

Aquifer Storage and Recovery and Aquifer Recharge with Reclaimed Water in Texas

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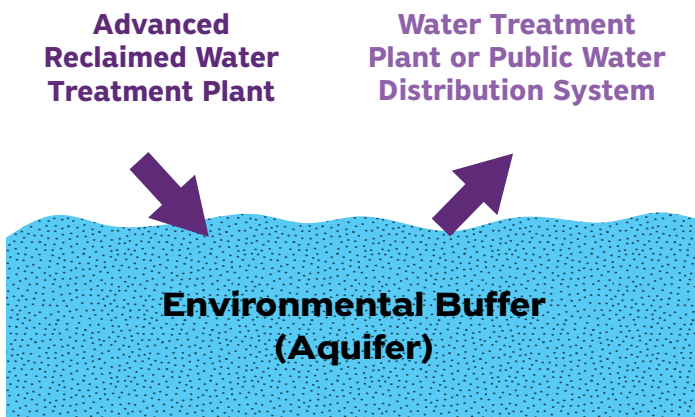
February 2026

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Introduction

Aquifer storage and recovery (ASR) and aquifer recharge (AR) are types of water supply management projects defined in Texas Water Code [§ 27.151](#) and [§ 27.201](#), and are most often used for water storage or replenishment. Reclaimed water is defined by [30 Texas Administrative Code § 210.3](#) as “domestic or municipal wastewater that has been treated to a quality suitable for a beneficial use.” Pairing ASR or AR with reclaimed water creates an indirect potable reuse project. In these projects, an aquifer provides storage and acts as an environmental buffer between the advanced treatment and public water supply distribution (Figure 1). These projects need to be carefully tailored to the operations, supplies, and hydrogeology being utilized to successfully meet entity goals and regulatory requirements.

Figure 1. Generalized diagram showing storage and recovery of reclaimed water using an aquifer as an environmental buffer



Highlights

Operational facilities

El Paso Water (EPW) has the only operational hybrid ASR and AR facility in Texas that stores reclaimed water. EPW worked with the U.S. Geological Survey to determine the feasibility of injecting advanced treated reclaimed water into the Hueco Bolson aquifer (Garza and others, 1980). Some details about the EPW system include

- the advanced reclaimed water plant and 10 injection wells were constructed between 1981–1985;
- the injection wells’ galvanized steel screens and casings have been replaced with PVC due to corrosion;
- the system continuously measures seven water quality parameters, including chlorine, dissolved oxygen, nitrates, ozone, pH, turbidity, and total organic carbon (White and Sladek, 1990; Reinert, 2017);
- EPW began replacing injection wells with infiltration basins in 2003 to lower maintenance costs; and
- over 92,000 acre-feet of reclaimed water has been used to recharge the aquifer since the project began.

Planned facilities

In the 2022 State Water Plan, seven recommended or alternative water management strategy projects propose using reclaimed water as part of an ASR or AR project (Figure 2, Table 1):

- Six of the 16 Regional Water Planning Groups include these strategies (Regions A, C, E, F, G, & N).
- These projects may include a single well, a well field, or infiltration basins and range in size from 25 to 14,573 acre-feet per year.
- Capital costs range from \$2.3 to \$90.2 million, with a total cost of \$249.6 million for all seven projects.
- Cost per acre-foot ranges from \$156 to \$8,920, with an average of \$1,887.

Figure 2. Map of operational and planned ASR or AR projects using or considering using reclaimed water in Texas. Planned projects may include multiple water sources and not represent all potential projects in the state.

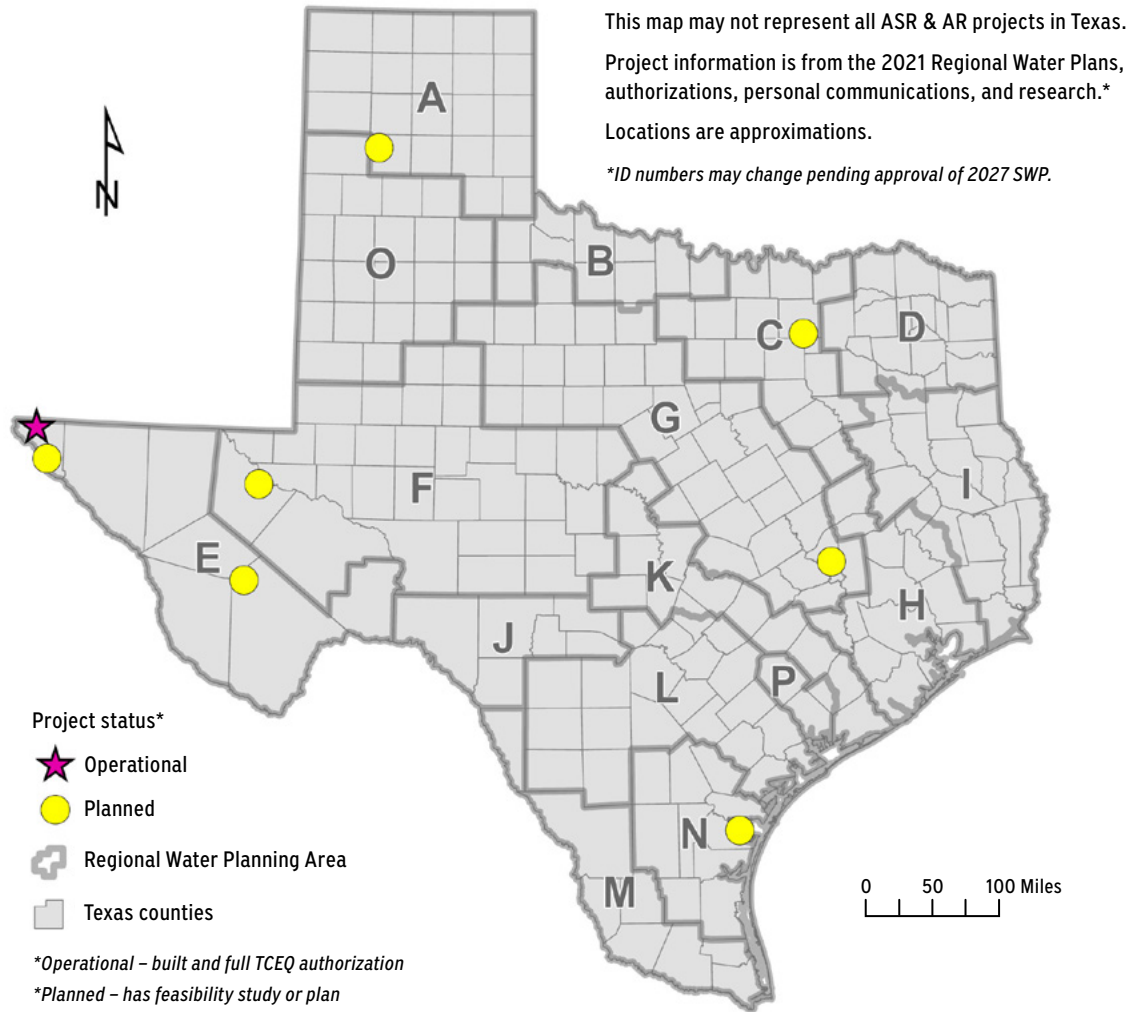


Table 1. List of operational or planned ASR or AR projects that use or may consider using reclaimed water in Texas.

Entity	22SWP Project ID	22SWP WMS ID	RWPA	Source	Recharge infrastructure	Online decade	Planned capacity (AFY)	Capital costs	Population benefiting (2070)
El Paso Water	0000	0000	E	R	infiltration	1980	2,630	not available	1,136,275
City of College Station	1847	3239	G	R	well or wellfield	2030	3,640	\$86,514,000	not available
Lower Valley Water District	2140	2997	E	Mix	well or infiltration	2030	5,589	\$23,509,000	101,287
City of Corpus Christi	4251	5224	N	R	well or wellfield	2030	14,573	\$90,199,000	manufacturing
City of Amarillo	3875	4842	A	Mix	well or wellfield	2030	6,500	\$11,472,000	353,937
North Texas MWD	3844	4939	C	Mix	well or wellfield	2030	2,500	\$6,041,000	not available
City of Pecos	4352	5405	F	R	well or wellfield	2030	925	\$29,541,000	11,460
City of Alpine	4109	5417	E	R	infiltration	2030	25	\$2,318,000	6,293

Table Key: 22SWP – 2022 State Water Plan; WMS – water management strategy; RWPA – Regional Water Planning Area; AFY – acre-feet per year; R – reclaimed water; Mix – multiple proposed sources that could include reclaimed water; MWD – Municipal Water District

Regulation and permitting

Early coordination with the Texas Commission on Environmental Quality (TCEQ) is beneficial for all proposed ASR and AR projects in the state. All ASR injection wells in Texas must be authorized as a Class V injection well by the Underground Injection Control Program at the TCEQ (Figure 3). In 2025, the Texas Legislature passed Senate Bill 2885, directing the TCEQ to consider treated reclaimed water as a source for Class V injection wells as part of ASR projects. Currently, there is no established regulatory path for authorizing ASR systems using reclaimed water as the injectate and would need to be accomplished on a case-by-case basis. The TCEQ is currently working on standards to be applied for this purpose.

A reclaimed water ASR or AR project that does not require a Class V injection well may have various permitting paths depending on the scope and scale of the project. Some of these projects may be considered “alternative reclaimed water systems”, which may be submitted to the TCEQ for consideration ([30 TAC § 210.41](#)). AR projects using reclaimed water may be permitted through a Texas Land Application Permit (TLAP), which authorizes disposal of treated reclaimed water. TLAPs may authorize disposal of treated effluent via irrigation, evaporation, surface land application, or drip dispersal systems. However, a TLAP may not be appropriate for all AR projects using reclaimed water. Different types of projects may require coordination with different divisions within the TCEQ, so early coordination is beneficial.

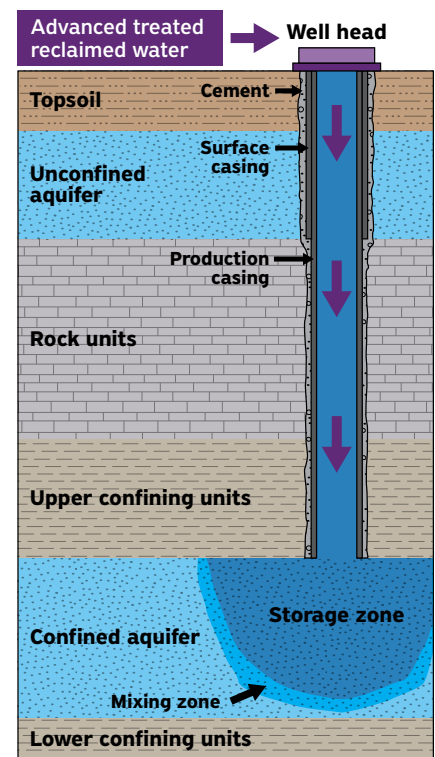
Health and safety

Water supply regulations are developed to protect the health and safety of the public. The regulations usually include setting health targets and contamination limits, approving treatment technologies that can meet health and safety goals, and requiring ongoing monitoring for verification of critical constituents.

ASR and AR projects using reclaimed water will require characterizing the aquifer to mitigate adverse biogeochemical reactions in the subsurface. Projects with Class V injection must not pollute underground sources of drinking water per federal code ([40 CFR § 144.12](#)). Potential contaminants of underground sources of drinking water that may acutely and chronically adversely affect human health include pathogens and some manmade and naturally occurring chemicals and compounds. There are over 200 known pathogens that can be transmitted by water and the concentration of these pathogens in wastewater systems is site specific (Rauch-Williams et al., 2023).

A variety of analytical methods may be employed to detect and quantify pathogens and compounds and to assess treatment effectiveness. However, testing for each contaminant is financially burdensome, so surrogates are used to represent contaminant classes (U.S. EPA, 2023; Rauch-Williams et al., 2023). The movement and retention of the advanced treated

Figure 3. Generalized diagram of a Class V injection well for ASR using advanced treated reclaimed water.



wastewater though an aquifer may aid in pathogen removal (Rauch-Williams et al., 2023). Although site specific conditions must be addressed, the U.S. Environmental Protection Agency (EPA) has made several health and safety considerations related to reclaimed water ASR and AR projects:

- Water quality parameters should meet the Clean Water and Safe Drinking Water acts (Table 2) (U.S. EPA and CDM Smith Inc., 2017).
- Potable reclaimed water projects could have the same pathogens risk benchmark as conventional drinking water, which is a 1 in 10,000 risk of infection annually (U.S. EPA, 2023).
- Treatment prior to recharge is often more efficient than treatment after recovery (U.S. EPA, 2023).
- Surface water quality may improve as effluent discharges are reduced via re-direction to advanced wastewater treatment plants (U.S. EPA, 2023).

Conclusions

Alternative water management strategies, such as ASR and AR, are being evaluated by entities across Texas to meet growing water demands from both population and industrial growth. Reclaimed water can provide a reliable, consistent supply of water to recharge aquifers, especially near urban areas. The City of El Paso is the first and only entity in Texas that

Table 2. Treatment steps and water quality parameters for recharging groundwater with reclaimed water for indirect potable reuse.

Type of project	Treatment steps	Water quality parameters
Aquifer Recharge (AR): Groundwater recharge via spreading and infiltration basins into potable aquifers	<ul style="list-style-type: none"> • Secondary¹ • Filtration² • Disinfection³ • SAT⁴ 	<ul style="list-style-type: none"> • No detectable total coliform • 1 mg/L Cl₂ residual (minimum) • pH = 6.5–8.5 • ≤ 2 NTU • ≤ 2 mg/L TOC of reclaimed water origin • Meets drinking water standards by exit from the vadose zone
Aquifer Storage and Recovery (ASR): Groundwater recharge via injection well(s) into potable aquifers	<ul style="list-style-type: none"> • Secondary¹ • Filtration² • Disinfection³ • Advanced wastewater treatment⁵ 	<ul style="list-style-type: none"> • No detectable total coliform • 1 mg/L Cl₂ residual (minimum) • pH = 6.5–8.5 • ≤ 2 NTU • ≤ 2 mg/L TOC of reclaimed water origin • Meets drinking water standards

Table Key: NTU = nephelometric turbidity units. TOC = total organic carbon. Modified from U.S. EPA and CDM Smith Inc. (2017).

¹ Refers to treatment processes such as conventional activated sludge, trickling filters, rotating biological contactors, and may include stabilization pond systems. Biochemical oxygen demand and total suspended solids should be < 30 mg/L.

² Filtration through soils, filter media such as sand or anthracite, or membrane filtration.

³ Disinfection can be achieved through chemical, physical, or biological processes so long as pathogen inactivation is accomplished (e.g. through chlorine, ozone, ultraviolet, and membrane processes).

⁴ SAT – Soil aquifer treatment improves water quality by reducing nutrients and pathogens through the processes of filtration, sorption, and predation through unsaturated conditions.

⁵ Examples of advanced wastewater treatment include chemical clarification, carbon adsorption, reverse osmosis, advanced oxidation, air stripping, and ultrafiltration.

implemented such a strategy and has been successfully recharging the Hueco Bolson aquifer since 1985. In 2025, the Texas Legislature passed Senate Bill 2885, which directs the TCEQ to consider authorizing ASR projects that store reclaimed water—supporting Texas water providers planning to use this technology to meet growing water demands. The TCEQ is currently working on developing standards to be applied for this purpose.

The use of reclaimed water for ASR and AR comes with specific health and safety challenges that must be considered. Many Texans depend on groundwater for their drinking water supply, so the protection of aquifers is critical. Water injected into an aquifer must be treated to be compatible with the aquifer and prevent degrading the quality of the native groundwater. Advanced treatment can be used for reclaimed water to accomplish this goal but will require site-specific considerations and multiple treatment steps. The use of an aquifer as an environmental buffer may also aid in pathogen removal (Rauch-Williams et al., 2023). As more water users contemplate using reclaimed water for ASR and AR projects, cost, risk management, and advanced treatment and monitoring must be considered.

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