DNAPL stabilization using ORGANOCLAY at superfund site in Virigina

The Atlantic Wood Industries (AWI) site is approximately 48 acres of land on the industrialized waterfront of Portsmouth, Virginia, along the Southern Branch of the Elizabeth River. From 1926 to 1992, a wood-treating facility operated at the site using both creosote and pentachlorophenol (PCP).

PROJECT DETAILS

Atlantic Woods Industries

CQA Engineer:
EA Engineering, Science and Technology

General Contractor:
Geo-Con, part of Geo-Solutions

LOCATION

Portsmouth, Virginia, USA

PRODUCTS USED

ORGANOCLAY™

BACKGROUND:

The Atlantic Wood Industries (AWI) site is approximately 48 acres of land on the industrialized waterfront of Portsmouth, Virginia, along the Southern Branch of the Elizabeth River. From 1926 to 1992, a wood-treating facility operated at the site using both creosote and pentachlorophenol (PCP). The site was contaminated from the treatment operation, storage of treated wood and disposal of wastes. This land is adjacent to the Norfolk Naval Shipyard. At one time, the Navy leased part of the property from AWI and disposed of waste on site.

Polynuclear aromatic hydrocarbons (PAHs), PCP, dioxins and metals contamination (mainly arsenic, chromium, copper, lead, and zinc) have been detected in soils, groundwater, and sediments. The groundwater and soil at the site are also heavily contaminated with creosote. Creosote contamination previously migrated into a storm sewer and discharged to an inlet of the Elizabeth River. Sediments in the Elizabeth River contain visible creosote.

CHALLENGE:

The AWI Site was added to the National Priorities List of most hazardous waste sites in 1990. AWI completed an EPA-directed removal action (short-term cleanup) in 1995. AWI installed a liner in a storm sewer to prevent creosote from entering into the sewer and migrating to the river. AWI also excavated approximately 660 cubic yards of contaminated sediment from the inlet. In 2002, EPA, AWI and the Navy reached an agreement to undertake a removal action to cleanup acetylene sludge from an on-site wetland. The sludge removal and the wetland restoration were completed in 2003.

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The most recent Record of Decision (ROD) issued by EPA describes cleanup activities to address soil, groundwater, and sediment contamination in the Southern Branch of the Elizabeth River. The main components of the selected remedy include: 1) a clean soil cover over the areas of contaminated soil; 2) in-situ solidification/stabilization of creosote and pentachlorophenol soaked soils on the west side of the site; 3) monitored natural attenuation (natural cleaning) of groundwater; 4) installation of a sheet pile wall off-shore in the Southern Branch of the Elizabeth River to prevent creosote migration to the river; 5) dredging of river sediments with disposal of dredged sediment mainly behind the sheet pile wall (creating new land); and 6) enhanced monitored natural recovery (natural cleaning) of sediments.

SOLUTION:

The remainder of this case study focuses solely on the remediation of OU-1, contaminated soils. In-situ solidification/stabilization (S/S) of soils was determined to be the most appropriate method to minimize the DNAPL within the contaminated soils as a continuing source of groundwater contamination. This was based upon an analysis and modeling using in-situ S/S bench-scale treatability study test data. The leaching test used in the treatability study was a semi-dynamic leach test. In a semi-dynamic leach test a monolithic solidified specimen is placed in a water bath and the leachate is sampled and replaced periodically. ASTM C1308, based upon an earlier semi- dynamic leach test ANS 16.1, was the method used for this treatability study. (Note: USEPA has drafted a semi-dynamic leach test method for organics, Pre-Method 1315m, which is expected to be finalized soon).

When performing risk-based corrective action, a semi-dynamic leach test can be more representative of actual conditions than either TCLP or SPLP. A semi-dynamic leach test determines mass transfer release rates of constituents from low-permeability material under diffusion-controlled release conditions. The mass flux at the surface of the in-situ S/S treated soil can be converted into a groundwater concentration (ITRC 2011). The groundwater concentration is then related to a concentration at the point of compliance (POC) through a dilution-attenuation factor (DAF). In applying a DAF it is recognized that groundwater concentrations in the pore space outside the in-situ S/S treated soil may be reduced due to dilution, dispersion, adsorption and attenuation prior to reaching the POC. This is consistent with the ITRC guidance on the calculation, measurement and use of mass flux and mass discharge in subsurface environments (ITRC 2010).

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RESULT:

In-situ S/S treatment promoted diffusion-controlled conditions in all mix designs which leads to significant reductions in mass transport of all constituents of concern (COCs). Under these conditions, the mass transport of a COC is primarily governed by its effective diffusivity (De). This then allows for a comparison of mass transport of each COC out of the mix designs based on De through the solid matrix in comparison to its diffusion rate in bulk solution (Daw). The rate of reduction in the mass transport due to the mix design, or the retardation factor [RF], is the ratio of Daw/De. The higher the RF, the more successful the mix was in reducing the migration of the COC. Further confirmation that the mix design is diffusion-controlled is obtained by evaluating the slope of the COC mass release for each COC in each mix. Here, a slope of 0.5±0.1 is evidence of diffusion-controlled conditions.

There were several ways that SDL test results were used to assess the performance of mix designs:

- The primary methods were comparisons based on the measured effective diffusivity (De), leachability index (LX) and shape (slope) of the cumulative mass curve of each constituent of concern (COC) from each mix design specimen. All mix designs were determined to be diffusion controlled based on the collective consideration of the leaching behavior of all SVOCs.
- Mix design performance was evaluated by average rank, which ordered the mix designs in terms of attaining the lowest De (highest RF) value per COC.
- Composite rank ordered mix design performance by the highest aggregate RF value across all SVOCs.
- Incremental improvement in mix design performance over control was evaluated on the basis of the highest RF difference between control on the basis of PCP only and all SVOCs.
- The LX for the mix designs was also compared to in-situ S/S industry guidelines for treated soils. From a remedial management approach, in-situ S/S treatment of organics-laden wastes corresponds to a minimally acceptable criterion of LX>8.

The treatability study was performed in two phases. In the Phase I study, powdered bentonite and granular activated carbon were tested as reagents along with Portland cement-slag. However, none of the mixes that were tested reduced leaching to acceptable levels. In Phase II of the treatability study, bentonite and GAC were replaced with CETCO ORGANOCLAY™ as the reagent with Portland cement-slag. Phase II test results showed that CETCO ORGANOCLAY effectively immobilized PCP and eight other SVOCs. Here, the cleanup goals include the groundwater PCP MCL of 0.001 mg/l. The PCP concentration data for the semi-dynamic leach test incorporated into a regional groundwater model demonstrated that the PCP MCL was satisfied at the POC.

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The two optimum design mixes specified, as determined by the treatability study and modeling, were 8% Portland cement/slag plus either 1 or 3% CETCO ORGANOCLAY. The higher CETCO ORGANOCLAY dose was specified for certain hot spots. Benefits of organophilic clay as a cement- based additive has been discussed in several USEPA documents (see CETCO TR-851). CETCO ORGANOCALY bonds with certain organic wastes (e.g., NAPL and SVOCs), thus aiding cement curing and improving cement-based in-situ S/S performance.

The USACE issued a contract valued at over $8 million to Geo-Con, part of Geo-Solutions, to treat creosote and pentachlorophenol contaminated soil in the western portion of the site by in-situ S/S. The design mix with 1% ORGANCOLAY addition was used to treat 30,500 cubic yards of contaminated soil. The design mix with 3% ORGANOCLAY addition was used to treat 15,200 cubic yards of highly contaminated soil. The in-situ S/S agents were mixed with water to create slurry. The slurry was then pumped to backhoes equipped with mixing tools. This allowed sufficient mixing of the in-situ S/S agents into the soil to the required depth. Post treatment quality control testing after 28-day cure included: unconfined compressive strength (UCS) per ASTM D1633 at a frequency of 1 per 1,000 cubic yards treated, and hydraulic conductivity per ASTM D5084 at a frequency of 1 per 2,000 cubic yards treated. Performance requirements were minimum 50 psi UCS and target maximum 4×10^{-6} cm/s hydraulic conductivity. Work was completed in the first half of 2013.

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cetco@mineralstech.com | cetco.com | 800.527.9948