HYDROGEOLOGY, HYDRAULIC PROPERTIES, AND WATER QUALITY OF THE SURFICIAL AQUIFER: A POTENTIAL ALTERNATIVE WATER SOURCE AT FORT STEWART, LIBERTY COUNTY, GEORGIA

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Abstract. In the coastal area of Georgia, the Upper Floridan aquifer is the principal water-supply source. Restrictions have been placed on withdrawals from the aquifer because of declining water levels and saltwater contamination, which has prompted interest in the development of alternative sources of groundwater. At Fort Stewart in Liberty County, Georgia, a well was completed to test the surficial aquifer as a possible source of irrigation water for athletic fields. The U.S. Geological Survey in cooperation with the U.S. Army conducted an evaluation in 2010 of the water-bearing potential of the surficial aquifer. This evaluation included describing the depth, thickness, and lithology of the surficial aquifer and its geophysical characteristics, hydraulic properties, and water quality. Results of a 24-hour aquifer test indicate that the aquifer is capable of well yields in hundreds of gallons per minute of suitable quality for irrigation use.

INTRODUCTION

The Upper Floridan aquifer is the principal source of water at Fort Stewart in Liberty County, Georgia. Declining water levels and localized saltwater contamination have resulted in State regulations restricting withdrawals from the Upper Floridan aquifer in parts of coastal Georgia and interest in developing supplemental sources of groundwater. The U.S. Geological Survey in cooperation with the U.S. Army, Fort Stewart, conducted an evaluation of the surficial aquifer as a source for irrigation supply. The scope of the study included construction of a surficial aquifer test well, collection of lithologic samples, borehole geophysical logging, an aquifer test and subsequent analysis, and the collection and analysis of water-quality samples.

Description of Study Area

The study area on Fort Stewart is in west-central Liberty County near the city of Hinesville, Georgia, in the Coastal Plain Physiographic Province (Fig. 1). Topographic relief across the area is low, with an approximate land-surface altitude of 80 feet (ft) above the North American Vertical Datum of 1988 (NAVD 88). Hydrogeologic units include, in descending order, the surficial aquifer system; the Brunswick aquifer system; and the Floridan aquifer system (Miller, 1986; Clarke, 2003).

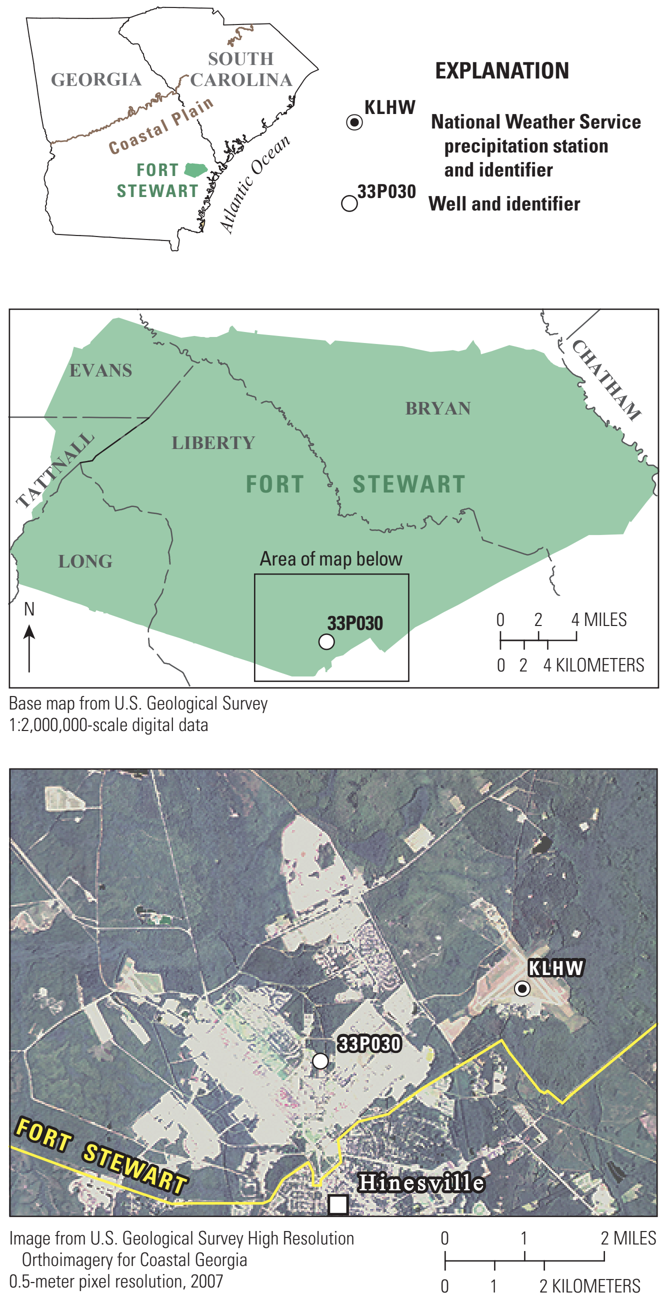

Figure 1. Location of the test-well site at Fort Stewart in Liberty County, Georgia.

The climate in the area is mild, with a mean-annual temperature of 67.7 degrees Fahrenheit at the National Weather Station KLHW at Wright Air Field (National Oceanic and Atmospheric Administration, 2002). For the 30-year period 1971–2000, mean monthly precipitation ranged from 2.69 inches for November to 5.92 inches for July, and mean annual precipitation was 48.32 inches (National Oceanic and Atmospheric Administration, 2002).

Methods of Study

Well 33P030 was installed adjacent to the Fort Stewart youth sport complex baseball fields. A test hole was drilled to a depth of 252 ft and penetrated interbedded sands and clays (Fig. 2) of Pleistocene and Miocene age as described by Clarke and others (1990). Upon completion of the test boring, borehole geophysical logs were collected and included natural-gamma

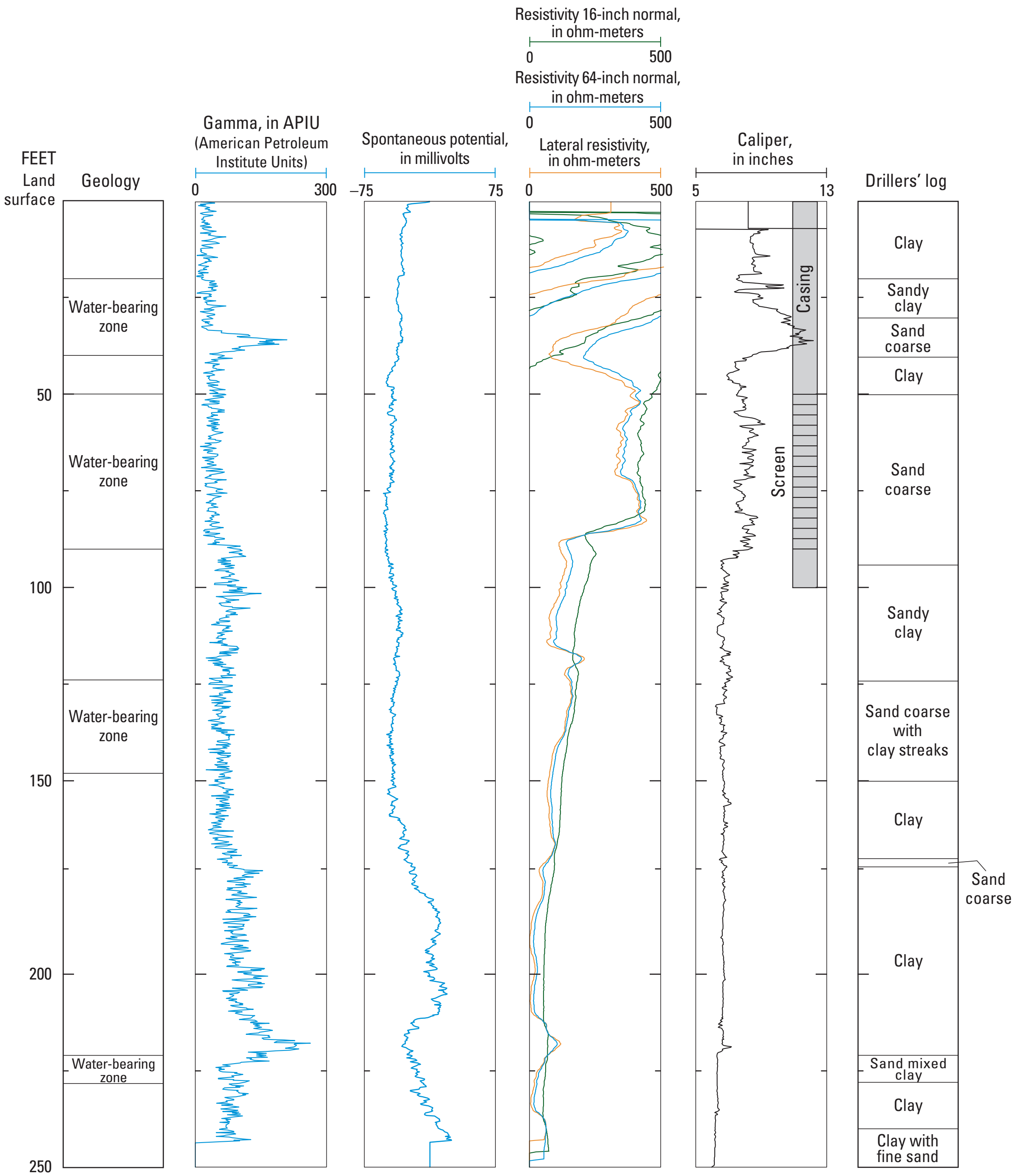

Figure 2. Geophysical data for test well 33P030 Fort Stewart, Liberty County, Georgia, April 7, 2010.

radiation, spontaneous potential, lateral and long- and short-normal resistivity, and caliper. Borehole geophysical logs and well cuttings were used to identify water-bearing zones, select casing depth and screened intervals for the well, and to verify the depths and thicknesses of stratigraphic units. Well 33P030 was completed to a depth of 100 ft with a screened interval from 50 to 90 ft, which includes a 10-ft sump at the bottom.

Upon completion of well construction and development, a 24-hour aquifer test was conducted at well 33P030. Transmissivity and specific capacity of the well were determined on the basis of measured discharge and 24-hour drawdown. At the end of the 24-hour pumping period, water samples were collected and analyzed for major anions, selected trace metals and nutrients, turbidity, alkalinity, hardness, and total dissolved solids.

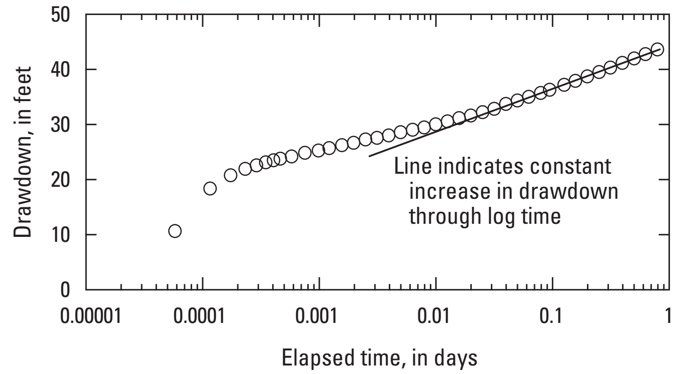

Figure 3. Drawdown as a function of log time in well 33P030 at a pumping rate of 552 gallons per minute, Fort Stewart, Georgia, April 26, 2010.

HYDRAULIC PROPERTIES

A 24-hour aquifer test at surficial aquifer well 33P030 was completed on April 26–27, 2010. The well was pumped at an average rate of 552 gallons per minute (gal/min). Water levels declined from a static level of 6.4 ft to a pumping level of 50.8 ft below land surface for a total drawdown of 44.4 ft (Fig. 3) and a specific capacity of 12.4 gal/min per foot of drawdown.

By May 4, 7 days after the cessation of pumping, the water level in well 33P030 had nearly fully recovered to the pre-test level of 6.8 ft below land surface (Fig. 4).

Analysis of drawdown and recovery data using the straight-line method of Cooper and Jacob (1946) indicated transmissivity of the surficial aquifer was 2,100–2,500 feet-squared per day. Aquifer-test response and dissolved-oxygen concentrations in the surficial aquifer suggest that the water-bearing zone from 50 to 94 ft is under confined conditions at Fort Stewart. Water levels increased at a constant rate through log time until the end of the test, which indicates that the surficial aquifer was under confined conditions throughout the test. Low dissolved-oxygen concentrations of less than 1.0 milligram per liter (mg/L)) in water samples from the surficial aquifer also indicate that the unit does not receive recharge rapidly from the atmosphere and, therefore, is under confined conditions.

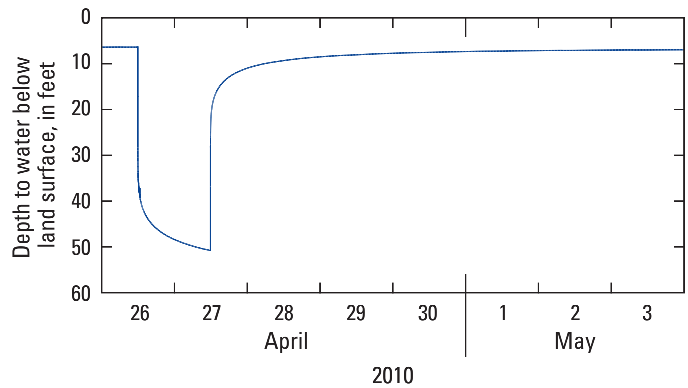

Figure 4. Measured water level in well 33P030 during a 24-hour aquifer test, Fort Stewart, Georgia, April 26–May 3, 2010.

GROUNDWATER QUALITY

A water sample was collected on April 27, 2010, near the end of the aquifer test after more than 23 hours of continuous pumping at 552 gal/min. The physical properties had stabilized prior to the sample collection, and specific conductance was 128 microsiemens per centimeter at 25 degrees Celsius, pH was 5.91, dissolved-oxygen concentration was less than 1.0 mg/L, and water temperature was 21.53 degrees Celsius. The water smelled of rotten eggs, which indicates the presence of hydrogen sulfide.

After the physical properties were measured, a water sample was collected and analyzed for major anions, selected trace metals and nutrients, turbidity, alkalinity, hardness, and total dissolved solids (Table 1). With the exception of iron, ammonia, and orthophosphate, constituent concentrations were all below State and Federal drinking water standards (Georgia Environmental Protection Division, 1997a,b; U.S. Environmental Protection Agency, 2000a,b). The ammonia and orthophosphate concentrations of 0.16 and 0.51 mg/L, respectively, were higher than is typical for uncontaminated groundwater. The dissolved iron concentration of 1,200 micrograms per liter (µg/L) was higher than the U.S. Environmental Protection Division Secondary Maximum Contaminant level of 300 µg/L. High iron concentrations may result in discolored water, stained plumbing fixtures, and an unpleasant metallic taste to the water, but the iron concentration is not an issue for irrigation supply (U.S. Department of Agriculture, 1999).

Table 1. Analytical results of selected water-quality constituents in water from well 30P030 at Fort Stewart, Georgia, April 27, 2010.

[NTU, nephelometric turbidity units; mg/L, milligram per liter; µg/L, microgram per liter; $CaCO_3$, calcium carbonate; N, nitrogen; Fe, iron; Mn, manganese; Zn, zinc; <, less than; NA, not applicable]

Constituent (samples raw, unfiltered)	Concentration result	Maximum contaminant level[a] (mg/L)
Turbidity, NTU	1.1	1.0/0.3 [b]
Hardness as $CaCO_3$, mg/L	63	NA
Alkalinity, total as $CaCO_3$, mg/L	56	NA
Sulfate, total, mg/L	<1.0	250 [c]
Chloride, total, mg/L	5.0	250 [c]
Fluoride, total, mg/L	<0.20	4.0 [d]
Dissolved solids, total, mg/L	93	500 [c]
Nitrate, total as N, mg/L	<0.050	10 [d]
Nitrite, total as N, mg/L	<0.050	1.0 [d]
Nitrite plus nitrate, total as N, mg/L	<0.050	NA
Nitrogen, total as N, mg/L	<0.25	NA
Ammonia, total as N, mg/L	0.16	NA
Orthophosphate, total, mg/L	0.51	NA
Iron, total as Fe, µg/L	1,200	0.3 [c]
Manganese, total as Mn, µg/L	64	0.05 [c]
Zinc, total as Zn, µg/L	<20	5.0 [c]

[a] U.S. Environmental Protection Agency, 2000a,b, and Georgia Environmetal Protection Division, 1997a,b.

[b] Drinking water standard for water-treatment plants using conventional or direct filtration and less than 0.3 mg/L in 95 percent of samples collected during a 30-day period.

[c] Secondary maximum contaminant level.

[d] Primary maximum contaminant level.

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