ALTERNATIVES FOR GROUND-WATER MANAGEMENT IN THE BRUNSWICK, GA AREA

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Abstract. The quality of ground-water withdrawals in the Brunswick, GA area has degraded over the years due to the upconing of highly mineralized water into the Floridan aquifer from the underlying Fernandina formation. The upconing has resulted in a saltwater plume in the Floridan aquifer that has migrated among various pumping centers. This degradation in water quality has threatened the potential of the Floridan aquifer as a long term water resource for both industrial and municipal water supply. Several alternatives to improve the water quality of withdrawals from the Floridan aquifer are offered. These alternatives include:
1) making withdrawls from the Upper Floridan aquifer, only 2) optimizing pumping schedules, 3) controlling vertical migration of the plume by manipulating aquifer pressures, and 4) selective pumping in areas outside the plume to control horizontal migration.

INTRODUCTION

Historically, ground-water withdrawals in the Brunswick area have been affected by highly mineralized water migrating upward from below the pumping regions (Wait and Gregg, 1973; Clarke, et al., 1990; and Milby, et al., 1991). Over many years, industrial pumpage at Brunswick Pulp and Paper (BP&P), Hercules, and LCP Chemicals (LCP), and withdrawals by the city of Brunswick for domestic water supply caused a plume of saltwater to develop within the primary artesian aquifer under parts of the industrial plants and the city of Brunswick. Based on a review of existing data obtained from the US Geological Survey (USGS) and the Georgia Geological Survey (GGS), recommendations for managing the saltwater intrusion problem and thus improving the water quality produced by wells in the Brunswick area are presented.

REGIONAL SETTING

Geologic Setting

The Brunswick peninsula is located in the Coastal Plain physiographic province on the Atlantic Coast of Georgia. The geologic units of interest extend from the surface to more than 2,800 feet (ft) below sea level. They are primarily a carbonate sequence; however, the upper 150 to 180 ft of sediment consists of sands, gravels, and silty sand, and from about 180 to about 500 ft, there are alternating beds of clays, sands, and limestone (Wait and Gregg, 1973; Clarke, et al., 1990). The rest of the stratigraphic column consists primarily of calcareous and dolomitic limestone (Wait and Gregg, 1973; and Clarke, et al., 1990). Much of the limestone sequence is made up of a paleokarst system with cavernous zones having a high degree of interconnection and possible vertical conduits between permeable zones (Krause, personal communication, 1995). In addition, there are possible faults having displacements of a few tens of feet (Maslia and Prowell, 1990).

Hydrogeology

The geologic units have been divided into hydrostratigraphic units (Figure 1). The underlying hydrostratigraphic units include, in order of increasing depth, a surficial aquifer, an upper semiconfining unit, and the Floridan Aquifer System. The Upper Floridan aquifer is the principal water bearing aquifer in Coastal Georgia containing good quality water (Clarke, et al., 1990).

The Floridan Aquifer System consists of the Upper and Lower Floridan aquifers, separated by the middle semiconfining unit (Figure 1). Locally, the Upper Floridan aquifer is approximately 460 ft thick and has upper and lower water-bearing zones (Jones and Maslia, 1994). Separating the upper and lower water-bearing zones is the dolostone semiconfining unit, which is approximately 200 ft thick (Jones and Maslia, 1994).

The Lower Floridan aquifer consists of two major zones separated by a semiconfining unit, as well (Jones and Maslia, 1994). The upper portion of the Lower Floridan aquifer consists of various water-bearing units and is approximately 670 ft thick (Jones and Maslia, 1994). A lower semiconfining unit then separates the upper portion of the Lower Floridan aquifer from the Fernandina Permeable Zone (Jones and Maslia, 1994) (Figure 1). This zone is highly permeable and is present only in the Brunswick area (Jones and Maslia, 1994).

Water Quality

Saltwater intrusion in the Upper Floridan aquifer has been occurring in the Brunswick area for the past 30 to 40 years (Clarke, et al., 1990; Maslia and Prowell, 1990; and Randolph

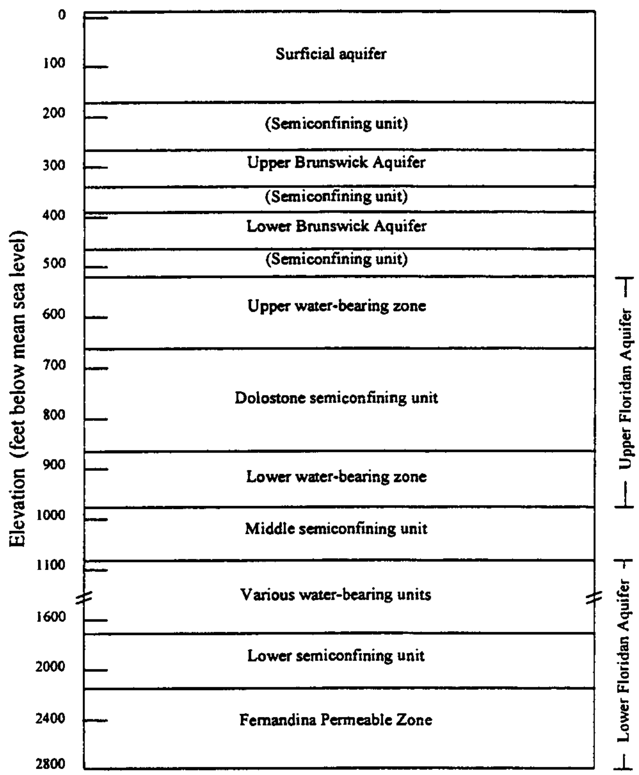

Figure 1. Generalized hydrostratigraphic units in the Brunswick area, Georgia.

and Krause, 1990). Background chloride concentration levels for the Upper Floridan aquifer were originally very low, less than 50 mg/L (Wait and Gregg,1973; Randolph and Krause, 1990). However, concentrations have increased over time at three distinct locations in the Brunswick area (Figure 2). The chloride plume maintains its shape because of the current cone of depression in the area caused by pumping at Hercules, the city well field, and BP&P.

The source of the contamination in the Upper Floridan aquifer has been shown to come from highly mineralized water in the Fernandina Permeable Zone of the Lower Floridan aquifer (Clarke, et al., 1990; and Randolph and Krause, 1990). The primary cause of the migrating saltwater has been a strong upward gradient between the Lower and Upper Floridan aquifers and discontinuities or interconnection between the aquifer units (Clarke, et al., 1990; Maslia and Prowell, 1990). However, the pathways for its migration are still unknown.

TECHNIQUES TO IMPROVE WATER QUALITY

Innovative alternatives for ground-water management are needed to help maintain and potentially improve the water quality of the Upper Floridan aquifer in the Brunswick area. Some alternatives for the management of water quality include: 1) plugging back production wells; 2) selected drilling of new production wells; 3) pumping to manage the chloride plume; and 4) pumping to control the chloride source.

Plugging Wells

Wells have generally been completed through the dolostone semiconfining unit. Plugging back production wells to the upper water-bearing zone could improve the water quality produced by the wells. Monitoring data suggest that on the outer edge of the plume the water quality may be better within the upper water-bearing zone of the Upper Floridan aquifer. Further, the water quality of withdrawals outside of the plume may also improve, if wells were restricted to only the upper water-bearing zone.

In addition to plugging back wells currently used for production, it may also be prudent to abandon selected wells that have been taken out of service and are no longer useful as a water supply. Wells should be abandoned, if they are no longer going to be used by the owner. These wells should be abandoned because of the possibility that an open borehole serves as a conduit for upward migrating saltwater, although the degree to which open boreholes contribute to the migrating saltwater is unknown.

The expected chloride concentrations of water after plugging selected existing production wells back to the recommended depth is 100 mg/L. This is reasonable since background concentrations are less than 50 mg/L. It is expected that plugged wells will produce water at 90 percent of their rated capacity because of decreased thickness in the production zone.

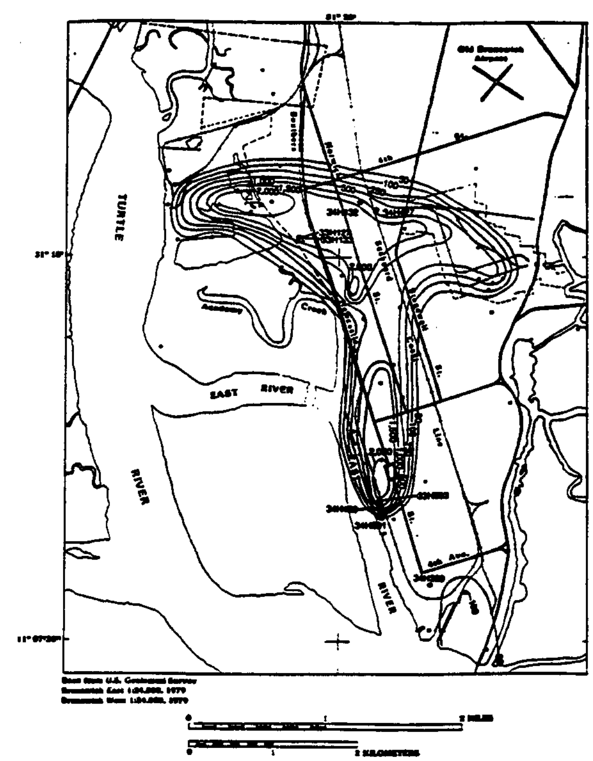

Figure 2. 1990 chloride plume in the Brunswick area (source: USGS Open-File Report 91-486). This distribution is still representative of the current extent of contamination.

Drilling Additional Wells

New wells may have to be drilled to replace wells currently producing poor quality water from within the chloride plume. These wells should be located outside of the existing chloride plume and completed in the upper unit of the Upper Floridan aquifer, a depth of approximately 700 ft to 750 ft, so that water is derived only from the upper water-bearing zone.

Managing the Wellfield to Control Plume Migration

A concern with drilling new wells outside the plume to replace those wells within the plume is that the additional wells could alter the existing cone of depression, thus causing the chloride plume to migrate to new pumping centers. Depending on the location of new wells and pumping rates, the effect of the migrating plume may not be seen for some time; however, unless some other action is taken, simply drilling new wells is, at best, a short term solution the water quality problems. A possible solution to this dilemma is to manage the wellfield in such a way as to maintain the location of the existing cone of depression. This may help to keep the plume in its existing location, thus providing good quality water from new wells for an extended period of time. To maintain the existing cone of depression, wells within the plume may have to be pumped continuously. Testing various pumping configurations will be necessary to optimize the management plan to control the plume.

Although continued pumping in the center of the plume will help to maintain water quality and control the plume, it is difficult to say how effective this will be. Well locations and pumping rates will have an impact on the center of pumping that develops as a result of the new wells. The development of a site specific model for the purpose of determining the best arrangement of wells to better manage the wellfield and the chloride plume would be very useful. The model could be used to simulate the impact of new wells and to help determine optimal locations and appropriate pumping rates. Further, models could simulate the location and migration of the center of pumping under various management scenarios.

Pumping from the Lower Floridan Aquifer

A potential solution for controlling the upward migration of saltwater would be to pump water from the Lower Floridan aquifer, thus lowering or reversing the head gradient that is helping to force the saltwater into the freshwater aquifer. By drilling a well into and pumping water from the Lower Floridan aquifer, it may be possible to decrease or reverse the head difference between the Upper and Lower Floridan aquifers. It is not likely that pumping a well open only to the in the Lower Floridan aquifer would have an immediate impact on the water quality of the Upper Floridan aquifer. However, the water quality of the Upper Floridan aquifer could freshen, if the source of saltwater is removed. This may offer a long term solution.

CONCLUSIONS

Poor water quality in the Brunswick area is a major concern. There are a limited number of options available for improving the water quality withdrawn from the Floridan aquifer. However, most options may only be short term solutions to a long term problem. The plugging back of wells and the drilling of new production wells can potentially produce improved water quality for the short term. However, unless the existing plume is managed properly, new production wells would likely cause the plume to migrate to new pumping centers. Additionally, as long as a strong upward gradient exists between the Upper and Lower Floridan aquifers, saline water will continue to migrate through the middle semiconfining unit and into the Upper Floridan aquifer. Although it would be experimental, pumping water from the Lower Floridan aquifer to potentially cut off the source of contamination of the Upper Floridan aquifer would be a potential long term solution for the area.

LITERATURE CITED

Clarke, J.S., Hacke, C.M., and Peck, M.F., 1990, Geology and ground-water resources of the coastal area of Georgia: Georgia Geological Survey Bulletin 113,106 p.

Jones, L.E., and Maslia, M.L., 1994, Selected ground-water data, and results of aquifer tests for the upper Floridan aquifer, Brunswick, Glynn County, Georgia, area: U.S. Geological Survey Open-File Report 94-520, 107 p.

Maslia, M.L. and Prowell, D.P., 1990, Effects of faults on fluid flow and chloride contamination in a carbonate aquifer system: Journal of Hydrology, v. 115, no.1-4, p. 1-49

Milby, B.J., Joiner, C.N., Cressler, A.M., and West, C.T., 1991, Ground-water conditions in Georgia, 1990: U.S. Geological Survey Open-File Report 91-486, 147 p.

Miller, J.A., 1986, Hydrogeologic framework of the Floridan aquifer system in Floridan and in parts of Georgia, South Carolina, and Alabama: U.S. Geological Survey Professional Paper 1403-B, 91 p.

Randolph, R.B. and Krause, R.E., 1990, Analysis of the effects of hypothetical changes in ground-water withdrawal from the Floridan aquifer system in the area of Glynn County, Georgia: U.S. Geological Survey Water-Resources Investigations Report 90-4027, 32 p.

Wait, R.L. and Gregg, D.O., 1973, Hydrology and chloride contamination of the principal artesian aquifer in Glynn County, Georgia: Georgia Geological Survey Hydrologic Report 1, 93 p.