THE SURFICIAL AQUIFER - AN ALTERNATIVE TO THE FLORIDAN AQUIFER IN CHATHAM COUNTY, GEORGIA

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Abstract. The water quality of the Floridan aquifer is in decline in some areas of coastal Georgia and South Carolina due to saltwater intrusion caused from over pumping. This paper's objective is to provide two examples of how the surficial aquifer in Chatham County can be developed for non-potable uses thus conserving the Floridan aquifer.

INTRODUCTION

This article describes the use of the surficial aquifer as a water resource alternative to the Floridan aquifer in Chatham County. This is a practical conservation solution, where available, to the constraints being placed on increased use of the Floridan aquifer. The lower permeable zone in the surficial aquifer system has proved to be of sufficient quality and quantity to irrigate three athletic fields at Savannah Country Day School in Savannah, Georgia. Similar uses could be made of this groundwater supply where it is available as is being done by thousands of home owners on Skidaway Island, Chatham County, Georgia. Administrators and design engineers responsible for identifying water resources to irrigate recreational fields need this information. The water supply described here has fewer restrictions applied to its use than municipal or private water supplies obtained from increased pumpage from the Floridan aquifer.

BACKGROUND

The Floridan aquifer is the principal water supply for eastern Georgia, southeastern South Carolina, and northeastern Florida (DNR, 1990). The Georgia Department of Natural Resources is educating the public that there is limited potential for increase groundwater withdrawal in eastern Georgia from the Floridan aquifer (DNR, 1991). The limited potential is due to seawater encroachment and saltwater intrusion into the Floridan aquifer in the coastal areas of Georgia and South Carolina. Saltwater intrusion into the Floridan aquifer reduces the water quality. Saltwater intrusion is due to extreme decline in potentiometric head of the Floridan aquifer because large volumes of groundwater are withdrawn in population centers along the coast from Hilton Head, South Carolina to Jacksonville, Florida.

Current constraints placed on increased withdrawal from the Floridan aquifer are based on models prepared by EPD (DNR, 1991). The models predict that no more than one million gallons per day of increased potential remains in the Floridan aquifer per any four square mile area in Chatham County, Georgia. EPD is trying to reverse the trend of saltwater intrusion and increase the quality of the Floridan aquifer where it has declined. Industries in affected areas are responding by reducing their usage of the Floridan aquifer. It is possible that some industries may consider relocating to areas where less constraints are placed on pumpage from the Floridan aquifer. Community water supply administrators have to consider the restrictions imposed on pumpage from the Floridan aquifer when they allow new water users to connect to their system. They may have to choose who can have water based on the proposed water use. Water for irrigating recreation fields will probably have a lower priority than water for drinking.

RELATED RESEARCH

In 1986, S&ME (S&ME, 1986) assessed the effects that current and future users of the surficial aquifer on Skidaway Island, Georgia would have on the surficial aquifer, the Floridan aquifer, and surrounding salt water marshes. They concluded that current use and projected use of the surficial aquifer will not adversely impact those water resources. Shallow wells are completed in the surficial aquifer to irrigate lawns and operate heat pumps on Skidaway Island. At the time of the report, 263 wells tapped the shallow aquifer system. Maximum peak use for all shallow wells was estimated to be 850,000 gallons per day. Skidaway Island is approximately ten square miles in size. If the community water system at Skidaway Island wanted to increase the pumpage from the Floridan aquifer to replace what was pumped from the shallow aquifer, they would use approximately 34% of the available capacity for the island based on EPD recommendations. Shallow wells currently number in the thousands on Skidaway Island, according to Mr. Paul Clawson, P. G. of Geothermics (Clawson, 1996) and salt water intrusion in the surficial aquifer system is not a problem. Skidaway Island is approximately six miles southeast of Savannah Country Day School. The description of the surficial aquifer given by S&ME is very similar to what was observed at the Savannah Country Day School.

S&ME described the surficial aquifer as a three unit Pliocene-Recent age system deposited on eroded Miocene age sediments. The thickness of the Pliocene-Recent sediments varies over short lateral distances. The upper unit is a fine-grained sand ranging in thickness from ten to forty feet. The saturated thickness of the water-table aquifer in the upper sand unit ranged from seven to seventeen feet. The middle unit is a silt and plastic-sticky clay confining bed. These low permeable sediments are saturated and range in thickness from nine to forty-three feet. The lower semi-confined to confined unit is a medium - to- coarse-grained, fairly well sorted sand. It is highly variable in thickness over short lateral distances, ranging from less than five to twenty-five feet thick. The average thickness was fifteen feet. The lower sand unit is a remnant of reworked underlying Miocene sediments. The water table elevation in the unconfined aquifer was reported to be approximately three feet higher than the potentiometric surface of the lower sand unit. Aquifer parameters for the lower sand unit were estimated based on sieve analyses of formation samples. The estimated hydraulic conductivity of the lower sand unit ranged from 40 feet/day (300 gallons/day-feet^2) to 400 feet/day (3000 gallons/day-feet^2). Transmissivity for the lower sand unit was estimated to range from 150 feet^2/day to 6000 feet^2 /day and averaged 3000 feet /day. Storativity was estimated to range from 0.01 to 0.001 based on typical values for shallow semi-confined to confined aquifers. The water quality reported for the one sample collected from the lower sand unit was good, although the iron concentration was high. Specific conductance was 155 μmhos/cm, pH was 7.71, temperature was 25 C°, Chlorides were 25 mg/l, sulfate was <1.0 mg/l, and iron was 0.79 mg/l.

EXPERIMENTAL DESIGN

Water Resource Exploration

EMC Engineering Services, Inc. designed three athletic fields totaling approximately six and one half acres for Savannah Country Day School. The school considered using the surficial aquifer to provide the 24,000 gallons per day needed to irrigate the fields. Mr. Jim McClain of McClain's Shallow Wells was contracted to investigate the availability of a shallow groundwater supply at the site that would produce approximately ninety gallons per minute for five hours per day. Mr. McClain has extensive experience installing shallow wells on Skidaway Island although the well yields required for domestic wells on Skidaway Island are usually in the range of fifteen gallons per minute. He proposed drilling a larger diameter well into the lower sand unit of the surficial aquifer and installing a submersible pump. A combined yield from three wells was hoped to be enough to meet the rate required by the school's irrigation system. McClain was directed where to begin drilling test borings. The borings were drilled mud rotary using biodegradable drill mud. Drill cuttings were inspected to estimate the potential yield of the saturated sediments. Boring locations were abandoned where the lower sand unit was too clayey to yield the required rate. New locations were explored along the perimeter of the middle athletic field in the direction of decreasing fines. The fourth boring drilled looked promising and it was completed as a four-inch diameter PVC well. The lateral distance from the first boring, where the lower sand unit was too clayey, to the fourth boring, where the lower sand looked clean enough to produce the required yield, was seven hundred and twenty feet. A ten-foot long PVC screen was installed in the lower sand unit from fifty-seven to sixty-seven feet. Mr. McClain slotted his well screens in his shop with a jig. Slot widths were two hundredths of an inch. A submersible pump was temporarily installed at fifty-five feet to perform a drawdown test. The initial water level was 10.85 feet below ground surface. The pump was turned on and ran for twenty minutes at which time the water level appeared to stabilize at 15.9 feet below ground surface. The pumping rate remained a constant thirty-seven and one-half gallons per minute. The water's turbidity was measured at 16.7 NTU's at the discharge point just before the pump was turned off. The yield and appearance of the groundwater produced looked adequate for the irrigation system. Two additional borings were located in the direction of decreasing fines in the lower sand unit. They too were completed as wells. The wells are located approximately one hundred and eighty feet apart in a "L" shaped layout around the outside of the middle athletic field. The two outside wells are three hundred and forty feet apart. A three horsepower submersible pump was installed in each well.

Surficial Aquifer Description

The surficial aquifer was found to consist of three distinct units: an upper fine sand ranging from twenty to twenty-one feet thick, a silt and sticky-clay confining bed approximately twenty-five feet thick, and a lower medium - to- coarse-grain well sorted sand ranging from sixteen to twenty-one feet thick. The amount of fines decreases with depth. The lower sand unit overlies a dark grey-green, hard clayey silt. The base of the lower sand unit ranges from sixty-one to sixty-seven feet below ground surface. Ground surface elevation is approximately twenty-one feet. This stratigraphy and lithology is very similar to that described by S&ME on Skidaway Island.

Lower Unit Aquifer Water Quality

The groundwater was sampled from the first test well with a disposable bailer after the pump test. Measured field parameters are: salinity < 0%, conductivity = 240 μmhos/cm, pH = 7.91, and temperature = 18.8°C. Laboratory analyses of the groundwater are: alkalinity, carbonate = 0.00 mg/l; alkalinity, total = 112 mg/l; bicarbonate = 112 mg/l; hardness, carbonate = 114 mg/l; hardness, calcium = 99.0 mg/l; hardness, magnesium = 15.2 mg/l; silica, dissolved = 12.9 mg/l; chloride = 16.6 mg/l; calcium = 39.7 mg/l; nitrate/nitrite < 0.02 mg/l; total solids = 107 mg/l; iron = 0.93 mg/l; manganese < 0.02 mg/l; and magnesium = 2.82 mg/l.

The water is non-encrusting based on the calculated values for the Ryzner Stability Index of 7.79 and the Langelier Index of -0.346 (Driscoll).

RESEARCH METHODS AND ANALYSIS

EMC Engineering Services, Inc. and Mr. Paul Clawson of Geothermics volunteered their time and materials to drill two groundwater monitoring well clusters for the purpose of assisting Savannah Country Day School students in preparing their Senior projects. Each well cluster consisted of a one-inch piezometer completed in the lower sand unit and a one-inch piezometer completed in the upper sand unit. The water level in the upper piezometer is six to seven feet below ground surface. The saturated thickness of the upper sand unit is approximately fourteen feet. The potentiometric surface of the lower sand unit is approximately eleven to twelve feet below ground surface. The head difference between the upper and lower sand units is approximately five feet. The hydraulic gradient is downward. One well cluster was located thirty feet and the other was located seventy-three feet from the middle production well. Arco, Inc., the irrigation contractor, turned on the central production well and measurements of the water level changes in the two well clusters were recorded. The pump was discharged to the ground surface at a constant fifty gallons per minute for nine hours. The water levels in the two well clusters were measured for the duration of the pumping.

RESULTS

No change was observed in water level measurements in the upper fine sand during the aquifer test. The changes in water level measurements in the lower sand unit matched the Theis drawdown curves for a confined aquifer. Based on the curve matching procedures described by Lohman (Lohman, 1979) transmissivity and storativity for the lower sand unit were determined. The mean transmissivity determined at the two piezometers was two $feet^2/min$ or 2880 feet/day. Mean storativity was determined to be 0.0004. The results of the aquifer test are consistent with the formation materials observed at the athletic fields and with the S&ME report.

DISCUSSION

The Irrigation system has performed successfully since it was completed in April, 1996. The only difficulties to date have occurred when the system was disrupted by lightening and vandals. Signs are posted at the fields advising the public that the irrigation water is not a source of drinking water. This caution and quick-connect couplings for attaching hoses to the system protect the public from drinking water that has not been determined to be a potable source. The school also has backflow preventers where their drinking water is connected to the City of Savannah's water supply to prevent any possible contamination of the City's supply.

SUMMARY AND RECOMMENDATIONS

Current constraints are being placed on increased withdrawal from the Floridan aquifer due to salt water intrusion from over pumping. EPD has asked the public to reduce their use of the Floridan aquifer by conservation and using alternative sources. Previous and present works show that the surficial aquifer system provides water of sufficient quantity and quality for irrigation and heat pump operation in Chatham County, Georgia. Aquifer parameters and water quality measurements are similar for the two study areas.

The surficial aquifer is a source of water for irrigation and non-potable uses that should be considered by design engineers and administrators. Precautions should be implemented to make the public aware that irrigation water from the surficial aquifer has not been determined to be safe for drinking. Also, cross contamination of potable and non-potable sources should be guarded against occurring.

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