GROUNDWATER RESOURCE MANAGEMENT PLANNING FOR NORTH GEORGIA

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Abstract. In North Georgia, groundwater can be a reliable, cost-effective, and long-term source of public water supply. Wells in the Piedmont and Blue Ridge provinces of Georgia have reported yields of up to 800,000 gallons per day (gpd), and wells in the Valley and Ridge province have reported yields in excess of one million gpd. While impressive, these wells may not sustain these yields without proper management. A Groundwater Resource Management Plan should be developed based on the aquifer test and recovery test for each well, and be subsequently modified based on well characteristics observed during long-term pumping.

Well testing is a major component of a Ground-water Resource Management Plan, and there are various types of tests for different applications. Drillers' air lift tests provide a rough estimate of the well's yield. Step drawdown tests are used to determine the size of the pump to be used for the drawdown test, which is a long-term measure of the well's production capability. Recovery testing, conducted at the end of the drawdown test, provides the data necessary to determine the well's safe yield and the production capacity.

Groundwater resource management strategies help ensure long-term sustained pumping. These strategies include:

• installing the production pump above the uppermost water-producing zone, to avoid dewatering the water-bearing zone and to prevent the introduction of iron bacteria into the well.

• maintaining accurate records of the production pumping rate, drawdown, pumping water levels, and pumping duration, to identify changes in water availability. Pumping rates can be adjusted to reflect the seasonal characteristics of the aquifer.

• allowing the well a recovery period, scheduled on a daily or weekly basis. In this way, a well's yield can be optimized while achieving a balance between the water demand schedule and necessary well recovery.

INTRODUCTION

Many political and economic considerations contribute to the development of groundwater resources in North Georgia. For years, small jurisdictions have developed and operated public groundwater supplies primarily due to economic reasons. More recently, some larger metropolitan jurisdictions that have traditionally relied on surface supplies are now finding that build-out conditions and/or existing land use patterns have seriously limited the availability of practicable sites for new surface water sources. In addition, development and operating costs for new surface sources are generally much greater than for a comparative-yield groundwater system. Groundwater for primary supply or as sources of peak demand has become an attractive, cost-effective alternative.

This paper does not address the identification of high-yielding wells in North Georgia since there is now a track record of success in the field. Rather, it provides an accumulation of research and field observation intended to optimize the performance of groundwater systems through appropriate resource management strategies. The purpose is to demonstrate to those currently assessing water supply options that adequate research and practice exists to define groundwater as a reliable, long-term source of water supply. Ground-water resource management planning, as discussed in this paper, is critical in ensuring the long-term viability of groundwater resources.

ELEMENTS OF A GROUNDWATER RESOURCE MANAGEMENT PLAN

Five elements are addressed in a Ground-water Resource Management Plan:

• **Wellhead protection and recharge area protection:** Groundwater, by virtue of its occurrence, has a natural protection system. Soils and geologic media can act as a filter, removing some man-made contaminants that can enter the saturated zone. Despite this, groundwater remains a vulnerable resource, needing protection from the negative impacts of land use activities. DNR rules and regulations provide for the establishment of control and management zones around wellheads and for land use controls in identified recharge areas. Current thinking on Piedmont hydrogeology indicates that groundwater is contributed to a well from an area other than an idealized circular radius of influence. The entire surface water drainage basin above the well may contribute to the well's yield (Daniel, 1990; 1983). Alternatively, groundwater contributions to a well may trace an elliptical pattern coincident with major fracture trends, but which crosses surface water divides (Daniel, 1990; 1983; Heath, 1991). Heath, in his North Carolina Piedmont study, attempted to quantify recharge to wells, and recognized the relationship between the location of a well and its contributing area. Heath's work also provides the basis for the State of Georgia's wellhead protection program. Operators of public groundwater supplies have two alternatives: first, the State will establish idealized circular control and management zones based on Heath's generalized curve relating well yield to radius of influence; or as a second option, local system operators may elect to conduct a hydrogeological study to define their well's contributing area, which may be elliptical or irregularly shaped. In many cases, the contributing area may be significantly different than the management zone identified using the fixed radius method. While this approach may require the local entity to incur some cost, we believe that this approach will be more cost-effective in the long run as local resources can then be allocated effectively to implement appropriate land use controls.

• **Well construction techniques:** Production wells should be installed in a two-step process. First, install a six-inch diameter test well, carefully logging all drilling data. Once the test well is installed and the well testing is accomplished, convert the well to a larger diameter production well, if such is warranted. The decision to convert to a production well should be based upon results of the aquifer test and the needs of the water system. Larger diameter wells are generally more efficient, experience lower drawdowns, provide more space for the pump to operate, and frequently have higher yields that the test wells have. Additional strategies for well management include setting the pump above the principal water-producing zone to avoid dewatering the fracture. If the principal water producing zone is not the uppermost structural discontinuity, then the pump should be set above the major water-bearing zone and the pumping water level should not extend below the upper water-bearing zone (Daniel, 1990). These practices have been proven to reduce both the maintenance costs for the pump and the incidence of declining well yields.

• **Aquifer tests:** Results from properly conducted and accurately interpreted tests are the most important tool available in developing an effective groundwater management plan. The practical application of this technique provides a cost-effective method of determining the optimal well yield and designing straightforward management strategies that a local well operator can rely on.

A driller's *air-lift test* is conducted during well drilling and estimates well yields, usually by visual means. A *step-drawdown test*, conducted upon the well's completion, increases the pumping rate at regular intervals to identify the proper pumping rate for the aquifer test. The *aquifer test*, also known as the drawdown or constant rate test, is used to obtain the data to determine optimal well performance. We recommend a test period of 72 hours in north Georgia to adequately characterize groundwater occurrence and to identify any flow boundaries. When the drawdown data are plotted arithmetically, any groundwater flow boundaries become apparent by changes in the slope of curve. Recharge boundaries are identified by a sudden flattening of the curve and occur where additional water is contributed from the formation to the well. A recharge boundary indicates that additional water supply may be available if the well is properly managed. Discharge boundaries, identified by a sudden steepening of the drawdown curve, occur when water-bearing zones are dewatered or other geologic phenomena interrupt or impede the flow of water, and may require a modification in pumping and recovery schedule to ensure that the well is not overpumped.

The *recovery test* involves periodically measuring the rising water level once the pump is turned off at the end of the aquifer test. Arithmetically graphing these data defines the recovery curve. A long, shallow-sloped recovery curve identifies a slow recharge rate, and indicates that the well will probably not recover quickly enough to be used as a principal supply. A recovery curve that is steeply sloping and rises nearly to the static water level in a short period of time indicates a well that is prolific and suited to principal supply. Considered together, drawdown and recovery data provide important information about the well's long-term sustainable yield, and form the basis for designing each well's initial pumping schedule.

• **Initial pumping schedule:** Daniel's groundwater investigations (1990) indicate that alternating pumping and recovery cycles, rather than continuous pumping, maximizes the yield of Piedmont wells. An intermittent pumping cycle causes less drawdown, allowing equilibrium conditions between the bedrock and overlying regolith; ensures saturated flow conditions in the water-bearing zones, which reduces the potential formation of iron bacteria; and minimizes drawdown, which results in less head loss and higher average pumping rate (Daniel, 1990, p. 25). The overall goal of establishing the initial pumping schedule will be to balance the timing of the drawdown and recovery periods with the water system demand.

• **Production monitoring** and modification of pumping schedule: After the well is placed into service, monitoring the drawdown and recovery of the well during pumping and resting cycles is important in refining the management strategy. Seasonal fluctuations can be identified by long-term, continuous well monitoring using pressure transducers and data loggers. Once these seasonal fluctuations are identified, this data can be used to refine pumping and recovery cycles to optimize the well's yield while meeting water demand. A frequent scenario is one in which groundwater levels are higher during the wet-weather periods of winter and spring, and lower during the dry-weather periods of summer and fall. During wet-weather periods when groundwater levels are higher, the well may be pumped at a higher rate or with fewer recovery cycles because additional groundwater is available. Once dryer conditions occur, the pumping rate may be adjusted downward to avoid dewatering. On an annual basis, this strategy will result in a higher average groundwater production than would either simple continuous pumping or maintaining the initial pumping schedule with no refinements.

CONCLUSIONS

In north Georgia, groundwater is a cost-effective source of public or industrial water supply, either as a sole source, to meet peak demand, or as a backup to a surface supply. The goal of most water systems, public or private, is to produce the maximum amount of water at a minimum cost. The key to achieving this goal is a Groundwater Resource Management Plan addressing wellhead and recharge area protection, appropriate well construction techniques, and documented 72-hour aquifer testing and recovery testing with analysis and interpretation of the results. Specific management strategies contained in the plan include both the application of the well test data and subsequent modifications to the original pumping/recovery schedule.

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