RESEARCH APPLICATIONS
RESEARCH IN USE #17

Aquifer Storage and Recovery

Feast or famine

This is typical for many water utilities. Water is plentiful during certain seasons, and drought conditions occur in other seasons. Water demand is also cyclical, with the highest demand often occurring when the least amount of water is available. Utilities face a constant challenge of how to store water during times of plenty so that adequate resources are available when needed.

Aquifer storage and recovery (ASR) is a rapidly emerging technology with about 40 applications in operation in the United States today as compared to just three in 1983. ASR is also being applied in Australia, Israel, Netherlands, South Africa, and England. ASR usually involves the recharge of treated drinking water into an aquifer during wet periods or when the raw water quality is the best, with recovery during dry periods or when the raw water quality is poor. A bubble of high quality water is formed in the aquifer, which can be recovered and used with minimal treatment requirements.

The application of ASR is now being expanded to include storage of reclaimed water, storm water, ground water from other sources, and other partially treated surface water. Drivers for ASR are also expanding beyond seasonal storage to include acting as a salinity barrier, emergency water supply, aquifer replenishment, and for water quality improvement.

The current issues surrounding ASR are

- Determining site suitability
- Understanding the impact on groundwater quality
- Understanding design and operational issues
- Addressing often conflicting state and federal regulations on aquifer recharge and recovery

Role of AWWARF Research

AWWARF has funded three projects directly related to ASR:

- Pyne, D.G. et al, 1996. *Aquifer Storage Recovery of Treated Drinking Water*. Denver, Colo.: AWWARF and AWWA
- Aquifer Storage Recovery of Drinking Water From the Cambrian-Ordovician Aquifer in Wisconsin, Project #2539. To be completed in 2001.
- Water Quality Improvements During Aquifer Storage and Recovery, Project #2618. To be completed in 2003.

AWWARF also has five related projects on aquifer recharge and soil aquifer treatment. Information on all these projects can be found on AWWARF's web site, <www.awwarf.com>.

Research has shown that with proper planning, design, and operation ASR can become a viable and cost-effective technology for utilities in managing water resources. Efficient well design is essential and with appropriate investigations operational problems can be minimized. Research continues to provide new insights on operations and management of ASR systems.

Research indicates that, in most cases, ASR leads to water quality improvements and does not degrade groundwater quality. For example, pathogen attenuation is becoming better defined, and disinfection by-products, which are formed during treatment, have been found to degrade during water storage. Ongoing research is characterizing chemical, physical, and biological processes that contribute to water quality improvements.

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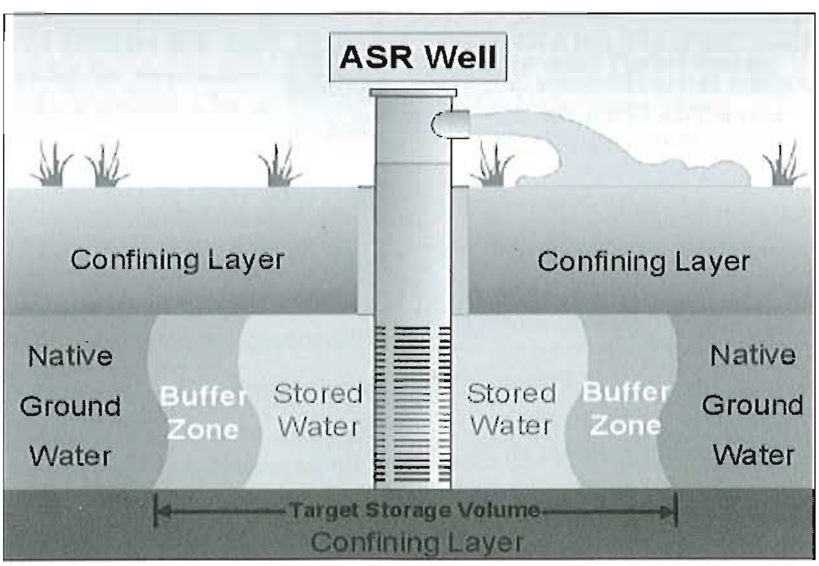
Utility Application

About 40 United States utilities are currently applying ASR technology. The following examples describe some of the unique empirical knowledge gained from their experiences.

Well bore analytical tool leads to improved performance. Las Vegas Valley Water District (LVVWD) developed one of the world's largest ASR programs to replenish an overdrawn aquifer, provide emergency storage, and satisfy summer demands for water. Currently 52 wells are used for recharge of up to 80 MGD of treated drinking water. Twenty-three of the wells are joint use (both recharge and recovery), with the remainder dedicated to recharge only.

One of the utility's largest breakthroughs came in the development of an ASR well performance prediction tool. Using this mathematical tool, LVVWD developed a comprehensive understanding of well bore and aquifer performance and is able to predict recharge performance with 98 percent accuracy. The utility also learned that 90 percent of decreased well performance was due to hydraulic actions, not clogging as originally thought. LVVWD found that by optimizing recharge rates (with flow changes as small as 3 to 5 percent) it was able to maximize recharge volume. By understanding the hydraulics of each well and separating the clogging component, LVVWD was able to eliminate the need for routine backwashing during their recharge cycle. The utility also found that well performance losses of 6 to 12 percent during the eight-month recharge season were regained during the four months of pumping. The dedicated non-recovery wells require redevelopment every 2 to 3 years to return them to original performance.



Typical ASR system. (Courtesy of David Pyne, CH2M Hill)

Over 14 years of operation, LVVWD has developed extensive ASR operating experience. LVVWD found the keys to successful operation were use of efficient wells, understanding the aquifer system, and developing an aquifer management program.

Short-term solution fits long term-strategy. With groundwater allocations being reduced from 10.2 MGD to 1.8 MGD, Brick Township Municipal Utilities Authority, N.J., began to look for alternatives. Their first move was to begin using a surface water source. During the peak summer season, when river flows were the lowest, groundwater was essential to meeting the demand. Groundwater was also needed in the winter to stabilize water temperature. With concerns for future growth, the potential for drought conditions, and increasingly tight restrictions on groundwater withdrawal, Brick developed a comprehensive water management plan.

For a long-term solution, Brick began to develop a surface water reservoir. In the interim, Brick converted one of its existing wells into an ASR well. Treated surface water is stored during winter months and withdrawn during the peak summer usage. Stored water is returned to the head of the treatment plant for iron removal due to slight increases in iron concentration during storage (0.5 to 0.6 ppm). Natural groundwater in the area has iron levels of 4 to 5 ppm.

Brick plans to continue to use ASR as a vital tool in maintaining operations flexibility, even though the surface water reservoir is scheduled to come on-line in 2003. The utility is also considering the development of a second ASR well.

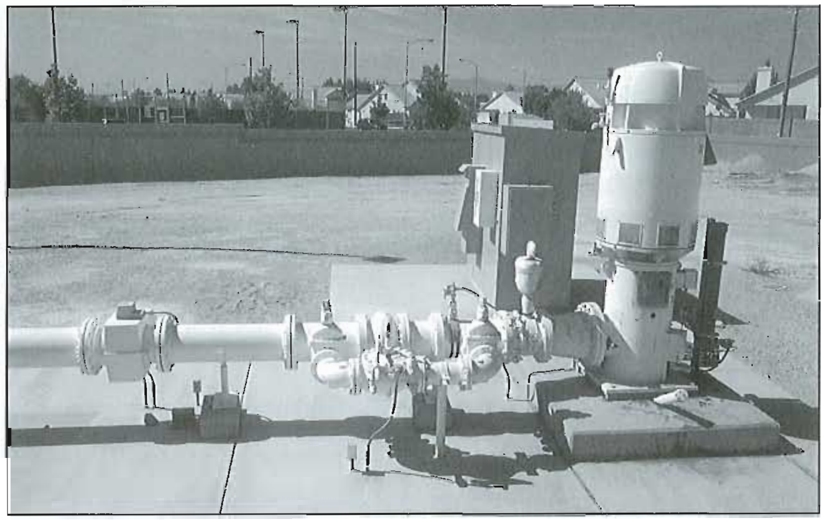
ASR can be a vital tool in maintaining operations flexibility.

Meeting stringent groundwater nondegradation requirements. Peak demands in Oak Creek, Wis., were rapidly approaching the capacity of the existing treatment facilities. Before embarking on a costly expansion, the utility began to explore other options for meeting increased demands. In 1998, Oak Creek began an ASR demonstration study.

Preliminary water quality investigations showed that even though total trihalomethanes (THM) concentrations of the treated water were very low (less than 20 ppb) they exceeded state ground water non-degradation standards. Wisconsin standards are based on a risk factor of 10^{-5} on a contaminant-by-contaminant basis. This equals a standard of 6 µg/L for chloroform and of 0.6 µg/L for bromodichloromethane. Data obtained through the demonstration study shows that THM levels in the aquifer degrade to below the standard in less than six weeks of storage.

The state of Wisconsin has conditionally approved operation of the ASR system to allow the collection of more data. Long-term approval will be contingent on a revision of state law. The state also approved an additional demonstration study in Green Bay, which began in 2000.

Public involvement paves the way to ASR. Faced with a rapidly growing community and a consistent reduction in surface water flow during the annual spring dry season, the City of Tampa, Fla., began exploring wet season water storage options. Understanding the potential impact on their consumers and private well owners in the area, the utility embarked on an aggressive public involvement program.



Las Vegas Valley Water District ASR well. (Photo courtesy of Las Vegas Valley Water District)

ASR emerged as a viable option after a series of public meetings. To address concerns over the location of well facilities in a residential neighborhood, some wells were constructed in underground vaults. The city also worked with individuals in the area that have private wells and developed a program to minimize the financial impacts of connecting to the municipal system.

Tampa currently has one ASR well in operation with seven more wells scheduled to come on line in 2001 (10 MGD capacity). The wells are expected to operate during the 100-day dry season.

Reducing water supply vulnerability. Calleguas Municipal Water District, Calif., is dependent on water imported from single pipeline. As such, the district's entire water supply is subject to a host of concerns ranging from drought and earthquakes to regulatory actions. ASR is being implemented as a joint project with the Metropolitan Water District of Southern California to reduce water supply vulnerability and enhance system reliability.

The district's plans call for recharging water into a confined aquifer, which has been subjected to overpumping. The $80 million project will be constructed over a ten-year period and consist of 30 ASR wells. The wells are estimated to have a recharge rate of 1.7 MGD and an extraction capacity of 2.2 MGD per day. One well is currently in operation and four more are in the final stage of operational testing. Fourteen additional wells have been drilled and pump motors are scheduled to be installed in 2001.

Beyond increased operational flexibility, the project offers potential benefits to existing well operators in the basin. Groundwater levels are expected to rise 100 to 300 feet in the aquifer, reducing pumping lifts for existing wells and, thereby, reducing energy costs. Reduced demand during drought periods should also benefit sensitive species and habitat in the Sacramento/San Joaquin Delta.

Emerging applications. A growing number of utilities are evaluating recharge with reclaimed water, groundwater, or partially treated surface water. At most, but not all of these sites recharge water would go into a nonpotable aquifer.

Reclaimed water for irrigation. The City of Chandler, Arizona will demonstrate ASR for reclaimed water starting in 2001. Water will be stored in an upper aquifer used primarily for agriculture and golf course irrigation. Drinking water is taken from a lower aquifer, and under state law, the utility will receive a 1:1 credit for ASR water. Plans call for the construction of four additional wells to be on line in 2001.

Environmental restoration. One of the most ambitious ASR projects being implemented is the Comprehensive Everglades Restoration Plan (CERP). This regional water management program will use over 333 wells located throughout southern Florida. Through the wells, 1,665 MGD of partially treated surface or groundwater will be recharged into a deep brackish-water aquifer bordering the Everglades to provide seasonal and long-term storage to meet ecosystem, agricultural, and urban water needs.

Stormwater reuse. Several sites in South Australia have been in operation since 1993 to recharge minimally treated rural and urban runoff into brackish aquifers for subsequent use for landscape irrigation. Studies have shown these wells to provide ample water supplies of suitable quality. Currently there are five operational sites, and five more are under investigation.

Conclusions

Experience with ASR technology continues to grow. At one time considered only applicable for recharge of treated drinking water, ASR is being expanded to reclaimed water, groundwater and partially treated surface waters. When developing an ASR program, a utility must have a clear understanding of the objectives for ASR, public concerns, and state and federal requirements. Successful operation requires understanding the aquifer, efficient well and well head design, and developing an effective management program.

Contacts and References

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- City of Tampa—Mike Bennett, +1 813.231.5254, <mike. bennett@ci. tampa.fl.us>
- Calleguas Municipal Water District—Susan Mulligan, +1 805.579.7115, <smulligan@ calleguas.com>
- City of Chandler—Robert Mulvey, +1 480.782.3624, <bob.mulvey@ci.chandler. az.us>
- Comprehensive Everglades Restoration Plan—Peter Kwiatkowski, +1 561.682.2547, <pkwiat@sfwmd.gov>
- Australian ASR Projects—Peter Dillon, 61 8 8303 8714, <peter. dillon@adl.clw.csiro.au>

Other General Sources

- <http://www.asrforum. com/>

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