

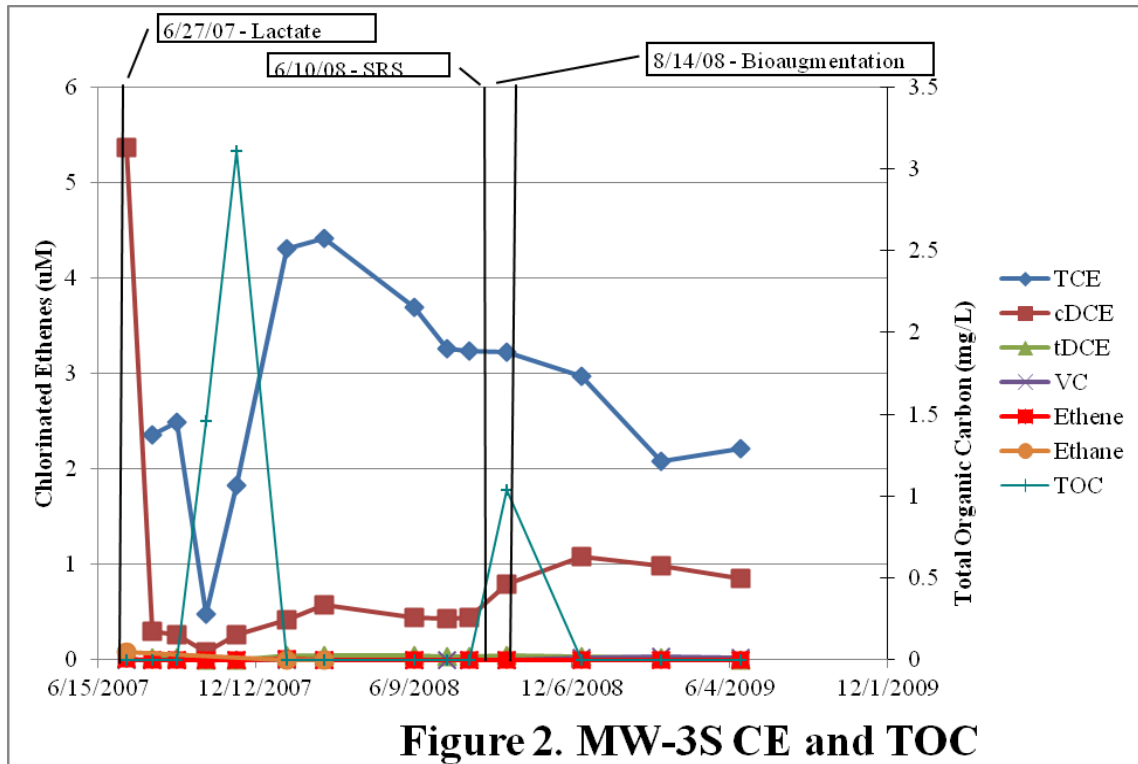
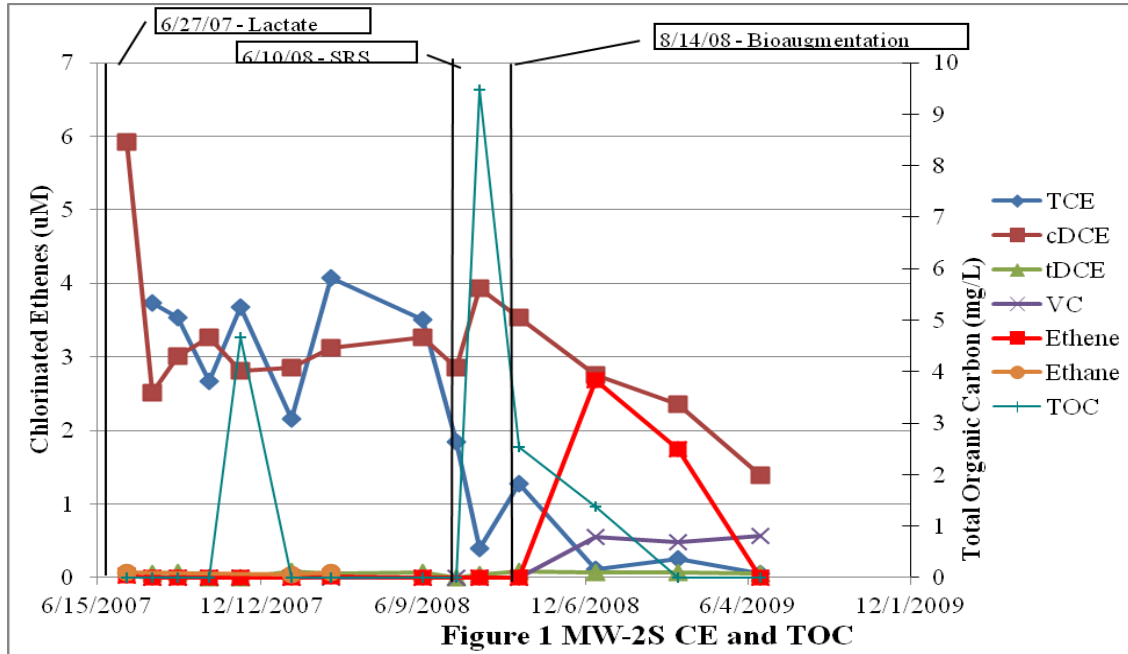


## SRS<sup>®</sup>-FR HIGH GROUNDWATER FLOW RATE CASE HISTORY

**Setting:** A railcar spill of trichloroethene (TCE) occurred in eastern Kansas. Groundwater beneath the site is contaminated with TCE, cis-1,2-dichloroethene (cDCE), and trans-1,2-DCE (tDCE). Further degradation products including vinyl chloride (VC), ethene, and ethane were not detected. The groundwater lies within a highly permeable sandy aquifer with a groundwater flow rate estimated to be 1.9 ft/day. The groundwater contained less than 0.05 *Dehalococcoides ethenogenes*/mL. Sodium lactate was injected first. Terra Systems Inc. emulsified vegetable oil product, SRS<sup>®</sup>-FR, was injected at the site about 12 months after the lactate along with the TSI-DC<sup>®</sup> bioaugmentation culture after 14 months. SRS<sup>®</sup>-FR is a larger droplet size emulsified vegetable oil (EVO) designed for application in fractured bedrock settings or other high groundwater flow settings.

**Pilot:** Thirteen injection wells were installed in a 250 foot wide barrier. The injection wells were screened from 20 to 40 feet below ground surface. A total of 6,355 pounds of the SRS<sup>®</sup>-FR was injected. Bioaugmentation with 220 L of the TSI-DC<sup>®</sup> culture occurred about two months later.

**Results:** Figures 1 and 2 show the chlorinated ethene concentrations on a micromolar basis and total organic carbon (TOC) for the shallow wells MW-2S and MW-3S. The monitoring wells are about 50 feet downgradient of the line of injection wells. In the shallow well MW-2S, TOC levels after the lactate injection reached only 4.7 mg/L and there was little evidence for dechlorination. Immediately after the SRS<sup>®</sup>-FR injection, the TCE concentrations began to fall and the cDCE increased even with a maximum of only 9.5 mg/L TOC. VC and ethene were produced. The TOC levels were depleted in nine months in the shallow zone MS-2S well. In the shallow well MW-3S, TOC levels after the lactate injection reached only 3.1 mg/L and there was little evidence for dechlorination. After the SRS<sup>®</sup>-FR injection, the TCE concentrations began to fall and the cDCE increased even with a maximum of 1.0 mg/L TOC. VC and ethene were not produced in this well. The TOC levels were depleted in three months in the shallow zone MW-3S.





Figures 3 and 4 show the chlorinated ethene concentrations on a micromolar basis and TOC for the deeper wells MW-2D and MW-3D. There was some transformation of TCE to cDCE in MW-2D following the lactate injection where TOC levels spiked at 520 mg/L. However, no VC and ethene appeared in MW-2D until after the SRS<sup>®</sup>-FR was injected and bioaugmentation occurred. Ethene made up 96% of the total chlorinated ethenes 9 months after the SRS<sup>®</sup>-FR injection. However, when the TOC was depleted approximately 12 months after the SRS<sup>®</sup>-FR injection, the ethene concentration had dropped to non-detect and TCE and cDCE were the predominant chlorinated ethenes. There was some transformation of TCE to cDCE in MW-3D following the lactate injection when TOC levels reached 1,760 mg/L. However, no VC and ethene were detected until after the SRS<sup>®</sup>-FR and bioaugmentation occurred. Twelve months after the SRS<sup>®</sup>-FR injection, ethene made up 77% of the total chlorinated ethenes. The counts of *Dehalococcoides ethenogenes* in the deep wells MW-2D and MW-3D increased to 2.0E5 and 4.9E5 cells/mL in December 2008. Only minor production of VC was observed following the SRS<sup>®</sup>-FR injections in shallow or deep monitoring wells approximately 225 feet downgradient.

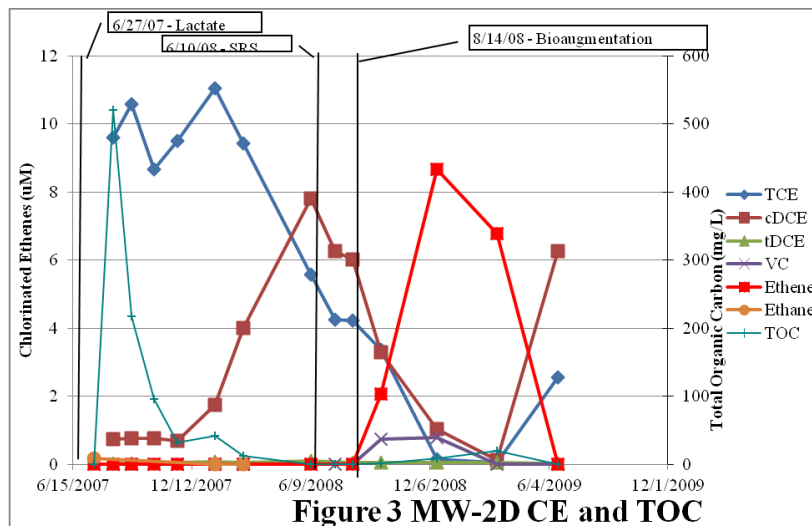


Figure 3 MW-2D CE and TOC

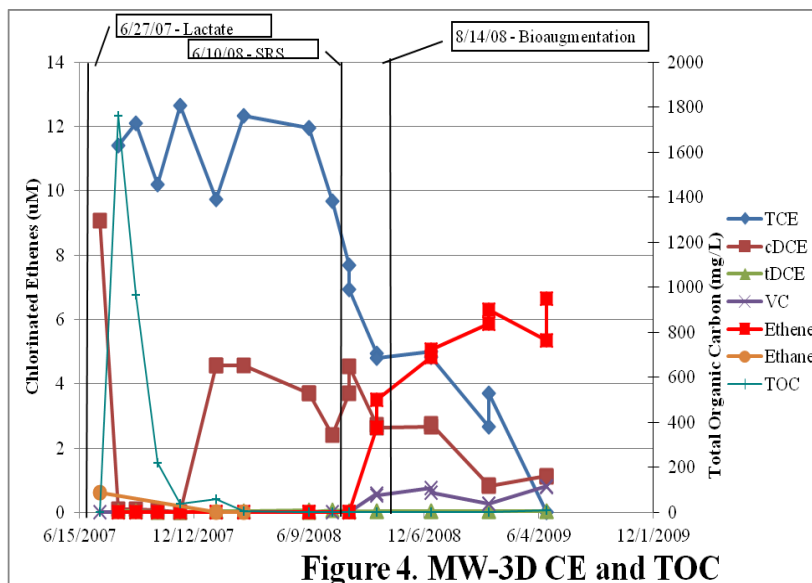


Figure 4. MW-3D CE and TOC



**Conclusions:** SRS<sup>®</sup>-FR was transported at least fifty feet downgradient from the point of injection and in conjunction with bioaugmentation was able to support almost complete dechlorination in the deeper zones for up 365 days. No impact of the SRS<sup>®</sup>-FR injection was observed on the wells 225 feet downgradient suggesting that the SRS<sup>®</sup>-FR did not wash away. The SRS<sup>®</sup>-FR injection was less successful in the shallow zone where TOC levels remained low. The pilot study provided information that helped the client design an improved injection pattern for the full scale system by targeted SRS<sup>®</sup>-FR injection in the shallow zone.

Based upon the successful pilot demonstration, plans were made to extend the treatment area with SRS<sup>®</sup>-FR.