



Remediation of Chlorinated
and Recalcitrant Compounds:
The Sixth International Conference
May 19-22, 2008 Monterey, California

Two Rapid Enhanced Flushing NAPL Recovery Methods

James A. Jacobs (jimjacobs@ebsinfo.com ; EBS, Mill Valley, California, USA),
Leif Nelson (Wolsey Parsons Komex, Calgary, Alberta, Canada) and
Jim Begley (in-Ventures Technoloiges, Inc., Canada)

Rapid free product removal of hydrocarbons and solvents has been a major challenge over the past three decades of remediation. Long-term product only or pump-and-treat systems are commonly used for removal of NAPLs. Failing rapid removal of free product allows for long-term dissolution around the edges of the NAPL, providing a continuing and unabated source of dissolved groundwater contamination. Two different enhanced flushing methods have been developed within the past two years to rapidly remove gasoline free product from within an aquifer. **Recovery Method 1** involves a field trial in Ontario, Canada. Supersaturated Water Injection (SWI) technology was used with carbon dioxide saturated water injection for controlled mobilization of VOCs to the water table for collection with soil vapor extraction (SVE) or dual phase extraction where NAPL was present. In the SWI process, water was supersaturated with CO₂ in a patented gas-liquid mass transfer system. The saturated water was injected into an aquifer test cell where a 200 liter hydrocarbon mixture had been placed forming a residual NAPL zone. CO₂ bubbles nucleated at the targeted area of the aquifer. The rising CO₂ bubbles contact with VOC NAPL ganglia in the saturated zone and cause volatilization of the VOCs into the vapor phase and mobilization of NAPL trapped in pores.

Extraction and reinjection wells were used to recirculate the CO₂ saturated water.. The CO₂ is distributed by flowing water resulting in effective gas distribution followed by heterogeneous bubble nucleation and continuous growth of gas bubbles in situ. A gas saturation front developed which expanded laterally and vertically towards the water table. VOCs mobilized to soil gas were extracted with a SVE system. Results indicated a significant proportion of VOCs were removed by SVE.

Recovery Method 2 was performed at a former tank pit at a northern California containing used hydraulic oil that was trapped beneath the saturated zone. Recovery Method 2 used a two-step flushing process which included high-pressure air injection and biosolvent injection to thin and mobilize the heavy oil, which was measured up to 41 cm in height in one well. The high-pressure air injection and biosolvents were used with high-vacuum extraction to recover both the used hydraulic oil and the biosolvent. The final stage separated the heavy oil from the unspent biosolvent and groundwater. Over

11 (55-gallon) barrels of free product were removed and a similar volume of biosolvent was recovered during the one week process. Site closure is imminent. These two remedial methods show rapid removal of free-product that was trapped within the pore spaces of the saturated zone.

CONTACT: Jim Jacobs, Environmental Bio-Systems, Inc., jimjacobs@ebsinfo.com Tel: 415-381-5195.