GROUND-WATER QUALITY OF THE UPPER FLORIDAN AQUIFER NEAR AN ABANDONED MANUFACTURED GAS PLANT IN ALBANY, GEORGIA

by Melinda J. Chapman

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CONVERSION FACTORS, VERTICAL DATUM, AND ACRONYMS

Multiply	by	to obtain
	Length	
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	Volume	
gallon (gal)	0.003785	cubic meter
	Area	
acre	0 .4047	hectare

VERTICAL DATUM

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929-- a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

ACRONYMS

AWGLC	Albany Water, Gas, & Light Commission
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
EPA	U.S. Environmental Protection Agency
MGP	Manufactured gas plant
PVC	Polyvinylchloride
SVOC	Semivolatile organic compounds
USGS	U.S. Geological Survey
VOC	Volatile organic compounds

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ABSTRACT

Organic compounds (hydrocarbons) were detected in 1990 in water samples from wells tapping the upper water-bearing zone of the Upper Floridan aquifer in the vicinity of an abandoned manufactured gas plant in Albany, Georgia. The wells were resampled in 1991; data from the water-quality analyses confirm the results of the 1990 investigation. Detected hydrocarbon compounds include 870 micrograms per liter (μg/L) naphthalene, 390 μg/L benzene, 170 μg/L acenaphthene, 55 μg/L total xylenes, and 41 μg/L toluene.

One additional well was drilled into the lower water-bearing zone of the Upper Floridan aquifer in 1991 to collect ground-water samples and monitor ground-water levels. Hydrocarbons detected in ground-water samples from the upper water-bearing zone were not detected in the ground-water sample collected from the lower water-bearing zone. Overall, ground water sampled from the lower water-bearing zone had lower specific conductance and alkalinity; and lower concentrations of dissolved solids, iron and manganese compared to ground water sampled from the upper water-bearing zone. Water-level altitudes and fluctuations in the upper and lower water-bearing zones were similar throughout the study period.

INTRODUCTION

From as early as 1816 and into the 1960's, most of the gas used for heating and lighting in the United States was produced at local or municipal manufactured gas plants (MGP). The plants produced gas from coal or oil, or a combination of both. By-products, including tar and oil residues, were generated during these processes. Other MGP wastes include spent oxides and ash materials (Edison Electric Institute, 1984; Gas Research Institute, 1987). MGP wastes can include a complex mixture of aromatic organic compounds, as well as cyanides and metals; many of these constituents are identified by the U.S. Environmental Protection Agency (EPA) (1986; 1989) as carcenogenic or priority pollutants, or as both (Chapman, 1991).

In January 1989, the U.S. Geological Survey (USGS), in cooperation with the Albany Water, Gas, and Light Commission (AWGLC), began an investigation in the vicinity of an abandoned MGP in Albany, Ga., to evaluate the extent and movement of residual MGP waste products in karstic hydrogeologic systems (Chapman and others, 1990). Areas of hydrocarbon contamination were delineated near the former gas-holding tanks during that preliminary (Chapman and others, 1990) investigation. Contamination was detected vertically downward to the top of the Ocala Limestone, the major formation of the Upper Floridan aquifer in the Albany area. Because of the possibility of contamination in ground-water in the Upper Floridan aquifer, a second phase of investigation was initiated by the USGS and AWGLC. During this second investigation (1990), similar hydrocarbon compounds were detected in the upper water-bearing zone of the Upper Floridan aquifer (Chapman, 1991); however, concentrations decreased substantially with distance away from the former gas-holding tank area. To confirm results of previous investigations, additional ground-water-quality data were collected (1991) from existing monitoring wells tapping the upper water-bearing zone of the aquifer. Also, one well was drilled into the lower water-bearing zone of the Upper Floridan aquifer to provide water-quality and water-level data.

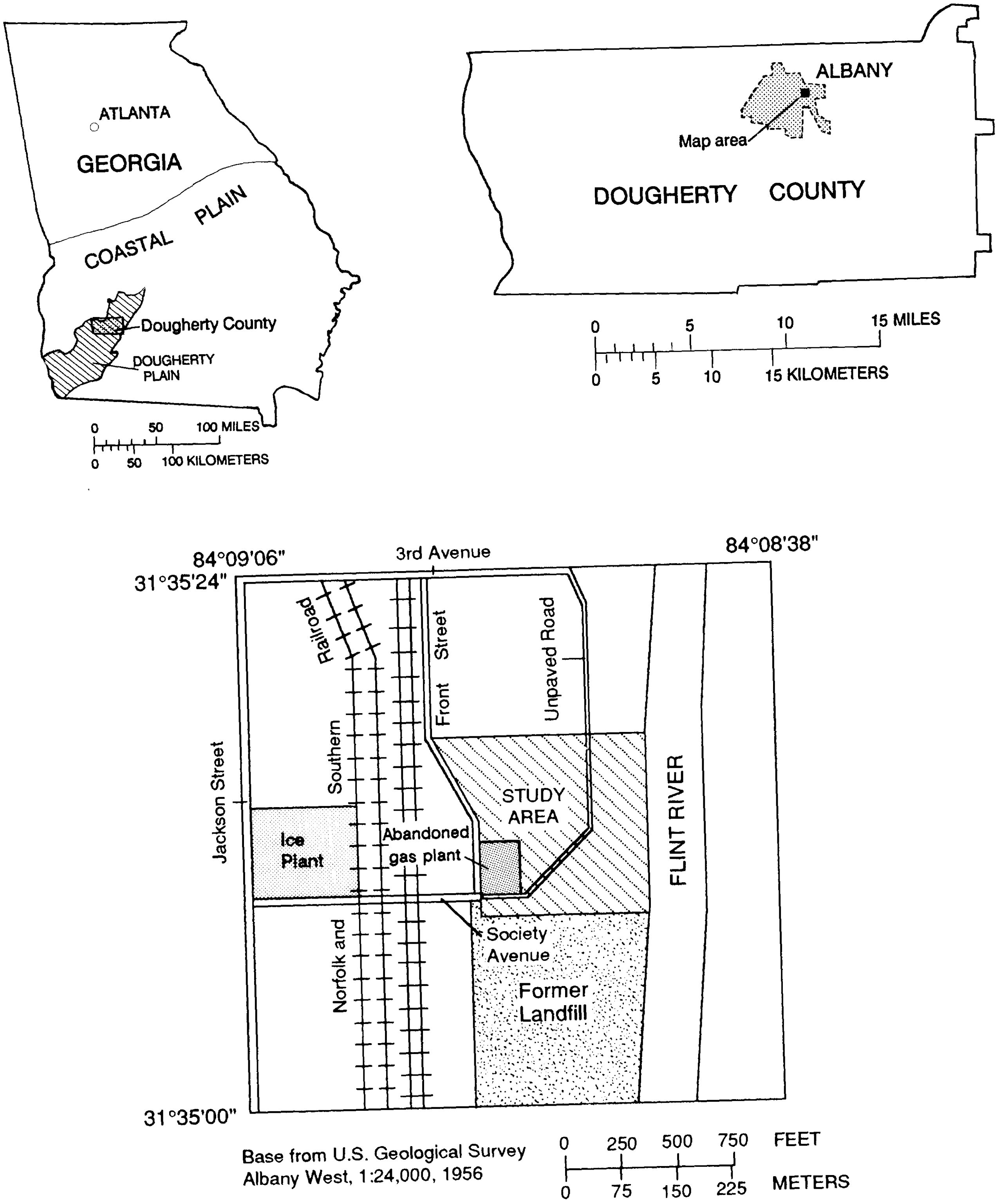
Purpose and Scope

The objectives of this investigation were to (1) verify the ground-water-quality data collected from the upper water-bearing zone of the Upper Floridan aquifer during an earlier investigation (Chapman, 1991), (2) evaluate the quality of ground water in the lower water-bearing zone of the Upper Floridan aquifer in an area near the abandoned MGP, and (3) further describe the hydrogeologic framework of the Upper Floridan aquifer.

This report describes the hydrogeologic characteristics and ground-water quality of the upper and lower water-bearing zones of the Upper Floridan aquifer using geologic logs, borehole geophysical logs, and ground-water-quality data. Geologic data on the upper water-bearing zone were collected from five monitoring wells drilled as part of an earlier investigation (Chapman, 1991); and information was collected on the lower water-bearing zone from the drilling of one additional well during this investigation. Borehole geophysical logs also were collected from this deeper (lower water-bearing zone) well. Ground-water-quality samples were collected from five wells tapping the upper water-bearing zone, and from one well tapping the lower water-bearing zone.

Description of the Area

The study area lies in the Dougherty Plain district of the Coastal Plain physiographic province in southwestern Georgia, in the city of Albany (fig. 1). The area encompasses about 12 acres and is characterized by relatively flat topography ranging in altitude from 150 to 187 ft above sea level. The Albany MGP was located on approximately 3 acres of the study area (Chapman, 1991). The operational layout of the former Albany MGP is shown on figure 2. The Flint River flows within 600 ft of the abandoned MGP and is the eastern boundary of the study area (fig. 1). Most of the wells within a 3-mi radius of the study area tap the Upper Floridan aquifer; however, many of these wells are used for nonpotable purposes, such as in irrigation or cooling systems (Chapman, 1991).



Base from U.S. Geological Survey
Albany West, 1:24,000, 1956

Figure 1.--Study area, ice plant, abandoned gas plant, and former landfill in the Albany area. From Chapman (1991).

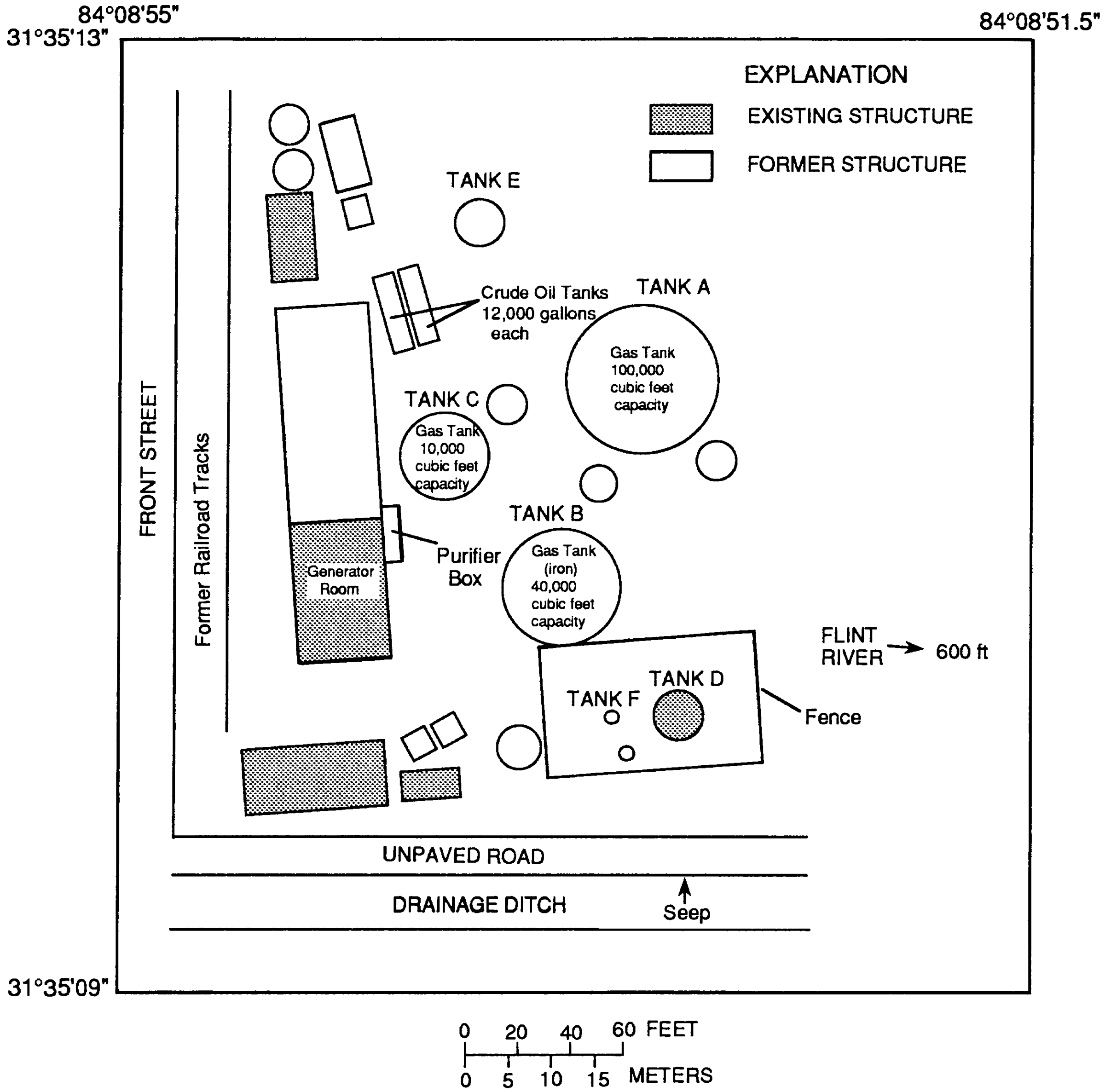


Figure 2.--General operational layout of the Albany gas plant. From Chapman (1991).

Methods of Investigation

One well was drilled into the lower water-bearing zone of the Upper Floridan aquifer using air-rotary drilling methods. A 12-in. borehole was drilled through the unconsolidated sediments to the top of the Ocala Limestone. An outer, 8-in. diameter steel casing was placed inside the 12-in. borehole, and driven into the upper part of the limestone to a depth of 39 ft. The 8-in. diameter casing was sealed by tremie-grouting the annulus to prevent vertical migration of contaminants from the unconsolidated sediments into the Upper Floridan aquifer. Core were collected at 5 or 10 ft intervals in the Ocala Limestone, unless drilling problems were encountered. The borehole was reamed to 7.875-in. diameter and advanced further into the Ocala Limestone (upper water-bearing zone), to the top of the lower water-bearing zone at about 88 ft. A 6-in. diameter steel casing was placed inside the borehole, driven into competent limestone, and tremie-grouted to land surface to prevent vertical migration of contaminants from the upper water-bearing zone of the Upper Floridan aquifer. Subsequent to grouting the 6-in. steel casing, the borehole was advanced to 130 ft by coring methods, and then reamed to 5.875-in. diameter. A 2-in. diameter polyvinylchloride (PVC) casing with a 10-ft screen completion was installed from land surface through the 6-in. casing to 130 ft, and the annulus was packed with sand to 2 ft above the screen. A 2-ft bentonite seal was completed above the sand pack, and the annulus was sealed, using tremie-grouting techniques, to land surface.

Water samples were collected from five existing monitoring wells completed in the upper water-bearing zone of the Upper Floridan aquifer (described in Chapman, 1991) and from the well completed in the lower water-bearing zone of the aquifer. Wells were purged prior to sampling using a small-diameter submersible pump. Purging was continued until at least three casing volumes of water were removed, the water became clear, and the pH and specific conductance of the water stabilized. Purging and sampling was completed using a stainless steel submersible pump equipped with Teflon[1/] delivery lines. Preservatives were added to the water samples for certain analyses. Ground water evacuated from the wells and rinsewater were stored in 55-gal drums for transportation to a regulated disposal facility. After each well was sampled, the pump and all other sampling apparatus were decontaminated using hexane, methanol, and acetone (as needed) along with soap and deionized water. Rinsewater (equipment blank) and trip-blank samples were collected to ensure proper quality control of the ground-water samples.

Ground-water samples were submitted to the USGS laboratory for analyses of organic compounds and inorganic constituents. The samples were analyzed for more than 30 volatile (purgeable) organic compounds (U.S. Environmental Protection Agency, 1988) and 50 semivolatile (methylene chloride-extractable compounds. The specific target compounds were identified by gas chromotography and electron impact mass spectrometry (GC/MS) and confirmed by comparison with standard samples.

[1/] The use of trade or brand names in this report is for identification purposes only, and does not constitute endorsement by the U.S. Geological Survey

Previous Investigations

The Upper Floridan aquifer has been the subject of several investigations in the Albany area. Hicks and others (1981) discussed the hydrogeology of major aquifers of the Albany area and included previously unpublished data on aquifer characteristics, as well as the potentiometric surface of the Upper Floridan aquifer (formerly Ocala aquifer). Hayes and others (1983) developed a ground-water-flow model of the Upper Floridan aquifer (formerly described as the principal artesian aquifer) in the Dougherty Plain physiographic district to simulate regional water-level changes in the Upper Floridan aquifer that may result from real or hypothetical pumping increases. Hayes and others (1983) also included data on the hydrogeology and hydraulic characteristics of the Upper Floridan aquifer.

Hicks and others (1987) conducted an investigation in the Albany area to evaluate (1) the development potential of the Upper Floridan aquifer as an alternative source of ground water for public supply, and (2) the chemical quality of water in the Upper Floridan aquifer. Torak and others (1991) assessed the effects of increased ground-water withdrawal from the Upper Floridan aquifer, and improved the understanding of aquifer characteristics and ground-water-flow paths in the Albany area.

Chapman and others (1990) described organic contamination in the shallow unconsolidated sediments near former gas-holding tanks at the Albany MGP. Chapman and others (1990) reported contamination to the top of the Ocala Limestone, which is the major formation of the Upper Floridan aquifer in the Albany area. Chapman (1991) evaluated the hydrogeology of the Upper Floridan aquifer and described contamination in the upper water-bearing zone of the aquifer in the vicinity of the Albany MGP. Chapman (1991) reported the presence of similar organic compounds in the upper water-bearing zone of the Upper Floridan aquifer as detected in the unconsolidated sediments near the former Albany MGP gas-holding tank area. Also, contaminant concentrations in ground water decreased in the upper water-bearing zone with increased distance away from the former gas-holding tank area.

Acknowledgments

Many individuals assisted in the successful completion of this project. The author extends special thanks to Lemuel O. Edwards, General Manager, AWGLC, for his support and assistance. Other members of the AWGLC staff who extended their assistance include James K. Goodin and Harold A. Bryan.

HYDROGEOLOGY OF THE UPPER FLORIDAN AQUIFER

The study area is underlain, in descending order, by surficial fill, unconsolidated sediments (sand and clay layers), and the Ocala Limestone (fig. 3) (Chapman and others, 1990). A shallow water-bearing zone is present in the upper sand layer of the unconsolidated sediments. The Upper Floridan aquifer is comprised chiefly of the Ocala Limestone and includes an overlying sand layer (lower sand layer) of the unconsolidated sediments in the study area (Chapman, 1991).

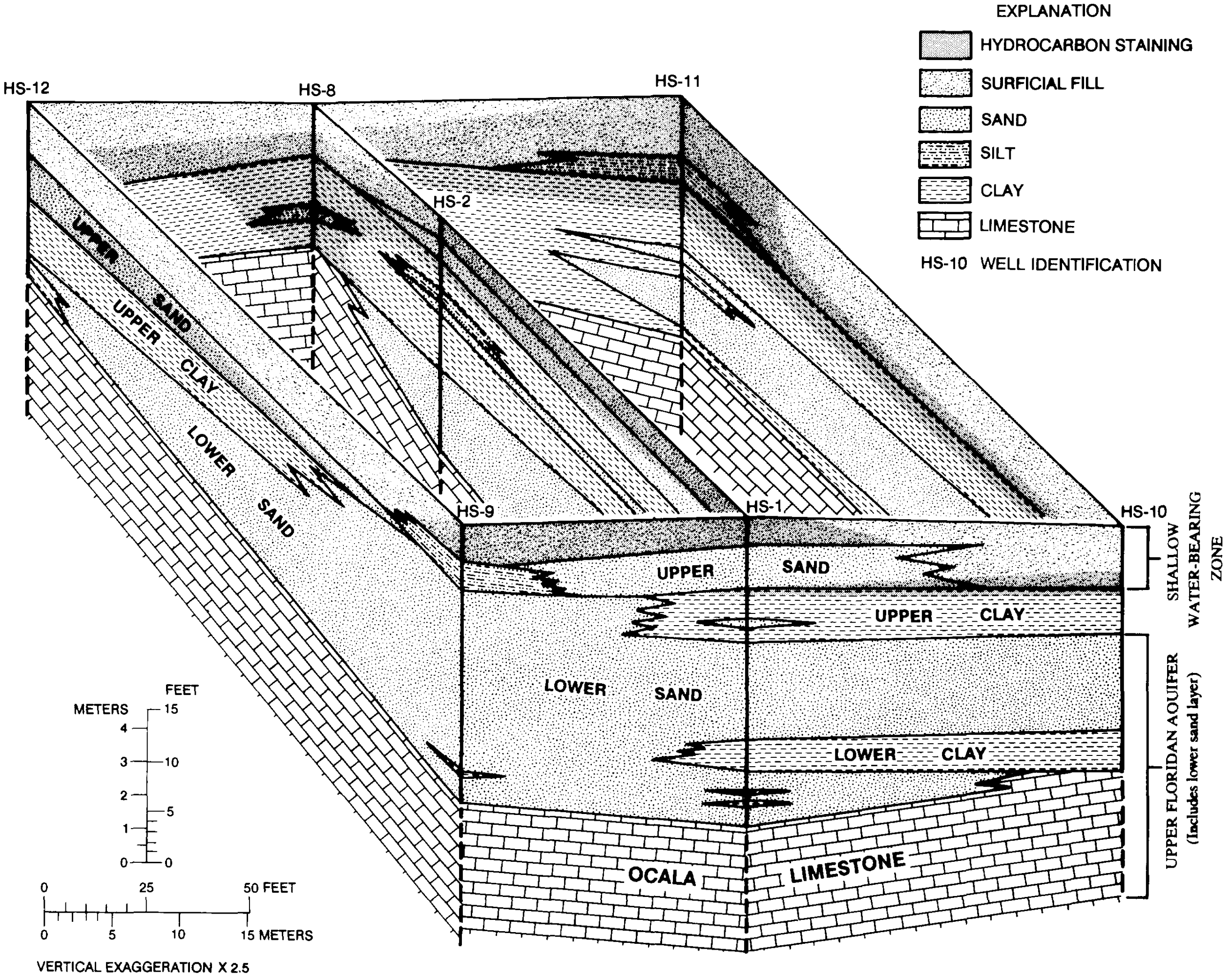


Figure 3.--Generalized fence diagram showing lithology of the area adjacent to the abandoned gas plant (trace of fence diagram shown in figure 5). From Chapman (1991).

Torak and others (1991) described upper and lower water-bearing zones in the Upper Floridan aquifer. The upper water-bearing zone is comprised of the highly weathered upper unit of the Ocala Limestone, and is considered to have a relatively lower permeability than the lower water-bearing zone. In the study area, a sand layer (lower sand layer, fig. 3) overlying the Ocala Limestone is considered to be part of the upper water-bearing zone of the Upper Floridan aquifer. The lower unit of the Ocala Limestone is a more crystalline rock having a high secondary permeability from solutioning along fractures, and is considered to be the "production" or major water-supply zone for wells tapping the Upper Floridan aquifer. A middle unit of the Ocala Limestone, a clayey limestone, is present in some areas near Albany, and is considered to be semiconfining, separating the upper and lower water-bearing zones of the Upper Floridan aquifer. The presence of the middle unit was not readily detected from core samples of the Ocala Limestone collected during the drilling of well OC-5, which taps the lower water-bearing zone (figs. 4, 5, and 6) in the study area.

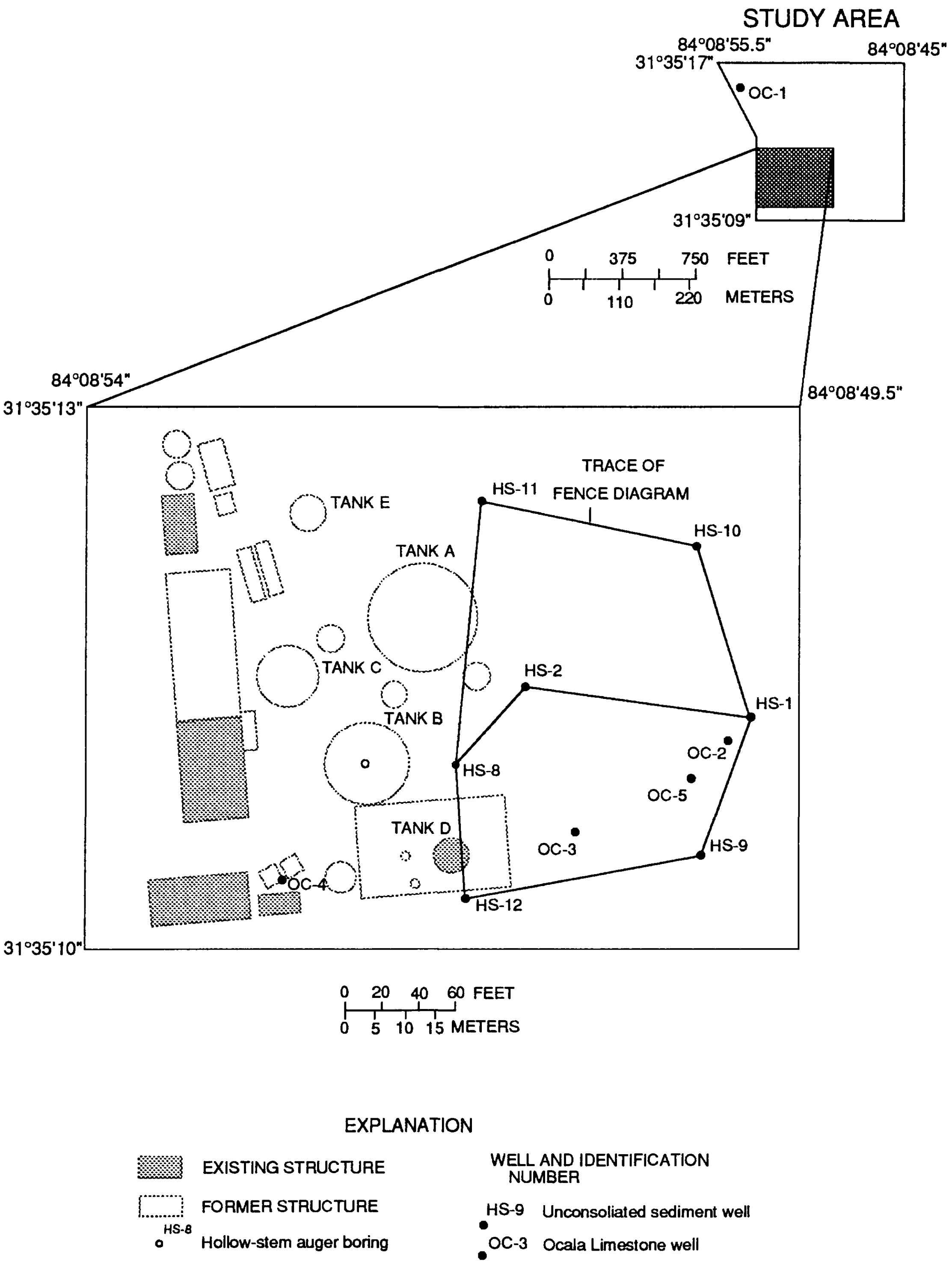


Figure 4.--Wells tapping the Upper Floridan aquifer in part of the study area.

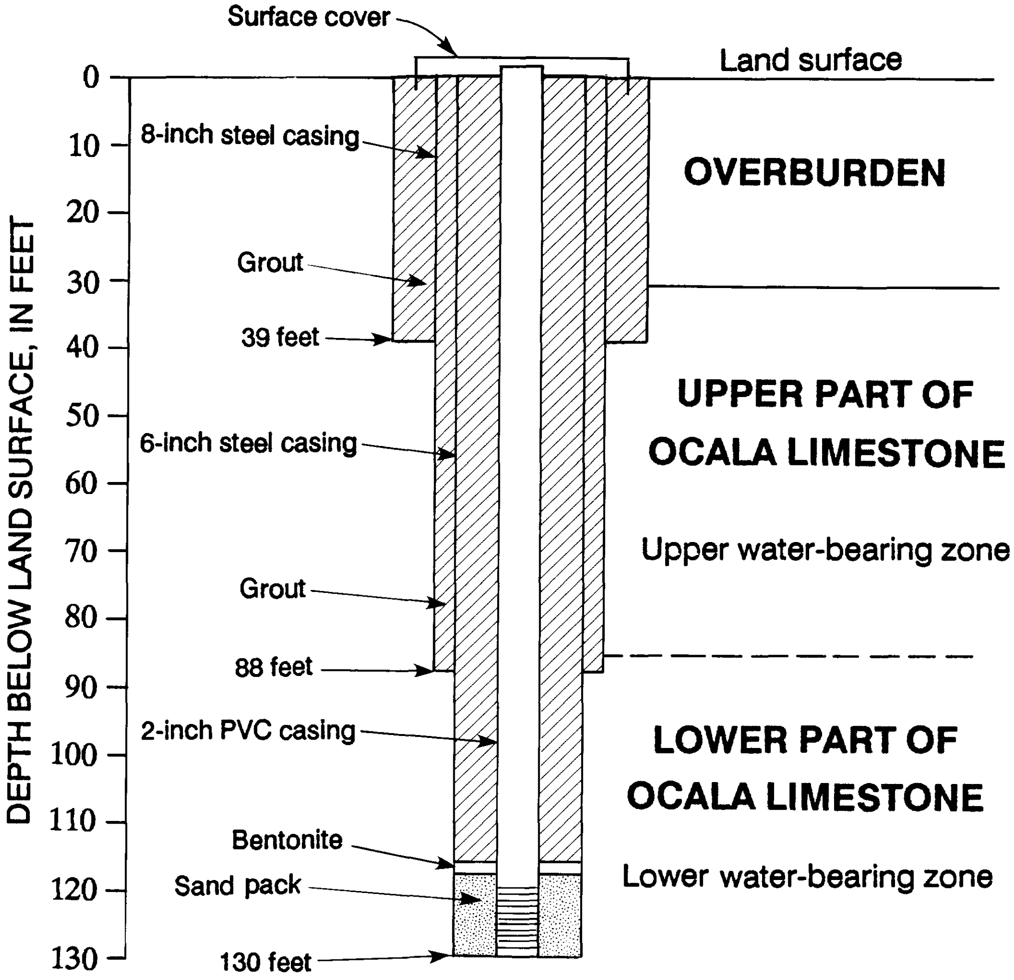


Figure 5.--General hydrogeology and construction characteristics of well OC-5.

Water levels in wells tapping the upper and lower water-bearing zones of the Upper Floridan aquifer had similar altitudes and fluctuations (fig. 7), suggesting a lack of confinement between these zones in the study area. However, because of the proximity of the Flint River and the hydraulic interconnection between the river and the Upper Floridan aquifer, the water level in the Upper Floridan aquifer is dominated by the stage of the river (fig. 8). Ground-water flow in the Upper Floridan aquifer generally is southeastward toward the river (Chapman, 1991).

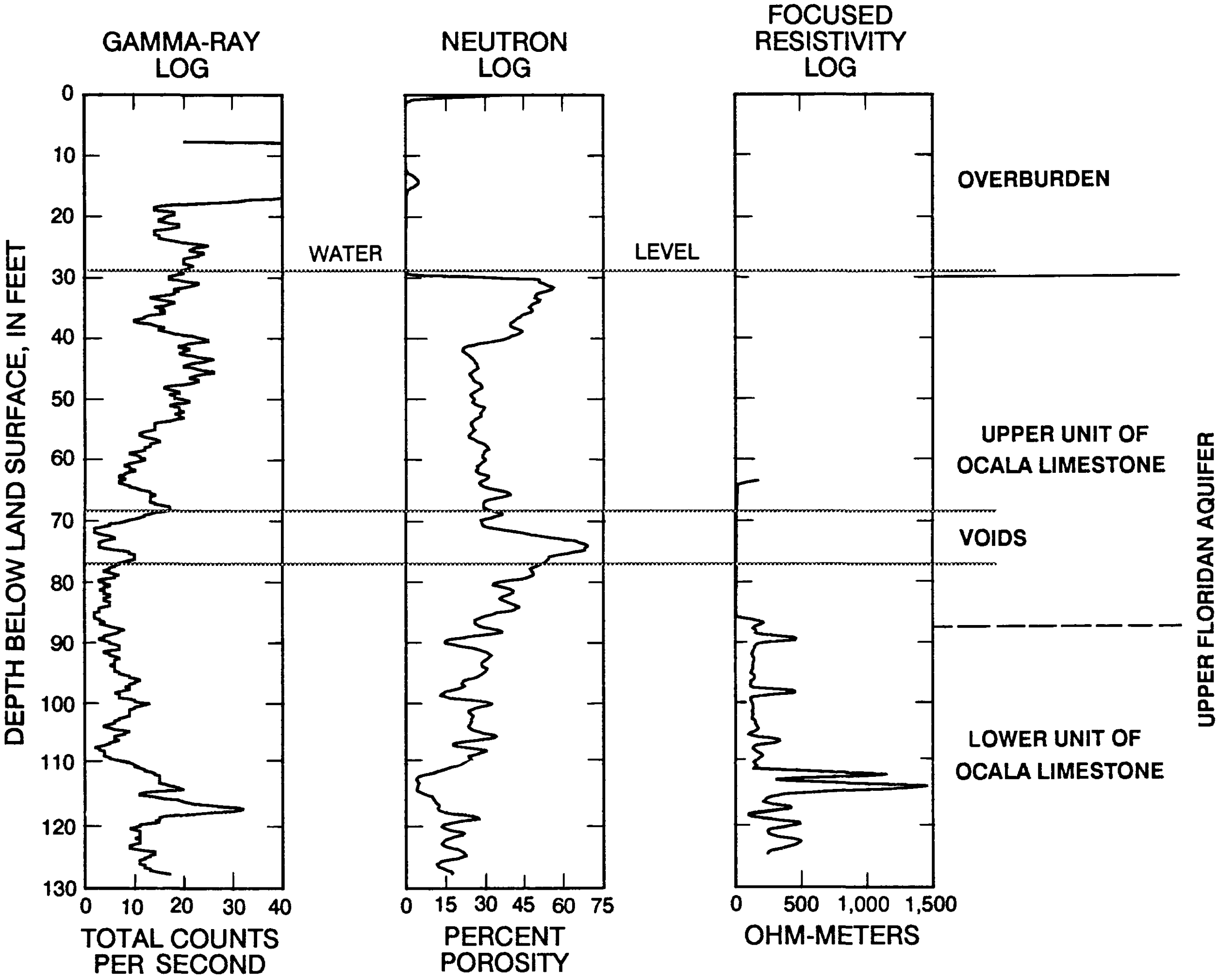


Figure 6.--Borehole geophysical logs of well OC-5.

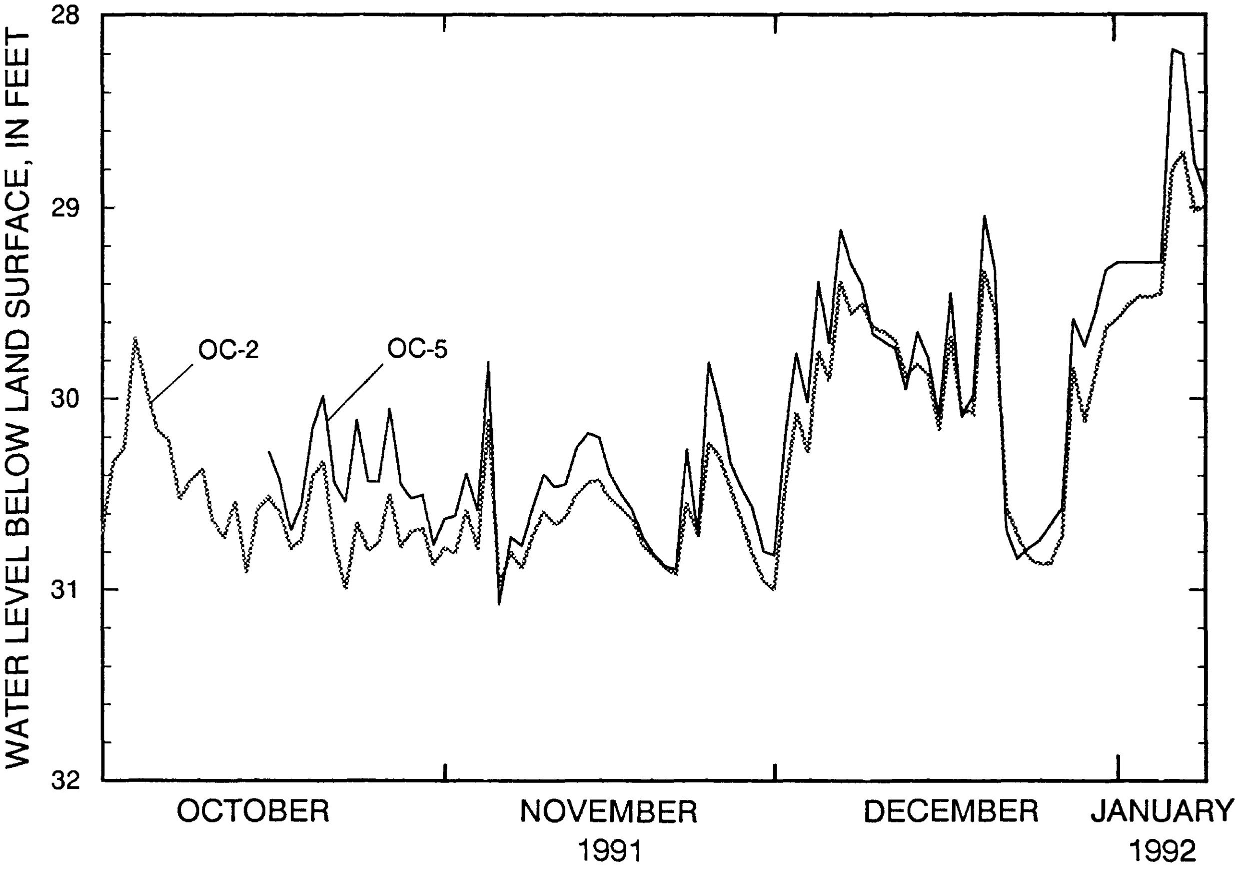


Figure 7.--Daily water levels in wells OC-5 and OC-2, October 1-January 9, 1992.

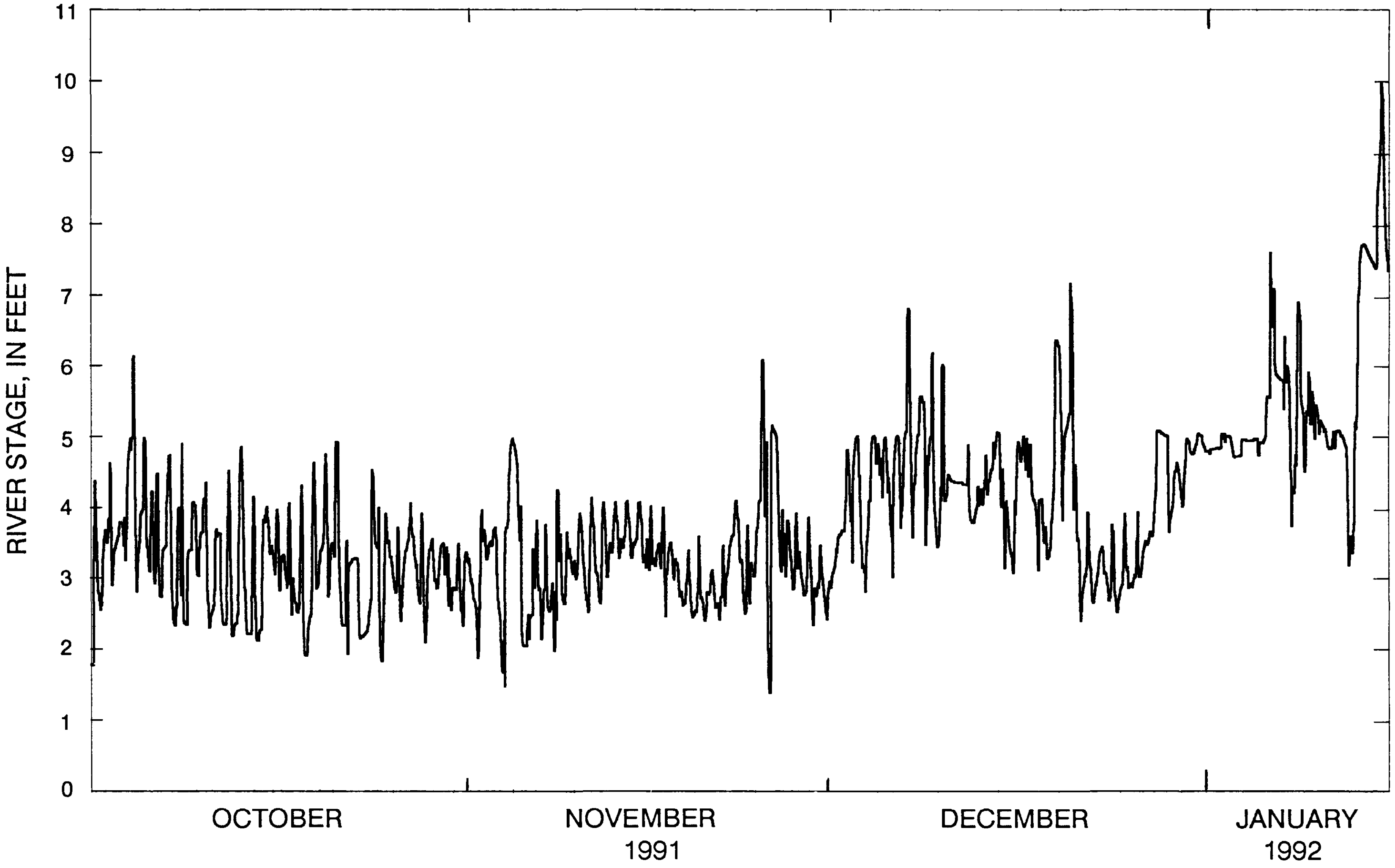


Figure 8.--Stage of the Flint River near the study area at Albany, October 1, 1991-January 16, 1992.

GROUND-WATER QUALITY OF THE UPPER FLORIDAN AQUIFER

Ground water in the Upper Floridan aquifer generally is of good quality and typically does not contain constituent concentrations that exceed Federal drinking-water standards (U.S. Environmental Protection Agency, 1986; 1990) (Torak and others, 1991). The water is a hard, calcium-bicarbonate type and is less mineralized than water in deeper aquifers (Hicks and others, 1981).

Upper Water-Bearing Zone

Results from the chemical analyses of ground water sampled during the previous investigation in March 1990 (Chapman, 1991) showed the presence of hydrocarbons and metals in the upper water-bearing zone of the Upper Floridan aquifer. Organic compounds having notably high concentrations included various aromatic and polyaromatic hydrocarbons, such as benzenes, xylenes, and toluenes, as well as naphthalene, acenaphthylene, acenaphthene, fluorene, anthracene, fluoranthene, phenanthrene, and pyrene. Water sampled from wells OC-3 and OC-4 in 1990 (fig. 4) contained the highest concentrations of hydrocarbons, while the water sample from well OC-2 contained only a low concentration of acenaphthene. The water sample from well HS-2 contained acenaphthene and low concentrations of benzene, toluene, ethylbenzene, and xylene (BTEX). Results of the inorganic analyses (Chapman, 1991) showed the presence of high concentrations of metals in well HS-2. High concentrations of iron and manganese were detected in wells OC-2, OC-3, and OC-4 (Chapman, 1991).

Analyses of a second set of water samples collected from the upper water-bearing zone of the Upper Floridan aquifer in March 1991, as a part of this investigation, confirmed the presence of hydrocarbons in monitoring wells OC-3, OC-4, and HS-2 (tables 1, 2, and 3). As previously detected in 1990 (Chapman, 1991), the highest concentrations of hydrocarbons were of various benzenes, toluenes, and xylenes, as well as naphthalene, acenaphthylene, acenaphthene, fluorene, and phenanthrene. Compared to the results from the previous sampling, hydrocarbon concentrations decreased in well OC-3, with the exception of naphthalene and acenaphthylene. Volatile organic compounds (VOC) generally increased in well OC-4, with the exception of naphthalene and acenaphthylene; and semivolatile organic compounds (SVOC) decreased in this well. In well HS-2, BTEX and acenaphthene concentrations decreased (table 3). Also, low concentrations of previously undetected compounds, including various benzenes, toluene, xylenes, and naphthalene, were detected in ground water collected from well OC-2.

The 1991 inorganic analyses data (table 4) confirmed the presence of high concentrations of metals in well HS-2. Also, as in previous samples, ground water in wells tapping the upper water-bearing zone of the Upper Floridan aquifer near the former MGP working area, contained higher concentrations of iron and manganese compared to ground water collected from the upgradient, background well OC-1 (fig. 4).

Lower Water-Bearing Zone

Results from the analyses of a ground-water sample from well OC-5, which taps the lower water-bearing zone of the Upper Floridan aquifer, did not show evidence of the benzene, toluene, xylene, naphthalene, acenaphthene, or other related compounds detected in the upper water-bearing zone of the aquifer in that part of the study area (fig. 4, tables 1, 2, and 3). Well OC-5 is near well OC-2 (fig. 4), where low concentrations of several hydrocarbons were detected in the upper water-bearing zone of the aquifer. Low concentrations of tetrachloroethane (3.1 μg/L), trichloroethane (1.0 μg/L), and 1,2-cis-dichloroethene (4.2 μg/L) detected in water from well OC-5 were not detected in the upper water-bearing zone of the aquifer in the study area.

Concentrations of inorganic constituents in water from the lower water-bearing zone were substantially lower compared to concentrations in water from the upper water-bearing zone of the Upper Floridan aquifer in the vicinity of the former gas-holding tanks (table 4, fig. 2). Iron and manganese concentrations in water from well OC-5 (lower water-bearing zone) were similar to upgradient results in well OC-1. Dissolved solids, specific conductance, and alkalinity were lower in well OC-5.

Table 1.--*Volatile organic compound concentrations in ground water from the Upper Floridan aquifer in the study area*

[Concentrations in micrograms per liter (μg/L); EPA, U.S. Environmental Protection Agency; nd, none detected; na, not applicable; *p*, proposed]

Organic compound	Well number						Reporting limit	EPA recommended limit for drinking water
	[1]OC-1	[2]OC-2	[2]OC-3	[3]OC-4	[2]HS-2	[4]OC-5		
Benzene	nd	0.8	7.9	390	0.8	nd	0.2	0.005
Toluene	nd	.2	nd	41	.3	nd	0.2	2.0*p*
Xylenes (total)	nd	1.7	6.1	55	nd	nd	0.2	10.0*p*
Ethylbenzene	nd	1.8	1.3	64	nd	nd	0.2	.7*p*
Isopropylbenzene	nd	.5	1.7	14	nd	nd	0.2	na
N-propylbenzene	nd	nd	0.3	4.9	nd	nd	0.2	na
1,3,5 Trimethylbenzene	nd	nd	1.7	3.4	nd	nd	0.2	na
N-butylbenzene	nd	nd	nd	nd	nd	nd	0.2	na
1,4-Dimethyl-2-ethyl-benzeme	nd	nd	nd	nd	nd	nd	0.2	na
1.3-Dimethyl-2-ethyl-benzene	nd	nd	nd	nd	nd	nd	0.2	na
1,2,3,5-Tetramethyl-benzene	nd	1.8	8.4	16	2.8	nd	0.2	na
1,2,4-Trimethylbenzene	ns	.8	4.1	26	nd	nd	0.2	na
1,2,3-Trimethylbenzene	nd	1.2	11	15	.8	nd	0.2	na
2-Ethyltoluene	nd	3.3	13	14	3.1	nd	0.2	na
2-Ethyl-1,4-dimethyl-benzene	nd	.4	2.1	8.4	.5	nd	0.2	na
2-Ethyl-1,3-dimethyl-benzene	nd	.3	.8	2.5	.8	nd	0.2	na
1.2.3.4-Tetramethyl-benzeme	nd	1.7	11	22	3.0	nd	0.2	na
Trichloroethane	nd	nd	nd	nd	nd	nd	0.2	200
Transdichloroethene	nd	nd	nd	nd	nd	nd	0.2	na
1,2-Cis-dichloroethene	nd	nd	nd	1.0	nd	4.2	0.2	na
Carbontetrachloride	nd	nd	nd	nd	nd	nd	0.2	5
Tetrachloroethane	nd	nd	nd	nd	nd	3.1	0.2	na
Trichloroethane	nd	nd	nd	nd	nd	1.0	0.2	na
Trichlorofluoroethane	nd	nd	nd	nd	nd	nd	0.2	na
Sec-butylbenzene	nd	nd	0.2	0.6	nd	nd	0.2	na
Vinylchloride	nd	nd	nd	1.1	nd	nd	0.2	.002
P-Isopropyltoluene	nd	nd	nd	5.4	nd	nd	0.2	na
Styrene	nd	ns	nd	6.4	nd	nd	0.2	.1*p*
Chloroform	0.8	nd	nd	nd	nd	1.1	0.2	na

[1] Collected on March 4, 1991.
[2] Collected on March 5, 1991.
[3] Collected on March 6, 1991.
[4] Collected on October 15, 1991

Table 2.--*Semivolatile organic compound concentrations in ground water from the Upper Floridan aquifer in the study area*

[Concentrations in micrograms per liter (µg/L); nd, none detected]

Organic compound	Well number [1]OC-1	[2]OC-2	[2]OC-3	[3]OC-4	[2]HS-2	[4]OC-5	Reporting limits
Naphthalene	nd	7.0	28	870	nd	nd	5.0
Acenaphthylene	nd	nd	22	36	nd	nd	5.0
Acenaphthene	nd	46	93	170	13	nd	5.0
Anthracene	nd	nd	nd	15	nd	nd	5.0
Fluorathene	nd	nd	nd	nd	nd	nd	10.0
Fluorene	nd	nd	26	61	nd	nd	5.0
Phenanthrene	nd	nd	23	79	nd	nd	5.0
Pyrene	nd	nd	nd	nd	nd	nd	5.0
Benzo(k) fluorathene	nd	nd	nd	nd	nd	nd	10.0
Benzo(a)pyrene	nd	nd	nd	nd	nd	nd	10.0
Chrysene	nd	nd	nd	nd	nd	nd	10.0
Benzo(a) anthracene	nd	nd	nd	nd	nd	nd	10.0
Phenol	nd	nd	nd	nd	nd	nd	30.0
Bis(2-ethylhexyl) phthalate	nd	nd	nd	nd	nd	nd	5.0
D-N-butyl-phthalate	nd	nd	nd	nd	nd	nd	5.0
Diethyl-phthalate	nd	nd	nd	nd	nd	nd	5.0

[1] Collected on March 4, 1991.
[2] Collected on March 5, 1991.
[3] Collected on March 6, 1991.
[4] Collected on October 15, 1991

Table 3.--Selected organic compounds in ground water from the Upper Floridan aquifer

[Concentrations, in micrograms per liter, µg/L; nd, none detected]

Well number	Benzene	Toluene	Ethyl-benzene	Xylene	Naphthalene	Acenaph-thylene	Acenaph-thene	Fluorene	Phenan-threne
					Spring 1990				
OC-1	nd	nd	nd	nd	nd	nd	nd	nd	nd
OC-2	nd	nd	nd	nd	nd	nd	9.0	nd	nd
OC-3	150	3.0	130	37	9.0	110	130	240	130
OC-4	77	3.7	nd	13	200	30	250	87	240
HS-2	7.7	0.6	4.0	1.2	nd	nd	23	nd	nd
					Spring 1991				
OC-1	nd	nd	nd	nd	nd	nd	nd	nd	nd
OC-2	0.8	0.2	1.8	1.7	7.0	nd	46	nd	nd
OC-3	7.9	nd	1.3	6.1	28	22	93	26	23
OC-4	390	41	64	55	870	36	170	61	79
HS-2	0.8	0.3	nd	nd	nd	nd	13	nd	nd
OC-5	nd	nd	nd	nd	nd	nd	nd	nd	nd

Table 4.--*Inorganic constituent concentrations in ground water from the Upper Floridan aquifer in the study area*

[µg/L, micrograms per liter; mg/L, milligrams per liter; µs/cm, microSiemens per centimeter; EPA, U.S. Environmental Protection Agency; nd, none detected; na, not applicable; *p*, proposed]

Physical property or constituent	Unit of measure	Well number						Reporting limits	EPA recomended limit for drinking water
		1/OC-1	2/OC-2	2/OC-3	3/OC-4	2/HS-2	4/OC-5		
Trace Elements									
Arsenic	µg/L	nd	nd	nd	nd	nd	nd	1.0	50
Barium	µg/L	120	250	130	370	25	17	2.0	5,000*p*
Beryllium	µg/L	nd	nd	0.6	nd	32	nd	0.5	na
Boron	µg/L	60	70	70	80	100	30	10	na
Cadmium	µg/L	nd	2.0	3.0	nd	41	nd	1.0	5*p*
Chromium	µg/L	nd	nd	nd	nd	20	nd	5.0	100p
Cobalt	µg/L	nd	nd	nd	nd	600	nd	3.0	na
Copper	µg/L	nd	nd	nd	nd	20	nd	10.0	1,300*p*
Cyanide	µg/L	nd	.20	.59	nd	1.7	nd	.01	na
Calcium	µg/L	110	160	200	120	160	75	.02	na
Iron	µg/L	16	5,100	7,100	3,200	9,000	11	3.0	300
Lead	µg/L	nd	nd	nd	nd	nd	nd	10.0	5*p*
Manganese	µg/L	3	2,600	3,400	1,200	51,000	nd	1.0	50
Molybdenum	µg/L	nd	nd	nd	nd	nd	nd	10.0	na
Nickel	µg/L	nd	nd	nd	nd	230	nd	10.0	na
Silver	µg/L	nd	nd	nd	nd	2	nd	1.0	50
Strontium	µg/L	64	220	300	180	880	130	5.0	na
Vanadium	µg/L	nd	nd	nd	nd	86	nd	6.0	na
Zinc	µg/L	9	5	6	7	2,500	nd	3.0	5,000
Antimony	µg/L	nd	nd	nd	nd	nd	nd	1.0	na
Lithium	µg/L	7	6	7	6	11	12	4.0	na
Selenium	µg/L	nd	nd	nd	nd	nd	nd	1.0	50*p*
Mercury	µg/L	nd	2.3	nd	nd	nd	nd	.01	2
Major Constituents									
Magnesium	mg/L	0.96	8.1	9.8	5.0	13	1.8	0.01	na
Sodium	mg/L	8.1	23	22	20	34	11	.2	na
Silica	mg/L	15	15	15	14	13	11	.01	na
Phosphorus	mg/L	.021	nd	.041	.021	nd	nd	.01	na
Potassium	mg/L	.4	4.1	3.3	3.2	9.4	0.9	.1	na
Chloride	mg/L	9.2	11	10	10	49	18	.1	250
Sulfate	mg/L	27	47	180	30	750	18	.2	250
Fluoride	mg/L	nd	nd	.20	nd	1.9	nd	.02	4.0
Physical Properties									
Dissolved solids	mg/L	318	532	715	411	na	256	na	500
Hardness	mg/L	280	430	540	320	450	190	na	na
Alkalinity	mg/L	245	426	439	340	1.0	191	na	na
pH	standard units	7.0	6.5	6.8	7.0	4.8	7.3	na	6.5-8.5
Specific conductance	µS/cm	601	762	934	608	1,230	428	na	na

1/Collected on March 4, 1991.
2/Collected on March 5, 1991.
3/Collected on March 6, 1991.
4/Collected on October 15, 1991.

SUMMARY

Manufactured gas plants produced gas for heating and lighting in the United States from as early as 1816 and into the 1960's. By-products, including but not limited to, oil residues and tar, were generated during these processes. Organic compounds (hydrocarbons) were detected in water in the upper water-bearing zone of the Upper Floridan aquifer near an abandoned manufactured gas plant (MGP) in Albany, Georgia, during an earlier investigation in 1990. Chemical analyses of additional ground-water samples collected from five existing monitoring wells in 1991 verify the presence of hydrocarbons and metals in the upper water-bearing zone of the Upper Floridan aquifer.

One well was drilled into the lower water-bearing zone of the Upper Floridan aquifer in 1991 for water-quality sampling and water-level monitoring. Analyses of ground water sampled from the well did not show evidence of benzene, toluene, xylene, naphthalene, acenaphthene, or other related compounds detected in the upper water-bearing zone in the study area. Low concentrations of tetrachloroethane, trichloroethane, and 1,2-cis-dichloroethene were detected in a water sample from this deeper well; however, these compounds were not detected in the upper water-bearing zone in the study area. Inorganic constituent concentrations also were substantially lower in the deeper well. Overall, ground water sampled from the lower water-bearing zone had lower specific conductance and alkalinity; and lower concentrations of dissolved solids, iron, and manganese compared to ground water sampled from the upper water-bearing zone. Water-level altitudes and fluctuations in the upper and lower water-bearing zones were similar throughout the study period.

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APPENDIX

Geologic Log for Well OC-5

[Samples collected at irregular intervals; PVC, polyvinylchloride;
--, coring not attempted; samples not collected from 10.5 to 30 ft]

Depth (feet)	Core recovery (percent)	Description
		Unconsolidated sediments:
0-10.5	--	fill, black, ashy; clay, reddish-brown; sand, reddish-brown; silty.
		Ocala Limestone:
30-39	--	limestone, white, sandy; lost circulation at 30 ft; thin, hard limestone layers in highly weathered zones; some coarse river sand (alluvium). Drove 8-in. black iron casing to 39 ft. Tremie-grouted to land surface; grout collapsed to 18 ft. Used 30 bags of grout and 2 bags of bentonite to seal upward to land surface.
39-49	--	limestone; alternating layers of resistant and weathered limestone; sand, clay with limestone fragments.
49-77	--	limestone; alternating layers of resistant and weathered limestone; voids noted at 68 to 70 ft and 75 to 77 ft.
77-82	7	limestone, white, sandy, chalky, medium to coarse-grained; fossiliferous; variable porosity; iron stains in vugs; greenish-brown clay at 78 ft; naphthalene odor in clay.
82-87	40	limestone, white to tan, sandy, coarse to medium-grained; fossiliferous; fractured; clay at 82 ft; staining and naphthalene odor along fractures; reamed borehole to 7.875 in., and drove 6-in. steel casing to 88 ft.
98-100	55	limestone, white, fine to coarse-grained; fossiliferous; vuggy, no naphthalene odor.
100-105	30	limestone; more resistant than above interval.
110-120	75	limestone, white to tan, sandy, fine to coarse grained; fossiliferous; fractured; harder drilling, oblique fractures common; iron staining along fractures and in vugs; some weathered zones; fossils recrystalized.
120-130	75	limestone, white to tan, sandy, somewhat chalky; high degree of textural variation, fossils not as large or recrystalized as above interval; some weathered zones. Reamed borehole to 5.875 in. to 130 ft. Completed with 2-in. diameter PVC casing from land surface to 120 ft with 10 ft of screened interval from 120 to 130 ft.