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Source zone free product removal continues to be one of the primary limiting factors to a successful groundwater restoration program. Conventional pump and treat schemes, although initially successful at recovering free product upon their commissioning, essentially become groundwater containment schemes over time. Further, the progression in the environmental industry from active to passive groundwater restoration programs, including natural attenuation and monitoring, or enhanced insitu degradation of contaminants through the subsurface introduction of nutrients or other agents under non-pumping conditions, remain primarily effective for dissolved phase contaminants. The challenges in recovering free phase product, which give rise to long term dissolved phase restoration programs, are due to a number of physical conditions, including the free product's specific gravity (or density), viscosity, interfacial tension and surficial tensional forces.

In order to reduce the free product's viscosity and tensional forces and thus aid in its recovery, surfactants, solvents or other such compounds have been introduced to the subsurface through a process termed "flooding". Flooding is a well documented secondary or tertiary oil recovery scheme employed in the petroleum industry whereby a fluid is pumped into the ground through a well to assist in the subsurface flow of liquids and thus to enhance the recovery of heavy oils from oil producing formations. Flooding effects are limited however, due to the development of viscous fingering and permeability channeling, which arise either due to permeability heterogeneities, or the physical interaction of fluids of varying viscosities.

In order to overcome the viscous fingering effects due to flooding, traditional flooding approaches have been enhanced, or augmented over the last four years by a newly patented technology (by PE-TECH Inc. of Cambridge, ON and Edmonton, AB) termed Pressure Pulse Technology (PPT). The PPT has been successfully implemented to significantly enhance the oil production rates at numerous petroleum producing sites located across the world.

PPT uses a process of periodic (eg. 15 pulses per minute) large-impulse hydraulic excitations (through the introduction of pressurized pulses of water) to introduce hydraulic strain energy into the formation. This energy, effective in geologic materials exhibiting elastic properties, (such as unconsolidated sediments and sedimentary rocks), dislodges blocked matter, opens perforations, increases pressure, re-establishes connectivity to reservoir pressures and generally enhances or restores the capacity of the well to produce fluids.

In 2000, the same Pressure Pulse Technology was employed at an operating industrial facility located in Cambridge, Ontario, Canada to assist in the recovery of a light non-aqueous phase liquid (LNAPL) and to ultimately enhance the effectiveness of the current free product pump and treat scheme which has been operating since 1995.

The LNAPL, referred to as bis (2-ethylhexyl) phthalate – or di-octyl phthalate (DOP), has a density of 0.9861 g/cm^3 and viscosity of 150 cp. The LNAPL layer has a measured average thickness of 0.5 cm within the on-site plume, and the historical recovery rate using conventional pump-and-treat technology has been approximately 14 litres/year.

The measured effects of PPT at the Site include an average water level increase of up to 1.0 metre, and an increased LNAPL thickness of 0.5 cm to in excess of 50.0 cm at monitoring well OWA, and from 0.5 to 3.5 cm at monitoring wells OWB and OWC respectively (see Plate 1). Overall recovery rates of LNAPL have also increased from 14 L/year to about 102 L/year.

The PPT, licensed to Wavefront Environmental Technologies of Kitchener, ON, and Edmonton, AB, has recently received approval from Environment Canada through the Environmental Technology Verification Program for application in the environmental industry.

In summary, PPT has had a direct impact at the Site, including an increased water level in the vicinity of the pulsing well by as much as 1.0 metre, an increased LNAPL thickness ranging from 300 to more than 1000%, and increased LNAPL recovery rates up to 7.5 times faster than non-pulsing rates. Data analysis indicates that at current non-pulsing rates free product removal will require about 40 years of continued pump and treat using conventional technology (for LNAPL volumes of approximately 500 litres (assuming porosity of 5%)). Conversely, for enhanced LNAPL recovery using PPT, recovery rates for free product removal may be reduced to about five years.

This reduction in time and mass of source zone removal through the application of PPT will significantly assist in the success of overall groundwater restoration schemes implemented, and the subsequent application of other schemes designed to restore groundwater with dissolved phase impacts.

Based on work conducted to date, additional environmental applications of PPT include:

- Mobilizing and enhanced recovery of LNAPL's and DNAPL's (density up to 3.4 g/cm^3);
- Introduction of bioactive agents and nutrients in a well dispersed manner;
- Stabilization of permeability channeling or viscous fingering;
- Increasing the basic flow rate so as to shorten any clean-up activity;
- Enhanced placement of grout or other binding agents;
- Unplugging, or rehabilitation of water wells through the mechanical perturbation effects of PPT;
- Purging aquifers of saline water encroachment caused by excessive groundwater pumping;
- Enhanced permeability of filtration beds or passive permeable barriers;
- Deep well disposal of liquid dominated slurries such as feedlot wastes.