TCH Case Study: NASA Marshall Space Flight Center CVOC Site

Site Information

Under contract to CH2M HILL, TerraTherm designed and operated an ISTD pilot test at Marshall Space Flight Center (MSFC), the principal propulsion development center for the National Aeronautics and Space Administration (NASA). MSFC, which is located in Huntsville, Alabama includes 79 sites regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and is a National Priority List (NPL) site. Groundwater at MSFC has been integrated into a single operable unit (OU-3). TerraTherm conducted the ISTD pilot test at a portion of OU-3 known as Source Area 13 (SA-13), and completed the project in 2007.

According to Cole et al. (2008)[1], the history and investigation results at SA-13 indicated that a former drum storage pad area outside of Building 4705 likely was the source area, with trichloroethene (TCE) being the primary soil and groundwater contaminant. TCE appears to have been released via facility operations in the building and on the concrete pad located above the treatment zone. The presence of dense, nonaqueous-phase liquid (DNAPL) is suspected, with TCE soil concentrations ≥ 260 mg/kg and groundwater concentrations ≥ 11,000 μg/L.

Treatment at SA-13 by In Situ Chemical Oxidation (ISCO) had limited effectiveness. On the basis of the ISCO results, NASA made the decision to evaluate In Situ Thermal Treatment (ISTT) at SA-13. Agencies suggested ISTT implementation as a CERCLA interim action under an Interim Record of Decision (IROD).

Subsurface Geology/Hydrogeology

The study area volume included:

- a clayey residuum from land surface to a depth of approximately 32 ft below ground surface (bgs);

[1] Cole, J., W.J. McElroy, J. Glasgow, G. Heron, J. Galligan, K. Parker and E.F. Davis. 2008. "In Situ Thermal Treatment of Trichloroethene at Marshall Space Flight Center". Presented at *Remediation of Chlorinated and Recalcitrant Compounds*, Monterey, CA, May 2008.

- the groundwater-bearing rubble zone at the base of the residuum; and
- the top 5 ft of limestone bedrock beneath the rubble zone.

The upper portions of the typical subsurface profile are composed of weathered, relatively low-permeability clayey media. Permeability of the residuum increases with depth. This hydrostratigraphic unit is underlain by carbonate bedrock formations that compose the Tuscumbia-Ft. Payne Aquifer, which contains a karst flowpath network. The bedrock occurs at depths from about 34 to 37 ft bgs beneath SA-13. The groundwater-bearing portions of the residuum and karst bedrock units form a complex, integrated groundwater system. The degree of hydraulic interconnection and vertical interchange of water between the units are both spatially and temporally variable throughout MSFC.

Due to this very challenging geology, including karst limestone below the DNAPL zone, and sensitivity of the risk of DNAPL mobilization, TerraTherm was selected as the preferred thermal technology provider by NASA and its consultant.

Project Goals

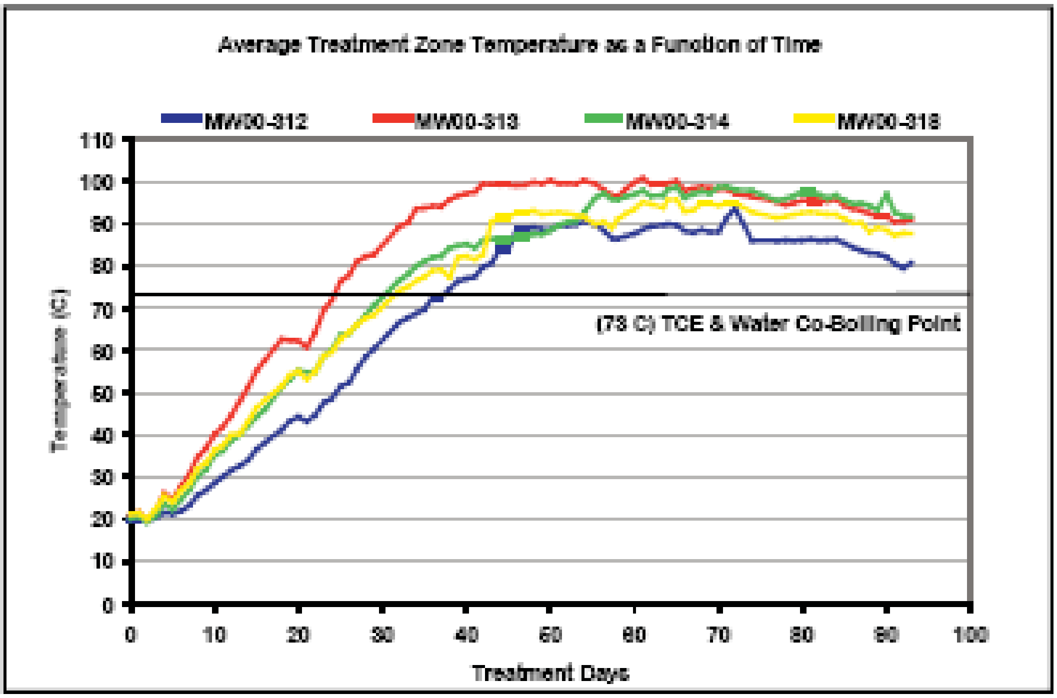
The treatment objectives of the SA-13 Interim Action were to reduce the estimated mass and average concentrations of TCE in soil and groundwater by 99% or greater. Specifically, the primary goal of the ISTD pilot test was to demonstrate the effectiveness of the ISTD technology in reducing concentrations of TCE in the subsurface within the "hot spot" of the source area. A target concentration for TCE of 1 mg/kg was selected for this pilot test. As stated below, the goals were met.

Project Approach

The ISTD technology was selected for the in situ thermal treatment demonstration. The target treatment zone (TTZ) occupied approximately 500 square feet, and extended from 15 to 42 ft bgs, including 5 ft into the underlying bedrock.

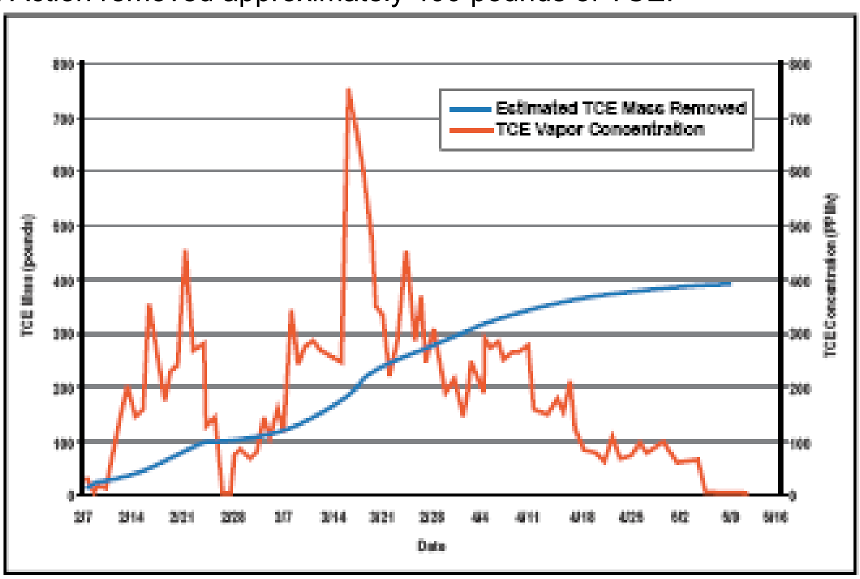
ISTD system design features included: a) minimum target temperature of 100°C; b) a wellfield (right) consisting of 18 thermal wells at 10-ft spacing, including 10 heater-only wells and 8 heater/vapor recovery wells, with ISTD heater elements installed to a depth of approximately 9 to 10 ft below the top of bedrock; c) 4 multiphase fluid extraction wells; d) 9 process monitoring wells to monitor temperature at 7 discrete intervals from 12 to 42 feet below ground surface, and pressure; e) a surface vapor barrier, and f) 8 groundwater performance monitoring wells, including 6 in the residuum and 2 in bedrock.

Project Results
The accompanying plot presents the average treatment zone temperatures as a function of time over the three months of the pilot test. It shows that average temperatures were well above the Eutectic Point (TCE-water) and close to the boiling point of water.



Summary

- The Interim Action removed approximately 400 pounds of TCE:



- This was the first application of ISTT at MSFC and in the state of Alabama.
- The interim remedial action objectives and goals established for ISTT at SA-13 were achieved. Post-treatment soil samples had a mean concentration of 0.06 mg/kg with a maximum post-treatment concentration of 0.56 mg/kg. Mean pre-treatment TCE

concentrations were 47.65 mg/kg with a maximum pre-treatment concentration of 240 mg/kg. ISTD reduced concentrations of TCE in the subsurface by an average of 99.87%.

- According to Cole et al. (2008), the ISTD technology proved highly effective for:
  - Source area mass reduction
  - Chlorinated solvent removal from the saturated and unsaturated residuum
  - Treatment of heterogeneous subsurface environments.

- No signs of DNAPL mobilization were observed, based on samples from the bedrock after thermal remediation was completed.

Based on these results, NASA is strongly considering using ISTD/TCH for full-scale remediation at several DNAPL source areas. Basically, this technology is the only one that has been demonstrated to be effective in this challenging hydrogeology.