REVIEW OF A FEASIBILITY STUDY OF AQUIFER STORAGE AND RECOVERY UTILIZING THE FLINT RIVER DISCHARGES

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Abstract. In the Flint River basin, traditional water supply resources are not reliably able to sustain future water demands of the agricultural and environmental interests. Cardno ENTRIX investigated the feasibility of applying aquifer storage and recovery (ASR) to help manage the water resource potential of the Flint River. The objective of the project was to find an alternative method of supplying water to new beneficial users without the need to increase dry-season withdrawals from the river or the Floridan aquifer in order to support new industry and growth in the region.

This presentation focuses on three key findings of the recently completed ASR feasibility assessment (for the Georgia Water Planning and Policy Center) of the Flint River basin: 1) ASR technology could be used to store large volumes of surface water during the rainy season when surface-water discharge rates are high. An ASR system could provide for seasonal storage of approximately 1.5 billion gallons of water to help mitigate drought impacts. Development of ASR facilities on even a larger scale might ultimately be feasible. 2) The potential sources of water to recharge the ASR system are the Flint River in the area of Lake Chehaw and Kinchafoonee Creek near Lake Worth or other alternative locations. 3) The most cost-effective approach to capturing and storing the river flows is to tap the high-stage river flows by use of shallow wells adjacent to the stream, and to store the water in a deeper, confined aquifer. This method of capturing the water will save considerable pre-treatment costs because any water that would be injected must meet primary drinking-water standards. Using wells to tap the surface flows via “bank filtration” eliminates the need to construct treatment facilities. This approach could potentially reduce source-water treatment costs and Operation & Maintenance requirements. This approach also minimizes the potential for metals leaching to occur during aquifer storage.

INTRODUCTION

The Flint River is a major source of water for farm irrigation, industrial use, and municipal supply in southwest Georgia. The river and its tributaries have provided a reliable source of fresh water for many beneficial uses since the region was first populated. Currently, increased withdrawals during the past few decades have caused flows in parts of the basin to fall below minimum rates considered necessary to protect aquatic habitats during periods of severe drought, and potentiometeric heads of the main groundwater irrigation sources to fall.

Concerns over safe yield in drought years prompted the Environmental Protection Division (EPD) of the Georgia Department of Natural Resources to stop processing more than 1,200 applications for water use permits within the basin beginning in November 1999. The water use permit moratorium was abolished in March 2006. However, issues over minimum flow in the Flint River are still very much of interest to Georgia and the bordering states of Alabama and Florida. Implementation of effective water conservation measures and development of alternative water supplies are therefore essential to the region.

This analysis assesses the feasibility of applying ASR technology as an effective water management strategy in the Albany area of the lower Flint River Basin (basin). Conceptually ASR stores either untreated or treated water from the Flint River, or an interconnected water source, in a deep artesian aquifer during periods of high flow. The stored water would be recovered during drought periods in order to augment existing flow in the basin. The target aquifer for water storage is the Paleocene age Clayton aquifer, which ranges in depth from approximately 625 to 750 feet below land surface (bls) in the study area.

The principal reason for considering ASR in the Flint River Basin, like other parts of the country, is the desire to balance water supply with increasing demand. Crop irrigation requirements in basin are low during the rainy season, which is the time that rivers and streams flow at maximum rates. The peak demand for water typically occurs during the dry season when surface water flows are low, raising the potential for stress to the system.

HYDROLOGIC CONSIDERATIONS

The Flint River Basin has the highest volume of surface and groundwater withdrawn for irrigation in the State of Georgia, with reported annual quantities in calendar year 2002 of 27 and 123 billion gallons, respectively (FRB Plan, 2006). Municipal water supply and industrial use by comparison account for less than 10% of the annual demand. The remainder of this discussion therefore focuses on irrigation water needs.

The FRB Plan, shows average annual irrigation trends in the basin for years 2000 and 2001. It can be seen from this figure that most water used for irrigation is withdrawn during the April to September growing season. Much of precipitation in the region generally occurs between early November and mid-April, so that river stages are normally beginning to recede at the start of the growing season. Irrigation water is needed most when the least amount of surface flow is occurring.

Surface water withdrawals have a direct influence on river stage and discharge. Much of the water pumped for irrigation in the basin is supplied by wells completed in the Floridan aquifer rather than surface water withdrawals. Groundwater pumping does have a significant influence on stream flow, however, because a high degree of hydraulic-connection exists between the aquifer and surface waters in the region.

The Flint River in the study area flows through a geologic province known as the Dougherty Plain, where permeable carbonate rocks of the Ocala Limestone that comprise the Floridan aquifer occur close to land surface. The province is characterized by karst topography with numerous sinkholes, depressions and other underground conduits that capture surface drainage (Torak and McDowell, 1996). The Flint River and its tributary streams are often incised through the upper Ocala Limestone strata. Studies show that pumping from the Floridan aquifer can cause reductions in base flow and spring discharge rates of more than 25 percent basin wide and higher in some areas due this connection. Torak and McDowell (1996) also report that the Flint River may receive as much as 500 mgd of groundwater discharge from the Floridan aquifer between Albany and Bainbridge.

HYDROGEOLOGIC CONSIDERATIONS

This section of the report describes the results of an initial hydrogeologic study conducted to assess the feasibility of developing an ASR system in the Albany area of the Flint River Basin, using the Clayton aquifer for water storage. The investigation was implemented by compiling and evaluating hydrogeologic data for the Clayton Formation and enclosing strata in the project area from the standpoint of ASR feasibility. The geologic and hydrologic (hydrostratigraphic) units of importance to the project and their characteristics with regard to native groundwater quality, hydraulic properties, storage zone confinement, regional flow characteristics, existing water use and other subsurface conditions were examined using data available from existing sources.

The primary areas currently being considered for the project are the Flint River near the west side of Lake Chehaw and Kinchafoonee Creek where it enters Lake Worth. The hydrogeologic investigation therefore focuses on that region. The target area discussed in the report refers to the junction of US Highways19 and 82 north of Albany. The study area boundaries extend out a radius of tens miles from that point

Most of the source material for this report consists of published reports by the U. S. Geological Survey (USGS), the Georgia EPD, and other sources. Some information came from the USGS National Water Information System (NWIS) web site. John Clarke and Nancy Barber at USGS made suggestions on pertinent information sources.

The following schematic hydrostratigraphic column showing the principal aquifers and confining units present in the study area between land surface and a depth of 900 feet bls. Geologic cross sections prepared by Wait (1963), Hicks, et al. (1981), and Clarke, et al. (1984) were utilized to correlate geologic structure over the study area.

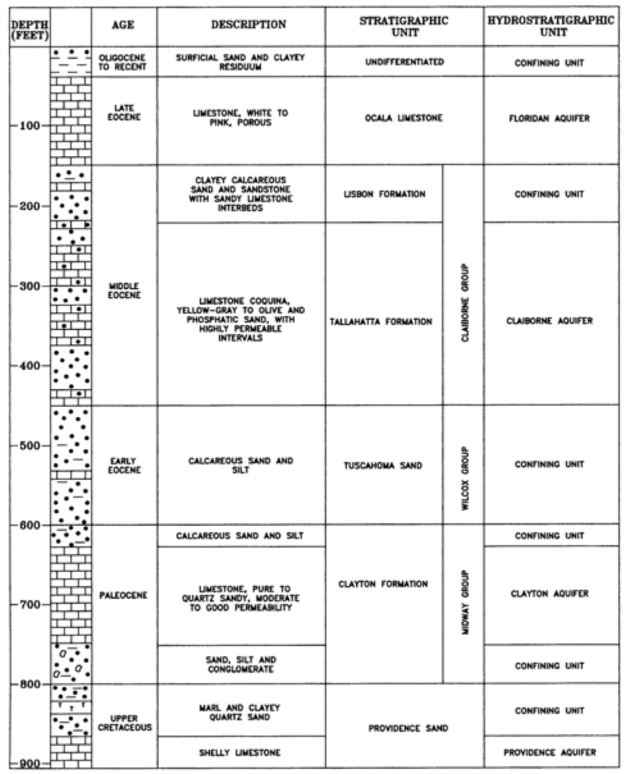

Figure 1.

The hydrogeologic investigation that follows focuses on the Clayton aquifer and adjacent strata that could influence the feasibility of storing water in the proposed interval. The Clayton aquifer is underlain by the Providence aquifer and Clayton-Providence confining zone. The Claiborne aquifer and Clayton-Claiborne confining zone overlie the Clayton aquifer. The characteristics of each of these units are described in this section.

The Clayton aquifer in the project area occurs within sediments of the Paleocene-age Clayton Formation

(Midway Group). The Clayton Formation in this area is typically comprised of three units; an upper calcareous sand, a middle limestone unit, and a basal sandy conglomerate. The middle carbonate is the principal water-yielding bed in the Midway Group and generally comprises the main producing interval of the Clayton aquifer. Fine-grained clastic sediments in the upper and lower part of the Clayton Formation confine the top and bottom of the aquifer.

The middle unit of the Clayton Formation typically consists of massive, white to light gray limestone. The limestone is composed of fossil shell fragments in a partially recrystallized, variably the limestone typically contains more quartz sand and becomes less coherent upward through quartz sandy, and well indurated limestone matrix (Wait, 1963; Clarke, et al., 1984). Glauconite and pyrite are common accessory constituents. The porosity developed in these rocks is mainly due to the presence of fossil molds (Wait, 1963).

The Clayton aquifer averages between 100 and 125 feet thick in the Albany area, with the top occurring at approximately 625 feet bls (Wait, 1963; Hicks, et al., 1981; Clarke et al., 1984). The Clayton Formation is essentially a clastic unit but it also contains limestone sections.

Reported transmissivity values to the southeast of Albany are generally less than 1,000 feet^2/day, while 4,000 to over 10,000 feet^2/day are more typical of aquifer conditions to the northwest. The closest multiple-well Clayton aquifer pumping test (aquifer performance test) to Albany, which was conducted 6,000 feet north of the target area, yielded a transmissivity value of 5,100 feet^2/day (Clarke, et al., 1984).

Reported TDS concentrations in the Albany area typically range from 150 to 200 milligrams/liter (mg/L). A relatively smooth and gradual lateral variation in dissolved solids through the aquifer is indicated.

Pyrite is a common accessory mineral in the sedimentary sequence that includes the Clayton Formation. This is of interest because pyrite can include arsenic in the crystal structure, which has the potential to be mobilized during aquifer storage. Arsenic is one of the analyzed parameters, and although the concentration of arsenic in native water may not be a good indication of the levels to be expected in water produced from an ASR well, the native water values are worth noting. In samples from six Clayton-aquifer wells, the arsenic concentration ranged from non-detect to 2 mg/L.

SURFACE WATER

The potential sources of surface water being considered to supply the ASR system in this study consist of the Flint River in the area of Lake Chehaw and Kinchafoonee Creek near Lake Worth. Raw water could be pumped from either one of these rivers or an adjacent lake, treated to meet primary drinking water standards, then injected to recharge the ASR system. An alternative approach of using shallow wells to supply surface water filtered by passage through the aquifer media is discussed later.

The feasibility of the ASR project regardless of the recharge water source is subject to seasonal trends in surface water flow and water quality in project area. Stream flow records and water quality data for two USGS gagging stations were obtained to help characterize past conditions. The stations are the Flint River at Newton (USGS #02353000) and Kinchafoonee Creek near Dawson (USGS #02350900).

Monthly average flows were graphed and seasonal flow patterns for both stations are very similar, although discharge rates for the Flint River are about an order of magnitude higher than Kinchafoonee Creek. Discharge rates for both stations peak between December and April when rainfall amounts are the highest. This five-month period would be prime time for water storage.

Average flow at the Flint River station between December and April exceeds 5,000 cubic feet/second (cfs). A 10 mgd withdrawal of water to recharge the ASR system at currently anticipated buildout capacity would represent less than 0.3 percent diversion of the total river flow. Discharge rates at Kinchafoonee Creek in an average year exceed 500 cfs during the prime recharge period. A withdrawal of 10 mgd in this case results in diversion of less than 3 percent the creek flow. Recharging the ASR well at a rate of 10 mgd for five months would produce a seasonal storage volume on the order of 1.5 billion gallons.

Water recharging the ASR well must meet primary drinking water standards. This means that the source water must be of high quality if costly pre-treatment is to be avoided.).

The available data show that concentrations of all constituents except coliform bacteria routinely meet primary drinking water standards. It is likely that disinfection to treat for coliform bacteria would be required prior to subsurface storage for any surface water source in the region.

Reported TDS concentrations for both USGS river gagging stations are less than 100 mg/L and chloride is below 5 mg/L. Dissolved iron, which can lead to ASR well plugging, ranges from 0.2 to 2.2. Turbidity values for both stations range up to about 95 NTU units. It is therefore assumed for preliminary design purposes that filtration of surface water would be required to remove suspended solids prior to injection in order to prevent ASR well plugging.

One feasible method for tapping high stage river flow would be via “bank filtration” by use of shallow wells adjacent to the stream, and to capture the water. This method will save considerable pre-treatment costs because any water that would be injected must meet primary drinking-water standards. Using wells to tap the surface flows eliminates the need to construct treatment facilities. This approach could potentially reduce source-water treatment costs and operation and maintenance requirements. This approach also minimizes the potential for metals leaching to occur during aquifer storage because groundwater withdrawn would have very low dissolved oxygen and metals mobilization has be shown to be caused by oxidants in the injected waters.

CONCLUSION

Existing data suggest that the Clayton aquifer north of Albany generally has favorable hydrogeologic characteristics for ASR development. The target interval for water storage is the Clayton aquifer, which occurs between the depths of 625 and 750 feet bls in the study area. This includes good native groundwater quality, moderate aquifer thickness, a high degree of overlying and underlying confinement, and matrix type porosity development. The transmissivity of the aquifer in the study area appears to be adequate to support a project, except to the southeast of the City of Albany, where low transmissivity values are indicated. Proximity to City of Albany supply wells completed in the Clayton aquifer also needs to be considered in siting the project.

Results of this study suggest that it is feasible to develop an ASR system in the Albany area of the Flint River Basin. Additional storage capacity could be added as needed by building more wells later, once the pilot system has been demonstrated to operate effectively. The pilot ASR system would be operationally tested to evaluate performance. Operational testing for a new ASR well generally involves at least two years of cyclic water recharge, storage, and recovery.

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