Tampa's Aquifer Storage Recovery Program: A Step Toward Regional Drought Minimization

Mark B. McNeal and Malachi C. Bennett

The city of Tampa recently experienced a one-in-200-year drought. Alternative water-supply projects such as aquifer storage recovery (ASR) and other technologies must be developed to meet the increasing demands on limited available water resources, even during non-drought events.

The Tampa Water Department recently brought its eight-well, 10-million-gallons-per-day (mgd) Rome Avenue Park potable-water ASR system on line at a time when the region is in desperate need of additional water supplies. Approximately one billion gallons of water was recovered to Tampa's drinking water system during the spring 2002 dry season. Water is conveyed approximately 4.5 miles to the city's water treatment plant to blend with other treated water to provide a consistent water quality for its drinking-water customers.

Considerable water-level and water-quality data will be collected during this long-term recovery event as part of the city's water-use permit. The goal is to provide water to supplement the Hillsborough River Reservoir during low-flow periods when insufficient supply is available, in effect building a "reservoir" beneath the existing reservoir.

The Hillsborough River, like many other rivers throughout west-central Florida, experienced extreme low-flow conditions during the 2000 and 2001 drought event. During normal wet-season hydrologic events, billions of gallons of water can flow over the dam each day, and the city intends to build the necessary infrastructure to capture a very small percentage of this flow (approximately 30 mgd at build-out). This will ultimately decrease Tampa's reliance on traditional regional groundwater sources and may actually enable the city to export water supplies to other utilities to help relieve their water shortage. Completely drought-proofing Tampa is the goal, and the ASR program is a major step toward accomplishing this goal.

Aquifer Storage Recovery is a proven, viable method of beneficial water storage. The concept involves storing excess water in a suitable aquifer for later use during periods when it is more beneficial to the community or the environment. Hundreds of ASR systems are in operation or in various stages of planning, permitting, design, or construction worldwide. Rapid growth of these systems and their overwhelming success have prompted innovative variations of ASR projects.

ASR is becoming increasingly popular worldwide as a method of managing various water, wastewater, and stormwater systems. During the 1980s and 1990s, the advancement of ASR for storing treated drinking water grew tremendously. Utilities, regulatory agencies, and the public now generally embrace ASR as a method of maximizing the use of existing treatment facilities and seasonal supplies. As population centers continue to grow and the urban watersheds are continually altered, the experience acquired from potable ASR applications may be applied to alternate applications. ASR is now being developed for various sources of storage, including:

- Treated drinking water from surface-water sources
- Treated drinking water from groundwater sources
- Treated drinking water from brackish-water sources
- Partially treated surface water
- Partially treated to untreated groundwater
- Highly treated reclaimed water
- Stormwater with various levels of pretreatment

Many states now have rules in place to guide the development and operation of potable ASR systems, but the federal rules are antiquated in respect to the development of alternative ASR systems. ASR wells are regulated under the Underground Injection Control Division of the U.S. Environmental Protection Agency (EPA), which regulates them as injection wells, although they are operated very differently.

The state of Florida recently adopted rules governing the development and operation of ASR systems designed to store and recover highly treated reclaimed water in brackish groundwater aquifers. Florida also recently unsuccessfully attempted to adopt state legislation designed to allow small-scale testing of ASR wells designed to store and recovery partially treated surface waters. This legislation was proposed in large part to allow testing to evaluate certain treatment aspects that subsurface storage can provide, including the likely reduction of certain bacteria and pathogens that may be present in select surface-water bodies.

Mark B. McNeal, P.G., is a senior technologist with CH2M Hill's Tampa office, where he serves as the firm's director of groundwater practices in the southeastern U.S. He is CH2M Hill's project manager for the Tampa's ASR program. Malachi (Mike) Bennett is the special projects and operations manager for the Tampa Water Department. He serves as the project manager for the city's ASR project.

Stormwater control with ASR has a great potential in many urban watersheds. Many stormwater systems that may be undersized–or may soon be undersized with further urban development–could effectively be enhanced through direct groundwater discharge into lower-lying aquifer systems during peak rainfall events or extended rainy periods. Water could then be recovered from these ASR systems during drier periods as necessary for recreational, agricultural, or aesthetic purposes.

Florida has many drainage wells constructed years ago that could not be constructed and permitted today due to the Safe Drinking Water Act and restrictive state rules that do not allow bacteria to be introduced into the drinking-water aquifers. These existing wells typically operate in a recharge mode only, whereas a recovery element of these systems could be used to enhance lake and wetland systems while also minimizing or eliminating the overall recharge volumes sent to the freshwater aquifers.

If these wells were designed similar to ASR systems, additional barriers would be in place to ensure that no aquifer degradation was occurring. This concept is becoming increasingly important to help replenish aquifers that are not receiving historical recharge quantities or are being overdeveloped due to urbanization or agricultural uses.

Many population centers are present near coastal areas, as people enjoy living by the water and many businesses and industries rely on the water for their services. This growth often stresses available water

Continued on page 38

Continued from page 37
resources to the point where alternative water supplies must be developed to provide a sustainable supply for the citizens and businesses of these communities. Groundwater supplies are often taxed to the point where saltwater intrusion is a significant concern. Water that previously returned to the groundwater regime through percolation and infiltration is now conveyed to our saltwater environments through extensive and growing stormwater systems, further reducing the amount of water available to replenish our groundwater supplies.

Urban ASR Issues

ASR systems have been constructed for a variety of reasons. Among the most prevalent are:

- Seasonal storage of drinking water to offset potable water treatment facility expansion or to provide a sustainable source during periods when the source water is limited
- Diurnal storage and recovery to meet peak day demands
- Long-term water banking to meet future demands
- Storage of reclaimed water to augment reuse systems during peak demand periods and minimize wet-weather discharges of a high-quality product
- Environmental enhancement, including wetland augmentation/restoration and minimum flow and level requirements for surface-water systems

While seasonal storage has been the most dominant reason for constructing ASR wells in the past, future uses of these wells may include conveyance and/or treatment. For example, in an urban watershed it quickly becomes expensive to convey water from one area to the next.

In many instances, the ASR system could be designed to recharge water at one location and recapture the water at another location from a different set of wells. This arrangement could, therefore, eliminate the need for large-diameter piping through heavily populated areas. The conveyance program could also provide a barrier against saltwater encroachment in some situations.

Many ASR systems are under development in urban settings. The many advantages to these systems include:

- Only communities that will benefit may be impacted.
- System pressure issues can be mitigated.
- There are limited environmental concerns regarding surface water impacts.
- Water is conveyed during recharge and recovery events .
- Existing groundwater may not be suitable for long-term supply due to possible contamination concerns.
- ASR helps to maximize local sources first.

Disadvantages to developing ASR systems in urban settings may include:

- They require drilling and other construction activities in residential areas.
- There are competing existing legal groundwater users.
- There is groundwater contamination from landfills, tanks, septic systems, etc.
- Ownership of stored water may need to be addressed.
- Stormwater systems may be altered.

The city of Tampa has faced many of these issues during the development of its ASR program.

Tampa's ASR System

The Tampa Water Department provides potable water to a large service area in west-central Florida. Although the Tampa area receives nearly 55 inches of rainfall over an average year, this area is extremely drought sensitive and water resources are becoming increasingly more difficult to develop.

Tampa's primary source of water is the Hillsborough River Reservoir system. Due to the flat topography in this area and the seasonal fluctuation in rainfall, the reservoir system is extremely shallow and can not sustain enough storage to adequately supply the approximately 70 million gallons per day (mgd) that Tampa must provide to its customers. Alternative water supplies must be developed to minimize the extent that Tampa relies on regional groundwater supplies during peak-demand (dry-season) periods.

Two distinct ASR programs are under development by the city's water department. A 10-mgd treated drinking-water ASR program has been constructed in the vicinity of the Rome Avenue Park, a remote location west of the Hillsborough River Water Treatment Plant (WTP). This program is

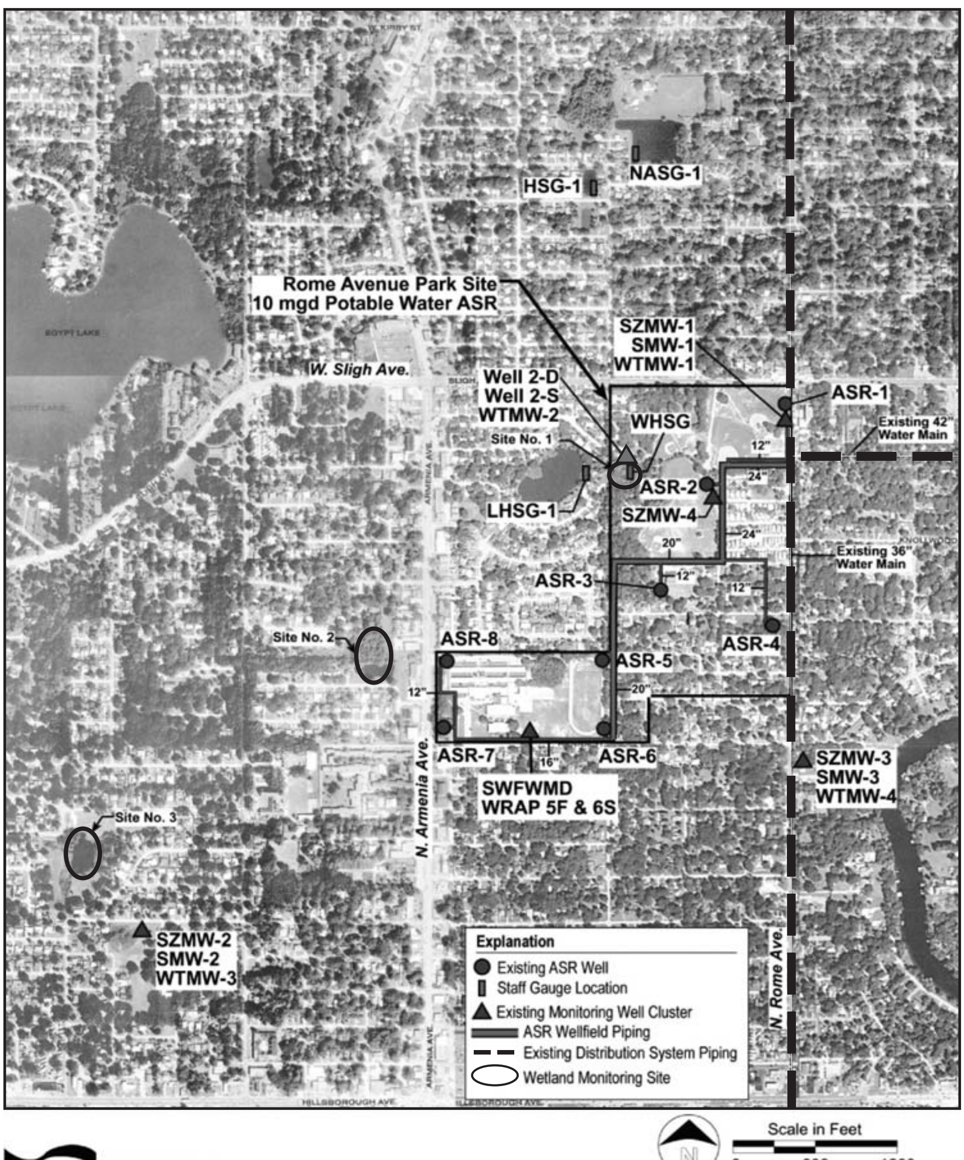


FIGURE 1
City of Tampa's Rome Avenue Park ASR System

designed to store excess treated drinking water during periods when supplies and treatment plant capacity exceed system demands. **Figure 1** shows the Rome Avenue Park ASR system.

In addition, a 20- to 30-mgd treated surface-water ASR program is in the early stages of development to store excess water available from the Hillsborough River during high-flow events. This water will be treated to drinking-water standards prior to storage in the ASR system.This program could provide a sustainable source of water for the Hillsborough River WTP during low-flow periods in the river by developing a "reservoir under the reservoir." Once fully permitted and operational, this integrated ASR program should allow the city to meet its near-term, dry-season peak demands entirely through water from the Hillsborough River Reservoir system without over-relying on the stressed groundwater resources in the Tampa Bay area.

As shown in Figure 1, the Rome Avenue Park area is highly urbanized. Many wetlands likely existed in this area before urbanization, though very few exist at the present. The current landscape is primarily irrigated by the local residents, so any minor water-level effect on the surficial aquifer system in this area will not result in damage to natural systems. This is an advantage to siting ASR wells in an urban setting, rather than an undeveloped setting where they should be designed to minimize impacts on wetlands and other natural systems. A comprehensive groundwater and surface-water monitoring program has been implemented to allow a thorough evaluation of the effect that operating the ASR system has on the hydrology in this area.

ASR systems typically have minimal land requirements–a major benefit to most utilities. Siting ASR wells in a highly urban/residential area, however, can be challenging. At the Rome Avenue Park ASR site, public parcels such as parks, schools, and stormwater property were used for all ASR well sites. This practice required no land acquisition, but easements were needed at many of these sites.

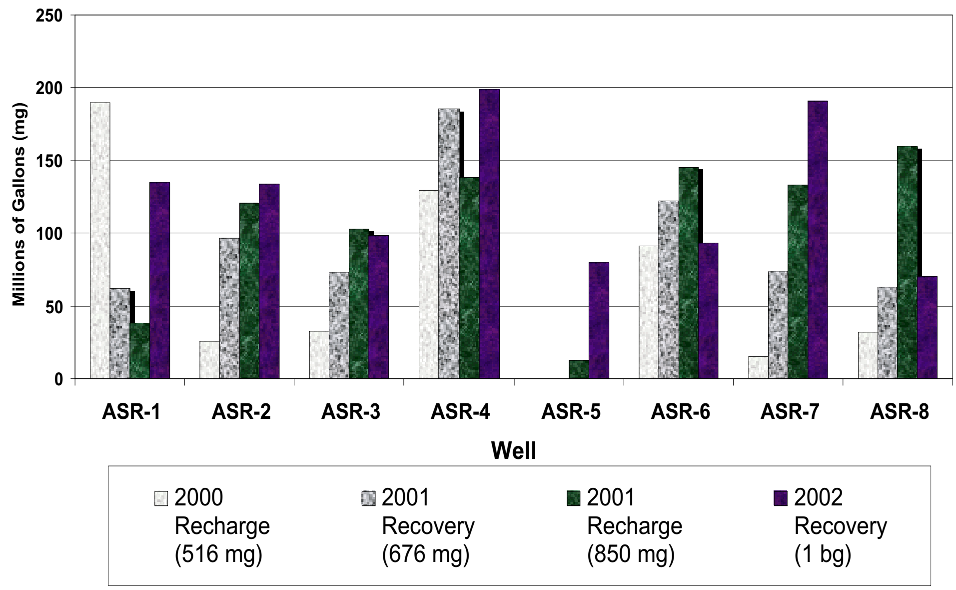
The Rome Avenue Park ASR system was strategically located in a freshwater aquifer, allowing the city to achieve 100 percent or greater recovery of its treated drinking water during the initial operational tests. The ASR wells are located in an area that would not support a traditional wellfield, because saltwater is present in the next permeable interval below the storage zone and laterally less than one mile toward the coast. Long-term operation of a traditional wellfield would induce saltwater intrusion into the area, which would impact not only its operations but potentially competing users.

Figure 2 shows recharge and recovery events for the system's first two years of full-scale operation. The city also recovered approximately one billion gallons of water from this system during the 2002 dry season. During the 2001 dry season, the ASR water provided up to 15 percent of Tampa's water supply during these drought conditions.

Competing well use is prevalent around the Rome Avenue Park ASR system. A few hundred private domestic and irrigation wells are located in this area. Impacts on existing users were minimized by selecting the deeper permeable interval for treated water storage. The ASR storage zone is locat-

Continued on page 40

Figure 2 - Tampa ASR Recharge/Recovery Volumes



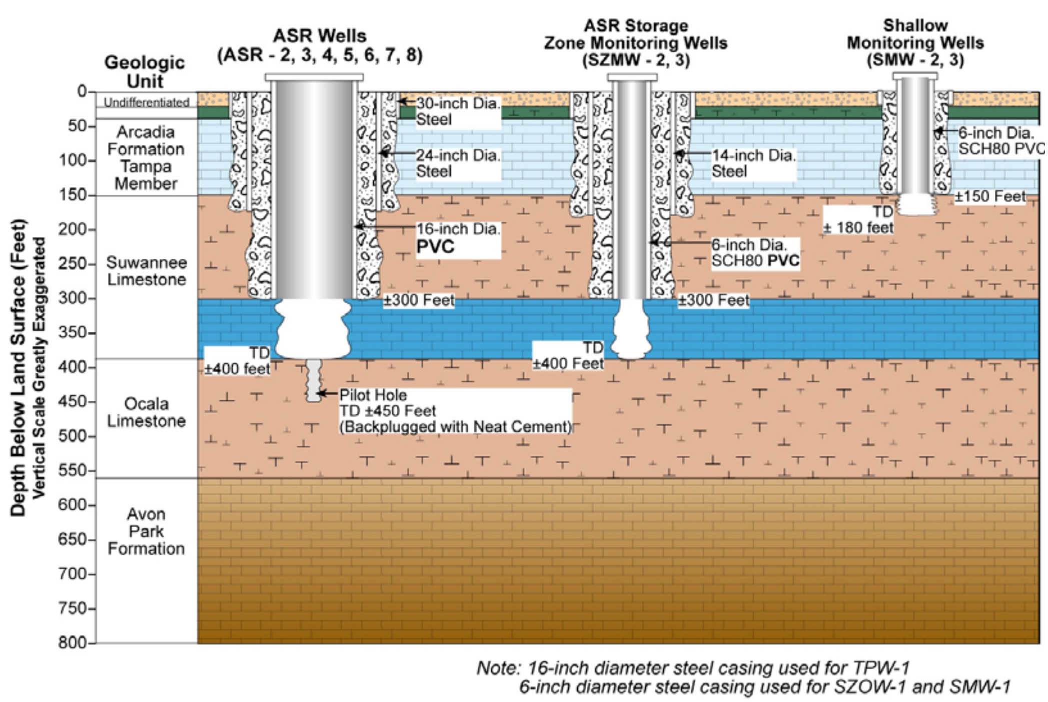


FIGURE 3
Generalized Potable Water ASR Artesian Well Construction Details

Continued from page 39
ed approximately 300 to 400 feet below land surface (bls), whereas most of the local competing users rely on a shallow, permeable zone typically less than 150 feet in depth, similar to the city's shallow monitoring wells as shown on **Figure 3**.

To ensure that the ASR operations did not deprive existing domestic well owners of water in their homes, the city passed an ordinance requiring domestic well owners to connect to its drinking water system if they fell within a "zone of probable influence" (ZOPI). The ZOPI is, in essence, an area which contains wells that may experience five feet or more of drawdown during ASR recovery operations.

Other incentives were included to encourage connection to the drinking-water system, including meter setting at no cost and a stipend to assist with onsite plumbing costs that may be incurred. Overall, this program was well received by the domestic well owners, with many residents joining the program immediately when it was made available. Incidentally, no irrigation or domestic well owners were confirmed to have impacts that precluded use of their wells during the initial 100-day recovery event at the design recovery capacity of 10 mgd.

Testing during well construction and initial operation of the ASR wells requires intermittent discharges of the test fluids to waste. This is often one of the more difficult issues to resolve during ASR program development. For the Tampa ASR system, the urban stormwater system was successfully utilized to convey test water from the ASR wells to the lower Hillsborough River. This included water produced during drilling, aquifer testing, and the initial-cycle testing activities.

Stringent turbidity control systems were implemented to provide a high-quality discharge to the river. Since the transmission system was constructed back to the Hillsborough River WTP, all recovered water during operational testing has been put to beneficial use for public supply.

Summary

Most states are becoming increasingly comfortable with storing and recovering water through proven ASR technology as the benefits of these systems become more transparent to utilities and regulatory agencies. Lessons learned from potable ASR system development are assisting with the rollout of alternative ASR applications where non-potable water supplies and water-management solutions are under development. As water resources become increasingly stressed through urbanization, ASR concepts will continue to play a major role in providing high-quality, sustainable water supplies for these communities.

Tampa has constructed a 10-mgd potable water ASR system in a highly urbanized area. Future ASR plans for Tampa may include up to an additional 20 to 30 mgd. During the 2001 drought, an additional 676 mg of water was provided from the ASR system, and approximately one billion gallons was recovered to help Tampa provide water to its customers during the 2002 dry season. Approximately an additional one billion gallons is available in storage at this time to help meet the city's anticipated needs during the 2003 dry season. Tampa's ASR program provides an important element of the region's alternative water supplies to help mitigate the impacts on the limited water resources during drought events.

References

- CH2M Hill, July 1999. *FDEP Class V, Group 7 Injection Well Construction Permit Application - Hillsborough River WTP Untreated Surface Water ASR*. Prepared for the City of Tampa Water Department, Tampa, Florida.
- CH2M Hill, June 2000. *Well Completion Report for the Phase III Part II Wells (ASR-5, ASR-6, ASR-7, WTMW-4, SZMW-3, and SMW-3) at the Rome Avenue Park ASR Site*. Prepared for the City of Tampa Water Department, Tampa, Florida.