CASE STUDY

FRACTURED BEDROCK REMEDIATION

TRAP & TREAT® PRODUCTS INC.

ABSTRACT

BOS 200® successfully remediates petroleum groundwater impacts in fractured bedrock at a former truck stop. Based on the post-injection groundwater results from the pilot test and full-scale injection, a No Further Action letter was issued in February 2015.

CHALLENGES

Over a period of 20 years, site investigation activities revealed a 320 foot (ft) long dissolved hydrocarbon plume within the fractured bedrock. Light non-aqueous phase liquid (LNAPL) was identified in one monitoring well and benzene concentrations ranged from 1.4 to 6.4 mg/l throughout the hydrocarbon plume. The subsurface lithology consisted of a 1 to 3 foot thick clay overburden underlain by Upper Ordovician Calloway Creek Limestone, Garrard Siltstone, and Clays Ferry Formation. Monitoring wells at the site were installed with screened intervals spanning multiple formations varying from 10 to 40 feet in length. The remedial goal of the project was to achieve a risked based cleanup objective of 0.4 mg/l benzene in groundwater. Although the vertical and horizontal limits of the groundwater impacts had been defined during historical characterization activities, the distribution of the petroleum impacts within the bedrock fractures required further delineation to properly design and implement a cost effective surgical injection approach.

APPROACH

A bedrock remedial design characterization (RDC), utilizing multiple geophysical methods and high density groundwater sample collection, was conducted to identify and characterize the bedrock fractures as well as to determine the transport mechanisms of the dissolved petroleum hydrocarbon plume. The geophysical methods included: 2-dimensional electrical resistivity imaging survey (2-D ERI) and borehole geophysical logging. The 2-D ERI was used to identify locations for the bedrock characterization and injection boreholes. The logging tools were used to delineate the vertical extent, orientation, and aperture size of the bedding planes and fractures (features). Discrete groundwater sampling and pump tests using a specialty straddle packer with an 18-inch sample interval were conducted at all features identified during the geophysical survey to determine: the transmissivity, constituent concentrations, and connectivity between features. The RDC data was used to develop a high density conceptual site model (HDCSM) and a surgical BOS 200® injection design. All RDC sample analyses were performed at the RPI Quality Assurance Laboratory at no cost to the client.

SOLUTION | BOS 200

19,450 POUNDS INJECTED

Eight bedrock characterization and injection boreholes were installed within the hydrocarbon plume in multiple weathered bedrock zones identified by the 2-D ERI. The data collected from the discrete groundwater sampling at each borehole identified between three and six individual fractures containing groundwater impacts. BOS 200® design loadings were developed for each individual borehole feature based on aperture size and groundwater concentration. Using a specialized injection system and straddle packer assembly, 19,450 pounds of BOS 200® was injected targeting individual features using high flow rate (up to 135 gallons per minute) injections. Hydraulic connectivity was continuously monitored during the injection event using pressure transducers emplaced throughout the treatment area.

RESULTS

Real time well monitoring aided in optimizing the injection volumes and confirming that uniform distribution of the BOS 200®slurry was achieved. The monitoring demonstrated that the area of influence (using a 250-gallon slurry volume) varied from 75 to 250 feet while injecting in the deeper (>13 feet) features and up to 50 feet when injecting in the shallow features (<13 feet). Four post injection groundwater sampling events demonstrated that the five targeted performance monitoring wells have achieved the targeted remedial goal of 0.4 mg/l and LNAPL has been eliminated. In four of the five monitoring wells, benzene concentrations were reduced below the maximum contaminant levels, thus exceeding performance goals by two orders of magnitude.

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