	ND	ND	ND	14	ND	ND	ND	ND	ND	20	ND	ND	NA	ND	ND	2,500	ND	ND	ND	ND	17	2,400	ND	ND
GWN-K9A Macon	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.4	ND	1.5	NA	330	ND	ND	ND	220	ND	ND	ND	1,100	ND	ND
GWN-K10B Peach	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.7	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND	1,300	ND	ND
GWN-K11A Houston	ND	ND	9.3	11	ND	ND	ND	ND	ND	ND	ND	6.3	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND	1,900	ND	ND
GWN-K12 Houston	ND	ND	10	ND	ND	ND	ND	ND	ND	ND	ND	5.6	ND	ND	NA	350	ND	5,400	ND	110	ND	ND	ND	1,300	ND	ND
GWN-K19 Richmond	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5.8	ND	ND	NA	ND	ND	ND	ND	23	ND	ND	ND	1,200	ND	ND
GWN-K20 Sumter	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND	3,000	ND	ND	ND	ND	ND	26,000	ND	ND
GWN-BUR2 Burke	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8.4	ND	ND	NA	ND	ND	ND	ND	24	ND	ND	ND	1,200	ND	ND
GWN-CHT1 Chattahoochee	ND	ND	6.7	21	ND	ND	ND	ND	ND	ND	ND	71	ND	1.3	NA	ND	ND	3,500	ND	1,400	ND	1,200	23	1,600	ND	ND
GWN-GLA1 Glascock	ND	ND	7.3	ND	ND	ND	ND	ND	ND	ND	ND	9.5	ND	ND	NA	ND	ND	1,200	ND	ND	ND	ND	ND	5,000	ND	ND
GWN-MAC1 Macon	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	47	ND	ND	NA	ND	ND	6,500	ND	940	ND	ND	17	1,100	ND	ND
GWN-MAR1 Marion	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.2	ND	ND	NA	ND	ND	ND	ND	38	ND	ND	ND	26,000	ND	ND
GWN-STW1 Stewart	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	31	ND	ND	NA	ND	ND	ND	ND	1,500	ND	ND	20	1,600	ND	ND
GWN-TAL1 Talbot	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.7	ND	ND	NA	ND	ND	14,000	ND	ND	ND	ND	10	31,000	ND	ND
GWN-TAY1 Taylor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.8	ND	ND	NA	ND	ND	ND	ND	140	ND	ND	ND	1,300	ND	ND

Table A-1. Groundwater 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-PD2A Webster	Preston Well #4	205	NG	NG	03/23/16	5.27	42	8.85	19.26	ND	ND	ND	2.00	0.02
GWN-PD3 Clay	Fort Gaines Well #2	456	NG	NG	03/08/16	8.72	387	8.02	21.56	ND	ND	ND	ND	0.03
GWN-PD6 Early	Blakely Well #4	1025	NG	NG	03/08/16	8.62	348	0.89	25.46	ND	ND	13	ND	0.02
GWN-STW2 Stewart	Providence Canyon SP Well	NG	NG	NG	06/28/16	6.83	144	8.95	20.98	ND	ND	11	ND	0.15
GWN-WEB1 Webster	Weston Well #1	NG	NG	NG	01/26/16	7.45	315	2.71	18.38	ND	ND	ND	0.38	0.04
	Aquifer Low Range					3.99	14	0.85	16.38		ND	ND	ND	ND
	Aquifer High Range					8.83	387	9.81	28.94		ND	37	2.10	2.80
	Aquifer Median (ND=0)					5.29	49	7.67	19.62		ND	ND	0.06	ND
	Aquifer Mean (ND=0)					5.88	106	6.29	20.11		ND	6	0.37	0.16

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

Station No. / County	Chromium ug/L	Nickel ug/L	Copper ug/L	Zinc ug/L	Arsenic ug/L	Selenium ug/L	Molybdenum ug/L	Silver ug/L	Cadmium ug/L	Tin ug/L	Antimony ug/L	Barium ug/L	Thallium ug/L	Lead 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-PD2A Webster	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	19.9	ND	ND	NA	ND	ND	3,700	ND	52	ND	1,100	ND	1,500	ND	ND
GWN-PD3 Clay	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.2	ND	ND	NA	ND	ND	6,300	ND	34	ND	1,200	ND	83,000	ND	ND
GWN-PD6 Early	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	6.3	ND	ND	NA	ND	ND	8,200	ND	ND	ND	4,200	ND	68,000	ND	ND
GWN-STW2 Stewart	ND	ND	ND	210	ND	ND	ND	ND	ND	ND	ND	7.4	ND	ND	NA	ND	ND	21,000	ND	1,300	ND	1,100	12	9,200	ND	ND
GWN-WEB1 Webster	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	17	ND	ND	NA	ND	ND	63,000	ND	ND	ND	1,600	ND	1,800	ND	ND
Aquifer Low Range												ND				ND		ND		ND	ND	ND	ND	1,100		
Aquifer High Range												71.0				350		63,000		1,500	ND	4,200	37	83,000		
Aquifer Median (ND=0)												6.9				ND		3,250		36	ND	ND	ND	1,850		
Aquifer Mean (ND=0)												14.3				31		7,436		316	ND	536	6	12,623		

Table A-2. Groundwater 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-CTB Schley	Weatherby House Well	80	NG	NG	04/20/16	4.39	47	8.37	17.93	ND	ND	ND	1.6	ND
GWN-SUM1 Sumter	Briarpatch MHP Well #1	NG	NG	NG	03/23/16	5.20	71	9.71	19.61	ND	10	ND	2.0	ND
GWN-SUM2 Sumter	Andersonville #1	230	NG	8	01/26/16	3.69	220	1.42	19.51	ND	ND	72	0.37	ND
	Aquifer Low Range					3.69	47	1.42	17.93		ND	ND	0.37	ND
	Aquifer High Range					5.20	220	9.71	19.61		10	72	2.00	ND
	Aquifer Median (ND=0)					4.39	71	8.37	19.51		ND	ND	1.60	ND
	Aquifer Mean (ND=0)					4.43	113	6.50	19.02		3	24	1.32	ND

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

Station No. / County	Chro-mium ug/L	Nick-el ug/L	Cop-per ug/L	Zinc ug/L	Arsen-ic ug/L	Selen-ium ug/L	Molyb-denum ug/L	Silver ug/L	Cad-mium ug/L	Tin ug/L	Anti-mony ug/L	Barium ug/L	Thal-lium ug/L	Lead 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-CT8 Schley	ND	ND	17	ND	ND	ND	ND	ND	ND	ND	ND	17	ND	ND	NA	90	ND	ND	ND	ND	ND	ND	18	3,000	ND	ND
GWN-SUM1 Sumter	ND	ND	18	18	ND	ND	ND	ND	ND	ND	ND	18	ND	1.5	NA	ND	ND	ND	ND	35	ND	ND	21	9,200	ND	ND
GWN-SUM2 Sumter	ND	10	5.2	36	ND	ND	ND	ND	ND	ND	ND	100	ND	4.6	NA	1,200	ND	17,000	ND	230	ND	8,600	110	2,700	ND	ND
Aquifer Low Range												17				ND		ND		ND	ND	ND	18	2,700		
Aquifer High Range												100				1,200		17,000		230	ND	8,600	110	9,200		
Aquifer Median (ND=0)												18				90		ND		35	ND	ND	21	3,000		
Aquifer Mean (ND=0)												45				430		5,667		88	ND	2,867	50	4,967		

Table A-3. Groundwater 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	01/27/16	7.34	208	6.84	19.66	ND	ND	ND	0.47	ND
GWN-CL4A Sumter	Plains Well #8	230	NG	NG	01/26/16	7.20	154	NA	19.65	ND	ND	11	ND	0.37
GWN-CL8 Dooly	Flint River Nursery Office Well	90	NG	NG	01/27/16	6.07	88	0.65	19.81	ND	ND	ND	ND	0.53
	Aquifer Low Range					6.07	88	0.65	19.65		ND	ND	ND	ND
	Aquifer High Range					7.34	208	6.84	19.81		ND	11	0.47	0.53
	Aquifer Median (ND=0)					7.20	154	3.75	19.66		ND	ND	ND	0.37
	Aquifer Mean (ND=0)					6.87	150	3.75	19.71		ND	4	0.16	0.30

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

Station No. County	Chromium ug/L	Nickel ug/L	Copper ug/L	Zinc ug/L	Arsenic ug/L	Selenium ug/L	Molybdenum ug/L	Silver ug/L	Cadmium ug/L	Tin ug/L	Antimony ug/L	Barium ug/L	Thallium ug/L	Lead 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	11	ND	ND	NA	ND	ND	42,000	ND	ND	ND	ND	ND	1,400	ND	ND
GWN-CL4A Sumter	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	11	ND	ND	NA	ND	ND	22,000	ND	2,000	ND	3,300	54	1,800	ND	ND
GWN-CL8 Dooly	ND	ND	ND	11	ND	ND	ND	ND	ND	ND	ND	40	ND	ND	NA	ND	ND	12,000	ND	570	ND	1,400	52	1,900	ND	ND
Aquifer Low Range												11				ND		12,000		ND	ND	ND	ND	1,400		
Aquifer High Range												40				ND		42,000		2,000	ND	3,300	54	1,900		
Aquifer Median (ND=0)												11				ND		22,000		570	ND	1,400	52	1,800		
Aquifer Mean (ND=0)												21				ND		25,333		667	ND	1,567	35	1,700		

Table A-4. Groundwater 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	02/24/16	7.13	225	4.83	19.03	ND	ND	ND	2.3	0.06
GWN-J4 Johnson	Wrightsville #4	520	NG	8	03/09/16	7.81	266	2.32	19.82	tcm=1.1 bdcm=1.1 dbcm=0.97	ND	ND	0.31	0.03
GWN-J5 Bleckley	Cochran #3	307	NG	NG	03/22/16	7.63	351	1.19	20.37	ND	ND	12	ND	0.03
GWN-J6 Jefferson	Wrens #4	200	NG	NG	02/24/16	7.29	221	0.88	19.31	ND	ND	13	ND	0.15
GWN-J8A Jefferson	Kahn House Well II	100	NG	NG	02/24/16	7.45	224	2.27	18.12	ND	ND	ND	ND	0.03
GWN-JEF1 Jefferson	Bartow #1	345	NG	NG	06/02/16	7.49	317	6.94	19.99	ND	ND	ND	ND	0.03
GWN-WAS1 Washington	Harrison #1	NG	NG	NG	03/09/16	7.71	296	3.58	19.80	ND	ND	ND	0.31	0.03
GWN-WAS2 Washington	Riddleville #1	NG	NG	NG	03/09/16	7.64	309	9.98	19.86	ND	ND	ND	0.08	0.02
	Aquifer Low Range					7.13	221	0.88	18.12		ND	ND	ND	0.02
	Aquifer High Range					7.81	351	9.98	20.37		ND	13	2.30	0.15
	Aquifer Median (ND=0)					7.56	291	2.95	19.81		ND	ND	0.04	0.03
	Aquifer Mean (ND=0)					7.52	279	4.00	19.54		ND	3	0.38	0.05

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

Station No. / County	Chromium ug/L	Nickel ug/L	Copper ug/L	Zinc ug/L	Arsenic ug/L	Selenium ug/L	Molybdenum ug/L	Silver ug/L	Cadmium ug/L	Tin ug/L	Antimony ug/L	Barium ug/L	Thallium ug/L	Lead 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	19	ND	ND	NA	ND	ND	45,000	ND	34	ND	ND	ND	3,300	ND	ND
GWN-J4 Johnson	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	20	ND	ND	NA	ND	ND	54,000	ND	ND	ND	2,500	ND	3,300	ND	ND
GWN-J5 Bleckley	ND	ND	ND	53	ND	ND	ND	ND	ND	ND	ND	9.0	ND	ND	NA	ND	ND	67,000	ND	ND	ND	2,600	62	3,200	ND	ND
GWN-J6 Jefferson	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	6.9	ND	ND	NA	ND	ND	55,000	ND	170	ND	1,600	ND	2,100	ND	ND
GWN-J8A Jefferson	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9.2	ND	ND	NA	ND	ND	68,000	ND	ND	ND	1,100	13	3,200	ND	ND
GWN-JEF1 Jefferson	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND	62,000	ND	99	ND	2,200	67	3,200	ND	ND
GWN-WAS1 Washington	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	88	ND	ND	NA	ND	ND	58,000	ND	ND	ND	2,300	ND	3,200	ND	ND
GWN-WAS2 Washington	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	31	ND	ND	NA	ND	ND	61,000	ND	ND	ND	1,300	ND	2,400	ND	ND
Aquifer Low Range												ND				ND		45,000		ND	ND	ND	ND	2,100		
Aquifer High Range												88.0				ND		68,000		170	ND	2,600	67	3,300		
Aquifer Median (ND=0)												14.1				ND		59,500		ND	ND	1,900	ND	3,200		
Aquifer Mean (ND=0)												22.9				ND		58,750		38	ND	1,700	18	2,988		

Table A-5. Groundwater Quality Analyses for Floridan Stations.
Part A: Station Identification , Date of Sampling, Field Parameters, VOCs, Anions, and Non-Metals.

Station No. County	Well Name	Well Depth feet	Casing Depth feet	Well Size Inches	Date sampled	pH	cond. uS/cm	diss O2 mg/L	Temp °C	VOCS ug/L	Cl mg/L	SO4 mg/L	NOx mg N/L	P mg/L
GWN-PA2 Chatham	Savannah Well #13	1004	NG	NG	07/28/16	8.04	252	0.72	23.32	ND	ND	ND	ND	0.03
GWN-PA4 Chatham	Tybee Island Well #1	402	NG	NG	07/28/16	7.96	635	0.73	22.97	ND	41	130	ND	0.02
GWN-PA5 Liberty	Interstate Paper Well #1	810	NG	NG	07/27/16	7.90	319	0.73	24.47	ND	ND	32	ND	0.02
GWN-PA6 Liberty	Hinesville Well #5	806	NG	NG	07/27/16	7.94	283	3.28	24.72	ND	ND	22	ND	0.02
GWN-PA9C Glynn	Miller Ball Park North East Well	1211	NG	NG	06/15/16	8.04	1,900	0.73	25.58	ND	880	270	ND	0.02
GWN-PA13 Ware	Waycross Well #3	775	NG	NG	04/19/16	7.97	405	0.89	25.41	ND	13	48	ND	0.02
GWN-PA14A Bulloch	Statesboro Well #4	413	NG	NG	03/22/16 06/14/16 09/07/16 12/07/16	8.01 8.13 7.96 7.84	240 247 244 251	NA NA NA NA	21.59 23.62 22.74 22.76	ND ND ND ND	ND ND ND ND	ND ND ND ND	0.04 ND ND ND	0.17 0.03 0.06 0.03
GWN-PA16 Jenkins	Millen Well #1	500	NG	NG	06/02/16	7.74	289	0.72	21.44	ND	ND	ND	ND	0.02
GWN-PA17 Emanuel	Swainsboro Well #7	260	NG	NG	06/02/16	7.72	253	3.48	24.11	tcm=0.67 bdcm=0.84 dbcm=0.66	ND	ND	0.04	0.05
GWN-PA18 Candler	Metter Well #2	540	NG	NG	06/02/16	8.05	221	6.09	21.79	ND	ND	ND	ND	0.02
GWN-PA20 Lanier	Lakeland Well #2	340	NG	NG	04/19/16	7.94	358	6.76	22.13	ND	ND	64	ND	0.09
GWN-PA22 Thomas	Thomasville Well #6	400	NG	NG	04/19/16	7.93	412	4.24	22.20	ND	ND	66	0.22	0.02

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

Station No. County	Chro- mium ug/L	Nick- el ug/L	Cop- per ug/L	Zinc ug/L	Arsen- ic ug/L	Selen- ium ug/L	Molyb- denum ug/L	Silver ug/L	Cad- mium ug/L	Tin ug/L	Anti- mony ug/L	Barium ug/L	Thal- lium ug/L	Lead 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-PA2 Chatham	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9.6	ND	ND	NA	ND	ND	24,000	ND	ND	ND	9,900	ND	18,000	ND	ND
GWN-PA4 Chatham	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8.5	ND	ND	NA	ND	ND	37,000	ND	ND	5,300	32,000	ND	60,000	ND	ND
GWN-PA5 Liberty	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	36	ND	ND	NA	ND	ND	27,000	ND	ND	ND	17,000	ND	18,000	ND	ND
GWN-PA8 Liberty	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	27	ND	ND	NA	ND	ND	28,000	ND	ND	ND	14,000	ND	16,000	ND	ND
GWN-PA9C Glynn	ND	ND	ND	310	ND	12.0	ND	ND	ND	ND	ND	53	ND	ND	NA	ND	ND	110,000	ND	1,000	9,400	85,000	ND	460,000	ND	ND
GWN-PA13 Ware	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	72	ND	ND	NA	ND	ND	43,000	ND	ND	ND	19,000	ND	17,000	ND	ND
GWN-PA14A Bulloch	ND	ND	35	24	ND	ND	ND	ND	ND	ND	ND	6.9	ND	1.1	NA	ND	ND	35,000	ND	ND	ND	6,800	ND	7,800	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.6	ND	ND	NA	ND	ND	32,000	ND	ND	ND	6,600	ND	7,400	ND	ND
	ND	ND	7.3	ND	ND	ND	ND	ND	ND	ND	ND	7.7	ND	ND	NA	ND	ND	35,000	ND	ND	ND	7,000	ND	8,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4	ND	ND	NA	ND	ND	35,000	ND	ND	ND	6,900	ND	7,300	ND	ND
GWN-PA16 Jenkins	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.2	ND	ND	NA	ND	ND	50,000	ND	ND	ND	3,700	51	5,600	ND	ND
GWN-PA17 Emanuel	ND	ND	5.6	ND	ND	ND	ND	ND	ND	ND	ND	170	ND	2.2	NA	ND	ND	48,000	ND	43	ND	1,800	ND	3,300	ND	ND
GWN-PA18 Candler	ND	ND	ND	ND	ND	5.8	ND	ND	ND	ND	ND	25	ND	ND	NA	ND	ND	32,000	ND	ND	ND	3,800	64	11,000	ND	ND
GWN-PA20 Lanier	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	25	ND	ND	NA	ND	ND	46,000	ND	160	ND	19,000	11	4,900	ND	ND
GWN-PA22 Thomas	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	25	ND	ND	NA	ND	ND	47,000	ND	ND	ND	23,000	ND	8,000	ND	ND

Table A-5, Continued. Groundwater 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	01/12/16	7.85	373	9.11	22.56	tcm=2.2 bdcm=1.2 dbcm=1.3 tbm=0.62	ND	45	0.02	ND
					04/05/16	7.93	345	2.98	22.86	tcm=3.0 bdcm=1.7 dbcm=1.8 tbm=0.50	ND	37	ND	ND
					07/12/16	7.81	372	0.96	23.30	tcm=0.82	ND	48	ND	ND
					10/13/16	7.79	359	8.34	23.00	ND	ND	39	ND	ND
GWN-PA25 Seminole	Donalsonville / 7th Street Well	174	NG	NG	03/08/16	7.62	316	7.07	21.14	ND	ND	ND	1.8	ND
					06/28/16	7.58	277	7.46	21.31	ND	ND	ND	1.8	ND
					09/27/16	7.68	308	4.21	21.02	ND	ND	ND	1.8	ND
					12/06/16	7.33	313	8.88	20.82	ND	ND	ND	1.7	ND
GWN-PA27 Mitchell	Camilla Industrial Park Well	360	NG	NG	04/19/16	7.86	235	1.95	20.23	ND	ND	ND	0.25	ND
GWN-PA28 Colquitt	Moultrie Well #1	750	NG	NG	01/12/16	8.06	463	6.68	23.40	ND	11	99	ND	ND
					04/05/16	8.00	554	5.15	23.47	tcm=1.9 bdcm=1.6 dbcm=2.0 tbm=1.1	14	160	ND	ND
					07/12/16	7.99	468	1.95	24.03	ND	11	110	ND	ND
					10/13/16	7.77	460	6.39	23.49	ND	ND	98	ND	ND
GWN-PA29 Cook	Adel Well #6	405	NG	NG	01/12/16	7.88	391	3.48	21.84	ND	ND	74	ND	0.05
					04/05/16	7.90	378	1.12	21.85	ND	ND	71	ND	0.05
					07/12/16	7.90	370	5.14	22.04	ND	ND	71	ND	0.05
					10/13/16	7.68	375	0.76	21.61	ND	ND	69	ND	0.05
GWN-PA31 Tift	Tifton Well #8	652	NG	NG	05/19/16	7.82	279	5.33	21.73	ND	ND	ND	ND	0.03
GWN-PA32 Irwin	Ocilla Well #3	637	NG	NG	05/19/16	8.03	212	6.59	20.98	ND	ND	ND	ND	0.02
GWN-PA34A Telfair	McRae Well #3	600	NG	NG	03/22/16	7.69	335	8.09	22.37	ND	ND	ND	ND	ND
					06/14/16	7.69	321	0.90	22.40	ND	ND	ND	ND	ND
					09/07/16	7.47	343	7.64	22.15	ND	ND	ND	ND	ND
					12/07/16	7.40	333	5.53	22.05	ND	ND	ND	ND	ND
GWN-PA36 Toombs	Vidalia Well #1	808	NG	NG	03/22/16	8.14	231	1.14	22.92	ND	ND	ND	ND	ND
					06/14/16	8.18	229	4.67	23.52	ND	ND	ND	ND	0.02
					09/07/16	7.88	237	0.62	22.90	ND	ND	ND	ND	0.02
					12/07/16	7.81	233	0.55	22.72	ND	ND	ND	ND	0.02

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

Station No. / County	Chromium ug/L	Nickel ug/L	Copper ug/L	Zinc ug/L	Arsenic ug/L	Selenium ug/L	Molybdenum ug/L	Silver ug/L	Cadmium ug/L	Tin ug/L	Antimony ug/L	Barium ug/L	Thallium ug/L	Lead 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	ND	ND	7.6	ND	38	ND	ND	ND	ND	120	ND	ND	NA	ND	ND	38,000	ND	58	ND	19,000	ND	14,000	ND	ND
	ND	ND	ND	ND	9.2	ND	36	ND	ND	ND	ND	110	ND	ND	NA	ND	ND	37,000	ND	54	ND	19,000	ND	13,000	ND	ND
	ND	ND	ND	ND	5.2	ND	26	ND	ND	ND	ND	120	ND	ND	NA	ND	ND	38,000	ND	ND	ND	19,000	ND	15,000	ND	ND
	ND	ND	ND	ND	8.0	ND	38	ND	ND	ND	ND	120	ND	ND	NA	ND	ND	38,000	ND	51	ND	18,000	ND	12,000	ND	ND
GWN-PA25 Seminole	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	6.9	ND	ND	NA	ND	ND	63,000	ND	ND	ND	ND	ND	3,700	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8.9	ND	ND	NA	65	ND	60,000	ND	ND	ND	ND	ND	3,700	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8.5	ND	ND	NA	ND	ND	63,000	ND	ND	ND	ND	ND	3,800	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	7.9	ND	ND	NA	ND	ND	59,000	ND	ND	ND	ND	ND	3,400	ND	ND
GWN-PA27 Mitchell	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	12	1.4	ND	NA	ND	ND	44,000	ND	ND	ND	1,400	ND	1,800	ND	ND
GWN-PA28 Colquitt	ND	ND	ND	ND	ND	ND	31	ND	ND	ND	ND	87	ND	ND	NA	ND	ND	35,000	ND	ND	ND	22,000	ND	25,000	ND	ND
	ND	ND	ND	ND	5.3	ND	41	ND	ND	ND	ND	76	ND	ND	NA	ND	ND	56,000	ND	27	ND	30,000	ND	29,000	ND	ND
	ND	ND	ND	ND	ND	ND	39	ND	ND	ND	ND	97	ND	ND	NA	ND	ND	39,000	ND	ND	ND	24,000	ND	28,000	ND	ND
	ND	ND	ND	ND	ND	ND	27	ND	ND	ND	ND	89	ND	ND	NA	ND	ND	36,000	ND	ND	ND	22,000	ND	28,000	ND	ND
GWN-PA29 Cook	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	12	ND	ND	NA	ND	ND	52,000	ND	32	ND	19,000	15	3,500	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	12	ND	ND	NA	ND	ND	51,000	ND	56	ND	19,000	16	3,400	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	13	ND	ND	NA	ND	ND	48,000	ND	38	ND	18,000	ND	3,900	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	12	ND	ND	NA	ND	ND	48,000	ND	38	ND	18,000	ND	3,900	ND	ND
GWN-PA31 Tift	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	52	ND	ND	NA	ND	ND	37,000	ND	ND	ND	7,400	ND	2,100	ND	ND
GWN-PA32 Irwin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	58	ND	ND	NA	ND	ND	31,000	ND	120	ND	5,400	26	2,200	ND	ND
GWN-PA34A Telfair	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	180	ND	ND	NA	ND	ND	49,000	ND	240	ND	11,000	97	4,800	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	130	ND	ND	NA	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	180	ND	ND	NA	ND	ND	51,000	ND	260	ND	12,000	100	5,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	180	ND	ND	NA	ND	ND	50,000	ND	240	ND	12,000	100	4,600	ND	ND
GWN-PA36 Toombs	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	130	ND	ND	NA	ND	ND	29,000	ND	39	ND	6,000	38	12,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	110	ND	ND	NA	ND	ND	27,000	ND	45	ND	5,800	37	12,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	130	ND	1.0	NA	ND	ND	29,000	ND	39	ND	5,900	40	12,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	130	ND	ND	NA	ND	ND	28,000	ND	29	ND	5,800	38	11,000	ND	ND

Table A-5, Continued. Groundwater 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-PA38 Dodge	Eastman Well #4	410	NG	NG	03/22/16	7.89	236	8.44	20.56	ND	ND	ND	0.28	0.02
GWN-PA39 Worth	SylvesterWell #1	196	NG	NG	05/19/16	7.57	301	7.16	22.29	tcm=0.61	ND	ND	0.04	0.05
GWN-PA41A Turner	Ashburn #4	600	NG	NG	05/19/16	8.35	164	0.99	22.40	ND	ND	ND	ND	ND
GWN-PA44 Turner	Sycamore Well #2	501	NG	NG	01/12/16	7.77	197	8.11	21.11	ND	ND	ND	0.23	ND
					04/05/16	8.03	189	7.71	21.19	ND	ND	ND	0.24	ND
					07/12/16	7.97	187	3.60	21.34	ND	ND	ND	0.24	ND
					10/13/16	7.80	196	7.38	21.03	ND	ND	ND	0.24	0.02
GWN-PA56 Grady	Whigham / Davis Avenue Well	604	NG	NG	03/08/16	7.98	407	1.62	22.81	ND	31	18	0.06	0.02
					06/28/16	7.99	361	1.39	23.07	ND	34	19	0.06	ND
					09/27/16	8.14	403	4.77	22.86	ND	33	18	0.04	ND
					12/06/16	7.75	405	1.07	22.49	ND	32	19	0.06	ND
GWN-PA57 Coffee	Ambrose Well #2	600	465	10	01/12/16	8.18	254	4.88	22.33	ND	ND	ND	ND	ND
					04/05/16	8.07	249	0.99	22.57	ND	ND	ND	ND	ND
					07/12/16	8.02	249	0.71	22.55	ND	ND	ND	ND	ND
					10/13/16	7.72	253	1.98	22.55	ND	ND	ND	ND	ND
GWN-PA59 Dougherty	Radium Spring	0	NA	NA	05/19/16	7.48	320	7.93	20.49	tce=0.63	ND	ND	2.2	0.03
GWN-PA60 Seminole	Smith House Well	NG	NG	NG	06/28/16	7.83	185	6.62	21.18	ND	ND	ND	1.0	ND
GWN-GLY2 Glynn	Hofwyl Broadfield Well	NG	NG	NG	06/15/16	8.05	526	3.05	24.23	ND	26	100	ND	0.02
GWN-GLY3 Glynn	Jekyll Island #5	850	NG	NG	06/15/16	8.13	408	NA	22.98	ND	14	71	ND	0.02
GWN-GLY4 Glynn	Hampton River Marina	750	NG	NG	06/15/16	8.10	500	1.48	25.67	ND	24	94	ND	ND
GWN-LIB2 Liberty	Fort Morris Well	500	NG	NG	07/28/16	8.10	329	0.52	22.43	ND	ND	40	0.04	0.02
GWN-MCI1 Mcintosh	Sapelo Gardens SD #1	660	NG	NG	07/27/16	7.55	395	0.73	25.32	ND	12	61	ND	0.02
GWN-THO2 Thomas	Waverly Four Corners #1	900	NG	NG	04/19/16	8.18	254	3.80	25.57	ND	ND	ND	ND	ND
	Aquifer Low Range					7.33	164	0.52	20.23		ND	ND	ND	ND
	Aquifer High Range					8.35	1,900	9.11	25.67		880	270	2.20	0.17
	Aquifer Median (ND=0)					7.90	316	3.54	22.55		ND	ND	ND	0.02
	Aquifer Mean (ND=0)					7.88	344	3.93	22.61		18	31	0.19	0.02

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

Station No. / County	Chromium ug/L	Nickel ug/L	Copper ug/L	Zinc ug/L	Arsenic ug/L	Selenium ug/L	Molybdenum ug/L	Silver ug/L	Cadmium ug/L	Tin ug/L	Antimony ug/L	Barium ug/L	Thallium ug/L	Lead 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-PA38 Dodge	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	100	ND	ND	NA	130	ND	45,000	ND	ND	ND	1,500	ND	2,100	ND	ND
GWN-PA39 Worth	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	190	ND	ND	NA	ND	ND	46,000	ND	ND	ND	8,000	ND	3,600	ND	ND
GWN-PA41A Turner	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	65	ND	ND	NA	ND	ND	18,000	ND	ND	ND	6,500	ND	1,500	ND	ND
GWN-PA44	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	140	ND	ND	NA	ND	ND	32,000	ND	ND	ND	4,800	ND	2,300	ND	ND
Turner	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	140	ND	ND	NA	ND	ND	30,000	ND	ND	ND	4,400	ND	2,200	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	150	ND	ND	NA	ND	ND	31,000	ND	ND	ND	4,700	ND	2,500	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	140	ND	ND	NA	ND	ND	32,000	ND	ND	ND	4,800	ND	2,500	ND	ND
GWN-PA56	ND	ND	ND	ND	ND	ND	8.2	ND	ND	ND	ND	130	ND	ND	NA	ND	ND	23,000	ND	ND	ND	15,000	ND	14,000	11	ND
Grady	ND	ND	ND	ND	ND	ND	9.0	ND	ND	ND	ND	150	ND	ND	NA	ND	ND	32,000	ND	ND	ND	21,000	ND	22,000	ND	ND
	ND	ND	ND	ND	ND	ND	8.2	ND	ND	ND	ND	140	ND	ND	NA	ND	ND	34,000	ND	ND	ND	22,000	ND	23,000	ND	ND
	ND	ND	ND	ND	ND	ND	9.3	ND	ND	ND	ND	150	ND	ND	NA	ND	ND	32,000	ND	ND	ND	20,000	ND	22,000	ND	ND
GWN-PA57	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	150	ND	ND	NA	ND	ND	24,000	ND	ND	ND	15,000	ND	7,800	ND	ND
Coffee	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	150	ND	ND	NA	ND	ND	25,000	ND	ND	ND	15,000	ND	7,800	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	190	ND	ND	NA	ND	ND	25,000	ND	ND	ND	15,000	ND	7,500	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	150	ND	ND	NA	ND	ND	24,000	ND	ND	ND	15,000	ND	8,400	ND	ND
GWN-PA59 Dougherty	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	19	ND	ND	NA	ND	ND	54,000	ND	ND	ND	1,400	ND	2,300	ND	ND
GWN-PA60 Seminole	ND	ND	ND	26	ND	ND	ND	ND	ND	ND	ND	3.3	ND	ND	NA	ND	ND	40,000	ND	ND	ND	ND	ND	2,500	ND	ND
GWN-GLY2 Glynn	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	36	ND	ND	NA	ND	ND	43,000	ND	1,200	ND	28,000	ND	29,000	ND	ND
GWN-GLY3 Glynn	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	34	ND	ND	NA	ND	ND	35,000	ND	59	ND	24,000	ND	15,000	ND	ND
GWN-GLY4 Glynn	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8.3	ND	ND	NA	ND	ND	38,000	ND	41	ND	28,000	ND	26,000	ND	ND
GWN-LIB2 Liberty	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	26	ND	ND	NA	ND	ND	29,000	ND	250	ND	18,000	ND	18,000	ND	ND
GWN-MCI1 McIntosh	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	60	ND	ND	NA	ND	ND	34,000	ND	56	ND	24,000	ND	20,000	ND	ND
GWN-THO2 Thomas	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	120	ND	ND	NA	ND	ND	22,000	ND	170	ND	15,000	ND	12,000	ND	ND
Aquifer Low Range					ND		ND					3.3						18,000		ND	ND	ND	ND	1,500		
Aquifer High Range					9.2		41.0					190.0						110,000		1,200	9,400	85,000	100	460,000		
Aquifer Median (ND=0)					ND		ND					72.0						36,000		ND	ND	14,000	ND	7,900		
Aquifer Mean (ND=0)					0.5		4.8					78.6						39,338		71	226	13,805	11	18,026		

Table A-6. Groundwater 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	09/13/16	7.83	242	2.08	23.88	ND	ND	ND	ND	0.03
GWN-MI2A Lowndes	Boutwell House Well	70	NG	NG	09/13/16	3.93	131	4.67	21.90	ND	13	ND	7.8	ND
GWN-MI9A Thomas	Murphy Garden Well	22	NG	NG	09/13/16	6.62	304	NA	23.92	ND	13	ND	20.0	0.10
GWN-MI10B Colquitt	Calhoun House Well	150	NG	NG	09/13/16	6.04	108	1.50	21.73	ND	ND	ND	ND	0.91
GWN-MI16 Liberty	Liberty County East District Fire Station Deep Well	400	NG	NG	07/28/16	7.94	309	1.03	23.16	ND	ND	33	ND	0.02
GWN-MI17 Effingham	Springfield Egypt Road Test Well	120	NG	NG	06/14/16	7.81	261	NA	19.06	ND	ND	ND	ND	ND
GWN-WAY1 Wayne	Raintree TP Main Well	400	NG	NG	07/27/16	7.72	215	1.22	22.15	ND	ND	ND	ND	0.07
	Aquifer Low Range					3.93	108	1.03	19.06		ND	ND	ND	ND
	Aquifer High Range					7.94	309	4.67	23.92		13	33	20.00	0.91
	Aquifer Median (ND=0)					7.72	242	1.79	22.15		ND	ND	ND	0.02
	Aquifer Mean (ND=0)					6.84	224	2.24	22.26		4	5	3.98	0.16

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

Station No. County	Chromium ug/L	Nickel ug/L	Copper ug/L	Zinc ug/L	Arsenic ug/L	Selenium ug/L	Molybdenum ug/L	Silver ug/L	Cadmium ug/L	Tin ug/L	Antimony ug/L	Barium ug/L	Thallium ug/L	Lead 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	42	ND	ND	ND	ND	ND	ND	ND	18	ND	ND	ND	ND	ND	23,000	ND	ND	ND	15,000	12	7,000	ND	ND
GWN-MI2A Lowndes	ND	ND	9.6	14	ND	ND	ND	ND	ND	ND	ND	29	ND	3.1	ND	190	ND	4,700	ND	20	6,800	3,400	11	5,100	ND	ND
GWN-MI9A Thomas	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	160	ND	ND	ND	65	ND	31,000	ND	23	7,900	9,800	ND	3,300	ND	ND
GWN-MI10B Colquitt	ND	ND	27	100	ND	23	ND	ND	ND	ND	ND	210	ND	4.3	ND	ND	ND	7,600	ND	11,000	ND	5,500	190	6,900	ND	ND
GWN-MI16 Liberty	ND	ND	ND	41	ND	ND	ND	ND	ND	ND	ND	26	ND	ND	ND	ND	ND	27,000	ND	ND	ND	17,000	ND	18,000	ND	ND
GWN-MI17 Effingham	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	18	ND	ND	ND	ND	ND	43,000	ND	ND	ND	1,900	12	8,300	ND	ND
GWN-WAY1 Wayne	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	29	ND	ND	ND	ND	ND	23,000	ND	ND	ND	8,800	93	11,000	ND	ND
Aquifer Low Range												18.0				ND		4,700		ND	ND	1,900	ND	3,300		
Aquifer High Range												210.0				190		43,000		11,000	7,900	17,000	190	18,000		
Aquifer Median (ND=0)												29.0				ND		23,000		ND	ND	8,800	12	7,000		
Aquifer Mean (ND=0)												70.0				36		22,757		1,578	2,100	8,771	45	8,514		

Table A-7. Groundwater 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 Meriwether	Luthersville Well #3	185	NG	NG	08/10/16	6.40	94	6.81	17.39	ND	NA	ND	ND	1.20	0.08
GWN-P5 Hall	Flowery Branch Well #1	240	NG	NG	07/22/16	6.83	181	4.87	16.50	ND	NA	ND	ND	1.10	0.03
GWN-P12A Butts	Indian Spring	0	NG	NG	02/10/16	7.44	280	NA	15.98	ND	4.7	10	23	ND	0.03
					05/04/16	7.52	256	NA	17.54	ND	4.5	ND	24	0.02	0.02
					08/23/16	7.50	264	NA	21.04	ND	4.5	10	24	ND	0.02
					11/02/16	7.33	270	NA	18.15	ND	4.5	10	22	ND	0.02
GWN-P20 Gwinnett	Suwanee #1	600	NG	NG	07/22/16	7.79	368	0.96	17.49	ND	NA	ND	12	0.18	ND
GWN-P21 Jones	Gray/Bragg Well	405	NG	NG	02/10/16	6.82	329	9.11	19.01	ND	NA	ND	25	0.16	0.03
					05/04/16	6.84	304	7.14	19.39	ND	NA	ND	27	0.14	0.03
					08/23/16	6.82	307	3.42	19.39	ND	NA	ND	24	0.15	0.03
					11/17/16	6.21	347	1.87	18.88	ND	NA	ND	37	0.34	0.03
GWN-P22 Fulton	Rahbar Well	200	NG	NG	07/21/16	5.16	37	6.64	17.47	ND	NA	ND	ND	0.94	ND
GWN-P23 Butts	Indian Springs State Park New Main Well	NG	NG	NG	02/10/16	6.61	153	2.42	17.74	ND	1.1	ND	ND	0.23	0.07
					05/04/16	6.62	137	2.35	18.16	ND	1.1	ND	ND	0.27	0.07
					08/23/16	6.64	150	8.86	18.36	ND	1.1	ND	ND	0.20	0.07
					11/02/16	6.47	152	5.10	17.98	ND	1.1	ND	ND	0.21	0.07
GWN-P24 Coweta	The Gates Well #1	705	NG	NG	09/28/16	7.28	255	1.94	18.95	ND	NA	ND	13	0.24	0.04
GWN-P25 Jones	Jarrell Plantation Staff House Well	NG	NG	NG	02/10/16	6.24	191	3.89	17.67	ND	NA	ND	ND	0.19	0.11
					05/04/16	6.42	202	6.42	18.31	ND	NA	ND	ND	0.16	0.09
					08/23/16	6.39	221	3.07	18.48	ND	NA	ND	12	0.12	0.08
					11/02/16	6.22	209	7.09	18.15	ND	NA	ND	12	0.17	0.09
GWN-P28 Coweta	Willow Court Well	NG	NG	NG	09/28/16	5.94	136	3.56	18.88	ND	NA	ND	ND	1.5	0.07
GWN-P30 Lincoln	Fizer House Well	220	NG	NG	02/09/16	6.89	475	5.89	18.75	ND	NA	25	23	3.3	0.06
GWN-P32 Elbert	Cecchini Deep Well	400	NG	NG	01/20/16	7.80	1060	0.71	15.28	ND	NA	ND	620	ND	ND
					04/06/16	7.87	820	6.42	17.39	ND	NA	ND	260	ND	ND
					07/13/16	7.87	897	0.64	20.79	ND	NA	ND	460	ND	ND
					10/18/16	7.67	899	0.81	18.80	ND	NA	ND	430	ND	ND
GWN-P33 Elbert	Cecchini Bored Well	47	NG	NG	01/20/16	6.84	130	9.09	16.73	ND	NA	ND	ND	1.20	0.03
					04/06/16	6.90	130	7.05	17.14	ND	NA	ND	ND	2.90	0.03
					07/13/16	6.09	74	9.03	18.18	ND	NA	ND	ND	1.70	ND
					10/18/16	6.36	131	8.47	17.85	ND	NA	ND	ND	1.60	0.04

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

Station No. / County	Chromium ug/L	Nickel ug/L	Copper ug/L	Zinc ug/L	Arsenic ug/L	Selenium ug/L	Molybdenum ug/L	Silver ug/L	Cadmium ug/L	Tin ug/L	Antimony ug/L	Barium ug/L	Thallium ug/L	Lead 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	53	ND	ND	NA	ND	ND	9,600	ND	ND	ND	2,600	ND	4,800	ND	ND
GWN-P5 Hall	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	38	ND	ND	NA	ND	ND	27,000	ND	ND	ND	5,400	ND	3,000	ND	ND
GWN-P12A Butts	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND	17,000	ND	ND	ND	2,900	21	40,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND	16,000	ND	ND	ND	2,800	20	39,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND	16,000	ND	ND	ND	2,800	21	40,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND.	ND	ND	ND	ND	ND	NA	ND	ND	18,000	ND	ND	ND	3,100	24	42,000	ND	ND
GWN-P20 Gwinnett	ND	ND	ND	35	ND	ND	ND	ND	ND	ND	ND	230	ND	ND	NA	ND	ND	54,000	ND	ND	ND	13,000	82	11,000	ND	ND
GWN-P21 Jones	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	15	ND	ND	ND	ND	ND	38,000	ND	ND	ND	8,800	44	17,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	16	ND	ND	ND	ND	ND	36,000	ND	ND	ND	8,200	55	16,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	14	ND	ND	ND	ND	ND	36,000	ND	ND	ND	8,400	46	16,000	ND	ND
	ND	ND	ND	28	ND	ND	ND	ND	ND	ND	ND	11	ND	ND	ND	ND	ND	41,000	ND	ND	ND	12,000	ND	16,000	ND	ND
GWN-P22 Fulton	ND	ND	110	ND	ND	ND	ND	ND	ND	ND	ND	23	ND	1.8	NA	ND	ND	1,200	ND	ND	ND	1,400	ND	2,500	ND	ND
GWN-P23 Butts	ND	ND	ND	10	ND	ND	ND	ND	ND	ND	ND	5.5	ND	ND	NA	ND	ND	12,000	ND	20	ND	3,900	ND	14,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	6.4	ND	ND	NA	ND	ND	11,000	ND	ND	ND	3,700	ND	14,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.9	ND	ND	NA	ND	ND	12,000	ND	37	ND	3,900	ND	15,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5.7	ND	ND	NA	ND	ND	13,000	ND	34	ND	4,300	ND	15,000	ND	ND
GWN-P24 Coweta	ND	ND	ND	10	ND	ND	ND	ND	ND	ND	ND	7.6	ND	ND	NA	ND	ND	35,000	ND	ND	ND	5,300	ND	12,000	ND	ND
GWN-P25 Jones	ND	ND	6.6	12	ND	ND	ND	ND	ND	ND	ND	23	ND	ND	13.5	ND	ND	13,000	ND	110	ND	5,600	58	17,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	21	ND	ND	ND	ND	ND	16,000	ND	110	ND	6,800	77	17,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	19	ND	ND	ND	ND	ND	18,000	ND	110	ND	7,300	95	18,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	21	ND	ND	13.0	ND	ND	16,000	ND	100	ND	6,800	89	17,000	ND	ND
GWN-P28 Coweta	6.0	ND	ND	ND	ND	5.5	ND	ND	ND	ND	ND	25	ND	ND	NA	ND	ND	10,000	ND	ND	ND	3,700	ND	10,000	ND	ND
GWN-P30 Lincoln	ND	ND	9.4	17	ND	ND	ND	ND	ND	ND	ND	4.2	ND	1.6	NA	380	ND	27,000	ND	510	ND	39,000	35	20,000	ND	ND
GWN-P32 Elbert	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.1	ND	ND	ND	ND	ND	260,000	ND	ND	ND	1,400	16	33,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	120,000	ND	27	ND	2,500	16	21,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.9	ND	ND	ND	ND	ND	200,000	ND	ND	ND	1,900	18	29,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	ND	ND	ND	ND	ND	160,000	ND	ND	ND	2,100	19	27,000	ND	ND
GWN-P33 Elbert	ND	ND	27	14	ND	ND	ND	ND	ND	ND	ND	24	ND	2.9	NA	470	ND	23,000	ND	360	ND	ND	ND	2,200	ND	ND
	ND	ND	14	10	ND	ND	ND	ND	ND	ND	ND	26	ND	ND	NA	280	ND	21,000	ND	240	ND	ND	ND	3,600	ND	ND
	ND	ND	9	14	ND	ND	ND	ND	ND	ND	ND	31	ND	ND	NA	81	ND	8,500	ND	65	ND	ND	ND	4,200	ND	ND
	ND	ND	13	16	ND	ND	ND	ND	ND	ND	ND	28	ND	ND	NA	ND	ND	19,000	ND	570	ND	ND	72	4,500	ND	ND

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

Station No. County	Well Name	Well Depth feet	Casing Depth feet	Well Size inches	Date sampled	pH	cond. uS/cm	diss O2 mg/L	Temp °C	VOCS ug/L	Cl mg/L	SO4 mg/L	NOx mg N/L	P mg/L
GWN-P34 Columbia	Mistletoe State Park Cottage Area Well	NG	NG	NG	02/09/16	6.14	133	8.18	18.13	ND	ND	11	0.42	0.14
					05/03/16	6.37	141	8.04	18.72	ND	ND	13	0.45	0.17
					08/22/16	6.32	146	9.09	18.85	ND	ND	13	0.52	0.18
					11/17/16	5.85	125	8.34	18.30	ND	ND	ND	0.63	0.17
GWN-P35 Franklin	O'Connor Well	150	NG	NG	01/20/16	7.11	201	0.98	16.58	ND	ND	ND	ND	0.02
					04/06/16	7.25	192	7.74	16.80	ND	ND	ND	ND	0.02
					07/13/16	7.24	193	4.92	17.23	ND	ND	ND	ND	ND
					10/18/16	6.90	195	0.60	16.86	ND	ND	ND	ND	ND
GWN-P37 Habersham	Mt. Airy/City Hall Well	500	NG	NG	01/20/16	5.56	587	8.20	16.28	ND	120	25	1.90	ND
					04/06/16	5.79	337	9.58	16.40	ND	60	19	2.00	ND
					07/13/16	6.48	348	4.54	16.69	ND	41	25	0.65	0.03
					10/18/16	6.29	380	3.49	16.38	ND	39	25	0.39	ND
GWN-P38 Carroll	Roopville Well #1	230	NG	NG	08/10/16	4.88	48	7.13	18.24	ND	ND	ND	1.8	ND
GWN-P39 Meriwether	Gay Well #1	600	NG	NG	08/10/16	6.16	69	NA	17.56	ND	ND	ND	1.1	0.06
GWN-P40 Greene	Siloam Well #2	300	NG	NG	02/09/16	5.98	98	6.76	18.59	ND	ND	ND	1.6	0.10
GWN-BAN1A Banks	Yonah Homer Road Well	445	NG	NG	05/17/16	8.21	321	1.01	19.52	ND	ND	63	0.05	ND
GWN-COU1 Columbia	Windy Acres Mobile Home Park Well #1	180	NG	NG	05/03/16	7.05	116	0.81	19.50	ND	ND	ND	ND	0.16
GWN-COU2 Columbia	Grovetown Well #1	NG	NG	NG	05/03/16	7.78	141	NA	21.06	ND	ND	13	ND	0.08
GWN-COU3 Columbia	Harlem Well #1	250	NG	NG	02/24/16	7.09	133	0.88	20.24	ND	ND	ND	ND	0.14
GWN-COU4 Columbia	Tradewinds Marina Well	NG	NG	NG	08/22/16	6.63	373	1.94	18.56	tcm=0.69 MTBE=1.1	11	ND	0.10	0.03
GWN-ELB1 Elbert	Beaverdam Mobile Home Park Well #1	250	NG	NG	04/06/16	6.41	176	9.42	16.77	ND	ND	15	1.50	0.10
GWN-FRA1 Franklin	Victoria Bryant State Park Well #101	NG	NG	NG	01/20/16	6.07	73	NA	16.68	ND	ND	ND	0.07	0.06
GWN-HAL1 Hall	Leisure Lake Village Well #1	380	NG	NG	05/17/16	7.08	241	8.09	17.27	ND	ND	26	1.3	0.03
GWN-HAS1 Harris	Valley Inn Well	NG	NG	NG	04/20/16	6.73	162	7.68	19.04	ND	ND	ND	0.02	0.03

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

Station No. / County	Chromium ug/L	Nickel ug/L	Copper ug/L	Zinc ug/L	Arsenic ug/L	Selenium ug/L	Molybdenum ug/L	Silver ug/L	Cadmium ug/L	Tin ug/L	Antimony ug/L	Barium ug/L	Thallium ug/L	Lead 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-P34	ND	ND	9.3	17	ND	ND	ND	ND	ND	ND	ND	19	ND	ND	10.4	ND	ND	8,700	ND	ND	ND	4,700	ND	10,000	ND	ND
Columbia	ND	ND	11	17	ND	ND	ND	ND	ND	ND	ND	22	ND	ND	ND	ND	ND	10,000	ND	ND	ND	5,400	ND	12,000	ND	ND
	ND	ND	ND	14	ND	ND	ND	ND	ND	ND	ND	17	ND	ND	ND	ND	ND	10,000	ND	ND	ND	5,400	ND	12,000	ND	ND
	ND	ND	5.9	10	ND	ND	ND	ND	ND	ND	ND	19	ND	ND	ND	ND	ND	7,900	ND	ND	ND	4,500	ND	11,000	ND	ND
GWN-P35	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	33	ND	ND	ND	ND	ND	23,000	ND	45	7,200	7,300	140	8,000	ND	ND
Franklin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	30	ND	ND	ND	ND	ND	19,000	ND	33	6,600	6,100	120	6,900	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	37	ND	ND	ND	ND	ND	20,000	ND	39	6,800	6,600	130	7,600	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	34	ND	ND	ND	ND	ND	21,000	ND	55	7,300	6,800	130	8,000	ND	ND
GWN-P37	ND	ND	ND	48	ND	ND	ND	ND	ND	ND	ND	83	ND	ND	NA	69	ND	44,000	ND	73	ND	15,000	120	38,000	ND	ND
Habersham	ND	ND	ND	83	ND	ND	ND	ND	ND	ND	ND	63	ND	ND	NA	ND	ND	25,000	ND	34	ND	10,000	57	16,000	ND	ND
	ND	ND	ND	11	ND	ND	ND	ND	ND	ND	ND	24	ND	ND	NA	ND	ND	42,000	ND	38	ND	9,800	96	10,000	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	22	ND	ND	NA	ND	ND	45,000	ND	88	ND	10,000	120	9,700	ND	ND
GWN-P38 Carroll	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	28	ND	ND	NA	76	ND	1,200	ND	ND	ND	ND	25	5,200	ND	ND
GWN-P39 Meriwether	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	39	ND	ND	NA	ND	ND	5,100	ND	ND	ND	1,300	ND	7,000	ND	ND
GWN-P40 Greene	ND	ND	ND	73	ND	ND	ND	ND	ND	ND	ND	21	ND	ND	NA	ND	ND	6,500	ND	ND	ND	1,500	ND	9,700	ND	ND
GWN-BAN1A Banks	ND	ND	ND	ND	ND	ND	5.6	ND	ND	ND	ND	18	ND	ND	12.5	ND	ND	36,000	ND	ND	ND	ND	ND	26,000	ND	ND
GWN-COU1 Columbia	ND	ND	ND	14	ND	ND	ND	ND	ND	ND	ND	33	ND	ND	NA	ND	ND	9,100	ND	970	ND	3,600	160	7,500	ND	ND
GWN-COU2 Columbia	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	86	ND	ND	NA	ND	ND	11,000	ND	61	ND	3,500	62	11,000	ND	ND
GWN-COU3 Columbia	ND	ND	ND	180	ND	ND	ND	ND	ND	ND	ND	7.3	ND	ND	NA	ND	ND	17,000	ND	1,700	ND	1,800	340	16,000	ND	ND
GWN-COU4 Columbia	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	11	ND	ND	ND	ND	ND	47,000	ND	160	ND	6,100	260	19,000	ND	ND
GWN-ELB1 Elbert	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	42	ND	ND	ND	ND	ND	21,000	ND	ND	ND	4,000	ND	12,000	ND	ND
GWN-FRA1 Franklin	ND	ND	40	240	ND	ND	ND	ND	ND	ND	ND	7.7	ND	3.8	ND	ND	ND	7,200	ND	350	ND	1,200	54	5,900	ND	ND
GWN-HAL1 Hall	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	33	ND	ND	NA	ND	ND	31,000	ND	ND	ND	5,500	ND	7,300	ND	ND
GWN-HAS1 Harris	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	10	ND	ND	NA	ND	ND	21,000	ND	62	ND	2,600	150	7,400	ND	ND

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

Station No. County	Well Name	Well Depth feet	Casing Depth feet	Well Size inches	Date sampled	pH	cond. uS/cm	diss O2 mg/L	Temp °C	VOCS ug/L	Cl mg/L	SO4 mg/L	NOx mg N/L	P mg/L
GWN-HAS2 Harris	F D Roosevelt State Park Spring	0	NA	NA	04/20/16	4.75	13	NA	16.69	ND	ND	ND	ND	ND
GWN-MAD1 Madison	Ila Well #1	650	NG	NG	05/17/16	7.63	195	7.52	17.79	ND	ND	11	ND	0.04
GWN-STE1 Stephens	Lake Harbor Shores Well #4	378	NG	NG	08/09/16	6.46	145	4.68	17.33	ND	ND	ND	0.22	0.04
GWN-UPS1 Upson	Country Village Well #13	NG	NG	NG	06/01/16	7.89	171	7.19	19.39	tcm=1.0	ND	ND	0.09	0.07
GWN-WAS3 Washington	Hamburg State Park	200	NG	NG	03/09/16	7.88	245	1.20	19.00	ND	12	ND	ND	ND
GWN-WHI1 White	Sweetwater Coffee House	NG	NG	NG	06/09/16	6.37	98	5.35	16.19	ND	ND	ND	0.80	0.07
GWN-WKE1 Wilkes	Rayle #1	NG	NG	NG	02/09/16	6.46	159	7.63	18.22	ND	ND	ND	3.5	0.13
GWN-BR1B Towns	Young Harris/ Swanson Road Well	265	NG	NG	02/25/16	7.09	144	3.04	15.46	ND	ND	21	0.04	ND
					05/17/16	7.14	180	7.47	15.61	ND	ND	21	0.02	ND
					08/09/16	7.18	180	1.47	15.66	ND	ND	20	0.05	ND
					11/01/16	6.92	177	1.41	15.36	ND	ND	20	0.07	ND
GWN-BR5 Murray	Chatsworth/ Nix Spring	0	NA	NA	02/25/16	5.51	24	NA	13.64	ND	ND	ND	0.32	0.04
GWN-TOW1 Towns	Brasstown Bald Spring	0	NA	NA	08/09/16	5.24	14	NA	11.82	ND	ND	ND	0.08	ND
GWN-UNI1 Union	Bryant Cove Well #2	605	48	NG	02/25/16	6.67	90	3.75	15.66	ND	ND	ND	ND	0.04
	Aquifer Low Range					4.75	13	0.60	11.82		ND	ND	ND	ND
	Aquifer High Range					8.21	1,060	9.58	21.06		120	620	3.50	0.18
	Aquifer Median (ND=0)					6.67	180	5.35	17.74		ND	ND	0.16	0.03
	Aquifer Mean (ND=0)					6.71	235	5.11	17.65		5	35	0.52	0.05

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

Station No. • County	Chromium ug/L	Nickel ug/L	Copper ug/L	Zinc ug/L	Arsenic ug/L	Selenium ug/L	Molybdenum ug/L	Silver ug/L	Cadmium ug/L	Tin ug/L	Antimony ug/L	Barium ug/L	Thallium ug/L	Lead 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-HAS2 Harris	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	11	ND	ND	NA	ND	ND	ND	ND	85	ND	ND	ND	1,100	ND	ND
GWN-MAD1 Madison	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	6.7	ND	ND	NA	ND	ND	22,000	ND	590	ND	4,400	140	10,000	ND	ND
GWN-STE1 Stephens	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	38	ND	ND	NA	ND	ND	14,000	ND	21	ND	6,000	ND	8,100	ND	ND
GWN-UPS1 Upson	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5.5	1.0	ND	NA	ND	ND	23,000	ND	ND	ND	4,100	ND	6,600	ND	ND
GWN-WAS3 Washington	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	83	ND	ND	10.6	ND	ND	28,000	ND	45	ND	2,900	270	17,000	ND	ND
GWN-WHI1 White	ND	ND	5.5	ND	ND	ND	ND	ND	ND	ND	ND	73	ND	ND	NA	ND	ND	8,500	ND	200	ND	1,700	ND	9,300	ND	ND
GWN-WKE1 Wilkes	ND	ND	ND	300	ND	ND	ND	ND	ND	ND	ND	56	ND	ND	ND	ND	ND	14,000	ND	86	ND	2,000	ND	12,000	ND	ND
GWN-BR1B Towns	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	72	ND	ND	ND	ND	ND	25,000	ND	56	ND	5,700	21	4,600	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	96	ND	ND	ND	ND	ND	22,000	ND	ND	ND	5,000	17	4,300	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	83	ND	ND	ND	ND	ND	22,000	ND	ND	ND	5,300	14	4,200	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	88	ND	ND	ND	ND	ND	22,000	ND	ND	ND	5,500	13	4,200	ND	ND
GWN-BR5 Murray	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	13	ND	ND	NA	ND	ND	2,700	ND	ND	ND	ND	ND	2,400	ND	ND
GWN-TOW1 Towns	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	6.0	ND	ND	ND	99	ND	ND	ND	ND	ND	ND	ND	1,100	ND	ND
GWN-UNI1 Union	ND	ND	5.0	66	ND	ND	ND	ND	ND	ND	ND	11	ND	ND	ND	ND	ND	12,000	ND	180	ND	1,600	ND	7,800	ND	ND
Aquifer Low Range												ND			ND	ND		ND		ND	ND	ND	ND	1,100		
Aquifer High Range												230.0			14.0	470		260,000		1,700	7,300	39,000	340	42,000		
Aquifer Median (ND=0)												21.0			ND	ND		19,000		20	ND	4,000	17	11,000		
Aquifer Mean (ND=0)												29.6			2.4	21		29,104		105	404	4,877	47	13,286		

Table A-8. Groundwater 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	06/29/16	7.87	231	7.24	16.17	ND	ND	ND	0.70	ND
GWN-VR2A Walker p	LaFayette Lower Big Spring	0	NG	NG	06/29/16	7.35	266	4.36	16.01	ND	ND	ND	1.40	ND
GWN-VR3 Walker	Chickamauga Crawfish Spring	0	NG	NG	06/29/16	7.66	240	7.01	15.69	ND	ND	ND	0.86	ND
GWN-VR6A Bartow	Chemical Products Corp. South Well	300	NG	NG	06/29/16	7.66	270	NA	17.91	1,1dce=1.8 pce=2.1	ND	ND	1.00	ND
GWN-VR8 Polk	Cedartown Spring	0	NG	NG	02/12/16	7.61	280	8.19	16.49	ND	ND	ND	0.86	ND
					05/16/16	7.53	273	7.02	16.53	ND	ND	ND	0.74	ND
					08/19/16	7.51	275	7.34	16.57	ND	ND	ND	0.68	ND
					11/01/16	7.37	272	7.51	16.31	ND	ND	ND	0.69	ND
GWN-VR10 Murray	Eton Spring	0	NG	NG	02/25/16	7.13	220	4.37	15.67	ND	ND	ND	1.60	ND
GWN-VR11 Polk	Davis House Well	200	20	NG	05/16/16	7.08	454	1.87	17.14	ND	ND	ND	2.60	ND
	Aquifer Low Range					7.08	220	1.87	15.67		ND	ND	0.68	ND
	Aquifer High Range					7.87	454	8.19	17.91		ND	ND	2.60	ND
	Aquifer Median (ND=0)					7.52	271	7.02	16.40		ND	ND	0.86	ND
	Aquifer Mean (ND=0)					7.48	279	6.10	16.45		ND	ND	1.11	ND

Table A-8. Groundwater 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 ug/L	Arsenic ug/L	Selenium ug/L	Molybdenum ug/L	Silver ug/L	Cadmium ug/L	Tin ug/L	Antimony ug/L	Barium ug/L	Thallium ug/L	Lead 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	10	ND	ND	NA	ND	ND	28,000	ND	ND	ND	17,000	ND	1,900	ND	ND
GWN-VR2A Walker	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	91	ND	ND	NA	ND	ND	41,000	ND	ND	ND	15,000	ND	1,600	ND	ND
GWN-VR3 Walker	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	91	ND	ND	NA	ND	ND	32,000	ND	ND	ND	16,000	ND	1,400	ND	ND
GWN-VR6A Bartow	ND	ND	ND	18	ND	ND	ND	ND	ND	ND	ND	540	ND	ND	NA	ND	ND	30,000	ND	29	ND	18,000	ND	8,700	ND	ND
GWN-VR8 Polk	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	13	ND	ND	NA	ND	ND	35,000	ND	29	ND	17,000	ND	1,700	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	17	ND	ND	NA	110	ND	32,000	ND	ND	ND	16,000	ND	1,600	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	12	ND	ND	NA	ND	ND	33,000	ND	ND	ND	16,000	ND	1,400	ND	ND
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	12	ND	ND	NA	ND	ND	35,000	ND	ND	ND	18,000	ND	1,700	ND	ND
GWN-VR10 Murray	ND	ND	ND	16	ND	ND	ND	ND	ND	ND	ND	45	ND	ND	NA	ND	ND	35,000	ND	35	ND	17,000	ND	2,500	ND	ND
GWN-VR11 Polk	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	66	ND	ND	NA	ND	ND	65,000	ND	70	ND	14,000	ND	5,400	ND	ND
Aquifer Low Range												10.0						28,000		ND	ND	14,000	ND	1,400		
Aquifer High Range												540.0						65,000		70	ND	18,000	ND	8,700		
Aquifer Median (ND=0)												31.0						34,000		ND	ND	16,500	ND	1,700		
Aquifer Mean (ND=0)												89.7						36,600		16	ND	16,400	ND	2,790		

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

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

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

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

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

Analyte	Reporting Limit/ EPA Method	Analyte	Reporting Limit/ EPA Method
Selenium	190 ug/L / 200.7	Selenium	5 ug/L / 200.8
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	10 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	Secondary MCL	Analyte	Primary MCL	Secondary MCL
Vinyl Chloride	2 ug/L	None	p-Dichlorobenzene	75 ug/L	None
1,1-Dichloro-ethylene	7 ug/L	None	o-Dichlorobenzene	600 ug/L	None
Dichloromethane	5 ug/L	None	1,2,4-Trichloro-benzene	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	Bromodichloro-methane (2)	Total 1,2,3,4 = 80 ug/L	None
1,1,1-Trichloro-ethane	200 ug/L	None	Chlorodibromo-methane (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-Trichloro-ethane	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 (A), and Secondary MCLs (B).

Analyte	Primary MCL	Second-ary MCL	Analyte	Primary MCL	Second-ary 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.