Fact Sheet 50

Managed Aquifer Recharge (MAR): Reuse of Treated Wastewater

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June 2026

https://doi.org/10.59691/EOFI1768

Introduction

Managed aquifer recharge (MAR) provides a means to supplement water supplies by intentionally recharging aquifers; it is a method to "slow water down" or store water with the intent of recovering it later during times of need or to achieve ecological benefit (NGWA, 2024; Parker and others, 2022).

MAR is typically implemented using two primary approaches: **surface infiltration** and **aquifer storage and recovery** (ASR; fig. 1). Surface infiltration methods allow water to percolate from the ground surface into underlying unconfined aquifers, whereas ASR systems use wells to inject and recover water from targeted aquifers. Each approach has advantages and limitations in urban environments. ASR generally requires less space, while surface infiltration allows water to move more gradually through the ground to the aquifer, which can help improve water quality (Bekele and others, 2011).

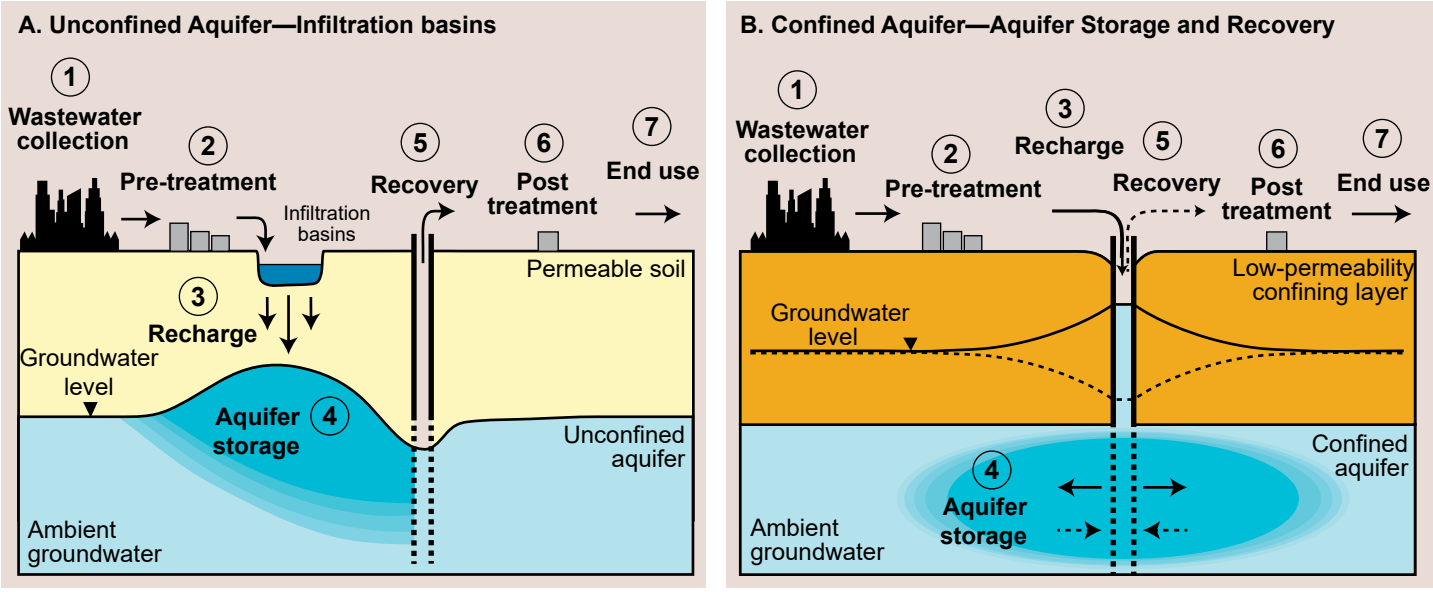

Figure 1. MAR examples of the steps using wastewater as a source of recharge to groundwater (adapted from Dillon and others, 2009).

Treated Wastewater as a Source for MAR

Surface water, particularly during high-flow periods, is commonly used as a source water for MAR. However, treated wastewater can provide a reliable, year-round source and involves several key steps (fig. 1):

① Source water collection and conveyance
② Pre-treatment or advanced treatment to meet recharge requirements
③ Recharge of the aquifer (e.g., infiltration basins or injection wells)
④ Aquifer storage and natural attenuation

If the water is intended for recovery, additional steps may include:

⑤ Water recovery (extraction)
⑥ Post-treatment, if needed, to meet end-use standards
⑦ Distribution and end use

Water-Quality Considerations

Water used for MAR may have water-quality considerations to address prior to recharge, particularly when using treated wastewater. MAR can act as a pathway for contaminants to reach the groundwater system. Contaminants of concern may include both naturally occurring and anthropogenic constituents (ITRC, 2023), such as:

- Major ions (i.e., sulfate, chloride, nitrate)
- Inorganic elements (i.e., arsenic, iron, lead)
- Agricultural and urban chemicals (i.e., pesticides)
- Pathogens (i.e., bacteria, protozoa, viruses)
- Emerging contaminants (such as PFAS, pharmaceuticals, microplastics)

Naturally occurring constituents in aquifer materials can also be mobilized under certain geochemical conditions and may require evaluation during MAR project design.

Wastewater Treatment for MAR

Because of the need to protect groundwater, treated wastewater used for MAR typically requires monitoring for regulated contaminants, pathogens, and, in some cases, emerging contaminants, with requirements varying by state (ITRC, 2023). As water infiltrates through soil and unsaturated sediments, natural physical, chemical, and biological processes can further reduce pathogens, nutrients, and many organic contaminants before water reaches the aquifer (Bekele and others, 2011; Mumberg and others, 2024).

A Leading Example

The use of treated wastewater for managed aquifer recharge is an established practice in several western states and has been used safely for decades under extensive monitoring and regulatory oversight. Western states that have implemented MAR projects with treated wastewater include Arizona, California, Texas, and Washington (El Paso, Texas, 2026; LOTT Clean Water Alliance, 2026; OCWD, 2024; Town of Gilbert, 2026). Among these, the Groundwater Replenishment System in Orange County, California is the world's largest water purification system utilizing highly treated wastewater for aquifer recharge (OCWD, 2024). Operated by the Orange County Water District, the system helps supply water to approximately 2.5 million residents across 19 cities. The treatment processes applied prior to recharge are shown in figure 2.

Figure 2. Example treatment process for wastewater for aquifer recharge (adapted from OCWD, 2026).

Once treated, the water is recharged into the aquifer through infiltration basins and injected into targeted areas (fig. 3). The water remains underground for months to years before being recovered, providing additional natural attenuation and monitoring opportunities.

Figure 3. Surface infiltration basins using treated wastewater (source: OCWD, 2024).

Check out our recently published MAR suitability analyses for Montana:

- Managed Aquifer Recharge (MAR): An initial hydrogeologic screening for surface infiltration suitability in Montana, https://doi.org/10.59691/SXSP1714
- Evaluating the hydrogeologic potential for aquifer storage and recovery (ASR) in the deep aquifer of the Flathead Valley, northwest Montana, https://doi.org/10.59691/YJBP7613

More information is available at mbmg.mtech.edu.

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