Large-Scale Green Remediation Field Test

Subsurface Coal Tar at a Former Manufactured Gas Plant Site

VeruTEK's Coelution Technology (S-ISCO™)

Executive Summary

VeruTEK Technologies, Inc. (VeruTEK) performed a large-scale green remediation field test. The test focused on treatment of subsurface coal tar at a former Manufactured Gas Plant with VeruTEK's Coelution Technology™, surfactant-enhanced in-situ chemical oxidation (S-ISCO™). The test results exceeded expectations. Greater than 4 times the test designed soil contamination was destroyed and the test achieved a sustainable reduction in groundwater contamination. A third party consultant performed oversight of the test. The consultant concluded that S-ISCO™ destroyed soil, groundwater, and soil gas contamination at the site in a safe and controlled manner and demonstrated that complete or near-complete treatment of MGP contaminated soils can be achieved.

One Hundred Year Old Tar Contaminated Soil @ 20 ft. Below Ground Surface
from a Manufactured Gas Plant Site

Introduction

Manufactured Gas Plants (MGPs) have been around for over 150 years. MGPs began in the mid 1800's by burning coal (coal gasification) and piping the off gas generated from the process down city streets to light the streets at night. At the turn of the century, MGPs expanded their delivery to homes for heating and cooking purposes. For the most part tar generated from the coal gasification process was pumped into a well or "tar pit" located on the property. These tar pits provide the source of soil and groundwater contamination at Former MGP sites across the country.

Site Background

The location of our Surfactant-Enhanced In Situ Chemical Oxidation (S-ISCO™) field test is a 6 acre property covered with sand, grass, and concrete slabs still remaining from former buildings. Our client, a major utility company, with the help of several environmental consultants, developed a cleanup solution. That solution includes the use of in situ chemical oxidation to destroy tar located in several tar pits on the site. The make up of the soil beneath the ground surface consists of sand. Tar, pumped into tar pits at the site traveled slowly over the past century through the sand in a downward direction until it reached a clay layer of soil that prevents further downward travel. From there the tar moves very slowly with groundwater in the direction of the nearest water body. Generally, groundwater at the site moves much faster than the tar moves. However small levels of the tar dissolve in the water and travel to the water body.

In July 2004, an ISCO remediation company performed three independent In Situ Chemical Oxidation (ISCO) field tests. This was in an attempt to demonstrate destruction of MGP contaminants in soil and groundwater at the site. Generally, an ISCO field test consists of pumping or injecting chemical oxidants (such as Sodium Persulfate or Hydrogen Peroxide) into the ground through delivery points or injection wells. To measure the tests effectiveness monitoring wells (installed similarly) are placed in the vicinity of these injection wells.

In all three field test areas, a treatment zone of 10-25 feet below ground was targeted. First soil and groundwater samples were collected from monitoring wells in the area to establish a current level of contamination at the test locations. The different chemical oxidants were then injected. When the injections were complete soil and groundwater samples were collected to compare results.

In all three cases there was no discernable change in the before and after samples of soil and groundwater. The two tests that utilized hydrogen peroxide increased the temperature of the ground by more than 30 degrees and caused foaming chemical oxidant to rise out of the ground. Additionally, the injected chemicals traveled less than 5 feet. The test that utilized sodium persulfate as the oxidant demonstrated that very little chemical reached the target depth. In fact, less than 1% of the injected persulfate was measured in the treatment zone. The common result; these three field tests failed.

S-ISCO/ISCO Background

Traditional ISCO processes involve injecting oxidants into contaminated areas. The oxidants will react with contaminants and cause them to decompose into harmless substances. Traditional ISCO methods have failed to remedy non-aqueous phase liquids (NAPLs) such as gasoline, coal tar, or hydraulic fluid, because these chemicals do not readily dissolve in groundwater. ISCO reactions predominantly take place in water in the ground, and have little to no impact on contaminants bound to soil or in the NAPL. An example of ISCO's failures has been seen in Colorado, where of 20 sites where ISCO was implemented 15 sites resulted in lack of success[1].

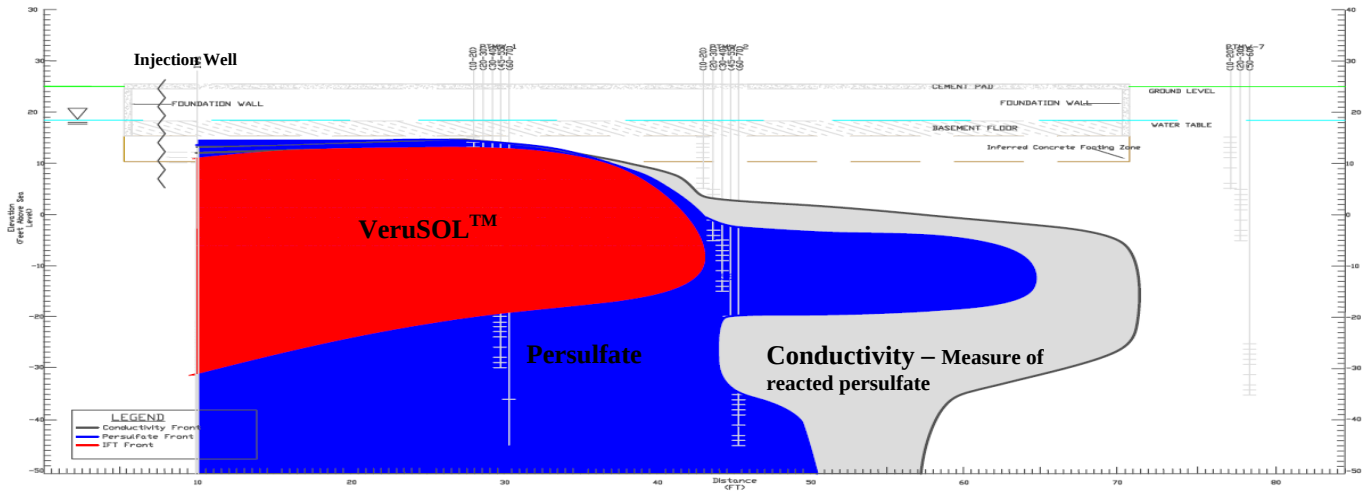
S-ISCO™ is a new, field verified Coelution Technology™ capable of reducing the amount of NAPL in soils. It also reduces the flux of groundwater contaminants associated with these sites. The patent-pending S-ISCO™ technology uses biodegradable, food-grade surfactants, which consists of a U.S. FDA-generally recognized as safe (GRAS) mixture of citrus-based cosolvents and plant oil-based surfactants (i.e. VeruSOL™) that dissolve organic compounds into groundwater and subsequently destroy the contaminants in-place using activated persulfate.

Field Test Results

The S-ISCO field test consisted of a 30-foot wide by 60-foot long area. The depth interval targeted for treatment in this area extended from 10 feet to 40 feet below the surface of the ground. To monitor the progress of the chemical injections 27 monitoring wells were installed in the treatment area.

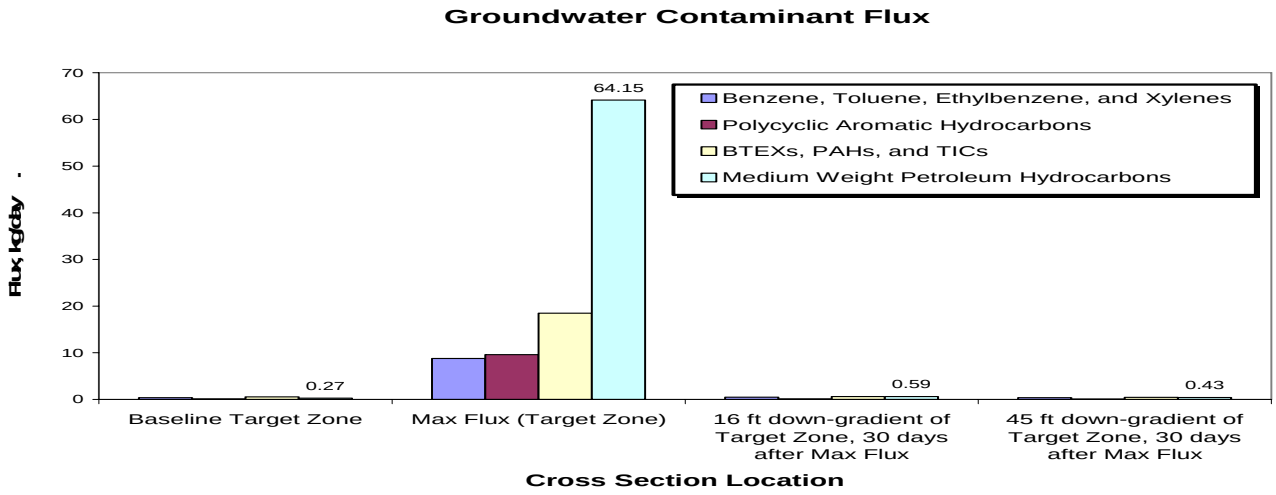
Due to failures of the previous ISCO field tests at the site the major objective of the S-ISCO field test was to demonstrate movement of the S-ISCO™ chemicals. Additional objectives included demonstrating control of the S-ISCO™ chemistry and reduction of groundwater contamination. The chemicals injected consisted of sodium persulfate activated with Fe(II)-EDTA, and VeruSOL™ to enhance contaminant solubility in water. Through the extensive monitoring well network VeruTEK was able to monitor the movement of the chemicals through the soil as the injections progressed. Groundwater samples for persulfate concentrations and interfacial tension (a signature mark of VeruSOL™ presence) were analyzed daily and the results were graphed on cross sections of the field test area.

[1] The Colorado Department of Labor and Employment Division of Oil and Public Safety. (2007) Petroleum Hydrocarbon Remediation by In-situ Chemical Oxidation at Colorado Sites, June 2007.



The graph provides a clear depiction of how VeruTEK™ controlled the S-ISCO™ process, such that all dissolved contamination was destroyed in the presence of excess persulfate.

VeruTEK also performed monitoring for groundwater contamination. This was conducted to demonstrate control of the S-ISCO™ chemicals and destruction of the groundwater contaminants. Groundwater samples were collected for analysis five times throughout the field test. The contamination of the samples was used to calculate average contaminant levels at three different locations.



The figure presents the level of groundwater contamination at different times and locations during the field test. The first quantity represents the groundwater contamination before the S-ISCO field test began. The second quantity represents the maximum observed contamination during the field test. From baseline conditions the amount of contaminants dissolved in water was increased by more than 230 times and was subsequently destroyed with in 16 feet of that location. These numbers are conservative because while the chemicals are traveling the 18 feet from the injection wells to the monitoring well simultaneous dissolution/destruction is occurring. During the S-ISCO Field Test, the speed of the groundwater and S-ISCO chemicals was measured at an average of 3 feet per day, therefore complete destruction of soil and groundwater contaminants (34 feet) took approximately 11 days.

VeruTEK also evaluated the long-term effects of the field test over the following year. The results shown below are from the third party consultant monitoring report for the site.

MGP Field Trial Groundwater Total PAH Results (ug/L)

Well Location	Baseline* Average	June 2006	Nov/Dec 2006	March 2007
Shallow MW ~ 120 ft down-gradient of field test area	2,357	1,647	1,652	1,647
Deep MW ~ 120 ft down-gradient of field test area	3,385	435	------	1,113
Shallow MW ~ 75 ft side-gradient of field test area	4,201	0	0	48
Intermediate MW ~ 75 ft side-gradient of field test area	5,442	4,565	3,214	4,359
Deep MW ~ 75 ft side-gradient of field test area	99	0	-----	39
Shallow MW ~ 275 ft down-gradient of field test area	4,663	-----	2,179	1,819
Deep MW ~ 275 ft down-gradient of field test area	10,947	-----	2,302	2,289

Note:
* Baseline based on average PAH concentrations measured between September 1992- March 2006

Even though, it was not an objective of the field test to eliminate the source contamination at the site, the field test achieved sustainable decreases in groundwater contamination in groundwater monitoring wells adjacent to the field test area. This result exceeded the expectations of the field test.

Soil gas samples were collected approximately 20 feet from the injecting wells. Our results indicate that S-ISCO reduces contamination in soil gas vapors efficiently enough to be a solution for soil gas vapor reduction.

Contaminant of Concern (parts per billion)	Baseline April 28, 2006 (ppb)	First Injection May 9, 2006 (ppb)	Post Sampling July 7, 2007 (ppb)
2,2,4-Trimethylpentane	1914.7	79.4	3.5U
Total BTEX	192.9	4.9	16.2
Total VOC	2994.6	235.8	271.7

Field Test Conclusions

- S-ISCO™ chemicals traveled together to targeted soil zones and contaminants were dissolved and destroyed in the Field Test. The Field Test demonstrated that S-ISCO™ can be used to treat MGP-related contaminants beneath buildings and other potential obstructions such as railroad tracks and highways.
- The Field Test was designed to treat approximately 900 kg of MGP-related contaminants. Results indicated that nearly 4,000 kg of MGP-related contaminants were destroyed in the Field Test.
- Groundwater analytical results indicate that MGP-related contaminants were dissolved and effectively destroyed within the target area.
- The Field Test demonstrated that complete or near-complete treatment of soils can be achieved.
- The Field Test demonstrated that S-ISCO™ can be safely implemented to treat subsurface MGP-derived contamination. It was also demonstrated that food-grade surfactants can be used to treat subsurface MGP residues.

Regulatory Approval

The New York State Department of Environmental Conservation (NYSDEC), Division of Environmental Remediation approved the field study in a letter dated July 2, 2007. In the letter it was stated by the NYSDEC that "…the Department is approving the use of the 'Surfactant enhanced In-Situ Chemical Oxidation Technology' for full scale implementation at the site..."