Groundwater Circulation Wells Using Innovative Treatment Systems

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Abstract: Groundwater circulation wells (GCWs) constitute an innovative technology which combines traditional pump-and-treat techniques with quasi in-situ treatment. The technology is attractive at the former Nebraska Ordnance Plant (NOP) site where the public perception of on-going pump-and-treat remedial action is mixed. An expanded remedial action consisting of additional pump-and-treat wells to hydraulically contain the contaminant plums combined with GCW to more rapidly remove greater masses of upgradient contamination is being considered. Two GCW systems are being pilot tested at two groundwater contamination hot spots on site. Both systems use standard submersible pumps to circulate groundwater from the aquifer to an in-ground treatment system at the wellhead. The pilot system at the location where the explosive compound RDX is found at relative high levels uses ultra-violet (UV) photolysis for treatment, and the second pilot system uses an "off-the-shelf" shallow tray air stripper to remove trichloroethene (TCE). The groundwater is recharged subsequent to treatment. Widely available groundwater flow models were used during the design of the pilot systems, and field analysis kits were used to measure contaminant concentrations during the pilot study. The effective treatment area for each system is characterized by evaluating the change in concentrations measured in nearby monitoring wells.

The Operable Unit 2-Groundwater Record of Decision defined a remedy that included two different applications of pump-and-treat aquifer restoration. The first application consists of installing 11 extraction wells that will hydraulically contain the leading edge of contaminant plumes by pumping groundwater at a total flowrate of 2,650 gpm. Subsequent to treatment, that water will be surfaced discharged or beneficially reused. Two of the eleven wells are currently in place and operating, and the construction of the remaining nine wells is on-going. The second pump-and-treat application defined in the Record of Decision included three focused extraction wells located at or near hot spots so that contaminant mass will be more rapidly removed from the aquifer relative to hydraulic containment alone. Project stakeholder's interest in conserving groundwater supply availability provided the motivation to consider groundwater circulation wells as an innovative replacement for the three focused extraction wells because groundwater circulation wells are a zero discharge technology. The purpose of the groundwater circulation well pilot study was to characterize the technical feasibility of using groundwater circulation wells to remediate relatively high concentrations of RDX and TCE. Secondary objectives of the pilot study were to collect cost and design data.

Two groundwater circulation well systems were constructed for the pilot study. The TCE system designated GCW-1 consists of the extraction, treatment, and recharge of groundwater at 50 gpm. A shallow tray air stripper installed in a vault is used to treat groundwater below the ground surface. Dedicated bladder pumps have been installed in 2 existing and 14 new

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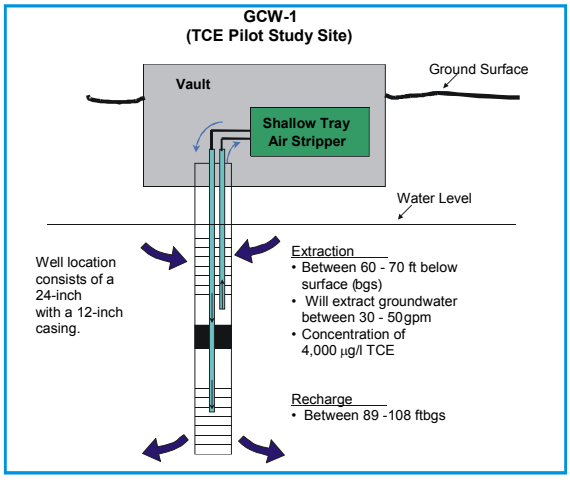
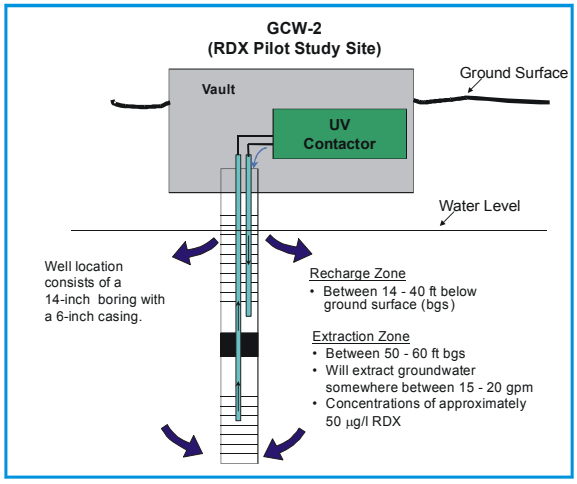
monitoring wells. Groundwater samples collected from those wells as well as samples collected from the air stripper influent and effluent sampling ports were analyzed with colorimetric field kits, and selected samples were transmitted to an off-site laboratory for confirmatory analysis. These data and the results of numerical groundwater flow modeling were used to estimate the effective treatment area in the aquifer. The figures below show the GCW-1 schematic and the shallow tray air stripper used in GCW-1.



GCW-1 WELLHEAD AND SHALLOW TRAY AIR STRIPPER

The RDX system designated GCW-2 consists of the extraction, treatment, and recharge of groundwater at more than 20 gpm. The groundwater is treated below the ground surface using a 3.5 kW medium pressure ultra-violet light commercial disinfection unit. Groundwater samples collected from 10 new monitoring wells as well as treatment system influent and effluent samples were analyzed with immunoassay field kits, and selected samples were transmitted to an off-site laboratory for confirmatory analysis. The figures below show the GCW-2 schematic and the UV/photolysis reactor used in GCW-2.



GCW-2 WELLHEAD AND UV CONTACTOR

Both systems operated as designed. The treatment efficiency of the GCW-1 air stripper ranges between 96 and 99 percent, with TCE influent concentrations ranging between 970

μg/L and 7,300 μg/L and effluent concentrations ranging between 13 μg/L to 150 μg/L. Approximately 24 gallons of TCE have been removed from 13 million gallons of water treated by the system. It is estimated that the effective aquifer treatment area is between 80 ft and 240 ft wide.

The GCW-2 pilot study location RDX concentrations are lower than desired, but even so, influent concentrations have ranged from around 5 μg/L to 78 μg/L. The treatment system reduced RDX concentrations in effluent samples to less than the detection limits of 5 μg/L or 1 μg/L. Approximately 240 grams of RDX have been removed from 5 million gallons of water treated by the system. It is estimated that the effective treatment area is between 60 ft and 180 ft wide.

Given that the pilot study results indicate that groundwater circulation well technology is technically feasible at the site, a cost comparison was developed between the existing focused extraction alternative and a groundwater circulation well focused remediation alternative. It was estimated that the construction of a groundwater circulation alternative consisting of the two pilot systems and twelve new pilot systems was the cost equivalent to the existing focused extraction alternative consisting of three pump and treat wells operating at a total extraction rate of 800 gpm. The annual operation costs were estimated to be lower for the groundwater circulation well alternative.

Numerical and analytical modeling was performed to compare the predicted performance of the two alternatives for the larger of two TCE plumes on-site. The estimated TCE plume restoration times developed using the analytical evaluation showed that the groundwater circulation well restoration time was approximately one-half of the value estimated for the current focused extraction alternative, and the results of the numerical modeling were similar between the two alternatives.

An analytical evaluation of the larger of two RDX plumes on-site indicated that the estimated restoration times for the groundwater circulation well alternative and the existing focused extraction alternative are equivalent.

The numerical modeling estimated that, initially, TCE mass would be removed at a greater rate for the groundwater circulation well alternative, although the existing focused extraction alternative would eventually remove more mass. However, the existing focused extraction alternative may result in the discharge of more than 300 million gallons of treated groundwater annually compared to zero discharge for the groundwater circulation well alternative.

It was recommended that the GCW focused remedial alternative be implemented as Phase II of the remedial action because:

- The cost and time-effectiveness was characterized as equivalent to the focused extraction pump-and-treat alternative
- GCW conserves the groundwater supply thereby satisfying a very important public concern