In-situ Stabilization of Uranium Contaminated Groundwater in Low Permeability Clay Using Phosphate Amendments with Prefabricated Vertical Drains

John E. Hughes[1]

Abstract

The RMI Titanium Company (RMI) Extrusion Plant is located in Ashtabula, Ohio is underlain with glacial till. The glacial till consists predominantly of silts and clays with a mean hydraulic conductivity of 1.9 x 10^{-6} cm/sec. Groundwater within the unconfined glacial till zone is contaminated with Uranium (U). Contamination in low permeability, high clay fraction soils poses significant technical challenges to in-situ remediation efforts. Conventional technologies such as pump and treat groundwater remediation are typically ineffective when applied to sites with low permeability soils. Laboratory studies have been performed using U contaminated groundwater, clay soil, and phosphate amendments to stabilize the U below the 20 µg/l treatment standard. Earthline Technologies (Earthline) proposes to use Prefabricated Vertical Drains (PVDs) as a cost effective, enhanced soil flushing delivery system to perform in-situ stabilization of U in the contaminated groundwater using the phosphate amendments. The potential benefits of this technology include accelerated remediation schedule and reduced cost for completion of the groundwater cleanup.

Background

The RMI extrusion plant facility consists of 25 buildings and occupies 7 acres of a 32 acre site. The facility is contaminated with both radiological and hazardous materials resulting from previous operations for the US Department of Energy (DOE). The primary function of RMI since 1962, has been the extrusion of closed-die forging of metallic depleted, natural, and slightly enriched U used in the production of nuclear fuel elements for the defense production reactors, extrusion operations for other government agencies, and the private sector. Extrusion operations ceased in 1990, since then the Nuclear Regulatory Commission (NRC) has required the facility to implement accelerated site clean up pursuant to its Site Decommissioning Plan. DOE's office of Environmental Restoration and Waste Management (EM) has contracted Earthline to conduct the Ashtabula Environmental Management Project (AEMP) by removing all radiological and hazardous contaminants to levels which permit the facility and adjacent areas to be released for unrestricted use.

The RMI site is underlain with glacial till. The glacial till consists of up to 33 ft of unconsolidated deposits, which overlie the shale bedrock near the plant. The glacial till consists predominantly of silts and clays with a mean hydraulic conductivity of 1.9 x 10^{-6} cm/sec. Groundwater within the unconfined glacial till zone is contaminated with U. The maximum observed concentration of U in groundwater has been measured at 8,380 pCi/l. The AEMP has an established U in groundwater cleanup criteria of 20 µg/l or 30 pCi/l. Earthline proposes to use Prefabricated Vertical Drains (PVDs) to perform in-situ stabilization of U in contaminated

[1] Technology Development Supervisor, Earthline Technologies, Ashtabula, OH, USA,
Ph (440) 993-1968, Fx (440) 993-2046, john_hughes@earthlinetech.com

groundwater using phosphate amendments in the low permeability, clay soils.

Geotechnical and Environmental Application of PVDs

In the area of Geotechnical engineering, PVDs are routinely used for improvement in the consolidation of soft soils. The PVDs shorten the drainage path for the removal of the pore water by either applying a surface surcharge to squeeze the soil, or by applying a vacuum to the PVDs causing a hydraulic gradient promoting pore water movement toward the drain. PVDs are a composite system of an inner core and outer filter jacket. The core is typically constructed of extruded polypropylene and the outer jacket is typically a durable, non-woven polypropylene geotextile, refer to Figure 1.

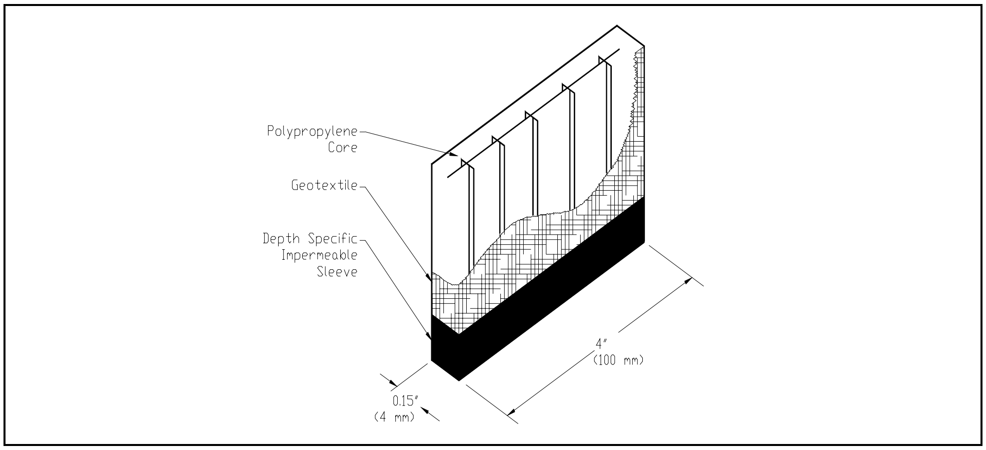

Figure 1 - Prefabricated Vertical Drain

The idea behind using the PVD system in a soil flushing scheme is to shorten the drainage path of groundwater flow and promote subsurface liquid movement for expediting the soil flushing process. The PVDs in this case are used for the injection of a flushing solution into the soil concurrent with an extraction process for removal of the contaminated solution. The flushing process occurs while the soil is in a saturated condition. The concept of the technology is illustrated in Figure 2.

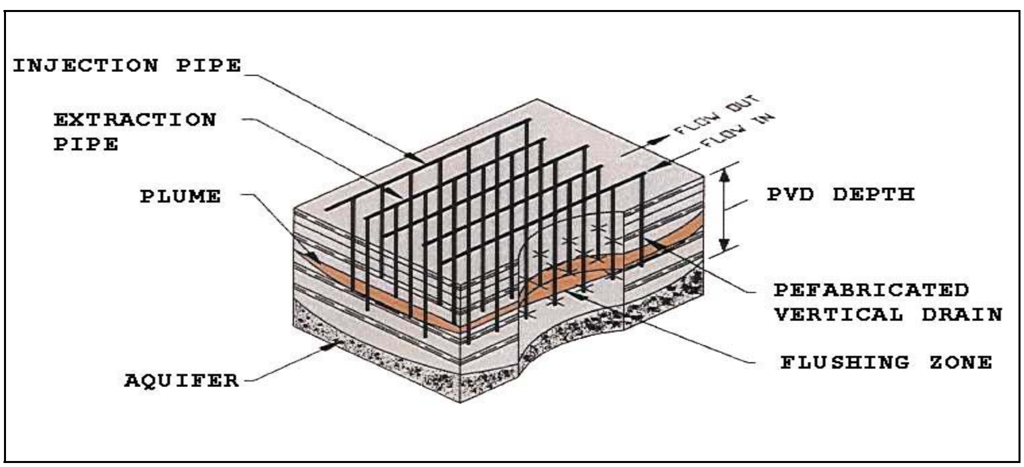

Figure 2 - PVD Application

Earthline proposes to modify the PVD design to include a small internal tube located between the inner core and geotextile. The tube allows for more efficient injection and extraction of the flushing solution. The tube would be either manifolded with the other injection wells, which are used to transport the injection solution; or manifolded with the other extraction wells, which are used to vacuum extract groundwater that collects from along the entire length of the PVD.

In this application, PVDs are utilized in lieu of conventional wells or sumps to extract groundwater and inject flushing solution. The PVDs may be cost effectively installed at relatively close spacing which shortens the groundwater drainage paths and accelerates the soil flushing process. The PVDs are installed using direct push technology (e.g. hydraulically driven mandrel) at fast rates of 10 ft/s into firm clay soils, which significantly reduces the cost associated with installation of conventional wells.

Description and Maturity of the Technology

The PVDs are an innovative groundwater remediation technology which has been successfully tested over the last three years at the AEMP in cooperation with the National Energy and Technology Laboratory (NETL) and North Carolina State University (NCSU).

Previous testing has focussed on the use of the PVD technology in a soil flushing and a soil vapor extraction mode to mobilize the TCE in the low permeability clay soils. The previous PVD pilot and field demonstration at the AEMP focussed on the mobilization of TCE through soil flushing using potable water and soil vapor extraction. Although the radionuclides were extracted during the testing, the testing did not demonstrate it could be used to satisfactorily remediate the groundwater to achieve the cleanup limit.

Earthline proposes to use of the PVDs to perform in-situ stabilization of the U in groundwater using phosphate amendments. The PVD technology lends itself to be used as an enhanced delivery system for these chemicals. The chemical selection is based upon Earthline's experience and specifically targets the stabilization of the U from groundwater.

Earthline currently performs ex-situ soil washing of uranium contaminated soil at the AEMP using a sodium carbonate leach solution. The sodium carbonate solution mobilizes the uranium to form a soluble anion, which is removed from the leach solution by ion exchange. After the leaching process is complete, the soil is dewatered and treated with phosphate amendments. The phosphate stabilizes the residual uranium in the treated soil in order to prevent U groundwater contamination after the soil is backfilled on site.

The soil washing phosphate stabilization chemistry developed by Earthline can be used in-situ with PVDs to stabilize the U. The phosphate reacts with the mobile hexavalent or uranyl form of uranium in groundwater to form uranyl phosphate, which is relatively insoluble in water. Earthline has performed bench scale treatability studies using groundwater contaminated at 7,830 μg/l and surrogate soil samples. This work has confirmed the phosphate stabilization chemistry reduces the uranium in groundwater below the 20 μg/l treatment standards.