MGP byproducts including DNAPLs and LNAPLs treated in-situ with cement-based S/S.

Redevelopment plans as a research park include office and parking structures built on treated soils.

Solidification/Stabilization Treatment at a Former Manufactured Gas Plant Site

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Brownfield legislation and initiatives provide significant incentives for cleaning up and redeveloping commercial properties in prime locations that have been under-utilized due to environmental impacts of past industrial practices. One such brownfields site is at the Cambridge Research Park in Cambridge, Massachusetts. The property is the former location of a manufactured gas plant (MGP). MGPs heated coal and oil to produce gas used for lighting and heating. Byproducts from this process include coal tars and other organic compounds that behave as dense non-aqueous phase liquids (DNAPLs) and light non-aqueous phase liquids (LNAPLs) when in groundwater. Experts estimate that there are over 20,000 former MGP sites in the U.S.

Cement-based solidification/stabilization (S/S) is an effective means to address contamination at former MGP sites. S/S treatment of contaminated soil involves mixing portland cement into the soil. Mixing can often be accomplished while the soil remains in-place or *in-situ*. At this particular site, cement was mixed into the soil using shallow soil mixing (SSM) technique. SSM consists of using a single large-diameter auger, generally on the range of 1.5 to 3 meters (5 to 10 feet) in diameter, capable of mixing to depths of up to 12 or 15 meters (40 or 50 feet). The mixing shaft, known as the kelly bar, is hollow stemmed and is attached to a single-flight auger which breaks the soil loose and lifts it slightly to multiple beater bars on the mixing shaft. As the auger penetrates the soil, cement grout is pumped through the mixing shaft and exits through jets located on the auger flighting.

The SSM technique was selected as the method for the *in-situ* stabilization of approximately 79,130 cubic meters (103,500 cubic yards) of NAPL-impacted soils at the ten-acre Cambridge site. Past operations of the former MGP on the site resulted in the release of hazardous chemicals into the soil and groundwater. The hazardous chemicals present in the soil and groundwater, over a 1.15 hectare (2.82 acre) area of the property, exceed the upper concentration limit established by the Massachusetts Contingency Plan (310 CMR 40.0996).

The site was divided into zones in which DNAPL, LNAPL, or both were present. Site investigations showed that the DNAPL was consistent with coal combustion products (coal tar) and LNAPL was similar to weathered diesel oil or #2 fuel oil. The downward migration of the DNAPL was restricted by the clay layer located approximately 22 feet below the existing ground surface, whereas the LNAPL was found present on top of the water table and exceeded a thickness of two feet in some monitoring wells. Stabilization in zones containing DNAPL only or both liquids was accomplished by mixing to a depth of 0.6 meters (2 feet) below the clay layer. The LNAPL zones were stabilized to a depth of 3.7 meters (12 feet) below ground surface.

Prior to stabilization, contractors completed the demolition of subsurface structures and obstructions by excavating to a depth of approximately 4.6 meters (15 feet) below ground surface. The majority of demolition debris consisted of concrete and steel piping left in place after demolition of the MGP. In some cases, an excavator equipped with a hoe ram was required to demolish existing concrete foundations. All demolition debris was separated and classified for offsite disposal, while the remaining soil material was placed back into the excavation area.

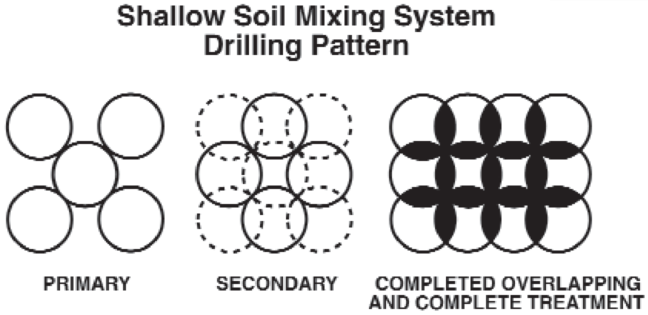
The most difficult challenge of the subsurface demolition work was the control of odors and volatile organic compounds (VOC) emissions. Two successful methods were used to address this challenge. The first method used an odor-controlling foam material, which was sprayed over open excavation areas, temporary stockpile areas, and demolition debris to suppress odors from newly excavated material. This proved to be the most effective method for controlling odors, because their release could be controlled immediately at the source. This method also aided in reducing VOC emissions. As an additional backup measure, a mist unit was also set up along the perimeter of the excavation area. This unit operated by releasing an engineered odor-reducing mist into the air. In addition, work crews implemented various passive odor reduction measures. Perimeter fencing with a wind screen/vapor barrier helped to elevate and disperse vapors. As a final control, excavation was limited to times of favorable wind and temperature conditions to minimize the impact to offsite receptors.

During the soil-mixing phase, a specialized Soil Vapor Extraction unit controlled odors. This unit consisted of a metal shroud or hood which was placed over the mixing area to trap potentially hazardous vapors and fugi-

tive dust released from the soils. During the stabilization process, vapors and fugitive dust were drawn through a vacuum hose attached to an opening in the side of the shroud. The vapors then entered the treatment unit, which included an air separator, high-efficiency particulate air filter, and activated carbon unit(s). Upon completion of the treatment process, the air was released through a discharge pipe.

The initial phase of stabilization involved performing a field test program to determine the proper reagent addition and equipment operation specifications necessary to produce a homogeneous mix. The total reagent addition was based on the dry weight of reagent in the grout mix to a percent weight of the soil. This also made it necessary to determine a workable grout mix ratio (water to solids ratio) that would satisfy the project requirements. The test program determined that a 7% cement to soil and 2% bentonite to cement mixture by weight would be used (grout mixed using a 1.25:1 Water:Cement ratio). The test program also determined specific equipment operations such as auger advancement rate through the soil, grout injection rate, and number of auger strokes necessary to produce a homogeneous mixture.

In reference to the limits of stabilization, a specific SSM column layout was designed using overlapping of adjacent columns to effectively stabilize 100% of the mixing area. Columns were identified and marked in the field by surveying methods, and the data was recorded and used to relocate columns for compliance sampling. This method was used exclusively throughout the duration of the project.



Samples were collected, photographed, and visually inspected for homogeneity and the presence of NAPL. In addition, inspectors analyzed the samples for physical parameters including hydraulic conductivity, bulk density, as-treated NAPL saturation, and post-centrifuge residual saturation. Sample collection was performed at a frequency of once per every 800 cubic meters (1,000 cubic yards) of stabilized soil for the first 8,000 cubic meters (10,000 cubic yards), for testing at curing times of 7 and 28 days. Upon completion of the first 8,000 cubic meters (10,000 cubic yards) of stabilized material, the sampling frequency was reduced to one sample for each 1,900 cubic meters (2,500 cubic yards).

Other samples, drawn from wet samples collected at the time of mixing, were also analyzed for TCLP volatiles (BTEX) and TCLP semi-volatiles. Additionally, samples for TCLP analysis were collected from post-28-day cured samples to assess the effects of curing on the TCLP results. The physical and chemical data support and demonstrate that the stabilization activities were performed in accordance with the project requirements and achieved the desired results.

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