ENGINEERING ASSESSMENT OF THE MIOCENE AQUIFER SYSTEM IN COASTAL GEORGIA

Jonathan S. Radtke[1], Christopher D. Hemingway[2] and Robert Humphries[3]

AUTHORS: [1]Senior Hydrogeologist, [2]Project Hydrogeologist, and [3]Geologist, Golder Associates Inc., 3730 Chamblee Tucker Road, Atlanta, GA 30341.

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Abstract. Under contract to the Georgia Geologic Survey, Golder Associates Inc. (Golder) performed an investigation to characterize the water-bearing properties of the Miocene aquifer system in coastal Georgia (also referred to as the upper and lower Brunswick aquifers). The investigation focussed on specific areas where a cap has been imposed restricting further withdrawals from the Upper Floridan Aquifer. At selected sites in Bryan, Chatham, Effingham and Glynn counties, Golder installed pumping wells and observation wells within the Miocene aquifer(s) and performed 72-hour pumping tests. Results of the investigation revealed that the lower Brunswick aquifer is absent at the sites in Chatham, Effingham and Bryan counties. Furthermore, the upper Brunswick aquifer at these locations is poorly developed, producing sustainable yields of only five to 15 gpm. However, there are Miocene wells within the Brunswick aquifer in Bryan County that produce upwards of 100 gpm, indicating significant variation in the hydraulic properties of the Miocene aquifer system in this area. Both the upper and lower Brunswick aquifers are present at the Glynn County site. While the upper Brunswick aquifer at this location is capable of producing only about 10 gpm, the lower Brunswick aquifer can produce a sustainable yield of over 300 gpm. In addition to providing water resource information to planners, developers and industry, the data produced from this investigation will also be incorporated into regional groundwater flow and transport models being developed by the USGS for management of groundwater resources throughout coastal Georgia.

INTRODUCTION

Extensive use of the Upper Floridan Aquifer system has caused cones of depression in the potentiometric surface along the Georgia Coastline (particularly around the communities of Savannah and Brunswick) and salt water intrusion has become a significant concern. Consequently, the Georgia Environmental Protection Division (EPD) has developed an *Interim Strategy for Managing Salt Water Intrusion in the Upper Floridan Aquifer of Georgia.* Key components of the strategy are to conduct research that will lead to development of measures to stop salt water intrusion and to develop a long term management plan to protect the Upper Floridan Aquifer. Consistent with these components, the Miocene aquifers, often referred to as the upper and lower Brunswick aquifers, are being considered as an alternative water source to the Upper Floridan aquifer. Potential use of the Miocene aquifers is of particular interest in Glynn County, Chatham County, and portions of Bryan and Effingham counties where a cap on further groundwater withdrawals from the Upper Floridan Aquifer has been imposed.

An investigation was conducted to characterize the Miocene aquifer system in these areas and determine to what extent these aquifers can be developed without adversely affecting the Floridan aquifer system or developing problems of their own. The investigation included installation of test wells and observation wells at four sites in Bryan, Chatham, Effingham and Glynn Counties, and performance of pumping tests at each site. The data were analyzed and evaluated to provide estimates of specific aquifer parameters and to determine the water-bearing capacity of the aquifer(s) at each location.

Information derived from this investigation can be used by local governments, commercial developers and industry for their water-supply planning. Specifically, the investigation provides information as to whether the Miocene aquifers offer an alternative source of water to the Upper Floridan Aquifer in the capped areas. The investigation also provides critical input parameters for regional groundwater flow and solute transport models currently being developed by the United States Geological Survey (USGS) and others.

BACKGROUND

The majority of the Miocene related work completed to date has focussed on identifying formation sequences using existing corehole data and geophysical logs (Clarke et al, 1990). Limited work has been performed defining the hydraulic characteristics of the Miocene aquifers (Steele and McDowell, 1998).

Hydrogeology of Miocene Aquifer System

The upper and lower Brunswick aquifers are formed by two Miocene depositional sequences. Each sequence forms a geologic unit consisting of a basal carbonate layer, a middle clay layer, and an upper sand layer. The upper sand layers represent the upper and lower Brunswick aquifers (Clarke, Hacke, and Peck, 1990).

The upper Brunswick aquifer consists of poorly sorted, fine to coarse, slightly phosphatic and dolomitic quartz sand and limestone. The aquifer ranges in thickness from less than 20 feet in Chatham county to 150 feet in Wayne County (Clarke, Hacke, and Peck, 1990). In general, the thickness of the upper Brunswick increases toward the south-south west along the Georgia coastline. Typically the upper Brunswick aquifer is separated from the overlying surficial aquifer by a confining unit consisting of phosphatic silty/sandy clay or limestone. Because few individual wells have tapped into the upper Brunswick there is limited hydrologic data available for this aquifer. As of 1990 there had been no pumping tests performed on the upper Brunswick.

The lower Brunswick also consists of poorly sorted, fine to coarse, slightly phosphatic and dolomitic, quartz sand and limestone. This unit is absent in the Savannah, GA area because the permeable upper sand layer has been eroded away or was never deposited. As with the upper Brunswick, the lower Brunswick aquifer thickens to the south and is thickest in the Glynn County area. The upper and lower Brunswick aquifers are separated by a confining layer that consists of silty clay and phosphatic limestone or dolomite.

Hydrographs from existing wells screened in the upper and lower Brunswick aquifers exhibit water level fluctuations and trends similar to one another, indicating a hydraulic connection between the aquifers. Likewise, the water levels fluctuate in response to seasonal climatic changes and regional pumping from the Upper Floridan aquifer, indicating some degree of communication with overlying and underlying aquifers. The degree of interconnection is largely dependent upon the thickness of the confining layers separating the aquifers.

The lower Brunswick aquifer is absent throughout most of Chatham and Effingham counties and occurs sporadically throughout Bryan County. Production wells installed near Richmond Hill in Bryan County were reportedly screened in the lower Brunswick aquifer. Analyses of pumping test data from these wells yielded transmissivity values of 2200 to 2700 $ft.^2/day$ (Jordan, Jones and Goulding, 1999). Although the upper and lower Brunswick units are relatively thin throughout much of the county, these data indicate that the potential for water supply from these units is good in some areas.

Several of the wells installed in the lower Brunswick aquifer are flowing wells. Well yields from the lower Brunswick aquifer in Glynn County range from as little as 3 gpm to over 1,000 gpm. Transmissivity values range from less than 1400 ft^2/day to 4700 ft^2/day (Clarke, Hacke, and Peck, 1999). Based on these data, the lower Brunswick aquifer in Glynn County is expected to have greater groundwater production potential relative to the other three counties.

AQUIFER ASSESSMENT PROGRAM

The Georgia EPD selected test sites in each of the subject counties. These locations are shown on Figures 1 and 2. The aquifer assessment program consisted of the following activities:

- Drilling and installation of a test well and corresponding observation well in the upper Brunswick and lower Brunswick (if present) aquifers at each site;

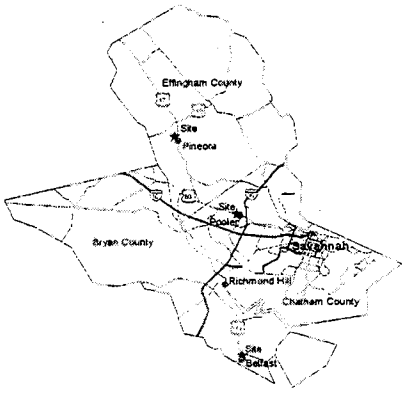

Figure 1. Test locations in Bryan, Chatham and Effingham counties.

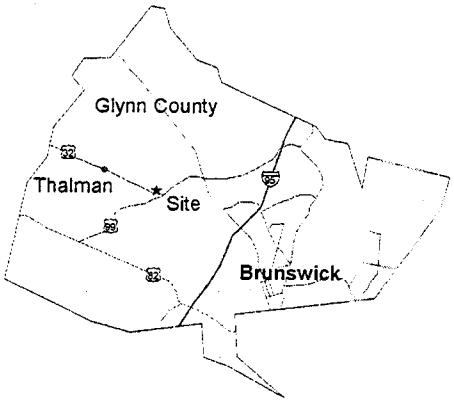

Figure 2. Test locations in Glynn County.

- Performance of a 72-hour pumping test in each test well to obtain data to adequately characterize the water-bearing properties of the aquifer(s);
- Analysis of pumping test data to calculate specific aquifer parameters such as transmissivity, storativity, hydraulic conductivity, etc.; and
- Evaluation of the pumping test results to determine the viability of the aquifer as an alternative water source and provide an estimate of sustainable yields.

Drilling and Well Installations

At each site, a pilot hole was advanced using mud rotary techniques through the Miocene deposits down to the top of the Floridan Aquifer. Lithologic logs were produced and downhole geophysical surveys were conducted for each pilot hole. Marker horizons depicted on gamma logs within the Miocene deposits were used to identify the depositional sequences within the Miocene deposits. These data, along with resistivity data, were used to identify the Brunswick aquifers and select the appropriate screen intervals for the pumping and observation wells.

At the Bryan, Chatham and Effingham sites, only the upper Brunswick aquifer was encountered. One pumping well and one observation well were installed at each of these locations. The screen intervals were set at depths of 230-265 feet below ground surface (ft.bgs) in Bryan County, 175-200 ft.bgs in Chatham County and 155-175 ft.bgs in Effingham County.

At the Glynn County site, both the upper and lower Brunswick aquifers were present. A total of four wells (one pumping well and one observation well in each aquifer) were installed at this site. The permeable portion of the upper Brunswick aquifer occurred at approximately 285-300 ft.bgs while the permeable portion of the lower Brunswick aquifer occurred at approximately 430-490 ft.bgs.

Aquifer Testing

Constant rate pumping tests were conducted at each test site to provide data for analysis of aquifer parameters and estimates of sustainable yields. The test wells were pumped for a period of 72 hours followed by a recovery phase. Pressure transducers and dataloggers were used to accurately measure and record water levels in the pumping and observation wells.

Prior to each pumping test, water levels in each well were monitored for a minimum of seven days to determine static water levels and assess ambient potentiometric trends. The subsequent pumping test data were corrected accordingly prior to analysis. The data were also corrected for barometric pressure effects.

The upper Brunswick aquifer wells at the Chatham County and Effingham County sites were each pumped at a rate of about five gpm with drawdowns of approximately 90 feet and 105 feet, respectively. The upper Brunswick well at the Bryan County site was pumped at a rate of 15 gpm with a drawdown of about 55 feet.

The upper Brunswick well at the Glynn County site was pumped at a rate of seven gpm with a drawdown of approximately 80 feet. The lower Brunswick well at this location was more prolific, producing 340 gpm with a drawdown of about 60 feet.

Aquifer Test Analyses

The pumping test data were analyzed to obtain estimates for transmissivity, storativity, and hydraulic conductivity. Methods for analyzing the aquifer test data were selected to provide appropriate aquifer parameter estimations in order to facilitate an accurate and comprehensive evaluation of the water-bearing characteristics of the Miocene Aquifers at each site.

To increase the reliability of the calculated aquifer parameters, the skin influenced portion of the data was identified and distinguished from the undisturbed formation properties. Also, to the extent practical, the degree of heterogeneity from changes in unit thickness or variation in properties away from the well were evaluated. This was accomplished using pressure derivative analysis methods (Spane and Wurstner, 1993). The data were also evaluated to determine possible effects from recharge boundaries and from leakage from overlying and underlying units.

AQUIFER TEST RESULTS

The pumping test data from each site were analyzed for transmissivity (T), storativity (S) and hydraulic conductivity (K). Using the pressure derivative approach, the relative heterogeneity of the aquifer away from the pumping well was evaluated along with the presence (or absence) of aquifer recharge boundaries and leakage. Aquifer test results for each site are summarized in Table 1.

The tests performed in Bryan, Chatham and Effingham counties did not exhibit significant leakage or indicate the presence of recharge boundaries within close proximity to the test sites. These tests did indicate some degree of heterogeneity within the aquifer (i.e. increasing or decreasing T away from the pumping well).

The Glynn county tests indicated slight communication between the upper and lower Brunswick aquifers. Any potential effects on the Upper Floridan Aquifer were inconclusive. However, data from the lower Brunswick test suggest that leakage from the overlying and underlying confining units was occurring and that a potential recharge boundary exists in the area. The apparent recharge boundary could be associated within increase in leakage from the Upper Floridan Aquifer at some distance away from the pumping well or may be a response to external influences such as the cessation of pumping in nearby wells. The tests did indicate a decrease in transmissivity away from the test well.

CONCLUSIONS AND RECOMENDATIONS

The water-bearing capacity of the Miocene aquifer system varies significantly throughout coastal Georgia. Based on the results of this investigation, the Miocene aquifers do not provide a viable alternative to the Upper Floridan Aquifer in Effingham and Chatham counties.

Table 1. Aquifer Test Results

County	Units	Effingham	Chatham	Bryan	Glynn	
Aquifer		Upper Brunswick	Upper Brunswick	Upper Brunswick	Upper Brunswick	Lower Brunswick
T	ft^2/day	10	12	86	23	2976
K	ft/day	0.5	0.5	2.4	2.3	50
S		1E-04	1E-05	1E-04	1E-04	1E-04
Q	gpm	5	5	15	7	340
Q/s	gpm/s	0.1	0.1	0.3	0.1	5.7

T = transmissivity
K = hydraulic conductivity
S = storativity
Q = pumping rate
Q/s = specific storage

The occurrence and thickness' of the upper and lower Brunswick aquifers is variable throughout Bryan County. The pumping test conducted during this investigation near Belfast indicated a relatively low transmissivity (85 ft^2/day) and sustainable well yield (15 gpm) for this area. However, lower Brunswick wells installed near Richmond Hill in Bryan County have reported transmissivities on the order of 2200-2700 ft^2/day. This indicates that the Miocene aquifers are capable of producing suitable quantities of water for public and private use in some areas of the county. Installation of additional test wells would be useful to further delineate where significant yields may be obtained within the Miocene aquifer(s) in Bryan County.

The upper and lower Brunswick aquifers in Glynn County are generally thicker and more prolific than in other areas. The lower Brunswick aquifer appears to be present throughout the county and wells screened in this aquifer are capable of yielding 300 gpm or more. However, with increased usage, it is important to properly manage the aquifer to avoid problems in the future. Development of accurate regional groundwater models will be helpful in predicting long-term impacts and will provide a useful tool for management of the aquifer. Additional monitoring wells may be required, specifically in coastal areas experiencing rapid growth, to monitor the effects of increased pumping from the Miocene aquifers.

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