ITRC (Interstate Technology & Regulatory Council). 2023. Managed Aquifer Recharge Guidance MAR-1. Washington, D.C.: Interstate Technology & Regulatory Council, MAR Team. https://mar-1.itrcweb.org/.

Developing a MAR project requires an organized, comprehensive, and transparent approach. Although a detailed discussion of MAR project planning is beyond the scope of this guidance document, this section briefly describes the important aspects of planning a successful MAR project from a project management perspective.

2.1 Project Team

A successful MAR project will require the diverse skill sets of many people with training in different backgrounds, such as:

- science (geology, hydrology, chemistry, ecology, natural resources)
- engineering (civil, environmental, etc.)
- program management
- stakeholder and community engagement
- public policy
- water rights law
- federal, state, and local permitting/agencies

2.2 Feasibility

A feasibility study is one of the first steps in planning a MAR project. As part of a feasibility study, the advantages and disadvantages of potential recharge technologies are quantified and evaluated, including costs related to permitting; implementation; and operations, maintenance, and monitoring (OM&M). Developing a full-scale MAR project can be expensive and time-consuming. Feasibility studies can help determine where obstacles and limitations may exist as well as guide a decision of whether to move forward with the proposed project or make pertinent changes to the approach. Often the feasibility study is divided into an initial hydrogeologic feasibility study followed by an engineering feasibility study.

The hydrogeologic component of a feasibility study looks at water sources, recharge zones, surface vs. subsurface recharge, and characterization of the receiving aquifer and geologic zones to determine how practical a MAR project in the geologic setting will be. This evaluation may include a quantitative ranking analysis based on GIS and remote sensing data to determine suitable locations for MAR (Chowdhury, Jha, and Chowdary 2010; Aju et al. 2021). The engineering component of a feasibility study looks at costs and funding, infrastructure gaps and requirements, constructability, and limitations of the proposed design.

2.3 Economics

Successful MAR projects generally require funding in the millions of dollars. Designing and implementing a successful MAR project requires not only a capital investment but also funding for long-term OM&M costs, including costs for mitigation of any adverse outcomes. Sometimes the OM&M costs can exceed the initial capital costs. Therefore, project economics and cost-benefit analysis should be addressed during the beginning stages and feasibility studies of a MAR project. Funding sources should be identified and discussions with local, state, and federal agencies should begin. Seasonal variations in the cost of water may make the economics of a MAR project more attractive by providing a financial incentive to store water when its cost is low.

2.4 Stakeholder Engagement and Environmental Justice

During the planning process (and throughout the project) thoughtful discussions and involvement with the stakeholders will improve the chances of success. These outreach efforts should be specifically written into the planning and implementation phases.

Stakeholder considerations can vary depending on the type of MAR project and the location; urban stakeholders concerns will likely be different from rural ones. Each MAR project typically presents a unique set of stakeholders that need to be considered during the planning and communication process. Relevant stakeholders can include water purveyors, environmental government agencies, nongovernmental organizations such as environmental groups, and private well owners. These stakeholders can present interests that are in favor of or in opposition to the project. Understanding stakeholder interests, both positive and negative, will likely help streamline the permitting process and ensure that potential negative consequences are fully considered.

2.4.1 Potential Stakeholders

Stakeholders vary from government agencies to nongovernment organizations (NGOs) such as environmental organizations. Proper project planning, communication, design, and monitoring are effective in promoting the benefits of MAR and reducing unintended negative consequences. Example MAR stakeholders and their potential interests and concerns are presented below:

Federal, state, and local government — At the federal level, stakeholder agencies may include:

- USACE, where source water is derived from rivers and streams classified as waters of the United States or where flood control structures may be impacted
- USEPA for Safe Drinking Water Act (SDWA) considerations (for example, when recycled water is used for recharge)
- federal land management agencies such as the Bureau of Land Management (BLM) or U.S. Forest Service (USFS) if projects occur on federally administered lands
- National Oceanic and Atmospheric Administration (NOAA) or the U.S. Fish and Wildlife Service (USFWS) if biological resources are potentially impacted, such as anadromous fish in coastal applications or endangered species in or near project areas

State stakeholders often include state agencies that focus on surface water, groundwater, health, land management, and wildlife or natural resources. At the local level, government stakeholders typically include county flood control agencies, municipal water suppliers, and municipal building departments.

Native American tribes — Tribal governments are sovereign entities. In many parts of the U.S., native tribes have specific rights to both surface water and groundwater supplies. In the case of a MAR project on tribal land, the tribe may be the stakeholder. Tribal government and community interests in MAR projects may align with early project stakeholder engagement actions, particularly in consideration of Traditional Ecological Knowledge—spiritual and legal connections of Indigenous peoples to the ecosystem, waters, and land within MAR project regions. Historic issues surrounding tribal governance and rights may present environmental justice concerns where MAR projects are proposed on tribal land.

Water districts and utilities — Water districts and utilities often have jurisdictional control over recharge operations. Special utility districts are often established with the primary purpose of replenishing groundwater supplies and levy a fee on groundwater users to replenish local aquifers. Utilities are also an alternative source of water and include wastewater treatment plants and stormwater utilities.

Water right holders — All types of water rights holders in states with a prior appropriation water rights doctrine will likely be stakeholder in MAR proposals; they include senior hydroelectric power, industrial, municipal, agriculture, ecological, and domestic water rights holders. This includes any water rights holder if they believe the MAR project could change or impact their ability to exercise their right, whether it's surface water, groundwater, or springs. Junior water rights holders may also try to take a position if they feel the proposed MAR project could impact their water use.

Agricultural — In general, agricultural stakeholders and interests are supportive of MAR projects, because they improve drought resilience. However, there can be negative consequences from MAR projects, including rising groundwater elevations resulting in impacts to crops and impacts on existing irrigation wells from MAR extraction wells, as well as possible soil and groundwater salinization. Costs to deal with infrastructure maintenance (for example, siltation, erosion), perceived risk to farmers' land, and perceived risk of losing control of how they operate their property are negative incentives for agricultural stakeholders.

Commercial and industrial — Commercial and industrial stakeholders can have varied interests in a MAR project that range from positive impacts on water supply wells to negative impacts on groundwater contamination plumes. For example, if a MAR project changes or increases the extent of an existing groundwater plume, the costs to mitigate the plume may increase. Contamination liability may be a concern in some circumstances; therefore, due diligence in understanding potential pollutants mobilization and liability risks should be addressed in the MAR project process. MAR can also be an asset in helping to hydraulically control plume migration and dilute contaminant concentration.

Rural domestic and small water systems — MAR can have a positive impact on rural domestic users by stabilizing and increasing groundwater storage or raising groundwater level, therefore reducing cost for domestic well pumping and removing the need from well deepening. Negative impacts can include excessive increases in groundwater levels and ground saturation. MAR can also positively or negatively impact groundwater quality in private wells.

Nongovernmental organizations (NGOs) — Environmental NGOs may have interests in coastal water fishery enhancement, wetlands creation, resource conservation, or wildlife conservation, among others.

Environmental justice–impacted communities — MAR projects should be conscientious about environmental justice concerns when identifying and including environmental justice–impacted communities. Possible negative impacts of MAR projects should also be carefully evaluated. In recent years, awareness about the impact of infrastructure-related water projects on communities has been growing, though there is still more to understand. Changes to water management approaches, such as those that can occur with MAR, can sometimes benefit one community, while other communities may encounter negative, unintended effects such as water shortages, flooding, water contamination, or other consequences. Changes should be made only after thoughtful planning and engagement with affected communities.

2.4.2 Environmental Justice

Environmental justice (EJ) issues might arise from purposeful changes to groundwater management. While there are many definitions of EJ, one that has been used relative to MAR is:

Environmental justice is defined as the fair treatment and meaningful involvement of all people, regardless of race, color, national or ethnic origin, disability, gender identity or sexual orientation, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies, with no group bearing a disproportionate burden of environmental harms and risks (USACE 2023).

Fair treatment means that no population bears a disproportionate share of the negative environmental consequences resulting from, in this case, the implementation of a MAR program. Meaningful involvement requires effective access to decision makers for all, and the ability in all communities to participate in informed decisions and take positive actions that will be equitable for all involved. One example is when the Texas Commission on Environmental Quality (TCEQ) provided interpretation and translation services at public meetings to ensure better participation and understanding of the meeting content (TCEQ Environmental Law Division 2021). Additionally, recently issued rules and guidance in Texas require most permits (air, water, waste) to include alternative language translations for people who don't speak English. These examples illustrate ways to facilitate more engagement but are just first steps in interacting with a community.

2.5 Regulatory Considerations and Permitting

Implementing MAR projects requires permitting and compliance with various federal, state, and local regulations, depending on the nature of the project. These permits are varied and typically can range from broad federal environmental regulation and permitting—for example, National Environmental Policy Act, state water resources and health department permitting, local and county construction permits, Clean Water Act permitting through the USACE (for example, Section 404 and Section 10), and SDWA permitting through states with primacy and/or the USEPA (UIC permits, Groundwater Rule, drinking water minimum standards, state-specific rules). The USEPA developed regulations applicable to recharge wells and basins through its underground injection control (UIC) regulations. UIC rules are designed to ensure the safety of underground sources of drinking water (USDW). If a USDW is not impacted, recharge wells can be authorized by regulatory agencies without requiring a permit. Permits may be required to ensure that a USDW is not endangered by operations. More information can be found at the USEPA UIC website: Protecting Underground Sources of Drinking Water from Underground Injection (UIC) | USEPA (USEPA 2023d).

Currently, thirty-one states and three territories have primacy for multiple well classes under UIC. USEPA manages all well classes for seven states and the District of Columbia. Most MAR projects fall under Class V wells for UIC regulation. For a complete listing of states, tribes, and territories with primacy and which well classes are covered under the primacy, see the USEPA Primary Enforcement Authority for Underground Injection Control website: Primary Enforcement Authority for the Underground Injection Control Program | USEPA.

States and tribal governments with primacy may enact additional regulations for MAR projects. State/tribal regulations do not supersede federal regulations precluding USDW endangerment. Federal regulations state: "no owner or operator shall construct, operate, maintain, convert, plug, abandon, or conduct any other injection activity in a manner that allows the movement of fluid containing any contaminant into underground sources of drinking water, if the presence of that contaminant may cause a violation of any primary drinking water regulation under 40 CFR part 142 or may otherwise adversely affect the health of persons" (40 CFR 144.12L).

MAR permitting can range from relatively straightforward to complex depending on the project location, source water characteristics, target aquifer, water rights, and intended use of the recovered groundwater. Two hypothetical examples, one in a rural setting and the other in an urban setting, highlight this range of complexities that may be encountered in permitting a MAR project.

Flood-MAR — Flood-MAR has become an important method for recharging depleted aquifers, particularly in rural areas (KRCD 2021). This method involves flooding farm fields with excess surface water to promote recharge (also known as agricultural MAR). Permitting can include the Army Corps of Engineers to access river flows, environmental permitting, flood control districts, and local or state groundwater agencies. Typically, no pretreatment of the surface water is required.

Recharging public supply aquifer with ATW — MAR using ATW is often a complex permitting challenge. These MAR projects are typically used in urban settings where a source of treated wastewater is available. Often these projects involve multiple state and local agencies and require complex studies that include:

- detailed water chemistry studies
- evaluation of subsurface residence times for the treated wastewater using tracer studies and/or groundwater models
- public participation
- construction permits
- rights-of-way permits to construct pipelines and other infrastructure
- potential impact to existing groundwater plumes
- detailed monitoring systems
- pilot and demonstration studies

Regulatory considerations are project-dependent and will likely continue to evolve over time at the federal, state, and local level. More information on state regulations regarding the use of recycled water in MAR can be found in USEPA's Water Recycling for Climate Resilience through Enhanced Aquifer Recharge and Aquifer Storage and Recovery report.

2.6 Pilot Testing

It is always good practice to design and implement a pilot testing program, and it is important to check with state regulators about proposal and approval processes before beginning a pilot testing program. The purpose is to test the planned program along with alternatives at a smaller scale to evaluate both the effectiveness of the MAR program and any possible negative impacts on the environment, particularly the receiving aquifers. Careful monitoring and study during the pilot program will provide the necessary data and increase the likelihood that the final program will be successful. In some states, submitting results to state regulators will be required or encouraged.

Each state will have both local and state, and often federal, requirements to implement a pilot testing program, as well as a final program. One of the keys to success is to engage as early as possible the regulatory personnel so that the requirements and possible hurdles are understood and discussed in the beginning. Some of the agencies that will be involved in the permitting process include those that oversee the water rights in the state, the division of environmental quality or protection that oversees the protection of the groundwater resources, and the division of drinking water that oversees public drinking water supplies. There may be federal agencies involved, such as the USFS, USFWS, and USEPA.

2.7 Operations, Maintenance, and Monitoring (OM&M)

During the planning process and after the implementation of a final MAR program, the ongoing OM&M efforts will require planning and execution. Planning and budgeting will vary depending on the type of MAR implementation. For example, surface infiltration has a set of maintenance requirements that differs from those of direct injection to the aquifer.

An OM&M manual is needed in most cases, including simple and complex MAR projects. Below are some possible OM&M items that should be considered for ongoing effectiveness of the MAR project:

- well monitoring and maintenance (injection well fouling, redevelopment)
- infiltration basin clogging and cleaning
- system design and performance monitoring (infiltration rates)
- routine surface water and groundwater quality monitoring
- mitigation of water quality issues

Automated systems may be able to handle much of the monitoring and control, but oversight is still required. Periodic review and updating of the OM&M manual are also necessary to ensure that information is current and best practices are included.