Applications of ASR for the Optimization of Water Management

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Abstract – This paper describes three successful implementations of Aquifer Storage and Recovery (ASR) projects in different parts of the words, each one with a different objective. It demonstrates that ASR systems are capable of regulating water supply and demand with multiple benefits of traditional storage systems.

Palavras-chave – Recarga Artificial Aquiferos

Introduction

In many parts of the world, the major water management challenge is reliably managing available supplies and demands on a long-term basis. Water shortages are often the result of temporal imbalances in supply and demand. Excess water may be available during part of the year or in wetter than normal years, which if captured and stored, could be put to beneficial use during periods of low supply or high demand. Local water shortages, therefore, are often due to inadequate storage of available water rather than an inadequate total supply.There is rapidly growing interest in the use of aquifers for the underground storage of water, because of the enormous storage capacities available and the often lack of suitable or economic alternative surface storage options.

Aquifer storage and recovery (ASR) is defined as the storage of water in a suitable aquifer through a well during times when water is available, and the recovery of the same or similar quality water using a well during times when it is needed (Pyne,1995, Maliva and Missimer, 2010). The main attractions of ASR are (1) that it can provide very large volumes of water storage at a substantially lesser cost than various surface storage options, (2) the storage can eliminate the need for expansion of water treatment and distribution infrastructure to meet peaks in demand, and (3) it has a minimal surface footprint. ASR systems have been constructed or are under development to store a variety of different types of water for different purposes, including:

- Potable water to balance seasonal variations in supply and demand,
- Reclaimed water for irrigation uses,
- Treated surface water for potable supply,
- Treated surface water for irrigation use and environmental restoration, and
- Potable water for long-term strategic storage in the case of disruption of primary water supplies (e.g., desalination facilities).

The following are examples of some actual ASR projects, which illustrate varied applications of the technology that have potential water resources management value in Brazil.

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Destin, Florida (USA), Reclaimed Water ASR System

The city of Destin is a resort area located on a barrier island in western Florida. Destin faces water and wastewater challenges that are common in many coastal areas. Destin obtains its freshwater supply from a deep aquifer, which is now considered to be regionally utilized at its sustainable limits. The city's reclaimed water flow is mostly reused for irrigation by residential, commercial, and recreational users, with excess reclaimed water disposed of by land application methods. Additional wet weather wastewater disposal capacity was needed, but the most viable option, offshore discharge, is a politically charged issue that would elicit strong public opposition because of concerns over impacts to the environment and beaches, and thus the economically important tourism industry.

ASR was determined to be a logical and highly cost-effective solution to DWU's wastewater management challenge. Excess reclaimed water could be stored in the ASR system during wet weather periods, which would address the need for additional peak disposal capacity. The stored reclaimed water could be recovered during high demand periods, which would increase the reliability of the water supply that is necessary to attract additional customers. Expansion of the reuse system will reduce demands on higher quality fresh groundwater resources.

Figure 1 - Destin ASR system wellhead

The DWU ASR system consists of seven (7) ASR (injection and recovery) wells and six (6) associated monitoring wells, and has a design injection and recovery capacity of 8,044 m^3 per day. The storage zone is a sand-and-gravel aquifer located from 35 to 50 m below land surface (bls). The storage zone contains non-potable freshwater, but is vulnerable to saline-water intrusion. Pilot testing of the first ASR well indicates that there is a high recoverability of the injected water. Modeling and monitoring results indicate that the system has a low degree of dispersive mixing and that the injected water remains close to the ASR wells.

Seminole Tribe of Florida ASR System

The main irrigation water source on the Seminole Tribe of Florida's Brighton Reservation is surface water obtained from South Florida Water Management District (SFWMD) canals. During drought periods, the Tribe's irrigation water requirements exceed its surface water entitlement. However, during the summer wet season, huge amounts of excess surface water are available for storage for later use during subsequent dry periods.

An ASR system is under development to capture excess surface water from the canals for latter irrigation use. The system will be located next to the main canal (C-41) in an agricultural area of the reservation. The canal water will require filtration and disinfection before injection. The recovered water will be discharged into the canal. The target system capacity is 150,000 to 450,000 m^3/d. Subsequent ASR system expansion phases would be implemented to meet more extreme drought events, and would be based on a cost-benefit analyses, considering actual ASR system construction and operation costs (from initial phases), and the potential economic impacts of various drought scenarios.

The results of an exploratory well program greatly exceeded expectations. The target storage zone, the Upper Floridan Aquifer, was found to be much more productive at the test well site than was suggested by the regional hydrogeologic data. A potential ASR storage zone was identified between the depths of 365 and 423 m bls that is likely transmissive enough for ASR wells with capacities of 11,400 to 18,900 m^3 per day. An additional important result of the exploratory well program is that a new aquifer composed predominantly of very coarse-grained quartz sand was encountered between 76 and 103 m bls, which may be used as a supplemental water source. A study has been completed on surface water treatment options. Construction of the Seminole Tribe of Florida ASR system has been delayed due to the economic downturn.

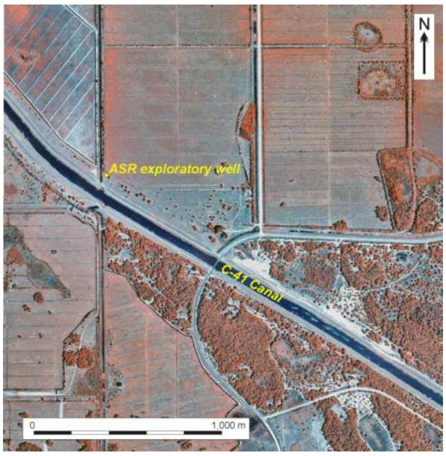

Figure 2- Aerial photograph showing Seminole ASR system site

Strategic Storage ASR in the United Arab Emirates

Water supplies are vulnerable to interruption to various degrees caused by human and natural causes, such as wars, contamination, equipment breakdowns, earthquakes, and major storms. The major cities in the Middle East have become largely (and in some cases essentially totally), dependent on desalination for their potable water supplies, and are particularly vulnerable to interruptions in the water supply. Most Middle Eastern cities have at most only several days of above groundwater storage available. A sudden long-term disruption of the water supply to a city or country could have catastrophic human consequences, if alternative supplies could not be quickly obtained from interconnections with neighboring unaffected areas or some form of storage. Above ground storage tanks and reservoirs are not an economically viable option for strategic storage, and aboveground storage is unattractive because of land requirements, vulnerability to contamination, and a very high evaporation rates. ASR provides a means for strategically storing large volumes of water that could be drawn upon in a crisis situation until either the normal supply is restored or alternative supplies could be obtained.

ASR for strategic storage is being actively developed in Sharjah and Abu Dhabi, which are member states of the United Arab Emirates (UAE). Strategic ASR is also being considered in other countries in the region. Although there is a great need for strategic storage of water in the Middle East, the concept is applicable to many other areas of the world, especially if global climate change locally results in more frequent and severe droughts. With respect to UAE strategic storage systems, a fundamental consideration in quantifying the need for strategic storage is the time that would be required for the construction of new desalination facilities, which would likely be one-year or more (Al-Katheeri, 2008). The strategic storage capacity should, therefore, be adequate to ensure a replacement of at least a one-year supply of water from the impacted facilities.

The site is located in a generally remote area of the desert. The Shwaib ASR system has a planned 1,381 million m^3 reserve of freshwater and an operational capacity of 20 MIGD (90,840 m3/day) with a potential expansion to 454,200 m^3/day) (Schlumberger Water Services, 2006).

Figure 3 - Schwaib ASR site, U.A.E.

Conclusions

ASR is now a proven technology that has many potential applications in Brazil and other countries. ASR has great potential for optimizing the use of water resources by allowing for improved management of supply and demand. Excess flows that would not otherwise be beneficial used can be stored for use in low supply or high demand periods. ASR systems are often inherently complex because of the need in some systems to predict and manage solute-transport, which is controlled by aquifer heterogeneity. The hydrogeological challenge is to quantitatively characterize aquifer heterogeneity and incorporate the heterogeneity into detailed solute-transport models that can be used for system design and the optimization of the operation of ASR systems.

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