

Technical Bulletin: DNAPLs and Organic Solvents



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Background

The Clean Water Act (CWA) requires that source protection committees list activities that are or would be drinking water threats in four types of vulnerable areas. Through regulations and technical rules, the Province has set out which activities, at a minimum, must be considered drinking water threats under specific circumstances. Specifically, Section 1.1 of Ontario Regulation 287/07 (General) lists activities that are prescribed as drinking water threats and the Tables of Drinking Water Threats in the Technical Rules specifies under what circumstances these activities are categorized as significant, moderate or low drinking water threats using the Semi-Quantitative Risk Assessment (now called the Threats Based Approach).

Nineteen of the twenty-one drinking water threats are related to water quality, including the following activities:

- The handling and storage of a dense non-aqueous phase liquid.
- The handling and storage of an organic solvent.

A number of questions regarding dense non-aqueous phase liquids (DNAPLs) and organic solvents have arisen from stakeholders developing policies to manage prescribed drinking water threats. The questions have also included the Ministry of the Environment's (MOE) rationale for classification of certain chemicals as DNAPLs or organic solvents.

This technical bulletin has been prepared to provide clarification on the MOE classification of certain chemicals as DNAPLs and organic solvents for the above drinking water threats. First, a brief introduction and description to the subject compounds is in order:

Dense Non-Aqueous Phase Liquids

The term "DNAPL" is not defined in any Ontario regulation. There is reference to DNAPLs in Schedule E of O. Reg. 153/04 under the CWA.

In general, a dense non-aqueous phase liquid (DNAPL) is defined as a heavier-than water organic liquid that is only slightly soluble in water. The primary classes of DNAPLs include:

- creosote
- coal tar
- PCB oils
- chlorinated solvents.

The United States Environmental Protection Act (EPA) defines DNAPLs as "a group of organic substances that are relatively insoluble in water and more dense than water. DNAPLs tend to sink vertically through sand and gravel aquifers to the underlying layer."

DNAPLs have been widely used in industry since the beginning of the 20th century. They exist in the subsurface as a separate fluid phase; immiscible with water. Common types of DNAPLs include timber treating oils such as creosote, transformer and insulating oils containing polychlorinated biphenyls (PCBs), coal tar, and a variety of chlorinated solvents such as trichloroethene (TCE) and tetrachloroethene (PCE).

A spill or release of DNAPL at the ground surface can lead to long-term contamination of both the unsaturated and saturated zones. DNAPLs have the ability to migrate down from the surface to the water table and then to below the water table. As they move downwards, DNAPLs slowly dissolve in groundwater, resulting in both the insoluble phase and dissolved phase, which results in contaminated aqueous phase plumes. The dissolved phase concentrations can still exceed drinking water protection criteria.

DNAPL contaminated sites have proven to be complex to investigate and challenging and costly to remediate. DNAPLs can flow through fractures or fissures in fractured rock and clay and it may take many decades for natural groundwater dissolution or natural breakdown of the DNAPL to dissipate DNAPL sources.

Organic Solvents

Solvent is defined in O.Reg. 153/04 (Record of Site Condition Regulation, under the EPA). "Solvent" means any volatile organic compound that is used as a cleaning agent, dissolver, thinner, or viscosity reducer, or for a similar purpose.

Chlorinated solvents such as trichloroethene (TCE), tetrachloroethene (PCE) and tetrachloromethane (carbon tetrachloride, CT, or CTET) form a class of DNAPL compounds that have been produced in large quantities throughout the world since the middle of the 20th century. Typical uses of these chemicals include dry cleaning, metal degreasing, pharmaceutical production, pesticide formulation and chemical intermediates.

Chlorinated solvents typically enter the subsurface as a result of past disposal directly onto land, storage and disposal into unlined evaporation ponds and lagoons, leaking storage tanks and vapour degreasers, leaking piping and accidental spills during handling and transportation.

Discussion

During the development of the Tables, the MOE selected five substances that were representative of DNAPLs, commonly found at contaminated sites in Ontario. Specifically:

- 1,4-Dioxane, PAHs (based on benzo[a]pyrene)
- perchloroethylene (PCE)
- tetrachloroethylene (PERC)
- trichloroethene (TCE)
- any vinyl chloride and any chemical that degrades to vinyl chloride.

The five substances are associated with common activities that have the potential to release DNAPLs to the environment, including landfills, commercial and retail dry cleaners, manufacturing (e.g. automotive, metals, electronics, aerospace), pharmaceutical production, pesticide formulation, and industries that use DNAPLs as chemical intermediates (1,4-dioxane, PCE, TCE, vinyl chloride). Other DNAPL sources in Ontario include coal tar¹, coal tar creosote² and users of heavy fuel oil (PAHs).

Why are some DNAPLs listed under the Storage of Organic Solvents Threats?

Stakeholders have noted certain chemicals that behave as DNAPLs and organic solvents have been classified in the Tables of Drinking Water Threats only as organic solvents, rather than DNAPLs. We recognize that the chemicals in the organic solvents list are DNAPLs, but the management of activities that use these chemicals as DNAPLs are already associated with activities captured by the chemical listed with the storage of DNAPL threats. Given this, these chemicals were used to represent activities that use organic solvents as their hazard rating is higher than the non DNAPL chemicals also associated with organic solvents.

What if an SPC wants to consider other DNAPLs?

The list of activities and chemicals listed in the storage DNAPL circumstances does not include all DNAPLs. However, the list was prepared based on the most common types of DNAPLs associated with this type of activity. Should a SPC wish to add new circumstances (chemicals) for the storage of DNAPL threat, that is not listed, they can submit their request to add this as a local threat.

¹ Coal tar is a by-product of blast furnace coke production. [Source: <http://www.epa.gov/nrmrl/pubs/600r09119/600r09119.pdf>]

² Coal tar creosote was commonly used to treat wood products. It is still used today in certain wood treating operations and as a component of roofing and road tars. [Source: <http://www.epa.gov/nrmrl/pubs/600r09119/600r09119.pdf>]