Aquifer Restoration after Uranium Recovery

Evaluation of aquifer restoration at sample uranium in-situ recovery sites

Background

In-Situ Recovery. In-situ recovery (ISR) of uranium is a mining practice that uses groundwater. First, wells are drilled into a uranium-bearing aquifer. Leaching fluids are injected into the wells to dissolve the uranium ore into the groundwater, and then the uranium is recovered by extracting the groundwater. Uranium extraction by ISR accounts for more than 90% of production since the mid-1990s. The uranium deposits where ISR is conducted are typically found in arid areas of the United States, such as Texas, Colorado, and Wyoming.

Groundwater Quality. Water stress, especially as a result of increasing populations and drought, is motivating communities and businesses to consider future drinking water sources that previously would not have been considered. To allow for the possible future use of groundwater found in a mining area, operators are required—per 40 CFR 192—to restore water quality to pre-mining concentrations for metals, metalloids, anions, and total dissolved solids after ISR mining operations cease. Several approaches have been used to restore groundwater quality, including groundwater sweeping, reverse osmosis treatment, subsurface injection of chemical reductants, bioremediation, and monitored natural attenuation. Even though mining companies are required to restore groundwater quality to pre-mining conditions, several water quality studies indicate that trace metals, anions, and leaching fluids remain in the aquifer after restoration is completed (Anastasi and Williams, 1984; Davis and Curtis, 2007; Borch et al., 2012; Stover, 2004).

Contaminant Migration. Aquifers near ISR operations may also be vulnerable to contaminants migrating through undetected or mischaracterized faults from the injection zone into any hydraulically connected aquifers. Additional research is needed to identify if contaminants are present at or near ISR sites and understand the potential for migration of contaminants, which would be useful to EPA's Underground Injection Control (UIC) program.

Permitting and Exemptions. ISR operations are required to have a Class III UIC permit and an approved aquifer exemption if injecting into an underground source of drinking water. The UIC regulations allow EPA to exempt aquifers from the protections afforded by the Safe Drinking Water Act. To qualify for exemption, the aquifer must not currently serve as a source of drinking water and will not serve as a source of drinking water in the future, among other criteria that must be met.

A mining operator who received an aquifer exemption could use the entire aquifer, or a portion of the aquifer, for mineral extraction or disposal purposes in compliance with the UIC requirements under the Safe Drinking Water Act. The EPA evaluates the boundaries of the proposed exempted area using available data so that nearby underground sources of drinking water continue to be protected by the Safe Drinking Water Act. A better understanding of contaminant transport within the mining area may improve EPA's ability to evaluate proposed exemption boundaries and protect surrounding drinking water sources.

State of the Science

In 2016, EPA's Office of Research and Development (ORD) published a state-of-the-science review paper, "Potential Aquifer Vulnerability in Regions Down-Gradient from Uranium In-Situ Recovery Sites" http://dx.doi.org/10.1016/j.jenvman.2016.08.049, which covers background information on the geology and geochemistry of uranium roll-front deposits; leach solutions that mobilize the uranium during ISR; potential interactions with other contaminants of concern, such as arsenic, selenium, molebdynum, vanadium, and radium; potential aquifer vulnerabilities related to in-situ leaching; data gaps, appropriate monitoring strategies, and key considerations for modeling applications. It also provides guidance for further focused laboratory, field, and/or transport and fate modeling research. In the review, knowledge gaps in understanding how contaminants may migrate during and after ISR operations were identified.

EPA Research

Research Recommendations. Based on the state of the science review, EPA's ORD recommended additional research activities focused on (1) methods of establishing geochemical stability of potential groundwater contaminants after the restoration period concludes, and (2) understanding the potential for vertical and horizontal migration of contaminants around ISR mining sites. Research will focus on the potential for contaminants to be present in the aquifer after restoration, which contaminants might be present, and, if present, the potential for those contaminants to migrate to nearby underground drinking water sources.

Research Approach. ORD's research approach involves reviewing existing data; developing field methods that can be used to trace contaminant movement (such as isotopic tracers); conducting laboratory studies to explore the geochemical behavior of uranium and associated trace metals; modeling approaches to simulate groundwater flow and transport of injected fluids and contaminants that could potentially impact underground sources of drinking water and influence aquifer exemption boundary determinations; and performing field studies that provide data for and verify the modeled approaches (proposed).

Research Objectives. The objectives of the field studies are to (1) verify that reducing conditions are re-established at ISR sites; (2) evaluate water quality characteristics down-gradient from post-mining ISR operations compared to ore-zone water quality, and where possible, to pre-mining water quality conditions; and, (3) document natural attenuation pathways of contaminants of concern.

Proposed Methodology. Field studies to investigate whether aquifer sediments will rebound or recover to pre-restoration concentrations will be conducted in several mining districts so that a range of characteristic geologic, geochemical, and hydrologic environments can be compared. Laboratory studies utilizing materials from the identified field research sites or from other sources to investigate geochemical interactions between redox-sensitive metals and aquifer solids are being conducted. These studies are aimed at better understanding the processes that control uranium mobilization and attenuation in groundwater, relationships with other contaminants of concern (e.g., As, Mo, and Se), and development of risk management approaches for restoring groundwater resources after ISR operations have ceased. In-house capabilities are being developed to determine uranium isotopic ratios in groundwater which can be used as a tracer to evaluate vertical and horizontal migration of uranium in groundwater.

Expected Outcomes. ORD's research will provide state-of the-science approaches and new data to inform standards for protecting the environment from hazards associated with uranium solution mining and processing. Results may also help EPA consider contaminant movement in aquifers when determining aquifer exemption boundaries and permit conditions. ORD's studies are expected to add to the following:

- Improved knowledge of the biogeochemical processes that control the long-term stability of contaminants in groundwater and surrounding rock.
- Identification of geochemical factors that impact contaminant stability and their role in determining effective restoration criteria.
- Development of tools for assessing the potential for contaminant migration and attenuation.
- Improved understanding of how groups of contaminants that are found in the same aquifer behave in site-specific instances.
- Identification of strategies for minimizing impacts from groups of contaminants based on appropriate scientific data and site restoration approaches.

Additional Information

Websites:

- EPA's uranium information: epa.gov/radiation/radionuclide-basics-uranium
- 40 CFR Part 192 : epa.gov/radiation/health-and-environmental-protection-standards-uranium-and-thorium-mill-tailings-40-cfr

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