Demonstration of the Horizontal Reactive Media Treatment Well (HRX Well®)

April 18, 2024

CONCEPT

This Horizontal Reactive Media Treatment Well (HRX Well®) is a new in situ remediation concept that uses large-diameter directionally-drilled horizontal wells filled with granular reactive treatment media to passively treat groundwater. The design leverages natural “flow-focusing” behavior induced by the high in-well hydraulic conductivity of the reactive media relative to the aquifer hydraulic conductivity to capture and treat proportionally large volumes of groundwater within the well.

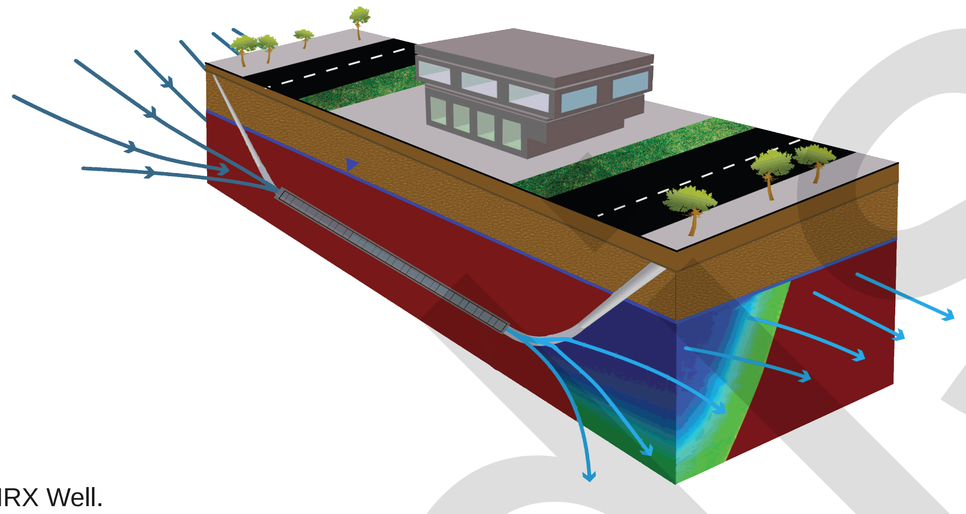

Figure 1. Conceptual depiction of an HRX Well. Groundwater (indicated by blue flowlines) is passively focused and flows into the fully-screened HRX Well (grey cylinder) where it is treated as it flows through granular reactive media before exiting back into the aquifer.

Table 1. Potential reactive media types and target groundwater contaminants for an HRX Well.

Reactive Media	Potential Target Groundwater Contaminants
Zero valent iron (ZVI) Bimetallics (e.g., ZVI + Pd, Pt, or Ni)	Chlorinated solvents (CVOCs), nitrate, perchlorate, energetics, chromium, arsenic
Granulated Activated Carbon (GAC), Organosilicates	CVOCs, Poly- and Perfluoroalkyl substances (PFASs), hydrocarbons, halomethanes
Sustained Release Oxidants	CVOCs, 1,4-dioxane, hydrocarbons, polyaromatic hydrocarbons (PAHs), phenolic compounds
Biodegradable particulate organic carbon (e.g., mulch)	CVOCs, nitrate, perchlorate, energetics
Ion exchange resins	PFAS, Brines
Phosphates (e.g., apatite)	Lead, uranium, other metals and radionuclides
Limestone, lime, magnesium oxide	Low pH, Acid Rock Drainage
Barium sulfate (barite)	Radium
Iron sulfide	Chromium, High pH
Zeolites	Ammonium, radionuclides, PFAS

Figure 7. A: Reaming the borehole with 18-inch reamer. B: Aligning screen section prior to welding. C: Final construction of the PVP monitoring cartridge. D: Jetting tool for well development. E: Wellhead completion.

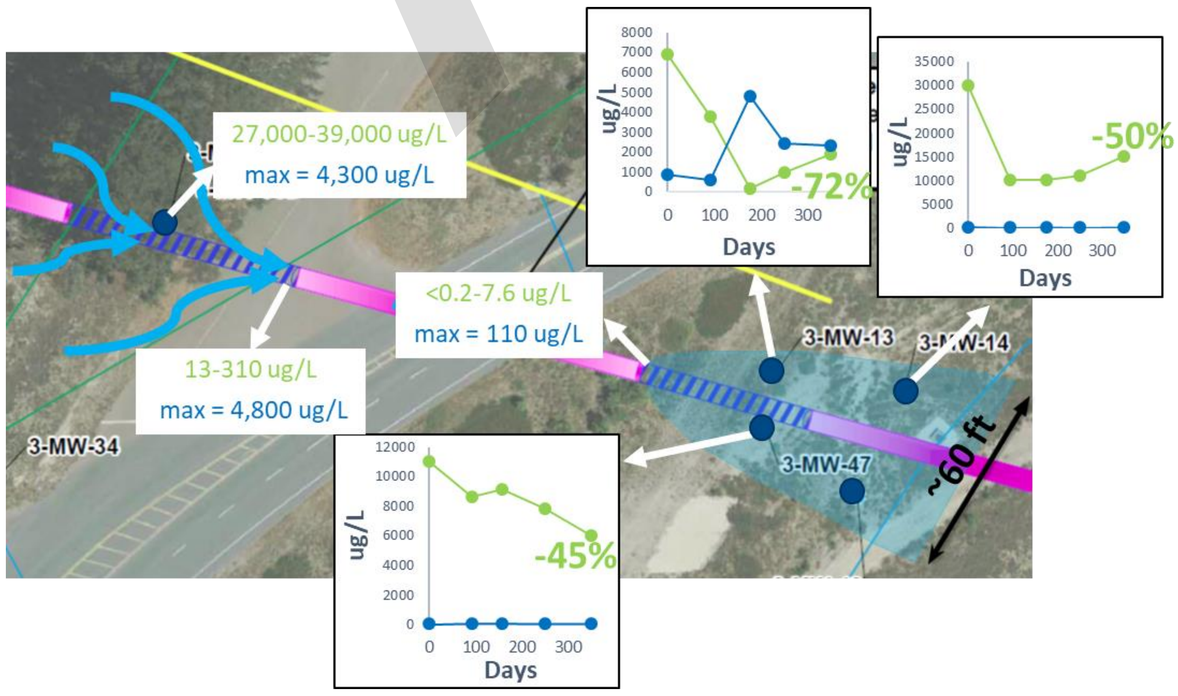

Figure 9. Contaminant concentration changes since HRX Well installation. Average TCE treatment after one year = 54%. Estimated TCE mass discharge reduction ~1.7 g/day

PERFORMANCE DATA AND RESULTS

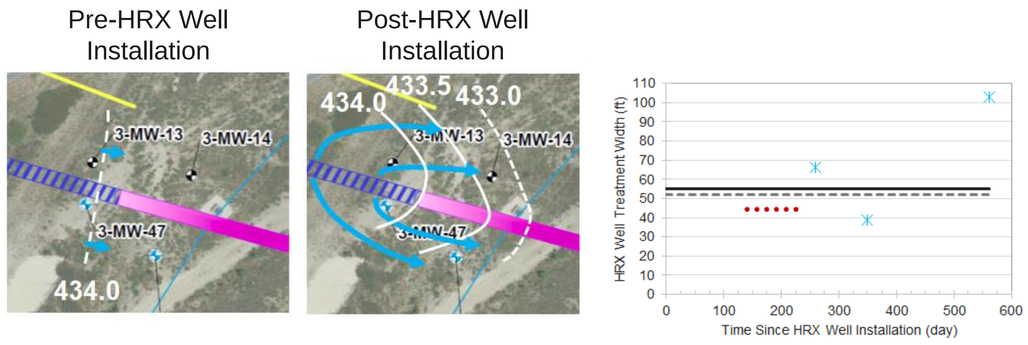

Figure 8. Left: Change in local hydraulic gradient before (left) and after (right) HRX Well installation. Right: Capture zone width calculated by Darcy’s Law (solid black line), the numerical flow model (dashed grey line), HRX Well tracer test (dotted red line), and PVP tests (blue stars).

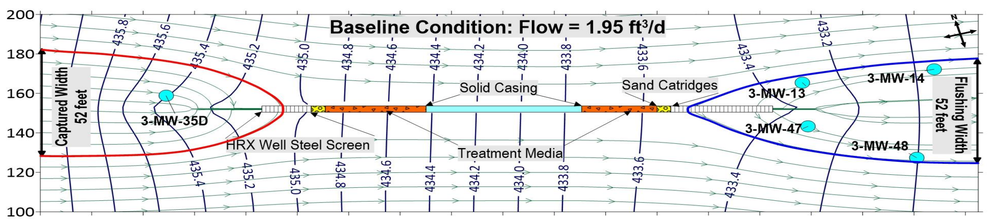

Figure 9. Model-calculated capture and treatment zones

SUMMARY

- **Flow focusing hydraulics verified, >50 ft treatment width under passive operation**
- **Near-immediate >99% TCE mass flux reduction and performance consistent with expectations**
- **Efficient media usage, many media options, cartridge removal/replacement straightforward**
- **Limited footprint, energy, water, and O&M requirements, favorable lifecycle costs**
- **Well-suited for long-term mass flux control for recalcitrant contaminants, including chlorinated solvents, PFAS, etc.**