# ASR in Roseville: *Navigating Water Quality Issues*

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The City of Roseville, in the Central Valley of California near Sacramento, is studying the feasibility of aquifer storage and recovery (ASR) to maintain water supply reliability during dry periods. An ASR pilot and demonstration project has been underway since 2004 to improve understanding of the hydrogeologic factors affecting well flow and water quality, identify and address regulatory concerns, and evaluate operational considerations associated with augmenting Roseville's water supply with ASR.

## *Water Supply*

The city's current annual surface water supply of 66,000 acre-feet is American River water diverted from Folsom Lake. The city maintains a contract entitlement with the U.S. Bureau of Reclamation for 32,000 acre-feet per year for Central Valley Project supplies and contracts with local agencies for the remaining 34,000 acre-feet per year, some of which is available only in normal and wet years. Roseville may also purchase Section 215 water, released by Reclamation from Folsom Lake in excess of the entitlements and rights of downstream users when it is available, but has not done so yet. Folsom Lake water treated to potable standards at Roseville's water treatment plant is being used for the ASR testing and will also be the supply for the long-term project.

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A county policy prevents Roseville from relying on groundwater as a source of supply. Roseville intends to operate its ASR program as a seasonal storage program, but would also like to retain some water in longer-term storage as protection against droughts. ASR is allowed by the county because it does not result in a net take from the basin: the volume of water extracted will not exceed the volume injected and stored in the aquifer.

## *Testing ASR Feasibility*

ASR testing at Roseville is being completed in two phases. First, a short-term pilot test was conducted in 2004 using the Diamond Creek well, which was installed as a dual-purpose injection-recovery well. It is screened from 310 to 450 feet below ground surface in a confined zone of the target aquifer, the Mehrten Formation (see figure, top right), a coarse-grained sand, gravel, and cobble of volcanic origin deposited in a fluvial environment. Three existing wells were used to monitor water level and water quality in the aquifer during the test.

Results from the short-term test indicated that ASR is feasible in Roseville, but that longer-term testing was needed to understand the fate and transport of disinfection byproducts (DBPs) in the subsurface. Therefore, Phase II demonstration testing began in November 2005 and was to be completed in May 2008. Water quality and water levels are again being monitored in the four wells. No problems have yet been encountered regarding well plugging associated with solids accumulation or geochemical precipitation in the well.

## *Enter the Regulatory Environment*

Although drinking-quality water might appear to be ideal to store underground, California's water quality regulators saw it differently. The State Water Resources Control Board oversees nine regional water quality control boards (RWQCBs) that develop and enforce water quality objectives and implement plans to protect the state's waters, recognizing differences in climate, topography, geology, and hydrology. This means that regulation of ASR has evolved inconsistently among regional boards throughout the state.

The Roseville ASR project lies within the purview of the Central Valley RWQCB. CVRWQCB determined that the ASR test project would be regulated under a conditional waiver of *waste discharge* requirements, even though the project is using *drinking water that meets all standards*. The problem is the drinking water contains DBPs at levels greater than the groundwater basin water quality objectives. The waiver allows the test project to proceed as long as DBP concentrations remain below EPA's maximum contaminant levels for a short-term, controlled project. The waiver requires:

- estimation of the aquifer volume to be impacted by injected drinking water;
- establishment of a monitoring program to confirm that stored drinking water is contained within that portion of the aquifer defined above;
- reporting of project status and testing results to CVRWQCB every 60 days;
- submission and implementation of contingency plans to clean up or abate unintended impacts on groundwater quality, should the demonstration project result in a violation of water quality objectives beyond the predicted injection front or after the stored water has been extracted; and
- the extraction phase of testing to continue until DBP concentrations are below basin objectives (1.1 micrograms per liter [μg/l] for chloroform).

## Results to Date

Results (see MWH, 2008) indicate that ASR in Roseville has two significant water resource benefits including:

- a rise in regional groundwater levels of approximately five feet during the five-month injection period, and

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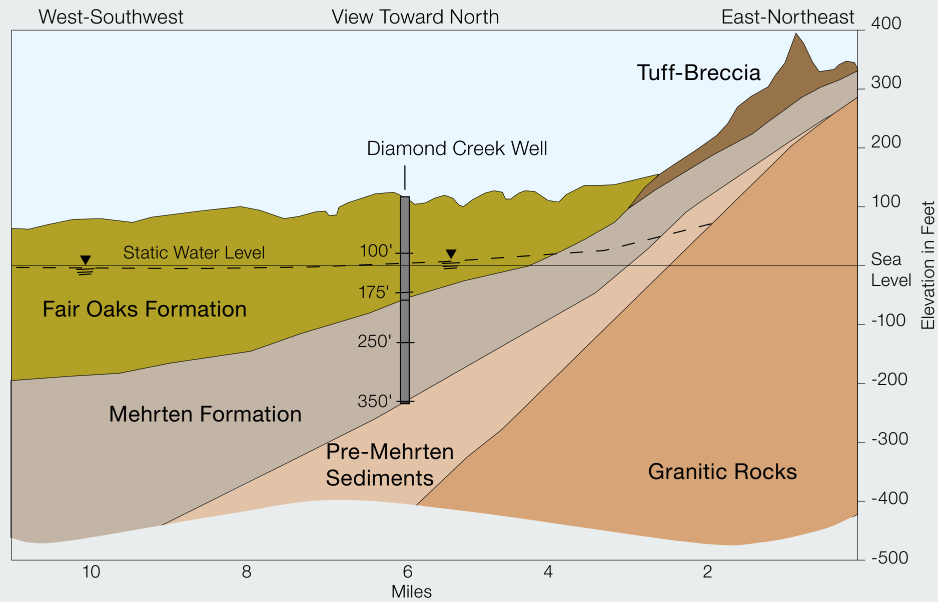


*Regional geologic cross-section through Diamond Creek well site. Modified from DWR, 1974.*


*Changes in concentrations of chloroform (top) and total haloacetic acids (bottom) during demonstration testing in the Diamond Creek well (DCW), three monitor wells (DCMW-1, 91 feet crossgradient of injection; DCMW-2, 193 feet upgradient; and DCMW-3, 402 feet downgradient), and the water treatment plant (WTP), compared to EPA's maximum contaminant level (MCL). Units are micrograms per liter (μg/l). The chloroform plot is nearly identical to that of total trihalomethanes (THM), as chloroform accounts for 90 to 95 percent of THM.*

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- a reduction in total dissolved solids (TDS) concentrations in the aquifer from an average of 457 milligrams per liter (mg/l) to 59 mg/l at the beginning of the storage phase, measured at the Diamond Creek Well. The TDS of the water being injected ranged between 47 and 62 mg/l.

The charts on the previous page show the changes in DBP concentrations during each period of the demonstration test. By comparing DBP to conservative constituents such as chloride and fluoride, it appears that haloacetic acids were naturally attenuated in the aquifer during the storage phase of testing: they were not detected after five months of storage. Trihalomethane (THM) concentrations (as represented by chloroform) were reduced during the storage period, but not completely eliminated. The mechanism of THM reduction is not fully understood, but appears to be caused by dilution, again based on correlation with chloride concentrations over the same time period.

## Long-Term Plans

Roseville expects to complete the demonstrate test by May 2008 and to have extracted 300 percent of the injected volume in an effort to remove DBPs below basin objectives (chiefly chloroform below 1.1 µg/l). Clearly 100 percent injection followed by 300 percent extraction is not sustainable for long-term operation, but was necessary to comply with the waiver for the testing phase of implementation. Roseville and CVRWQCB now have a better understanding of the water quality implications of a long-term ASR operation.

What's next? Roseville has begun discussions with CVRWQCB management and staff regarding long-term operation of ASR in Roseville and expansion of the program to eventually include up to 12 operating ASR wells over the next three to five years. In striking a balance between the water supply benefit of ASR and the need to protect groundwater quality, it is anticipated that a long-term operational permit will:

- allow a designated portion of the aquifer to be impacted above basin objectives during the operational life of the ASR program;
- establish institutional controls to prevent other beneficial users from accessing the portion of aquifer designated for ASR;
- allow a point of compliance within the aquifer downgradient of the project;
- require a reasonable monitoring program, agreed upon by Roseville and CVRWQCB; and
- likely require that water quality objectives be restored to either pre-project conditions or reasonably achievable conditions at the end of the project.

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## References

*California Department of Water Resources (DWR), 1974, reprinted 1980. Evaluation of Groundwater Resources: Sacramento County. Sacramento Bulletin 118-3.*

*MWH, 2008. Diamond Creek Well Phase II Demonstration ASR Project: Monitoring Report 13, Jan. 22.*

*ASR Primer, continued from page 17*

removed by traditional wastewater treatment processes. Much research is being conducted on the potential health risks associated with introducing reclaimed water to potable aquifers. Lastly, pathogen removal by chlorination can cause formation of disinfection byproducts, such as trihalomethanes, that can persist in some ASR systems (NRC, 2008).

## Getting It Back

Recovery is a critical component of any ASR system because the objective is to recover the recharged water, or a nearly equivalent amount, in the future. However, full capture and recovery is not always feasible due to aquifer characteristics and the practical placement of wells. As a result, the potential exists for losing a portion of recharged water. However, water recovery issues can also be political or legal in origin, as when a governing entity intervenes and imposes limitations on the rate or volume of water that can be recovered.

The management, monitoring, and accounting of recharged water are inherently obscure as groundwater is not visible. Therefore, computer models, monitoring wells, and sophisticated accounting systems are employed to accomplish these tasks. Even with these tools it can be challenging to adequately demonstrate control and capture of recharged water. Many western states utilize some form of prior appropriation to allocate scarce water resources. Some states such as Colorado administer groundwater and surface water conjunctively, and others administer these resources discretely. The protection of senior water rights can represent a significant barrier to ASR projects, particularly with respect to accounting and recovery. It must be demonstrated that ASR operations will not cause an out-of-priority diversion of stream flows or native groundwater that is not otherwise replaced.

Source water availability can be the limiting factor for some entities, even when a suitable aquifer and recovery system are available. However, these situations can engender creative solutions such as "borrowing" source water from a surface water provider in exchange for delivering groundwater to the same provider during periods of drought.

ASR is expanding in scope and complexity as more projects are initiated, long-term data become available, monitoring and analytical technologies advance, and the demand for water increases with respect to supply. Not every situation or set of conditions is favorable for implementing ASR, and ASR will not displace the need for surface storage. However, it is a viable alternative and a beneficial water management technique where and when the necessary ingredients exist.

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## References

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*Pyne, R.D.G., 1995. Groundater Recharge and Wells: A Guide to Aquifer Storage Recovery, CRC Press Inc.*