

**STAFF REPORT
AQUIFER STORAGE AND RECOVERY PROJECTS
IN THE CENTRAL VALLEY**

Introduction

In January 2003 the City of Roseville (City) submitted a Report of Waste Discharge (RWD) to the Central Valley Water Quality Control Board (Water Board) to implement an Aquifer Storage and Recovery Project (ASR Project) within the limits of the City's jurisdictional area. The ASR Project was implemented in two phases and served as a pilot project to allow the Board to evaluate and assess the potential or actual impacts ASR Projects could have on groundwater quality. The Water Board waived waste discharge requirements for both phases of the project. Phase I of the project was authorized under Waiver Order No. R5-2003-0083 adopted by the Water Board in April 2003. Phase I was completed in December 2004. The City submitted a RWD in May 2005 to seek Water Board authorization to conduct Phase II of the ASR Project. The Water Board adopted Waiver Order No. R5-2005-0106 in August 2005. The City is nearing completion of Phase II, and plans to submit a final report by the end of April.

This Staff Report will provide the Water Board:

- An overview of ASR Projects,
- Discuss the initial concerns of Water Board staff for ASR Projects,
- Summarize the initial regulatory approach and requirements the City was required to meet during its pilot ASR Project,
- Summarize the results and findings of the City's ASR Project
- Discuss the outstanding issues or concerns of Water Board staff regarding ASR Projects, and finally,
- Discuss proposed alternatives for Water Board regulatory actions in the future for these ASR Projects.

Overview of ASR Projects

California faces an increasing demand for water supplies due to current and projected population growth. Building dams and reservoirs to store natural runoff is expensive and has associated environmental impacts. The California Department of Water Resources' (DWR) mission is to manage the water resources of California in cooperation with other agencies, to benefit the State's people, and to protect, restore, and enhance the natural and human environments. DWR has been working to further conjunctive water management projects throughout the state. Conjunctive water management generally improves regional water supply reliability by increasing the coordinated use of surface and ground water. In a conjunctive use project, when surface water is abundantly available, the surface water is used to recharge a groundwater basin.

At times when surface water is not available, water is withdrawn from the aquifer, which essentially has become a subsurface “reservoir” for water supply.

There are in general two types of systems that provide the artificial aquifer recharge that is necessary to improve the long term viability of conjunctive use projects. The first employs the use of spreading or infiltration basins to collect water and allow it to percolate through the soil and into the aquifer. Flood basins that are used by many communities, may also serve as spreading basins. They require a sizable surface area and geological studies to ensure the site is suitable for the anticipated water volume and infiltration. The second system uses an active approach by injecting water through one or more wells directly into a designated groundwater aquifer.

The injection and/or infiltration and subsequent recovery of a water resource is referred to as aquifer storage and recovery. This approach eliminates the need for large areas of land to apply water for infiltration. Long-term implementation of ASR Projects are designed and operated to move water into the aquifer during times when water supplies are plentiful and to extract water when needed to augment domestic/municipal water supplies.

The source of water for ASR Projects includes:

- Surface water from natural water bodies,
- Treated surface water in municipal water supply systems, and
- Highly treated effluent from sewage treatment plants.

This Report addresses only the sources identified in the first two bullets, and in particular highlights the experience Water Board staff gained from the City’s project, which used treated surface water as its source water. The Water Board does not currently have any actual or proposed ASR Projects that involve the injection of treated effluent from sewage treatment plants.

ASR Projects are not a new or emerging concept. Many such projects have been in existence and used to augment groundwater supplies in areas throughout California, the United States and the World. The experience gained from these existing systems were considered by the City and its consultant when designing their Project. The experts agree that while these projects are generally understood, pilot projects in the field are desirable, that these projects should start small, use a learn-as-you-go approach, and expand as needed¹.

The advantages of ASR Projects for a community and the State include;

1. Enhanced reliability of water supplies.

¹ International Symposium on Managed Aquifer Recharge 6, *Management of Aquifer Recharge for Sustainability*, Acacia Publishing, 2007, Forward, ix pp.

2. Ability to take advantage of seasonal availability of water supplies and opposing seasonal demand.
3. Increased flow in rivers and streams during peak seasonal demand of water resource.
4. Reduced blockage of river passage caused by dam construction.
5. Decreased loss of water resources to evaporation relative to reservoir storage.
6. Storage of chlorinated water allows the water supply district to avoid infrastructure improvements to the water treatment plant.
7. Recharge using injection allows ASR Projects where large surface areas are not available for spreading basins.
8. Recharge using injection allows ASR Projects where low permeability surface soils hinder infiltration and render spreading basins ineffective.

Regulatory Approach by Water Board

Initial Water Board Staff Concerns

While ASRs are not a new or emerging concept in areas outside the Central Valley, they were new for the Water Board when the City of Roseville first approached Water Board staff to discuss their proposed ASR Project. Water Board staff had many concerns and questions that needed to be addressed, such as the potential impact ASR Projects would have on groundwater quality and the possibility for injected waters to negatively impact the beneficial uses of the aquifer, which the Water Board is charged by law to protect. Initial concerns by Water Board staff regarding ASR Projects were:

- Injected water may be of very different quality than groundwater in the aquifer.
- Injected water may degrade or even pollute the groundwater resource.
- ASR Projects must comply with the State antidegradation policy (Resolution 68-16).
- Disinfection byproducts from the injection of drinking water treated with chlorine (free and combined) may persist in groundwater. Many of the disinfection byproducts are known to cause cancer in humans.
- Meeting drinking water standards may not be protective of all beneficial uses of the groundwater.
- Changes in groundwater chemistry may occur when groundwater is mixed with the source water, and may cause constituents in undesirable concentrations to leach from the soil.
- Constituents may be in the source water that are not currently detected in groundwater supplies, such as pesticides, pharmaceuticals and others.
- Access by other uses and users of the water within the storage zone.

Proposed Pilot Project Regulatory Approach

To address staff concerns, staff proposed the City conduct a two-phased demonstration or pilot project that would be regulated under waivers of waste discharge requirements adopted by the Water Board.

During the pilot project the City was required to:

- 1) Verify in-situ attenuation and/or dilution of constituents of concern occurred, and
- 2) Demonstrate that ambient groundwater met water quality objectives at some distance from the well or well field and within a zone under the control of the project proponent. This distance delineates the storage zone.
- 3) Assess and define the nature, extent and duration of water quality impacts from the pilot phase.
- 4) Ensure that groundwater augmented during the pilot project met water quality objectives at the end of the pilot phase of the project.
- 5) Monitor within and outside the storage zone area.
- 6) Establish and implement a contingency plan to correct any violations of the waiver conditions.
- 7) Establish institutional controls to ensure that no other users of the aquifer storage zone exist now or in the future.
- 8) Finally, the City was required to extract a minimum of 300 percent of the volume of water injected.

The waivers for both phases established groundwater quality limits set at levels staff proposed would be protective of all uses of the groundwater. For disinfection byproducts the waivers established limits based on maximum contaminant levels (MCLs) established by USEPA and/or California Department of Public Health (CDPH), action levels, advisories and public health goals:

Constituent	Water Quality Limit, ug/l	Reference
Chlorine residual	2	Odor Threshold
Total THMs	80	US EPA Primary MCL
Chloroform	1.1	Cal/EPA Cancer Potency Factor
Bromoform	4	US EPA IRIS Cancer Risk Level
Bromodichloromethane	0.27	Cal/EPA Cancer Potency Factor
Dibromochloromethane	0.37	Cal/EPA Cancer Potency Factor
Total HAAs	60	US EPA Primary MCL
Dichloroacetic acid	0.7	US EPA IRIS Cancer Risk Level
Trichloroacetic acid	20	US EPA Health Advisory
Chloroacetic acid	30	US EPA Health Advisory
NDMA	0.0022	Cal/EPA Cancer Potency Factor

Within the storage zone the City was required to meet MCLs for all constituents.

Summary City of Roseville Pilot Project

The City's pilot ASR Project involved the injection of treated surface water from Folsom Lake into the groundwater basin underlying Placer County. Folsom Lake is high quality surface water that exceeded the quality of the groundwater basin augmented through the pilot project.

Phase I of the City's pilot project consisted of 26 days of injection at approximately 1,350 gallons per minute (gpm), and approximately 29 days of extraction at approximately 3,400 gpm. The total volume of water injected during Phase I was approximately 158 acre-feet, and the total amount extracted was 439 acre-feet or approximately 278 percent of what was injected. Treated Folsom Lake water entered the drinking water distribution system at the City's water treatment plant (WTP) and was conveyed approximately 13.2 miles to the ASR injection/extraction well. Monitoring of the injection/extraction activities occurred during the project.

The efforts of Phase I allowed the City to develop a numerical model to estimate the anticipated injection front and capture zones for the second phase of the project.

Phase II of the City's project also involved the injection of treated Folsom Lake water and:

- One month of baseline data collection,
- Injection of 1,094 acre-feet (356 million gallons) of treated surface water at a rate of 1,375 gpm into the aquifer over a six month period using the Diamond Creek Well,
- Storage of the injected water in the aquifer for a period of four months,
- A ten month extraction phase at 2,500 gpm recovering 3,314 acre-feet (1.08 billion gallons) of water,
- Two months of post testing,
- Extraction of 300 percent of the total volume injected during the project, and
- Development of a contingency plan in the event that monitored constituents were identified beyond the storage zone boundary or present at the end of the final extraction phase of the project.

Summary of Pilot Project Results

Monitoring data from the completion of Phase I found chloroform detected at 1.5 micrograms per liter ($\mu\text{g/L}$), dissolved fluoride at 0.2 milligrams per liter (mg/L), and dissolved organic carbon at 2.3 mg/L . These were the only constituents that remained in groundwater at concentrations slightly higher than baseline conditions.

Monitoring data collected for five consecutive months, during Phase II found chloroform concentrations above the receiving water limit of 1.1 ug/L as established in the waiver: Chloroform was detected in groundwater samples in a monitoring well (DCMW-3) outside the defined aquifer storage zone at the highest concentration of 2.4 ug/l. Detection of chloroform at these levels violated conditions established in the waiver.

The City also found that extraction of 300% of the source water injected resulted in the City extracting natural groundwater in addition to the higher quality source water injected into the aquifer. This negatively impacted the quality of the City's drinking water supplied to its residents by increasing the total dissolved solids. However, the salinity increase from ASRs and extraction of groundwater may have less of an impact than if the City had to curtail surface water use during a drought and make even heavier use of groundwater to augment city water supplies.

Remaining or Outstanding Issues or Concerns Regarding ASR Projects

There are two main concerns regarding the regulation of ASR Projects within the Central Valley Water Board that staff seek input and direction from the Water Board on. These include:

- Monitoring data collected throughout the project found that disinfection by-products exceeding U.S. EPA and Cal EPA recommended criteria were found to persist in the groundwater basin after the source water was extracted. However, the concentrations of the byproducts did not exceed MCLs. The City, as well as other potential ASR Project proponents, has expressed concerns over the use of water quality limits that are more stringent than MCLs established by CDPH or USEPA. In addition to the City and other proponents, the State Water Board and CDPH have also expressed concern regarding the use of nonregulatory standards as effluent limits, where the standards are more stringent than MCLs. This was highlighted in an action taken by the State Water Board in response to a petition challenging the use of lower standards in an ASR Project in another Region.

In April 2006, the State Water Board adopted Order WQ 2006-0001, a precedential decision, regarding the use of Notification Levels adopted by the Department of Health Services (DHS) in a permit issued by the Los Angeles Water Board to regulate the Alamitos Barrier recycled water project. The project involves injecting highly treated wastewater into a groundwater aquifer for use against seawater intrusion and for supplying drinking water. The State Water Board found that, in light of the public policy in favor of water reclamation and the full protection of public health by the project and the other permit limitations and requirements, it was inappropriate for the Los Angeles Water Board to include Notification Levels as effluent limitations. Using Notification Levels was also inappropriate because CDPH could revise them, and setting effluent limitations based on a "moving target" posed practical

problems. The Order further notes that it is lawful to adopt permit limitations based on non-regulatory criteria only if the limitations are supported by appropriate findings, and that the order was based on the State Water Board's policy determination.

Precedential decisions and orders provide guidance for later decisions and orders. The nine Regional Water Boards must follow State Water Board precedents, or provide a reasoned analysis why the precedential decision does (or should) not apply to a different project.

Staff is seeking direction from the Water Board on the use or inclusion of limits more stringent than MCLs in future ASR Projects.

- The City and other potential ASR Project proponents have expressed concern over the Water Board's requirement that other uses and users of the water within the storage zone be prevented through appropriative water rights or institutional controls. The City was able to comply with this because the storage zone was within their jurisdictional land-use area. However, not all project proponents, such as water districts, have authority to impose land-use controls and could not institute such restrictions. During development of the City's pilot project staff believed it was necessary to require such controls to protect other uses or users that may be impacted by augmented groundwater.

Staff is seeking direction from the Water Board on the need for restrictions on the access to groundwater within the storage zone of ASR Projects and the types of restrictions or requirements the Water Board believes may be appropriate for ASR Projects.

In addition, in regard to the City's regulatory strategy during the pilot project phase, some observations should be noted.

- The City was accommodating in that during this early experience with ASR, it provided for securing the target aquifer from use by other groundwater users. This action is not within the power of other ASR proponents. The driving consideration behind this action is unclear (i.e., whether it was required to facilitate using this project to obtain data on ASR, or whether it was necessary to protect groundwater). It appears punitive to the neighboring land owners and possible groundwater users, raises questions with regard to groundwater rights and is inconsistent with the fact that designated beneficial uses are determined by use.
- During Phase I about 278% of the volume injected was subsequently extracted and this was repeated during Phase II, with an approximately 300% overdraw. This overdraw does not model the intended long term ASR operations at the site, as most ASR Projects inject greater volumes of water into the aquifer than they ultimately extract over a long period of time. The Regional Water Board found in Waiver Order R5-2005-0106 that: "the

injection of drinking water for future extraction is not a discharge of waste that warrants issuance of waste discharge requirements due to the limited nature, extent and duration of the above-described discharge, the preclusion of other uses and users, and the fact that all injected water will be recovered. However, an injection of drinking water that exceeds MCLs within the aquifer storage zone or results in an exceedence of water quality objectives outside the aquifer storage zone may be subject to waste discharge requirements that require compliance with the Basin Plan and/or remediation of water quality impacts ...”

- During Phase I and Phase II, the discharger conducted only a single cycle of injection and recovery. Thus, there is limited data available to model the aquifer under long term ASR implementation. The goals of the ASR Phase II should have included obtaining aquifer performance during multiple and subsequent cycling.
- The subsurface fate and transport of the byproducts of disinfection are poorly understood. DWR and ASR Project proponents should fund academic research within California in this area of study.
- The majority of water quality problems arise from the use of free or combined chlorine and its associated byproducts. No feasibility study including a cost-benefit analysis was conducted to assess either; 1) varying the chlorine concentration dose during injection cycles, 2) implementing alternative disinfection methods, or 3) modifying the drinking water distribution network to allow for the injection of drinking water prior to its disinfection.
- When native groundwater was being pumped out during the ASR test, complaints were received from citizens that the quality of the water being received at their homes was degraded by the ASR Project (elevated TDS and hardness). The increased salinity in the potable water distribution system was the result of overpumping the aquifer to maximize recovery of injected water, and is not inherently an issue with ASR Projects.

Alternative Approaches to Regulating Future ASR Projects

The following presents various alternative approaches to regulating ASR Projects that staff would like the Water Board to discuss at the workshop. These alternatives do not address the regulation of ASR Projects involving injection of treated effluent from wastewater treatment plants; any such proposed projects would be addressed separately.

Alternative 1: Use the regulatory approach envisioned by staff in 2005 when developing Phase II of the City’s ASR Project.

In a 2005 staff report to the Water Board regarding ASR Projects, staff envisioned the that the future regulatory mechanism to authorize ASR Projects

would be through a conditional waiver of waste discharge requirements with a monitoring and reporting program (MRP) adopted by the Water Board.

The 2005 staff report described the general strategy a project proponent would follow in order to have an ASR Project authorized under the waiver. Staff envisioned a two-phase project being implemented through the waiver that follows the same structure as the project implemented by the City of Roseville that was described above. In summary, this strategy includes:

- Fully characterizing the source water for groundwater augmentation and ambient groundwater quality conditions.
- Implementing a pilot or test phase project with a monitoring program to verify the project will be successful and to evaluate impacts to ambient groundwater quality.
- Implementing a contingency plan in the event the project fails or ambient water quality is impacted.
- Preventing third party access to the augmented aquifer.
- Based on the results of the pilot project, a full-scale project may or may not be implemented by the project proponent. If a full-scale project does not proceed, the project proponent would be required to fully extract groundwater (both ambient and injected source water) that has been impacted by the injected source water and exceeds water quality objectives.

Alternative 2: Waive the submittal of reports of waste discharge for all ASR Projects.

Presumably most ASR proposals would be designed to protect groundwater quality, since the goal of ASR is to ultimately be able to withdraw groundwater for use as drinking water. Water stored in the aquifer may, however, degrade groundwater quality in a manner of concern to the Water Board, but not of concern to the water supply district. The waiver must be conditional and must be consistent with the Basin Plan, but need not require monitoring if the Water Board determines that the ASR Projects do not pose a significant threat to water quality. Waiving of submittal of a report of waste discharge will lessen the paperwork and reviews associated with development of new ASR Projects, which will make it easier and faster to implement these water supply projects. However, without submittal of a report of waste discharge, the Water Board will have limited knowledge of proposed projects.

Alternative 3: Waive the submittal of reports of waste discharge for selected types of ASR Projects that have lower water quality concerns.

Conditions for this waiver could include the relative salinity of the ASR Project water source and the native groundwater, whether the source of injected/infiltrated water is chlorinated, or likelihood of groundwater being withdrawn by parties not involved in the ASR Project.

Alternative 4: Require submittal of reports of waste discharge for all ASR Projects, injection and infiltration.

This alternative would allow each project to be individually considered and site-specific requirements established. This may result in significant staff resources to develop individual requirements.

Alternative 5: Develop a general conditional waiver or general waste discharge requirements that could expedite permitting for all ASR Projects.

Alternative 6: Regulate ASR Projects through the Basin Plan.

This alternative would require staff to develop and implement a Basin Plan amendment that would specify the conditions under which an ASR Project would be allowed. The Basin Plan provision would take the form of a conditional prohibition that prohibited any ASR that failed to meet requirements specified in the Basin Plan. This would allow all ASR Project proponents to understand the regulatory and monitoring requirements for ASR Projects in the Central Valley. Due to the procedural requirements for basin planning, this alternative offers the least flexibility to modify the requirements for ASR Projects as more information about project impacts becomes available.

Alternative 7: Implement a non-regulatory approach to condition and control ASR Projects.

Develop Unified Statewide ASR Guidelines that would be implemented through a Memorandum of Understanding between the State Water Board, DWR and the California Department of Public Health (CDPH). This Unified Statewide ASR program would be developed through a collaborative effort of the State and Regional Water Boards, DWR, CDPH and USEPA. So long as a project proponent followed the guidelines the Water Board would not impose additional conditions through a waiver or waste discharge requirements.