GROUNDWATER & ENVIRONMENT NEWSLETTER

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MODELLING LNAPL RECOVERY

What is LNAPL?

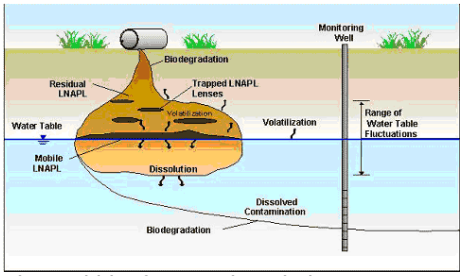
Hydrocarbon spillages or leaks into aquifers pose a significant environmental threat. When present in soil or groundwater it can form a continuous source of contamination until recovered. Light Nonaqueous Phase Liquids (LNAPL) floating on the water table as Phase Separated Hydrocarbons (PSH) can also form a continuous source of dissolved phase contamination to groundwater flow. The recovery of hydrocarbons from aquifers can be complicated as LNAPL may be trapped in the soil and water pore spaces.

http://www.epa.gov/oilspill/photo.htm

Characterisation of LNAPLS in Groundwater

LNAPLS are complex multi-component organic mixtures with varying properties, such as solubility. The complexity in characterisation needed prior to remedial work is reflected in:

- Partitioning (separation) between LNAPL, water, air and soil
- Fluctuations in the water table
- Slow rates of LNAPL dissolution
- Viscosity variations
- Complex subsurface geologic environment



Flow within fractured rock is even more complex due to the properties of the fluid, the geometry of the fracture network, and physical/ chemical reactions between the rock matrix and the solute/ groundwater regime.

Numerical solutions to characterise LNAPL releases to a natural system are therefore complex and often multiple stage solutions are needed.

LNAPL Recovery Models

Selected models for hydrocarbon recovery include:

- *API **LNAPL Distribution and Recovery Model** (LDRM) simulates different hydraulic technologies to recover PSH.*
- ***Petral Eclipse***
- ***MARS2D/3D** (finite-difference model for groundwater & LNAPL migration with **Biof&t:** transient multi-solute L/DNAPL flow*
- ***MOVER**, an areal three-phase (water, oil and gas) finite-element model, simulate the flow of water, oil and gas, & optimize the recovery of LNAPL and water by minimizing NAPL entrapment in the saturated/ unsaturated zones.*
- ***NAPL Simulator** estimates the contamination of soils and aquifers from the release of organic liquids*
- ***BIOPLUME -** 3D Transport of dissolved hydrocarbons undergoing oxygen-limited biodegradation.*

The NAPL transport models are often coupled with two-dimensional contaminant transport models to predict contamination of soil gas and groundwater resulting from a LNAPL migrating on the water table.

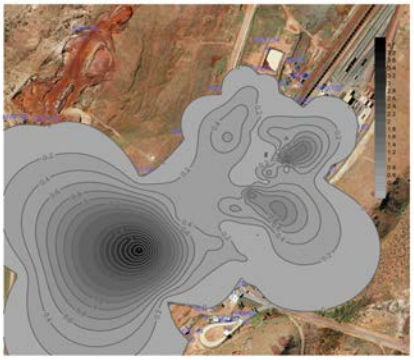
MARS2D/3D

The Multiphase Areal Remediation Simulator (MARS2D) was recently used by Hydrosolutions to characterise LNAPL occurrence & optimise recovery at a 7ha diesel spillage site. It models the coupled areal flow of water and LNAPL, and can be used with other software such as BIOF&T (2D or 3D) to represent dissolved phase transport of up to five species in groundwater. Input parameters may include:

- Soil characteristics (i.e. porosity, van Genuchten parameters alpha and n, irreducible water saturation, residual LNAPL saturations in the vadose and saturated zones.
- Fluid properties (i.e. density, viscosity, and interfacial tensions).
- Groundwater elevations.
- LNAPL thickness in the monitoring well.

Case Study

Hydrosolutions constructed a numerical model to assess remedial options at a hydrocarbon spill site in WA. MARS 2D incorporated field derived groundwater elevations, apparent PSH thickness & hydraulic conductivity parameters. Model calibration was achieved by varying the hydraulic conductivity, corresponding soil parameters and recharge values. The model simulated a combination of Total Fluid Recovery bores and skimmer bores in the downgradient direction that will control further downgradient migration of PSH.



Under a range of scenarios, the model successfully simulated the number of recovery bores, pumping volumes, and reinjection rates required to dispose of water from dual-phase recovery without significantly raising the heads in groundwater. A recovery and dewatering scheme is currently being designed.

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Next issue – Remedial Options for Hydrocarbon Contaminated Aquifers

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