Aquifer Storage and Recovery In Southeast Florida: Long and Short Term Benefits

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Overview

The use of aquifer storage and recovery (ASR) is rapidly gaining momentum as a water management tool in Southeast Florida as indicated by rekindled interest by regulators and utilities alike in exploring the benefits of ASR. ASR is the injection of water into a suitable aquifer for storage and withdrawal. Typically potable water is recharged into the aquifer during periods of excess water supply for later withdrawal during times of need. Simple concept, but how does ASR benefit a utility in an environment of rapidly increasing water demands, limited water supply allocations, and individually unique water supply and treatment facilities?

Under historic permitting practice, the ASR concept can potentially provide two areas of water supply enhancement. Water use allocations for a period of 5 to 10 years allow an annual pumpage rate based upon population and average per capita demand in the final permit year. Assuming a growing demand, the permitted pumpage rate during the initial permit period is greater than actual demand. The difference between permitted and actual demand provides for excess permitted supply available for long term storage. If multiyear storage is confirmed at the ASR site, the potential long term benefit to the utility is to extend the period between permit allocation requests and wellfield expansions.

In the short term, water supply enhancement may be realized by "peak shaving" where uniform pumpage is sustained at the annual demand rate. In this scenario excess water supply (the difference between water demand and permitted allocation) is stored during the below average demand period, typically November through April, and withdrawn to eliminate peak demands during the May to October dry period. The benefits realized through "peak shaving" using treated water for ASR recharge include potential reduction in future treatment plant and wellfield expansions. If raw water is used for ASR recharge, then wellfield expansion may be reduced, but treatment plant capacity would be required to meet peak day demand as would be the case without ASR.

Wet weather allocations are being addressed by regulating agencies for groundwater currently and hopefully will be considered for surface water in the near future. Additional groundwater allocations may allow for withdrawal of surplus surficial groundwater for storage during the wet season. This allocation would provide water for use beyond the base permit allowance without impacting modeled wellfield drawdown limits. In the same vein, surface wet weather allocations may be beneficial in using water normally lost to natural runoff as a conservation tool, salinity control, urban water supply or agriculture supply.

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Aquifer Usage in Storage and Recovery

ASR is the injection of water into a suitable aquifer typically for short-term storage and withdrawal. The aquifer performs like an underground reservoir or storage tank. Water is typically injected during periods of excess water supply for later withdrawal during times of need. This process is performed through the same well. The temporary storage of water in the selected aquifer zone is accomplished by pressure induced recharge through a well. Success of the cyclic aquifer storage and recovery is typically gauged by the volume of withdrawn water meeting a specific chloride, sodium or dissolved solids concentration expressed as a percent of water recharged. Variations in recovery, which can range from 30% to 130%, are affected by hydraulic, physical and chemical characteristics of the receiving water aquifer as well as the recharge and recovery schedule.

Storage in the ASR System. Aquifer characteristics play an important role in the ability to store freshwater over time. In Southeast Florida, potential aquifer storage zones have been identified in the Upper Floridan Aquifer System at a depth ranging from approximately 1000 feet to 1600 feet below ground surface. The South Florida Water Management District (SFWMD) has recently completed work in both Broward and Dade counties which confirmed the existence of correlatable recharge zones. These zones have been found to contain acceptable salinity concentrations and adequate aquifer storativity and transmissivity characteristics to provide storage.

The Upper Floridan water quality is brackish and is currently being used for limited industrial and agricultural supply and for use in reverse osmosis water treatment plants. Since this part of the Floridan Aquifer System also has the potential for storage of freshwater using ASR, there is the potential issue of conflicting uses of similar aquifer intervals. Therefore, it is expected that future regulatory rules may address the issue of Upper Floridan Aquifer System use by potentially delineating the shallow interval (1000 to 1200 ft) for reverses osmosis use and the intermediate interval (1500 to 1600 ft) for ASR use.

Once recharged into the brackish aquifer, freshwater will migrate upward with the brackish water pushing or buoying it from below. If sufficient lithologic confinement (low vertical hydraulic conductivity) exists, the freshwater water will collect towards the bottom of the well and recoverability will be enhanced. The thickness of the storage interval, porosity and hydraulic gradient also play important roles in the ability of the aquifer to provide storage. Recharge into a thick interval creates less radial extent and greater vertical dimension to the freshwater "bubble". Greater porosity reduces the lateral extent of the zone of dispersion. Depending on project scale and operation objectives, thickness and porosity may have a significant impact on recovery and efficiency. The diameter of the freshwater "bubble" is a function of its volume and the thickness and porosity of the storage interval. The greater the volume of recharged water, the less the immediate effects of downgradient movement. Even if a shift takes place, the well would still be near the middle of the "bubble" which can be controlled by recharge and recovery.

Type of Water Injected in ASR. Traditionally, finished drinking water has been the injected ASR fluid, conforming to allowable regulatory water quality standards. Other potential types of ASR fluids, however, may include raw groundwater and treated or untreated surface water. The type of injected water has direct bearing on water treatment and distribution, specifically on plant size.

Storing finished drinking water is accomplished by treating it to drinking water standards, storing the water in the aquifer and recovering it later for use during periods of water supply need. Recovered treated water can also provide an alternative water supply for potential use during emergencies or when regular facilities are not operating. In the case of treated ground or surface water storage, no further treatment of the recovered water is usually required other than disinfection. However, recovered water of acceptable quality may potentially go directly to distribution or conversely be of less than acceptable quality and require full or partial retreatment. The issue of water quality and effects of storage require site specific investigation to determine the appropriate post recovery distribution plan. Finished water storage primarily benefits water treatment plants at or near capacity. More specifically, ASR utilizing finished water optimizes use of existing facilities and minimizes capital expenditures by postponing the need for expansion of water treatment plant facilities.

Storing raw groundwater in the aquifer for later recovery is advantageous in some cases where groundwater quality is good and treatment is not necessary. The use of untreated groundwater may also benefit a utility that is operating a water treatment plant below capacity if recovered water can be treated without expanding the plant capacity.

Raw water storage may also reduce costs associated with potential freshwater losses in the aquifer during storage, as compared to storage of more costly treated water.

Use of untreated surface water for ASR storage may provide a way to conserve water that would naturally be lost to runoff. Potential uses for this water may include potable raw water supply. As in the use of raw groundwater, untreated surface water may require an aquifer exemption may be required to meet water regulatory requirements.

Basic Storage and Recovery Concepts

Under present SFWMD permitting practices, the storage and recovery concept can potentially provide two areas of water supply enhancement. Present SFWMD practice is to allow a yearly pumpage rate based upon the population and average per capita demand in the final permit year. SFWMD has historically provided allocations for a 5 to 10 year time period. Assuming a growing demand, the permitted pumpage rate during the initial permit period is therefore greater than actual demand. The difference between permitted and actual demand provides for excess permitted supply available for long term storage. As discussed previously, the fate of water stored for long periods is problematic and would require site specific study to confirm the practical limits for available multiyear storage.

The primary area ASR can potentially provide water supply enhancement under current SFWMD permitting practice is demand "peak shaving". For example, assume that the daily peak demand for a system is approximately 1.2 times the yearly average daily demand and the plant's yearly average demand is 10 mgd. This means the peak daily demand is 12 MGD. With the ASR well providing 2 MGD, the peak daily demand of 12 MGD can be provided with the annual pumping rate of 10 MGD. If treated water is provided directly from the ASR system, then the wellfield and plant can be sized at 10 MGD. If raw water is stored, the plant would require a 12 MGD capacity, but the wellfield can remain at 10 MGD.

The above presentation has explained how water theoretically can be stored when demand is low, and withdrawn from storage to effectively keep the system pumping rate at the annual average. If a system can effectively store and then reuse the water supply for demands above the annual average day, then the peaking demand on the water supply is eliminated. This concept is termed "peak shaving".

In addition to the potential benefits of ASR discussed above, several secondary considerations exist. The analysis presented above assumes no changes or modifications to the SFWMD historic regulatory practices. However, it can be expected that SFWMD would consider certain justified changes to help accommodate the ASR concept.

Traditionally, public water supply systems employ ASR to store finished drinking water for later recovery use. ASR can also be used to store excess wet season groundwater or surface water for later recovery during the dry season as needed to augment drinking water supplies and for other uses, such as agricultural irrigation. This ASR use for storage of surficial (Biscayne) aquifer groundwater is a relatively new permitting concept currently in use and is referred to as a wet weather allocation. Wet season flows which do not exceed the modeled drawdown from permitted wellfield withdrawal (typically definedat 90 days with no recharge) may be considered available for storage during the wet season and for recovery during the dry season. Surface water allocations of this type may be addressed in permits in the future for use in salinity control and agriculture and may be advantageous for use as a conservation tool for water quality providing recycling benefits and reducing evaporation losses.

Other secondary issues to consider include providing treated water ASR as a readily available treated water supply to meet such emergency conditions as hurricanes. Also, in certain locations treated ASR wells could be located within the distribution system. Being located throughout the distribution system may provide hydraulic benefits for certain systems and/or provide emergency back up if isolation from the water plant of portions of the distribution system can occur.

Short and Long Term Benefits

Southeast Florida is well situated to utilize ASR as a water management tool. A suitable aquifer exists for storage and withdrawal of potable or non-potable water during times of excess and need, respectively. Utilities are faced with meeting increased water demands, limited water supply allocations and individually unique water supply and treatment facilities. While ASR may not provide all the answers to the complex question of future water supply it does allow utilities to maximize existing water supplies and allocations.

The first water supply enhancement using ASR is storage of permitted pumpage in excess of the actual annual average demand. This concept works within the duration of the permit with maximum benefit realized in the early years of the permit when estimated demands are lower. Long term storage of ASR water, however, is problematic and requires site specific confirmation. The long term benefit to the utility is to extend the period between allocation requests and wellfield expansions.

The primary potential benefit of ASR, however, is peak shaving. This practice may have immediate benefit. By providing for peak shaving of either raw or treated water, the maximum wellfield pumping rate could be reduced. This reduction would allow for less aquifer drawdown and therefore possibly increase the pumping allocation of the existing utility wellfields. If treated water is recharged to the ASR system, treatment plant capacity needs can be reduced.

Wet weather allocations are being addressed by regulating agencies for groundwater currently and hopefully for surface water in the future. Wet weather groundwater allocations may allow for withdrawal of surplus surficial groundwater for storage during the wet season. This allocation could provide water for use beyond the base permit allowance without impacting modeled wellfield drawdown limits.

In the same vein, surface wet weather allocations may be beneficial in using water normally lost to natural runoff as a conservation tool, salinity control, urban water supply or agriculture supply.