Drinking Water Source Protection Background Document
The Handling and Storage of Dense Non-Aqueous Phase Liquid
v.2 January 2011

Table of Contents

1. Definition 1

2. What causes this activity to be a drinking water threat? 2

3. Understanding the nature of the drinking water threat 9

4. Applicable legislation, policies and programs 9

5. Gaps in existing legislation, policies and programs 19

6. Policy considerations 20

Appendix A. Toxic Substances List Description of DNAPLs and Organic Solvents 24

Appendix B – Local Information on the Drinking Water Threat 31

Appendix C – Reference List 34

Appendix D – Additional Resources 36

NOTE TO THE READER

This document is one of eighteen background reports now under development by staff at various Conservation Authorities and Conservation Ontario in support of Source Protection Plan development. The final set of reports will cover all nineteen prescribed water quality threat types. Each report looks at the nature of one or more types of drinking water threat, describes the local occurrence ("is" and "would be") of those threats, assesses existing policies/programs, and introduces related 'policy concepts' for source protection planning. ***While every effort has been made to ensure the accuracy of the information in this document, it should not be construed as legal advice or relied on as a substitute for the legislation.***

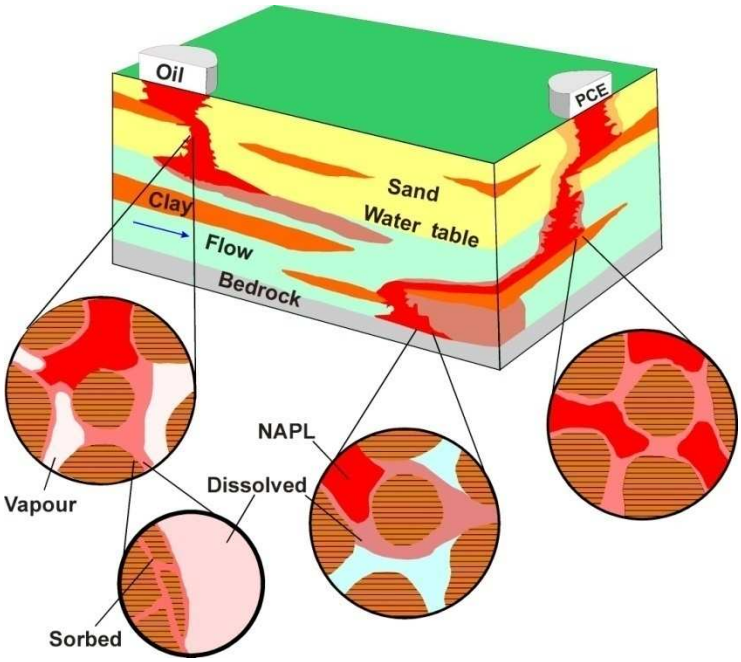
This version is considered to be a ***working draft*** because it will be going through additional review by MOE and subject experts. SPA/SPRs can use these documents with the understanding that additional refinement will occur. Any questions on these reports can be directed to Nicole Barbato, Source Water Protection Liaison (via nbarbato@conservationontario.ca). Thank you!

1. Definition

This paper provides background information for **<u>prescribed drinking water threat 16</u> – the handling and storage of dense non-aqueous phase liquid.**

The primary consideration for reducing or eliminating drinking water threats related to the handling and storage of a dense non-aqueous phase liquid (DNAPL) is to make sure it does not enter surface water and/or groundwater. A primary objective is to eliminate or manage significant drinking water threats such that they cease to be significant (i.e. manage the risk).

A DNAPL is a liquid that is denser than water and tends to be sparingly soluble in water. This means that the immiscible liquid(s) sink to the bottom of groundwater aquifers and surface water bodies as a separate phase liquid. DNAPL tend to be also characterized by their high solubility to toxicity ratio (i.e., $>10^3$ to 10^4). Once entrained in the groundwater column, the liquids will sparingly dissolve into the passing groundwater at a rate which is very much higher than potable drinking water standards creating a "contaminant plume". The slow solubilization of the contaminant mass suggests that the contaminating source can be present in the subsurface aquifer for decades to centuries before being depleted. The most prevalent types of DNAPL are chlorinated solvents since they were produced and used in large quantities in the 1960's through to the 1990's (i.e., hundreds of millions of kilogram per annum).



Other well-known DNAPLs tend to be recalcitrant and persist in the environment for long periods of time or bioaccumulate at receptor sites (i.e., polychlorinated biphenyls [PCBs] and polyaromatic hydrocarbons [PAHs]). Mercury is the heaviest DNAPL with a molecular weight ~14 times greater than water.

DNAPL will distribute quickly in the environment and then slow leach from the contaminating sources creating dissolve-phase contaminant plume downgradient of these sources. These plumes can extend kilometers in length and affect a large portion of the potable aquifer system. It is noted that the majority of the contaminating mass is not found in the significant groundwater contaminant plumes but sorbed to geologic media or present as a separate free-phase product in the geologic profile. The characteristics of some DNAPLs facilitate movement down infinitesimally small fracture planes in clays and bedrock environments. Thus, the vertical

penetration of DNAPLs can be quite deep and is not readily prevented by less pervious formations. This accounts for their "special" status in Source Water Protection evaluation (i.e., 5-year TOT [WHPA-C]).

DNAPLs, particularly those listed in the Ministry of the Environment (MOE) Tables of Drinking Water Threats (2008, as amended in 2009), have been readily used in vast quantities for decades in industrial and commercial applications such as dry cleaning, cleaning / degreasing solvents, electronics, aerosols, plastics, pesticides, pharmaceutics, wood preservation, asphalt operations, varnishes and the repair of motor vehicles and equipment. These chemicals can also be found in small quantities in common household products (ex., adhesives and cleaners).

2. What causes this activity to be a drinking water threat?

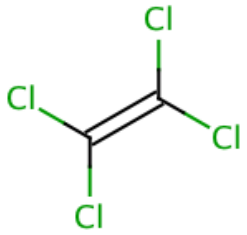
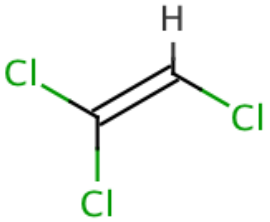
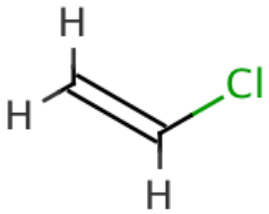
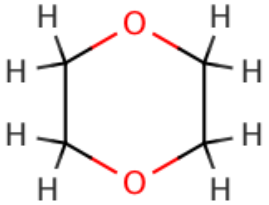
The MOE Tables of Drinking Water Threats (Ontario Ministry of the Environment, 2009) identify five (5) types of DNAPLs that could make their way into surface and groundwater as a result of a spill from the handling and/or storage of these chemicals (circumstances 102 to 111, 1098 to 1112, and 1225 to 1272 respectively). The following chemicals could threaten the safety of drinking water sources in certain situations.

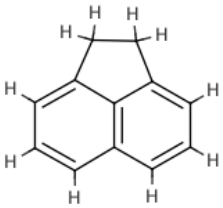
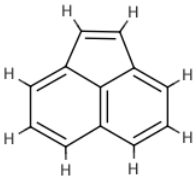
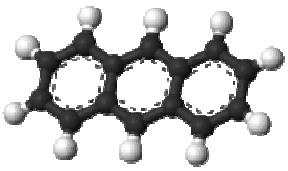
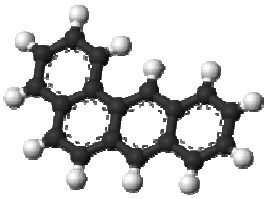
<u>DNAPLs:</u>

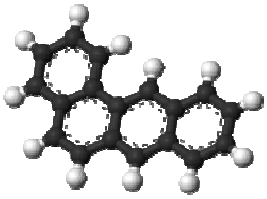
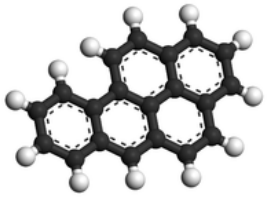
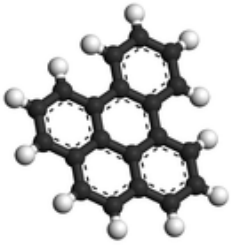
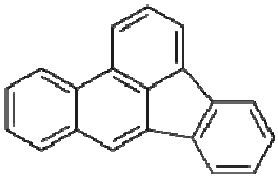
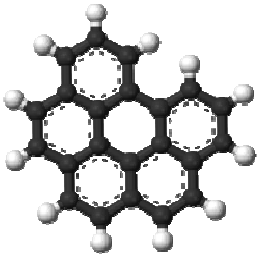
- 1,4-Dioxane
- Tetrachloroethylene (Perchloroethylene [PCE])
- Trichloroethylene [TCE]
- Vinyl Chloride [VC]
- Polycyclic Aromatic Hydrocarbons [PAHs]

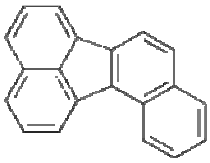
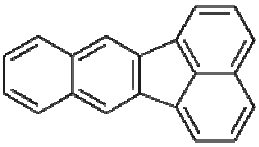
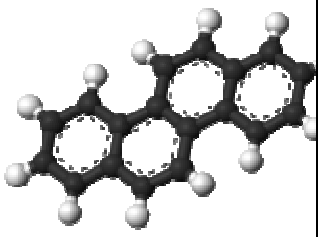
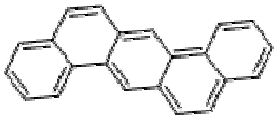
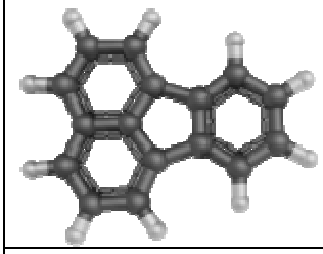
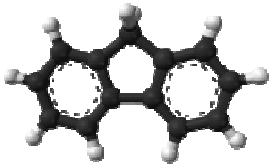
A Drinking Water Threat Contaminants Summary (see Appendix C) outlines some general information about these chemicals including potential sources. The Drinking Water Threat Contaminants Summary includes details on relevant drinking water standards, guidelines or objectives, the health or aesthetic concerns and other useful information for these parameters.

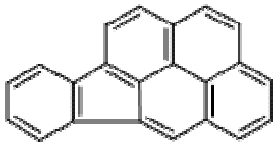
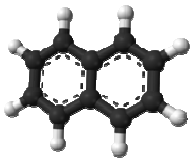
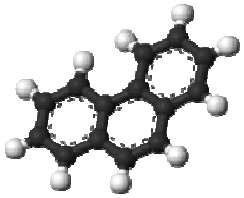
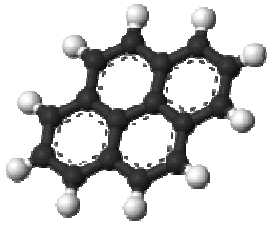
Table 1.0: Drinking Water Threat Contaminants

Contaminant	ODWQS (µg/L)	Standard Type	Comments
PCE 	30	Health	The solubility limit for PCE is 200,000 µg/L which makes the parameter ~6,600 times more soluble than the drinking water limit. PCE breaks down through reductive dechlorination to TCE and then dichloroethylene (DCE) and finally chloroethylene or vinyl chloride (VC). PCE was readily used in the dry cleaning industry, but has been replaced by more environmentally friendly products (see below)
TCE 	5	Health	The solubility limit for TCE is 1,100,000 µg/L which makes the parameter ~220,000 times more soluble than the drinking water limit. TCE was a widely used solvent for numerous applications. cis-DCE is also a regulated compound but tends to degrade relatively quickly to VC and therefore is not overly persistent.
VC 	2	Health	The solubility limit for VC is 2,700,000 µg/L which makes the parameter ~1,350,000 times more soluble than the drinking water limit. VC was a commercially-used solvent for numerous plastic applications. The reductive dechlorination process noted above tends to terminate at this parameter. Methodologies have been found to complete the reductive dechlorination process, albeit under engineered solutions
1,4-Dioxane 	N/A		This product was used primarily as a stabilizer in organic processing / handling. It reportedly is quite miscible (i.e., fully soluble at 20°C) and potentially fully miscible in water. USEPA sets the 1:1,000,000 risk factor at 0.35 µg/L. No drinking water limit currently exists. Interim values for site restoration were reported at 6.1 µg/L by USEPA (2004). MOE sets a background water quality at 50 µg/L and a site remediation target for ground water restoration at the same value (O.Reg. 511/09).

Polycyclic Aromatic Hydrocarbons (PAH)		
Overview PAHs are traditionally atmospheric pollutants (16 in total) that consist of fused aromatic rings (i.e., benzene ring structure) and do not contain side chains or other "substituents"[1]. PAHs occur in oil, coal, and tar deposits, and are produced as byproducts of fuel burning (whether fossil fuel or biomass). As a pollutant, they are of concern because some compounds have been identified as carcinogenic, mutagenic, and teratogenic. PAHs are found in most burnt substances due to incomplete combustion of organic materials (i.e., cooked foods). Studies have shown that high levels of PAHs are found, for example, in meat cooked at high temperatures such as grilling or barbecuing, and in smoked fish.		
Contaminant	ODWQS[2] (µg/L)	Comments
Acenaphthene 	N/A	There is no drinking water limit for this parameter. The USEPA has established an "ambient water quality" of 200 µg/L in the absence of health data on this compound. MOE sets a background water quality at 4.1 µg/L and a site remediation target for ground water restoration at the same value (O.Reg. 511/09). CCME[3] has set an aquatic health guideline of 5.8 µg/L. The experimental water solubility limit is 3,900 µg/L at 25°C.
Acenaphthylene 	N/A	There is no drinking water limit for this parameter. No interim guidelines were found for this parameter. MOE sets a background water quality at 1 µg/L and a site remediation target for ground water restoration at the same value (O.Reg. 511/09). The experimental water solubility limit is 16,100 µg/L at 25°C.
Anthracene 	N/A	There is no drinking water limit for this parameter. The BC MOE has established an "interim aquatic water quality" of 4 µg/L in the absence of health data on this compound. MOE sets a background water quality at 0.1 µg/L and a site remediation target for ground water restoration at 2.4 µg/L (O.Reg. 511/09). CCME has set an aquatic health guideline of 0.012 µg/L. The experimental water solubility limit is 40 µg/L at 24°C.
Benz[a]anthracene 	N/A	There is no drinking water limit for this parameter. The BC MOE has established an "interim aquatic water quality" of 0.1 µg/L in the absence of health data on this compound. MOE sets a background water quality at 0.2 µg/L and a site remediation target for ground water restoration at 1 µg/L (O.Reg. 511/09). CCME has set an aquatic health guideline of 0.018 µg/L. CCME lists this compound as a carcinogen. The experimental water solubility limit is ~10 µg/L at 25°C.

Contaminant	ODWQS (µg/L)	Comments
Benz[a]anthracene 	N/A	There is no drinking water limit for this parameter. The BC MOE has established an "interim aquatic water quality" of 0.1 µg/L in the absence of health data on this compound. MOE sets a background water quality at 0.2 µg/L and a site remediation target for ground water restoration at 1 µg/L (O.Reg. 511/09). CCME has set an aquatic health guideline of 0.018 µg/L. CCME lists this compound as a carcinogen. The experimental water solubility limit is ~10 µg/L at 25°C.
Benzo[a]pyrene 	0.01 Health	The federal drinking water limit for this parameter is the same as for the province. MOE sets a background water quality at 0.01 µg/L and a site remediation target for ground water restoration at the same value (O.Reg. 511/09). CCME has set an aquatic health guideline of 0.015 µg/L. CCME lists this compound as a carcinogen. The experimental water solubility limit is ~2 µg/L at 25°C.
Benzo[e]pyrene 		There is no drinking water limit for this parameter. No interim guidelines were found for this parameter. MOE has no limits for this particular compound. The experimental water solubility limit is ~2 µg/L at 25°C.
Benzo[b]fluoranthene 	N/A	There is no drinking water limit for this parameter. MOE sets a background water quality at 0.1 µg/L and a site remediation target for ground water restoration at the same value (O.Reg. 511/09). CCME lists this compound as a carcinogen. The experimental water solubility is ~2 µg/L at 25°C.
Benzo[ghi]perylene 	N/A	There is no drinking water limit for this parameter. MOE sets a background water quality at 0.2 µg/L and a site remediation target for ground water restoration at the same value (O.Reg. 511/09). CCME lists this compound as a carcinogen. The experimental water solubility is ~0.3 µg/L at 25°C.

Contaminant	ODWQS (µg/L)	Comments
Benzo[j]fluoranthene 		There is no drinking water limit for this parameter. No interim guidelines were found for this parameter. MOE has no limits for this particular compound. CCME lists this compound as a carcinogen. The experimental water solubility is ~2 µg/L at 25°C.
Benzo[k]fluoranthene 	N/A	There is no drinking water limit for this parameter. MOE sets a background water quality at 0.1 µg/L and a site remediation target for ground water restoration at the same value (O.Reg. 511/09). CCME lists this compound as a carcinogen. The experimental water solubility is ~2 µg/L at 25°C.
Chrysene 	N/A	There is no drinking water limit for this parameter. MOE sets a background water quality at 0.5 µg/L and a site remediation target for ground water restoration at the same value (O.Reg. 511/09). CCME lists this compound as a carcinogen.). CCME lists this compound as a carcinogen. The experimental water solubility is ~5 µg/L at 25°C.
Dibenz[a h]anthracene 	N/A	There is no drinking water limit for this parameter. MOE sets a background water quality at 0.1 µg/L and a site remediation target for ground water restoration at the same value (O.Reg. 511/09). CCME lists this compound as a carcinogen. The experimental water solubility is ~3 µg/L.
Fluoranthene 	N/A	There is no drinking water limit for this parameter. MOE sets a background water quality at 0.5 µg/L and a site remediation target for ground water restoration at the same value (O.Reg. 511/09). The experimental water solubility is ~260 µg/L at 25°C.
Fluorene 	N/A	There is no drinking water limit for this parameter. MOE sets a background water quality at 120 µg/L and a site remediation target for ground water restoration at the same value (O.Reg. 511/09). The experimental water solubility is ~1,690 µg/L at 25°C.

Contaminant	ODWQS (µg/L)	Comments
Indeno[1 2 3-cd]pyrene 	N/A	There is no drinking water limit for this parameter. MOE sets a background water quality at 0.2 µg/L and a site remediation target for ground water restoration at the same value (O.Reg. 511/09). CCME lists this compound as a carcinogen. The experimental water solubility is ~0.2 µg/L at 25°C.
Naphthalene[5] 	N/A	There is no drinking water limit for this parameter. MOE sets a background water quality at 7 µg/L and a site remediation target for ground water restoration at 11 µg/L (O.Reg. 511/09). Some states have provided an interim MCL[3] / HAL at 100 to 150 µg/L. The experimental water solubility is ~31,110 µg/L at 25°C.
Phenanthrene 	N/A	There is no drinking water limit for this parameter. MOE sets a background water quality at 0.1 µg/L and a site remediation target for ground water restoration at 1 µg/L (O.Reg. 511/09). Florida has imposed a HAL of 210 µg/L. The experimental water solubility is ~1,150 µg/L at 25°C.
Pyrene 	N/A	There is no drinking water limit for this parameter. MOE sets a background water quality at 0.2 µg/L and a site remediation target for ground water restoration at 4.1 µg/L (O.Reg. 511/09). The experimental water solubility is ~135 µg/L at 25°C.

Notes:

[1] The United States Environmental Protection Agency (EPA) has designated 32 PAH compounds as priority pollutants. The original 16 are are naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]flouranthene, benzo[a]pyrene, dibenz(ah)anthracene, benzo[ghi]perylene, and indeno(1,2,3-cd)pyrene.

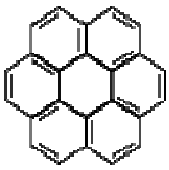
[2] ODWQS – Ontario Drinking Water Quality Standard (O.Reg. 169/03)

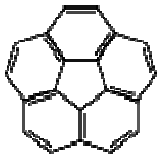
[3] CCME – Canadian Council of the Ministers of the Environment CCME provides for a methodology where suspected carcinogens are ranked in terms of benzo(a)pyrene (BAP) toxicity equivalence to provide an equivalent BAP ranking for a given soil / water quality since many PAHs are often found together.

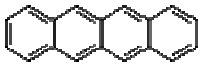
[4] MCL – Maximum Concentration Limit (USEPA terminology)
HAL – Health Advisory Limit (state terminology)

[5] Naphthalene is not always considered a PAH

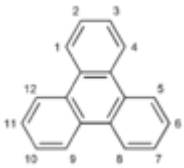
Other PAHs compounds

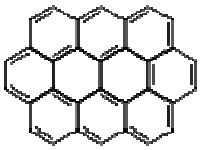
Coronene 

Corannulene 

Tetracene 

Pentacene

Triphenylene 

Ovalene 

The listed DNAPL compounds can be broadly subdivided into two or three groupings consisting of: chlorinated solvents (i.e., PCE, TCE, VC); solvents (1,4-Dioxane) and PAHs. The characteristics of these compounds and their influence on the environment vary considerably. Solvents are identified because of their mobility in the environment. These particular compounds having historically been produced in large quantities are of particular concern. In contrast, PAHs are relatively immobile in the environment, but are recalcitrant and unlikely to breakdown over time even when measured in years and decades. Another significant difference between these two classes of compounds is their solubility in water. PAHs are marginally soluble (see Table 1.0) whereas the solvents tends to be much more soluble in an aqueous environment. However, both classes of DNAPL pose health issues in a dissolved state.

It is assumed that the solvents noted about are being dealt with as a “pure” product as opposed to a trace element in a mixture. For example, 1,4-Dioxane does not need to be considered when present in trace quantities (i.e., shampoo, cosmetics). Consider that 1,4-Dioxane has a relative density of 1.033 meaning that it is marginally more dense than water in its pure phase form. As a trace constituent in products this attribute is lost and therefore does not constituent the DNAPL designation that the pure-phase product has. This is noted despite the fact that there are no volumetric limits on the consideration of DNAPL sources.

PAHs are commonly associated with coal tar as a product but represent carbon compounds commonly found in incomplete combustion reactions. This is noted since the PAHs can be found throughout the environment as combustible by-products (i.e., soot, smoke) but in this form it is suggested that the PAHs do not possess the DNAPL properties that coal tar does in moving through the environment. Thus, PAHs when produced in trace quantities from combustion processes (i.e., a bonfire, BBQ, cigarette, car emissions) need to be differentiated from DNAPL liquids containing PAHs.

3. Understanding the nature of the drinking water threat

As indicated above, the majority of DNAPLs are used in industrial and commercial applications. These chemicals can also be found in small quantities in common household products such as paints, adhesives, and have been present historically in even smaller / trace quantities in other products (i.e., shampoo, cosmetics), having been significantly phased out of such products over recent times.

Staff have assumed that DNAPLs are currently handled and stored in the majority of the vulnerable areas, and that this activity can occur in all of the vulnerable areas in the future.

DNAPLs

The MOE's Tables of Drinking Water Threats (2008, as amended in 2009) classifies the handling and storage of a DNAPL as a significant, moderate or low drinking water threat is dependent on its specific location (vulnerability score) and whether it is handled and stored above or below grade.

This handling and storage of DNAPLs is or would be a significant drinking water threat in wellhead protection areas (WHPA) A, B and C. It is or would be either a moderate or low drinking water threat in the other vulnerable areas.

4. Applicable legislation, policies and programs

The majority of information found on legislation, policies and programs generally relate to the prevention of pollution related to the handling and storage of DNAPLs. Pollution prevention is an important measure in reducing the risk to drinking water associated with these activities. This is noted since the cost to remediate a DNAPL spill / release is drastically larger than the cost to implement pollution prevention system(s). Consider that the USEPA has historically considered the cleanup of most major DNAPL sites "technically impracticable". Emerging site restoration technologies are currently grappling with such challenges. Some technologies are commercially-available but are extraordinarily expense to implement. This is markedly different than several years ago when no technologies existed that could effectively restore such sites (prompting the "technically impracticable" designation by the USEPA).

a) Federal

Canadian Environmental Protection Act (Government of Canada, 1999)

The *Canadian Environmental Protection Act* 1999 (CEPA) gives the federal government the authority to protect the environment and public health from risks associated with pollution and dangerous substances. Environment Canada and Health Canada are responsible for assessing

threats posed by these substances and for undertaking risk reduction measures. Unless otherwise specified, the information in this section was extracted from the CEPA Environmental Registry websites (See Appendix D for a weblink to the site).

The Priority Substances List identifies substances that need to be assessed to determine whether they are toxic, and if they pose a risk to human health or to the environment. The majority of the DNAPLs of interest to the drinking water source protection initiatives are on the Priority Substances List. Of those substances that were assessed, the majority of them were determined to be toxic and were placed on the Toxic Substances List (see Appendix A).

The Toxic Substances Management Policy addresses how substances on the Toxic Substances List are to be managed. There are two tracks of substances. The intent is to virtually eliminate Track 1 substances from the environment. These substances result predominantly from human activity, and are persistent and bioaccumulative (i.e. they build-up in fatty tissues). Track 2 substances are to be managed throughout their entire life cycles (i.e. development to disposal) to prevent or minimize their release into the environment. The toxic substances of interest to our project require full life cycle management.

A number of risk management tools have been developed by Environment Canada for specific substances including:

- Sector regulations
- Notices requiring the preparation and implementation of pollution prevention plans
- Environmental performance agreements
- Codes of practice
- Recommendations on the design and operation of facilities

Sector Regulations

Some industries that use specified chemicals are regulated in order to manage the life cycle of the chemical. Regulations of interest include:

- Vinyl Chloride Release Regulation (Government of Canada, 1992) – limits the release of vinyl chloride from vinyl chloride plants and polyvinyl chloride plants; requires plans to control fugitive emissions and contingency plans; requires reporting to Environment Canada.

- Solvent Degreasing Regulations (Government of Canada, 2003) – applies to degreasing operations who use more than 1000 kg of trichloroethylene (TCE) and tetrachloroethylene (PCE) each year; froze consumption then required a 65% reduction in consumption; requires annual reporting to Environment Canada. These regulations would most likely apply to big industry (such as manufacturing).

- Tetrachloroethylene (Use in Dry Cleaning and Reporting Requirements) Regulations (Government of Canada, 2003)– applies to owners and/or operators of dry-cleaning machines or facilities that use PCE, and to sellers, importers and recyclers of PCE. For dry-cleaning operations, the regulation restricts the use of PCE, requires containment systems and waste water management, record keeping and annual reporting to Environment Canada.

Pollution Prevention Plans

Pollution prevention planning is a process that examines current operations and develops a plan to eliminate or reduce pollution at the source. The Pollution Prevention Planning Handbook (Environment Canada, 2001) was developed to help persons subject to a Pollution Prevention Planning Notice (mandatory implementation) and persons looking to voluntarily implement pollution prevention practices in their organization. For the chemicals of interest to source water protection, notification for pollution prevention planning has been made for dichloromethane (DCM) where greater than 1000 kg is used per year for aircraft paint stripping, flexible polyurethane foam blowing, industrial cleaning, or adhesives formulation activities.

The plan involves a six step process:

1. Establish a commitment to pollution prevention
2. Conduct a baseline review of business and processes
3. Develop a plan that sets objectives and targets, and identifies, evaluates and selects options
4. Implement the plan
5. Monitor implementation
6. Evaluate, review and improve the plan

According to Environment Canada (2001), the most common and effective pollution prevention practices are:

- Product design and reformulation
- Equipment modifications and process changes
- Materials and feedstock substitution
- Operating efficiencies and training
- Purchasing techniques and inventory management
- On-site reuse and recycling
- Co-operative pollution prevention action between facilities

Environment Canada maintains an on-line database of pollution prevention resources that can be used to prepare a pollution prevention plan (Canadian Pollution Prevention Information Clearinghouse – see Appendix D for weblink). The database includes measures related to the handling and storage of chemicals.

Environmental Performance Agreements (Environment Canada, 2001)

Environmental Performance Agreements can be used to achieve specified environmental results that are significant and measurable, such as reducing the use and emission of substances on the CEPA Toxic Substances List (Environment Canada, 2001). Environment Canada can negotiate an agreement with a variety of parties ranging from a single company to sector associations. Other federal departments, provincial and municipal governments and non-governmental organizations may also be parties to these agreements.

An example of an Environmental Performance Agreement is the 2001 Memorandum of Understanding with the Chemistry Industry Association of Canada (CIAC) to reduce the release of volatile organic compounds (VOCs) through voluntary, non-regulatory action under the CIAC Responsible Care program by encouraging and publicly recognizing progress on the part of the CIAC and its member companies. The member companies reduced their VOC emissions in one year to meet the set target.

Codes of Practice

Codes of practice identify and describe best management practices that can be used by specific industries to conserve the use of a particular chemical and minimize environmental releases. The implementation of codes of practice is voluntary.

There is a code of practice for commercial furniture refinishing and other stripping applications that use paint strippers containing dichloromethane (Environment Canada, 2003). This code identifies measures such as manual stripping, the use of low dichloromethane-containing strippers, capture and reuse of stripper. Codes of practice also exist for commercial and industrial degreasing facilities, dry cleaning facilities, and vinyl chloride manufacturing.

Responsible Care Program

The Responsible Care program is a global voluntary initiative of the chemical industry that is implemented in Canada by the Chemistry Industry Association of Canada (CIAC) – see link to program in Appendix D. The intent of the program is to continuously improve the health, safety and environmental performance of companies, and to communicate with stakeholders about chemical products and processes (Responsible Care, 2010). It involves information sharing and support networks, and a rigorous system of checklists, performance indicators and verification procedures.

b) Provincial

Toxics Reduction Act (Government of Ontario, 2009)

Ontario has a Toxics Reduction Strategy that is focused on managing and reducing the use and creation of toxic substances to improve the protection of the environment and human health,

and on informing Ontarians about toxic substances. This strategy is enacted through the *Toxics Reduction Act*, 2009.

Ontario Regulation 455/09 – General, made under the Act, applies to about 2000 facilities at which manufacturing activities or mineral processing activities take place involving toxic substances in the form specified in Schedule 1 of the National Pollution Reporting Inventory (NPRI) Notice (see the Industrial Sewage Report for more information on NPRI). These facilities are required to prepare toxic substance reduction plans; however, implementation of the plans is voluntary. The majority of these facilities do not likely use or create tetrachloroethylene, trichloroethylene, and vinyl chloride, which are on the list of toxic substances regulated under O. Reg. 455/09. Their actions related to these substances must be reported annually to MOE and to the public (Government of Ontario, 2009).

Environmental Protection Act: Regulation 347 General – Waste Management (Government of Ontario, 1990)

In general, waste storage facilities must comply with the *Environmental Protection Act* and Regulation 347 General – Waste Management. Under the Regulation, spent DNAPLs are considered to be hazardous wastes that must be managed throughout their life cycles: collection, storage, transportation, treatment, recovery and disposal. These considerations are necessary to reduce adverse effects to human health and to the environment.

Environmental Protection Act (Government of Ontario, 1990)

Part X of the *Environmental Protection Act* outlines the required reporting and clean up of spills. The discharger is required to contact the MOE Spills Action Centre and the municipality in which the spill occurs. He or she is also required to contain and clean up the pollutant as quickly as possible under the circumstances, or arrange for these actions to be carried out, and to restore the spill site to pre-spill conditions (Environment Canada and United States EPA, 2001).

Details on spills reporting are outlined in Spills Reporting - A Guide to Reporting Spills and Discharges (Ontario Ministry of the Environmental, 2007). Ontario Regulation 675/98 - Classification and Exemption of Spills and Reporting of Discharges exempts persons who have developed spill prevention and contingency plans from having to report certain spills to the Spills Action Centre (Government of Ontario, 1998). The exemption can be removed under certain circumstances, such as if certificates of approval are revoked. The table summarizing the exemptions from the above guide is included in the Reference Materials.

Table 4.1 – Classification and Exemption of Spills (Ontario Regulation 675/98)

Class	Details
Approved Discharges	• Authorized with a certificate of approval, order, licence or permit
Water from Reservoirs and Water Mains	• Where discharge is caused by natural events or part of operations
Household Fires	• Discharge of pollutants from a fire representing 10 of fewer households
Planned Spill	• Consented to by the Director
Refrigerants	• Spill of refrigerant to which Ontario Regulation 189/94 applies
Motor Vehicles	• Spill of not more than 100 L of fluid (other than fluid transported as cargo) • Does not enter and is likely not to enter any waters • Does not cause and is not likely to cause any adverse effects • Arrangement for the remediation are made and carried out immediately
Electrical Utilities	• Spill of not more than 100 L of mineral oil from electrical transformers or capacitors excluding PCB liquids • Does not enter and is likely not to enter any waters • Does not cause and is not likely to cause any adverse effects • Arrangement for the remediation are made and carried out immediately
Petroleum Sector	• Spill of gasoline or an associated product defined in Ontario Regulation 217/01 (Liquid Fuels) • not more than 100 L in areas restricted from public access, or • not more than 25 L in area with public access • Does not enter and is likely not to enter any waters • Does not cause and is not likely to cause any adverse effects • Arrangement for the remediation are made and carried out immediately

Class	Details
Transport of Dangerous Goods	• a spill of a material under those circumstances that, but for the quantity discharged, make the spill subject to immediate notification requirements under the Transportation of Dangerous Goods Act, 1992 (Canada) or the Dangerous Goods Transportation Act and the regulations under those Acts if the quantity spilled is less than the minimum reportable quantity specified in the Transportation of Dangerous Goods Regulations under the Transportation of Dangerous Goods Act, 1992 (Canada) • Does not enter and is likely not to enter any waters • Does not cause and is not likely to cause any adverse effects • Arrangement for the remediation are made and carried out immediately
Non-Reportable Spills	• a spill that, immediately before it occurs, is identified as "non-reportable" under subsection 6 (2) of Ontario Regulation 224/07 (Spill Prevention and Contingency Plans) made under the Act, in spill prevention and contingency plans that satisfy the requirements of that regulation. O. Reg. 225/07, s. 5 • Does not enter and is likely not to enter any waters • Does not cause and is not likely to cause any adverse effects • Arrangement for the remediation are made and carried out immediately
One Window Reporting	• A spill that is reportable to a provincial or federal agency

The requirements for spill prevention and contingency plans are detailed in Ontario Regulation 224/07 (Government of Ontario, 2007). The plans could apply to spills on the property; and specifies what types of on-site spills must be reported to Spills Action Centre. All spills that egress off property must be reported.

Spills Action Centre

The Ontario Ministry of the Environment (MOE) is the lead provincial agency for environmental emergencies. Guideline G-2 Ontario Spills Action Centre Operations (Ontario Ministry of the Environment, 1994) indicates that MOE operates the Spills Action Centre (SAC) which was established under the *Environmental Protection Act* to:

- maintain a province-wide, toll-free service for receiving, evaluating and initiating responses to notifications of spills and other urgent environmental matters that require immediate reporting to MOE on a 24-hour basis;
- serve as a provincial focal point for activities dealing with spills and related emergencies;
- liaise with other agencies on spills and related emergencies;

- maintain a provincial spill database for the Ministry; and,
- provide contingency planning functions and related spill response training.

In addition to receiving reports of spills, SAC is responsible for determining the adequacy of reported spills response activities, facilitating or triggering a response where it appears the response is inadequate, and activating an Ministry field response (on-site assessment), as required (Ontario Ministry of the Environment, 2007). MOE is expected to notify other agencies in a timely manner, and assists in warning "downstream" users or potentially affected parties. SAC Operating Procedure Cards, which are routinely updated, contain decision process guidelines for co-ordinating responses and for notifying other agencies, as required.

There are three levels of MOE field response to a spill (Environment Canada and United States EPA, 2001; Ontario Ministry of the Environment, 2007). The Level I District Response involves an initial site assessment and an analysis of the data available to determine what further actions or assistance are required (up to 2 hours after hours) after the spill. The Level II Regional Response involves providing additional support staff, equipment and expertise, providing air or water monitoring, modeling, and analysis, and continuing to provide direct advice on appropriate response and cleanup techniques (up to 4 hours after hours) after the spill. The Level III Head Office Response is to deploy a Trace Atmospheric Gas Analyzer (TAGA) Unit to conduct highly sophisticated air quality surveys for the environmental emergency. In rare cases, the MOE may have to exercise the statutory options available to the MOE for pre-empting an inadequate response.

<u>Environmental Protection Act: Ontario Regulation 323/94 – Dry Cleaners (Government of Ontario, 1994)</u>

Under O. Reg. 323/94 – Dry Cleaners, there must be at least one full-time trained employee at commercial establishments that operate dry cleaning equipment. This trained employee must have successfully completed a course in the management of solvents and wastes in connection with the operation of dry cleaning equipment. The Dry Cleaner Certification Program is offered by MOE and Seneca College in class and through distance learning.

<u>Guidelines for Environmental Protection Measures at Chemical and Waste Storage Facilities (Ontario Ministry of the Environment, 2007)</u>

The Guidelines for Environmental Protection Measures at Chemical and Waste Storage Facilities are intended to be used by Ontario Ministry of the Environment (MOE) staff to develop certificate of approval conditions or to promote environmental protection measures at facilities arising from inspections and in response to environmental incidents. The guidelines would also be used to assess existing storage equipment and/or spill containment provisions against a set of best practices to determine whether the design and operation of a facility presents an unacceptable risk or may result in an adverse effect. The guidelines cover a variety of topics including tank requirements, secondary containment, inspections and monitoring, and emergency preparedness.

MOE Pollution Prevention Office

The Ministry of the Environment has an office dedicated to the promotion of pollution prevention. The office has four main programs: Pollution Prevention Partnerships (memorandums of understanding between MOE and industrial associations, private companies, environmental organizations and municipalities), the Pollution Prevention Pledge Program (encourages the adoption of pollution prevention measures and rewards success), education and training support, and leadership initiatives (see weblink to program in Appendix D).

Ontario's Environmental Leaders Program

The Environmental Leaders program is a free voluntary initiative that offers incentives to companies that make future commitments to go beyond compliance with their environmental improvements (see weblink to program in Appendix D). The companies must have an environmental management system, a good environmental compliance record and commit to going beyond compliance with pollution reduction targets. The program has a five year term in which members complete their commitments, such as reducing pollution associated with waste water discharges.

The types of incentives available include: front-of-the-line approvals, meetings with senior ministry officials, expedited approvals for new technologies, reduced environmental penalties, enhanced comprehensive certificates of approval.

Best Management Practices for Industrial Sectors

A number of documents have been prepared for the Ministry of the Environment that describe various best management practices (BMPs) to achieve pollution prevention and a reduction of specific contaminants that may be present in the effluent discharges of specific facilities. The sectors that are targeted include: textiles, fabricated metal products, motor vehicle parts manufacturing, automotive repair and maintenance, dry cleaning and laundry services, and chemical manufacturing. Since most of the contaminants that are considered in the BMP documents are listed in the MOE Tables of Drinking Water Threats, these documents could provide examples of effective risk management measures for drinking water threats.

Ontario Fire Code (Office of the Fire Marshall, 1997)

The Ontario Fire Code contains specifications for fixed storage tanks (capacity greater than 230 L) containing flammable or combustible liquids that generally apply to existing development. The specifications include setbacks from buildings and property lines, clearance, and fire department access. This Code may not be implemented consistently across municipalities depending on their available resources (e.g. staff, time, funding).

c) Municipal

Land Use Planning

Large volumes of DNAPLs would generally be located at a manufacturing industry. These types of activities are generally permitted on lands that are zoned for industrial uses. Future industrial land uses ('would be' threats) would likely occur in the same location as existing industries because these are the only locations zoned for this use in our municipalities. Municipalities have strict control over where these activities can occur within their municipal boundaries, and the majority of IPZs and WHPAs are in established settlement areas that would not accommodate an industrial use of this nature.

Smaller volumes of DNAPLs may be stored and used at establishments such as automotive or other mechanical repair shops, dry cleaners, and retail stores.

Sewer Use By-laws

Municipalities can regulate waste water services and discharges to municipal sewers through sewer use by-laws. These by-laws generally apply to industrial, commercial and institutional establishments. Sewer use by-laws may include requirements for compliance programs and pollution prevention planning. As an example, the City of Toronto Municipal Code Chapter 681 (sewers) requires specific sector industries that discharge specific pollutants to prepare a detailed six-year pollution prevention plan unless the industry continually meets the requirements and is participating in a Best Management Practices Plan approved by Council. A pollution prevention plan must include a description of the processes that use or produce the pollutants; the types, quantities and concentrations of pollutants discharged to a sewer; current waste reduction, recycling, waste treatment and prevention activities with respect to sewer discharges; description and evaluation of pollution prevention options; and a list of three- and six-year targets to reduce or eliminate the discharge of pollutants to the sewers.

Where a municipality requires a pollution prevention plan related to pollutant discharge to a sewer, it may be easier to gain acceptance for other activities such as the handling and storage of chemicals to also be included in a pollution prevention plan.

d) Other jurisdictions

Pollution Prevention Resource Exchange

The Pollution Prevention Resource Exchange was created by the United States Environmental Protection Agency. It is a network of eight regional pollution prevention information centers that is intended to provide easy to access, high quality pollution prevention information that promotes waste reduction throughout the United States (see Appendix D for a weblink). The exchange maintains a comprehensive collection of pollution prevention resources and case studies that can be used to select pollution prevention measures for specific activities.

Region of Waterloo

The Region of Waterloo has been actively involved in source water protection for almost twenty years through its Water Resources Protection Master Plan (2008) and the implementation of community-wide programs (see weblink in Appendix D).

The Business Water Quality Program (from 2001 to 2005) provided financial incentives to businesses to prevent spills to groundwater, surface water and sewers. Grants (50% cost-share) were made available for projects such as secondary containment structures for waste oils, spill kits, and employee training programs. The program was funded by the Region of Waterloo, Environment Canada and the Ontario Ministry of the Environment. A steering committee made up of local businesses and government representatives helped to develop and market the program. The program was managed by an outside agency, the Ontario Centre for Environmental Technology Advancement (now part of Canadian Pollution Prevention Centre), to preserve confidentiality and maximize links with other similar programs.

The Region also had a series of water pollution prevention fact sheets for specific activities, such as fabricated metal product manufacturing, that discussed topics such as the handling and storage of organic solvents.

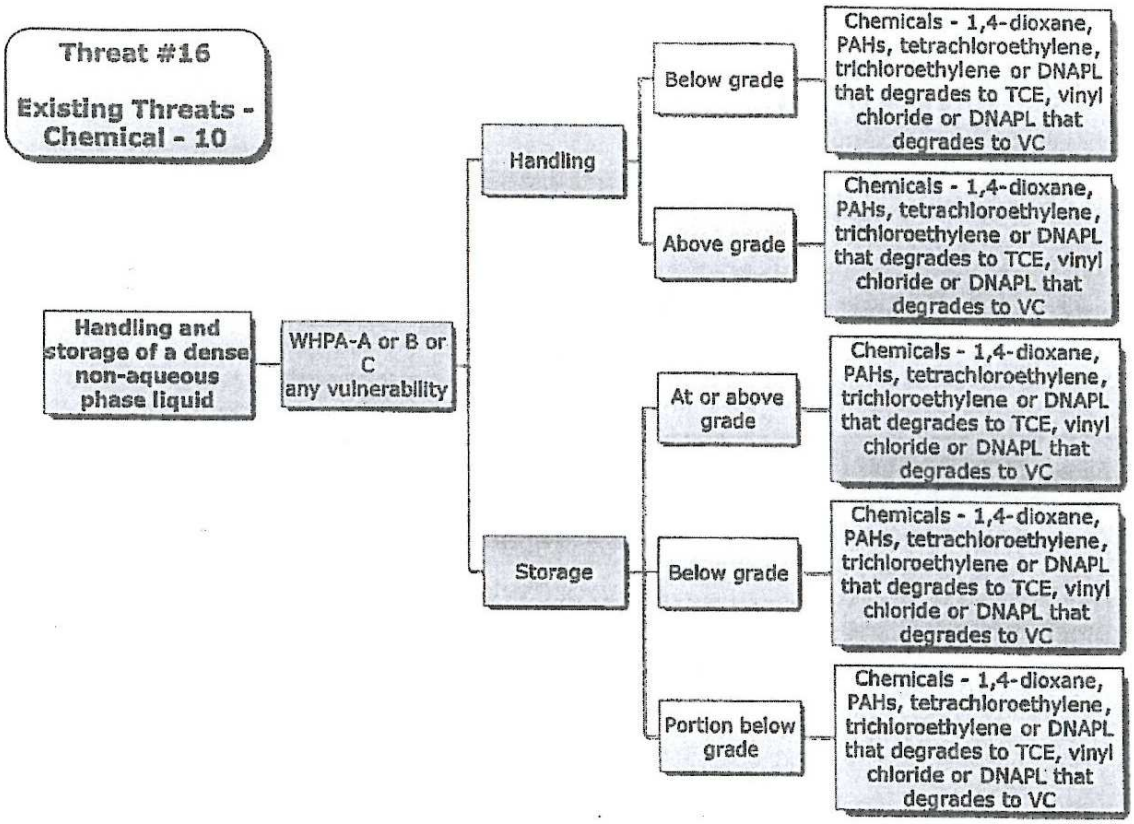
5. Gaps in existing legislation, policies and programs

- Research to-date suggests that there are limited regulatory requirements for the handling and storage of specific chemical classes (as they pertain the environment), with the exception of certain chemicals (e.g. tetrachloroethylene) or land uses (e.g. dry cleaners). Pollution prevention planning is a major factor in managing the risk associated with these activities.
- It is also noted that current chemical uses and trends tend to preclude these identified compounds (contaminants of concern) as discussed in Appendix A.
- The evaluation of “conditions” in the environment is also considered to be an extremely costly undertaking with a fair degree of risk (i.e., re-mobilizing contaminant mass in source areas). Often little is known about the source(s) / release locations or the quantity of product lost / remaining in the environment (e.g., due to the partitioning of the contaminant in the environment [i.e., the dissolved-phase plume contains little of the total contaminant mass]). Small degrees of heterogeneity in the environment can promulgate a significant shift in the product movement in the subsurface. The level of investigation typically undertaken in the commercial sector does not consider this level of detail and therefore information obtain is general considered to be rudimentary (despite the sophistication of the investigation techniques that can be employed).
- Considerable caution needs to be exercised in evaluating DNAPL source areas so not to move the contaminants deeper into the subsurface. The intrusive nature of site investigation work has lead to the conclusion by researchers that work within these areas should be limited to the extent possible or precluded all together.

- Another consideration is whether there is a "threshold" volume under which to consider environmental release of DNAPL products. Is it necessary to protect against a spill of 1 L or 10 L or 100 L? For other threats (i.e., solvents and fuels) the MOE has established minimum threshold volumes for consideration. Similarly, exemptions to "spills" exist in the legislation under certain circumstances and volumetric size (i.e., Ontario Regulation 675/98 - Classification and Exemption of Spills and Reporting of Discharges – see Appendix B).
- Given this propensity for vertical migration it is also question whether there is a need to distinguish between above grade and below grade systems since virtual no substantial mass may be required to migrate 10 m or more into the subsurface under a variety of environmental settings.

6. Policy considerations

The attached flow chart outlines the threat requirements associated with DNAPL storage and handling. The organization is similar to that of fuels in the there is a differentiation between above ground and below ground storage and handling of these liquids. Similarly, the threat can be address from a handling perspective which can be different than that from a storage perspective. The storage of DNAPL (and/or solvents) liquids is not covered by TSSA as are fuels,



although for all practical purposes the mechanics of this process / operation are essentially the same (see Appendix B for regulatory authority). Thus, the mandatory safeguards afforded fuel handling and storage through the Fuel Handling Act is not subject to chemical storage facility. A notable difference between DNAPLs and solvents and fuels is the absence of specific volumetric limits. No such limits exist with DNAPLs possibly due to the fact that even relatively small releases can migrate relatively deep within the subsurface.

- REMINDER: The primary consideration for reducing or eliminating drinking water threats related to the handling and storage of a DNAPL is to make sure it does not enter surface water and/or groundwater.

- Each section of the source protection plan will need to include a high-level policy approach ("a catch-all policy") to address those "would be" significant drinking water threats that are unlikely to occur in a given vulnerable area. For example, a general policy may be appropriate in a residential setting even if it is unlikely that large quantities of DNAPL would be stored there.

- There are challenges in developing an effective strategy to address specific situation such as a process change that would introduce such a chemical into an existing manufacturing area that is dealing with SWP issues. However, given the trend away from such chemical uses this may be an academic exercise.

- There is no effective means to regulate a use but it is possible to regulate land use (i.e., manufacturing) on the environmental landscape.

- It is also question how rigorous the policy development process needs to be in addressing this or other related issues. For example, should a Risk Management Official (RMO) be allowed to negotiate an acceptable Risk Management Plan (RMP) or should sufficient safeguards be put in place to ensure the RMP is restricted (i.e., maximum allowable storage vessel or storage vessel leak safeguards [secondary confinement / routine monitoring]).

- Outstanding issue(s) exist with whether specific transport "corridors" should prohibit the movement of certain chemicals in order to safeguard WHPA areas.

<u>Examples of risk management measures and policy ideas</u>

For discussion purposes, this section of the report provides examples of risk management measures and policy ideas that could be applicable to the management of DNAPL fluids. It is not an exhaustive list.

The examples are categorized by the types of policy tools that can be used to meet the source protection plan objectives. The MOE Water Quality Risk Management Measures Catalogue (Version 2, 09/07/2010) was reviewed as part of this exercise and measures were incorporated

where appropriate. The "Catalogue" suggests that the maximum separation distance between a DNAPL source and wellhead is desirable along with a pro-active long-term operation / preventative maintenance program preferably with monitoring sources.

Table 6.1 - Examples of risk management measures and policy ideas for DNAPLs and organic solvents

Policy Tool	Examples
Education and Outreach	• Educate businesses about the importance of proper hazardous waste disposal. • More and better advertising of local hazardous waste collection days, especially in smaller municipalities, for household products. • Encourage businesses (especially smaller ones) to dispose of hazardous waste properly. • Foster local chemical manufacturing association that will promote BMPs within the industry. • Educate associated industries such as the insurance sector to promote BMPs within the industry and reflect in their premiums. • Advertise entry into significant WHPA / IPZ zones and vulnerable areas (i.e., road signs)
Incentive Programs	• Grant program for projects such as: o process / technology review / revision evaluations, o relocation of chemical storage, o secondary containment, o reducing individual tank volumes, o replacing UST for AST, o employee training.
Land Use Planning	• Revise existing municipal zoning plans that are not in keeping with vulnerable area designation under SWP. • Revise and/or develop "alternative" corridor access routes around / into designated areas and enforce by-law action(s). • Incorporate SWP elements into future municipal service expansion plans • Develop longer-term servicing alternatives to eliminate existing vulnerable WHPA / IPZ systems • Encourage municipalities to enact floor drain by-laws or sewer use-by-laws, conduct inspections to make sure that floor drains are not connected to sanitary and/or storm sewers, and that there is proper disposal.

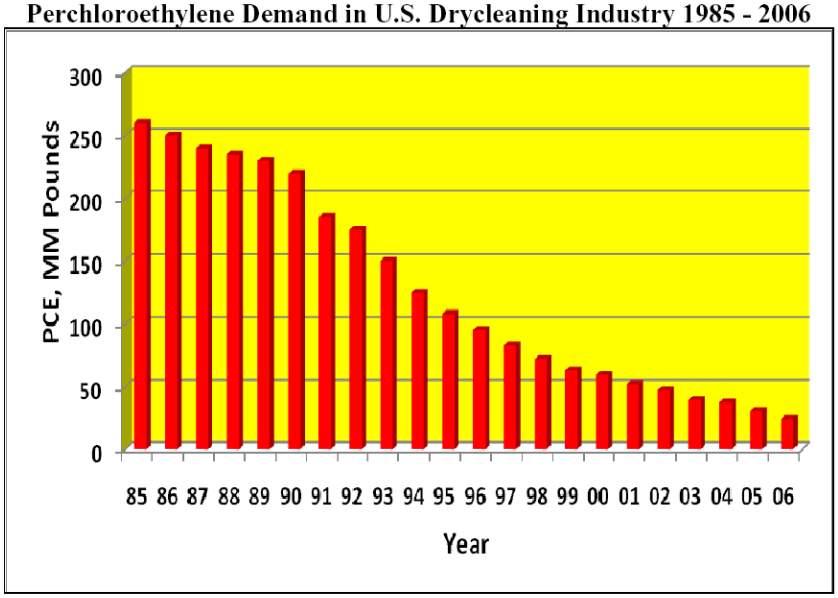
Policy Tool	Examples
Land Use Planning (Future)	• Prohibit the types and sizes of land uses that would handle and store DNAPLs in volumes that would make the activity a significant drinking water threat. • Require minimum standards for liquid chemical storage such as secondary containment throughout the storage and delivery process and active monitoring / reporting and expiration dates for containment vessels similar to that currently in place for fuels. • Establish enhanced building requirements for identified vulnerable areas such as prohibiting UST above specific sizes (or all together) and limiting liquid chemical storage tank sizes. • Challenge / remove illegal property-use changes which introduce these potential threats into identified vulnerable areas
Prescribed Provincial Instruments	• Use instruments to establish minimum standards should they ever come into existence under new legislation for this threat type. • Use instruments to establish minimum performance monitoring requirements should they ever come into existence under new legislation for this threat type.
Municipal Operations / Infrastructure	• Establish protocol that will flag new development in specified areas for risk evaluation concerning SWP (i.e., mandatory RMO review) and require this additional assessment as part of any new development scheme in such areas. • Establish independent "sentry" well monitoring system in WHPA areas that would trigger evaluation and action(s) of specific chemical detections • Establish contingency plan / system redundancy in the event that the system operation(s) had to be curtailed due to contaminant detection.
Land Securement	• Purchase or place easements on land in IPZs and WHPAs.
Risk Management Plans (RMPs)	• Conduct formal site inspections on a prescribed schedule within specific WHPA / IPZ zones of private sector occupants to identify potential threats within their properties (i.e., former fire insurance plans / mapping) • Require Plans for activities involving the handling and storage of DNAPLs in WHPA A, B and C. The Plan could address items of operating practises including containment and management, employee training as well as a spill contingency plan. Other areas to be covered could include proper waste disposal, monitoring of groundwater, appropriate alarm system and automatic valves to ensure containment of leaks and spills, periodic testing of storage systems, secondary containment systems as well as other items. Require annual inspection as part of plan.
Prohibition	• Prohibit the handling and storage of DNAPLs in WHPAs where these activities are or would be significant drinking water threats.
Restricted Land Uses	• Flag those land uses that are associated with the handling and storage of DNAPLs as restricted land uses in WHPAs where these activities are or would be significant drinking water threats so that municipal planners and building official consider implications of the proposed development.

Appendix A. Toxic Substances List Description of DNAPLs and Organic Solvents

DNAPL	Description
Dioxane-1,4	A colorless, flammable liquid with a faint, pleasant odor, the synthetic industrial chemical is used as a solvent for extracting animal and vegetable oils and in the formulation of inks, coatings, and adhesives. 1,4-Dioxane is used primarily as a solvent in paints, varnishes, lacquers, cosmetics, deodorants, cleaning and detergent preparations, and in scintillating fluids. Literature searches also indicated the potential for use as a solvent in the processing of crude petroleum, petroleum refining, petrochemicals, pulp and paper, explosives, commercial printing, electroplating/polishing, pesticide and agricultural manufacture, dyes, fiber manufacture, pharmaceuticals, adhesives, semiconductors, electronic components, photographic equipment, magnetic recording media, polymers, plastics, rubber manufacture, and organic and inorganic chemical manufacture. 1,4-Dioxane often has been used with chlorinated solvents, particularly 1,1,1-trichloroethane (TCA), as a stabilizer and corrosion inhibitor. 1,4-Dioxane is highly flammable and potentially explosive if not stored properly. The chemical is a cyclic ether that is highly miscible in water; in fact, it mixes with water so readily that it can be found in groundwater plumes far in advance of any solvents with which it might have entered the subsurface originally. It also migrates rapidly in soil. Contamination often can be found in association with releases of chlorinated solvents. USEPA has listed the compound as a probable human carcinogen based on the results of animal studies, but little information is available on the long-term effects of 1,4-dioxane on human health. The compound does not respond to air stripping or granular activated carbon treatment, nor does it biodegrade in the subsurface other than very slowly. Researchers are developing new treatment technologies for 1,4-dioxane, but advanced oxidation processes involving hydrogen peroxide and ultraviolet light or ozone have been applied successfully, and phytoremediation shows promise for its removal at depths accessible to plant roots. 1, 4-Dioxane generally is used as a solvent or intermediate. Only one manufacturer now produces the compound in the US. Production of the chemical has fallen significantly from the nearly 15,000,000 pounds produced in 1982, possibly because all but critical uses of trichloroethane (TCA), to which it was added as a stabilizer, have been banned in the US. According to the Toxic Release Inventory for 2009, ~70,000 pounds of 1,4-Dioxane were released to the air, ~45,000 pounds to surface waters, none to land, and ~135,000 pounds were transferred from the user to off-site disposal. Due to its widespread use as a stabilizer for chlorinated solvents, the chemical is detected frequently at sites contaminated with chlorinated solvents. Because conventional pump-and-treat technologies such as air stripping and carbon adsorption do not capture the compound, reinjection of treated ground water from which 1,4-dioxane has not been adequately removed has resulted in shutdown of domestic and municipal supply wells. Source: http://www.clu-in.org/contaminantfocus/default.focus/sec/1,4-Dioxane/cat/Overview/

DNAPL	Description
Polycyclic Aromatic Hydrocarbons (PAHs)	PAHs are on the *Canadian Environmental Protection Act* (CEPA) Toxic Substances List (Track 2 Full Life Cycle Management). Mixtures such as coal tar and creosote are often made from different feedstocks, their composition is extremely variable. The materials considered mixtures for this DNAPL classification lack a predominant chemical component in association with lesser additives or contaminants. Instead they contain hundreds of individual chemicals that can have vastly different chemical properties and behaviors when considered separately. All of the DNAPL mixtures are more viscous than water—some much more so—and they have a wide range of solubility, Koc, and Kow values. Common components, such as some PAHs with high Kow values, have a tendency to bioaccumulate. When released to ground water or surface water, mixtures typically behave differently based on their constituents. Coal tars and creosotes sink when released to ground water or surface water. While some components of DNAPL mixtures are biodegradable, if they separate from the mass by dissolving or volatilizing, many are very recalcitrant to biodegradation. Large masses of coal tars have been found at gas manufacturing plants that have been closed for 50 to 100 years. Coal tars are generally produced during the fractional distillation of coal to make coke for the steel industry and through a different distillation process to make gas. Their environmental occurrence is tied to improper disposal practices, mainly within the coking and manufactured gas industries. The most widespread environmental problems posed by coal tars occur at closed manufactured gas plants. (Coal tar) creosotes are made from the fractional distillation of coal tar. Ninety-seven percent of the creosote produced is used as a wood preservative. Exposure to creosotes occurs mainly from the mishandling of creosote at wood treatment sites and from the leaching of creosote chemicals from treated wood. Chemicals associated with creosote can be found in the soil around treated wood, including home decking, and in the sediment near piers made of treated wood. Sites of interest tend to be closed wood treatment sites. Source: http://www.clu-in.org/contaminantfocus/default.focus/sec/Dense_Nonaqueous_Phase_Liquids_%28DNAPLs%29/cat/Environmental_Occurrence/p/6

DNAPL	Description
Tetrachloroethylene (PCE)	Tetrachloroethylene is not manufactured in Canada, and is on the *CEPA* Toxic Substances List (Track 2 Full Life Cycle Management). It is imported for use by dry-cleaning and metal-cleaning (degreasing) industries. Improper disposal of cleaning solvents and leaching from underground tanks are the main sources of PCE in groundwater. Certain household products contain PCE, such as automobile cleaners, paint removers and strippers, water repellents, and spot removers. Tetrachloroethene (PCE, CAS # 127-18-4) is a highly volatile compound with an ethereal odor. Howard (1991) estimated the K_{ow} at 3.40 and the K_{oc} at 209 to 238 (different reference sources). The Henry's constant is moderately high at 1.49 x 10^{-2} atm-m^3/mole at 25° C, while water solubility and vapor pressure are 150 mg/L at 25° C and 18.49 mm Hg, respectively. The low K_{ow} indicates that PCE will not accumulate significantly in terrestrial or aquatic plants and animals. PCE's movement through soil is dependent on its K_{oc} value, which is an indication that it is sensitive to soil properties and reacts chemically in soil. The K_{oc} value is moderately low, denoting an aversion to adsorption onto particles and a high to medium mobility through soil and ground water. PCE is leached more readily through sandy soil, and, due to its vapor pressure, it is volatilized more rapidly in dry soil. Slow degradation by soil microorganisms occurs more quickly in anaerobic conditions when an appropriate microbial consortium is present. If the consortium is not present there may be no degradation or stalling at 1,2-dichloroethene (DCE). The high Henry's constant signifies that PCE will volatilize from surface waters. Howard (1991) found the half-life of this compound in surface waters to range from three hours to several weeks. This range is due to differences in the water body properties. The chemical and physical properties of the water, such as temperature, width, depth, season, and energy, also contribute to this range. In air, PCE exists as a vapor, as indicated by its high vapor pressure, and is subject to photooxidation. Due to its solubility in water, it is subject to some washout in rain. PCE degrades in air by reacting with hydroxyl radicals. Degradation rates range from complete degradation in one hour to a half life of two months (Howard 1991). Half-life estimates reported in TOXNET range to 96 days. The longer half-life estimates are supported by the fact that PCE is present in the atmosphere world-wide and at locations far removed from anthropogenic emission sources (ATSDR 1997). Atmospheric breakdown products of PCE include phosgene, chloroacetylchlorides, formic acid, carbon monoxide, carbon tetrachloride, and hydrochloric acid. Millions of pounds of PCE have been produced in the US and abroad for use in drycleaning operations, degreasing metal, and as a solvent and chemical intermediate. Its greatest use is as a chemical intermediate, although this use is declining due to the ban on chlorofluorocarbons (ATSDR 1997). Despite their considerable historical usage these products have fallen out of favour in a

DNAPL	Description
	lot of usages and thus their threat potential to the environment / water resources compared to their historical use is greatly diminished, albeit not completely (for example "dry cleaning" which used to use PCE now tends toward newer chemical formulations being glycol ethers and liquid silicones [ex. "green earth cleaning product"]). The other contributing factor is that the chemical's threat on the environment is now well known and handled more appropriately. **Perchloroethylene Demand in U.S. Drycleaning Industry 1985 - 2006**  Source: Textile Care Allied Trades Association PCE is one of the most widely detected organic chemicals at NPL sites. Zogorski et al. (2006) found PCE to be the second most commonly detected volatile organic compound in aquifers and the third most commonly detected compound at concentrations of concern to human health from private and public water supplies. It has been found in relatively remote areas as well. The 2005 US Toxics Release Inventory identified 316 facilities that released an estimated ~2,000,000 pounds of TCE to the air and disposed of an additional ~143,500 pounds at RCRA Subtitle C facilities. These numbers are conservative since not all facilities are required to report. Sources: http://www.clu-in.org/contaminantfocus/default.focus/sec/Dense_Nonaqueous_Phase_Liquids_%28DNAPLs%29/cat/Environmental_Occurrence/p/3/n/5 http://en.wikipedia.org/wiki/Dry_cleaning

DNAPL	Description
Trichloroethylene	Trichloroethylene is a man-made chemical that does not occur naturally in the environment. The clear, colorless, nonflammable liquid evaporates quickly and has a sweet chloroform-like scent. The chemical is used primarily as a large volume degreasing agent for metal and electronic parts. It also has found use as an extractant for oils, waxes, and fats, a solvent for cellulose esters and ethers, a dry cleaning fluid, refrigerant and heat exchange fluid, fumigant, carrier agent in paints and adhesives, a scourant for textiles, and as a feedstock for manufacturing organic chemicals. In homes, trichloroethylene can be found in typewriter correction fluid, paint, spot removers, carpet-cleaning fluids, metal cleaners, and varnishes. Trichloroethylene also is known as trichloroethene, and is commonly referred to as TCE. Regulation of TCE by the USEPA began in the 1980s. It is regulated under the *CEPA* Toxic Substances List (Track 2 Full Life Cycle Management). The Safe Drinking Water Act, which sets Maximum Contaminant Levels (MCLs) for TCE. The Occupational Safety and Health Act sets a limit for exposure to TCE in workplace air. Trichloroethylene does not appear to be manufactured in Canada Industrial processes are the main sources of TCE in the environment. It is commonly found in air and water. Once it is released into the air, TCE will break down within a week or less. TCE breaks down more slowly in surface water and soil than in air, and it can pass through the soil into underground water. Most TCE in air comes from metal degreasing activities associated with tool and automobile production. TCE also can enter ground water and surface water from industrial discharges or from improper disposal of industrial wastes at landfills. TCE has been found in many drinking water supplies in the United States. TCE generally is thought of as an industrial solvent and is produced in the millions of tons in the United States and abroad. TCE has been used in dry cleaning operations, in metal degreasing, and as a solvent for fats, greases, waxes, cellulose ester, ethers, dyeing, oils, and household cleaners for walls, clothing and rugs. It also has been used as a refrigerant, a heat exchange liquid, in organic synthesis, a fumigant, an inhalation analyzer or anesthetic, a diluent in paints and adhesives, an industrial solvent in extraction processes, an analgesic, a chain terminator for PVC production, an extractant in food processing (e.g., for decaffeinated coffee), a disinfectant and detergent for skin, minor wounds and surgical instruments, and a chemical intermediate in the production of pesticides, gums, resins, tars, paints, varnishes and specific chemicals, such as chloroacetic acid. TCE has been used in cleaning and drying electronic parts, textile processing, aerospace operations (flushing liquid oxygen), and the treatment of trigeminal neuralgia, The compound finds its greatest use in metal degreasing applications. TCE is the most widely detected organic chemical at NPL sites in the US. In a 1999 study of US public drinking water systems, it was one of the more common volatile organics detected. A recent US report under the Right to Know provisions of SARA shows that 525 facilities nationwide released over 8 million pounds of TCE to the air, 400 pounds to surface water, and 12,600 pounds to the land. Source: http://www.clu-in.org/contaminantfocus/default.focus/sec/Trichloroethylene_%28TCE%29/cat/Overview/

DNAPL	Description
Vinyl chloride	Vinyl chloride is a colourless, flammable, explosive gas with a vapour pressure of 2530 mmHg at 20°C and a boiling point of -13.4°C. It is slightly soluble in water (1.1 g/L at 28°C) but highly soluble in fats and organic solvents. It polymerizes in light and in the presence of a catalyst. On combustion, it degrades to hydrogen chloride, carbon dioxide and traces of phosgene. It has a pleasant, ether-like odour at low concentrations. Vinyl chloride is on the *CEPA* Toxic Substances List (Track 2 Full Life Cycle Management). In 1982, 86% of the Canadian production of vinyl chloride was used to manufacture polyvinyl chloride (PVC), 4% was used to manufacture 1,1,1-trichloro-ethane and 10% was exported. PVC is used in electrical wire, insulation and cables, industrial and household equipment, medical supplies, food packaging materials, building and construction products and piping. In addition, PVC is used as a raw material in the paper, glass, rubber and automotive industries. Vinyl chloride and PVC copolymers are distributed and processed in a variety of forms, such as dry resins, plastisol, organosol and latex. Concentrations of vinyl chloride monomer in PVC were reduced drastically between 1973 and 1975 and range from 1 to 10 ppm. Vinyl chloride is a synthetic chemical with no known natural sources. It is now used with stringent methods for containment and recovery. Releases to the environment will be limited to areas where vinyl chloride is produced and used and to leaching of the entrapped monomer from PVC pipe. Its presence in the aquatic environment is primarily a result of industrial discharges from chemical and latex manufacturing plants. Vinyl chloride is also formed from the breakdown of TCE and PCE in groundwater. The low boiling point, high vapour pressure and low water solubility of vinyl chloride indicate that any vinyl chloride released to surface water will migrate rapidly to air, where it will be photodegraded in a few hours. Vinyl chloride that is released to the ground does not adsorb onto soil; any that does not evaporate migrates readily to groundwater, where it is expected to remain for months to years. The half-life of 1 ppm vinyl chloride monomer in open water at a 1-m depth is estimated to be 26 minutes, and 90% is lost by evaporation within 96 minutes. Under aerobic conditions, vinyl chloride in samples taken from a shallow aquifer (groundwater) was readily degraded, with more than 99% being degraded after 108 days and approximately 65% being mineralized to carbon dioxide. Vinyl chloride does not bioaccumulate in animals or food chains. In a national survey of 30 Canadian water treatment facilities conducted in 1979, vinyl chloride was detected at <1 µg/L in one sample each of treated and raw water collected in the months of November and December but was not present in August and September samples. It was also detected in U.S. drinking water at concentrations up to 10 µg/L. In recent years, PVC pipes have been used for conveying potable water. The World Health Organization has concluded that the occurrence of vinyl chloride in potable water is primarily associated with the use of PVC water pipes manufactured with incompletely polymerized vinyl chloride monomer. Drinking water that ran through recently installed PVC pipes contained vinyl chloride at 1.4 µg/L, whereas water that passed through nine-year-old pipes contained vinyl chloride at 0.03 to 0.06 µg/L. A number of product standards exist that specify the quality of PVC water pipes in order to limit the quantity of

DNAPL	Description
	free monomer present. The Canadian Standards Association's standard for all plastic pipes was revised in 1990 and includes a leaching test for vinyl chloride from pipes; the maximum allowable leaching of vinyl chloride in water from pipes is 0.002 mg/L. If pipes of this quality are used, only very low concentrations of vinyl chloride monomer are likely to be present in drinking water. Source: http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/vinyl_chloride/index-eng.php#Identity

Appendix B – Local Information on the Drinking Water Threat

1. Local scale of the drinking water threat?

[Insert description and/or map of local threat context]

- The handling/storage of DNAPLs is or would be a significant, moderate, or low threat in {insert areas}.
    - This activity is most likely to occur in {insert area}
    - Include maps or tables
    - Other information may include:
        - The handling and storage of DNAPLs was assumed to occur throughout the **name of** Source Protection Area. These activities are or would be significant drinking water threats in portions of the WHPAs: **names of municpalities.**
        - There are about **<<number>>** (**X**) facilities in the **name of** Source Protection Area that are required to submit reports to the NPRI, mostly for air emissions. Examples of local facilities that report to NPRI for land and water discharge include **<<list>>**.
        - In the **name of** Source Protection Area, the **name of** Generating Station, **name of** Company Inc. (**location**), and **name of** Canada Company (**location**) plants are required to have spill prevention and contingency plans. It is unknown at this time if any other plants in our area require plans.
        - In the **name of** Source Protection Area, the majority of land set aside for industrial uses are located in the HVAs and SGRAs along the **location** and at the **location** of **name of municipality**.

Table A identifies where the handling and storage of a DNAPL is or would be a significant, moderate or low drinking water threat based on the MOE Tables of Drinking Water Threats (2008, as amended in 2009).

Table A – DNAPL Handling and Storage Threats in the **name** Source Protection Area

Vulnerable area		V.S.	Handling and Storage of DNAPLs S	M	L
Name of well/groundwater system	WHPA A, B	10	✓		
	WHPA C	8	✓		
	WHPA D	6		✓	✓
	WHPA E	7		✓	✓
Name of well/groundwater system	WHPA A, B	10	✓		
	WHPA C	8	✓		
	WHPA D	6		✓	✓
	WHPA E	7		✓	✓
Name of well/groundwater system	WHPA A, B	10	✓		
	WHPA C	8	✓		
	WHPA D	6		✓	✓
HVA/SGRA		6		✓	✓
Name of surface water system	IPZ 1	9		✓	
	IPZ 2	8.1		✓*	✓
Name of surface water system	IPZ 1	9		✓	
	IPZ 2	8.1		✓*	✓
Name of surface water system	IPZ 1	9		✓	
	IPZ 2	8.1		✓*	✓
	IPZ 3a	6.3			✓
Name of surface water system	IPZ 1	6			✓
	IPZ 2	4.2			✓
Name of surface water system	IPZ 1	6			✓
	IPZ 2	4.2	n/a	n/a	n/a
Name of surface water system	IPZ 1	7		✓	✓
	IPZ 2	6.3			✓
Name of surface water system	IPZ 1	7		✓	✓
	IPZ 2	6.3			✓
Name of surface water system	IPZ 1	7		✓	✓
	IPZ 2	5.6			✓
Name of surface water system	IPZ 1	7		✓	✓
	IPZ 2	5.6			✓

Where V.S. means vulnerability score, S means significant drinking water threat, M means moderate drinking water threat, L means low drinking water threat. *moderate drinking water threat for storage of DNAPL only.

2. Local approaches to managing these drinking water threats.

a. Land Use Planning

[Insert description of local land use approaches that are being used]

- The following municipalities in the **name of** Source Protection Area have sewer use by-laws: **names of municipalities**.

b. Other Local Programs

[Insert discussion on local programs including Stewardship, Education/Outreach, Incentive, etc. implemented by Conservation Authority, Municipality, or other watershed/community groups.]

c. Cross Jurisdiction Considerations

[Insert discussion on policy approaches being considered by neighboring Source Protection Areas/Regions.]

3. Further Research for Specific Vulnerable Areas

- **[insert additional background research needed, where applicable]**
- For example:
  - Additional research by staff is required to investigate insurance industry requirements for the handling and storage of DNAPLs and organic solvents.
  - More information about O. Reg. 717/94 is required to determine its relevance and implications for the drinking water source protection program.
  - A request has been made of MOE staff to discuss the provincial requirements associated with the handling and storage of DNAPLs and organic solvents.
  - Determine which local industries and businesses use the listed DNAPLs and organic solvents, in products and processes.

Appendix C – Reference List

Environment Canada. 2001. Policy Framework for Environmental Performance Agreements. www.ec.gc.ca/epe-epa/564C0963-955A-428D-822A-D6856DBA2E20/2001-06%20Final%20Eng.pdf

Environment Canada. 2001. The Pollution Prevention Planning Handbook. www.ec.gc.ca/planp2-p2plan/default.asp?lang=En&n=56875F44-1

Environment Canada. 2003. Code of practice for commercial furniture refinishing and other stripping applications. www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=B7812356-1&offset=2&toc=show

Government of Canada. 1992. Canadian Environmental Protection Act. Vinyl Chloride Release Regulation. http://laws.justice.gc.ca/eng/SOR-92-631/index.html

Government of Canada. 1999, Canadian Environmental Protection Act. http://laws.justice.gc.ca/eng/C-15.31/FullText.html

Government of Canada. 2003. Canadian Environmental Protection Act. Solvent degreasing Regulation. http://laws.justice.gc.ca/eng/SOR-2003-283/index.html

Government of Canada. 2003. Canadian Environmental Protection Act. Tetrachloroethylene (Use in Dry Cleaning and Reporting Requirements) Regulations. http://laws.justice.gc.ca/eng/SOR-2003-79/index.html

Government of Ontario. 1990. Environmental Protection Act. www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90e19_e.htm

Government of Ontario. 1990. Environmental Protection Act. Ontario Regulation 347 – General Waste Management. www.e-laws.gov.on.ca/html/regs/english/elaws_regs_900347_e.htm

Government of Ontario. 1994. Environmental Protection Act. Ontario Regulation 323/94 – Dry Cleaners. www.e-laws.gov.on.ca/html/regs/english/elaws_regs_940323_e.htm

Government of Ontario. 1998. Environmental Protection Act. Ontario Regulation 675/98 - Classification and Exemption of Spills and Reporting of Discharges. www.e-laws.gov.on.ca/html/regs/english/elaws_regs_980675_e.htm

Government of Ontario. 2007. Environmental Protection Act. Ontario Regulation 224/07 - Spill prevention and contingency plans. www.e-laws.gov.on.ca/html/source/regs/english/2007/elaws_src_regs_r07224_e.htm

Government of Ontario. 2009. Toxic Reduction Act. www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_09t19_e.htm

Government of Ontario. 2009. Toxic Reduction Act. Ontario Regulation 455/09 – General. www.e-laws.gov.on.ca/html/source/regs/english/2009/elaws_src_regs_r09455_e.htm

Office of the Fire Marshall. 1997. Ontario Fire Code. www.ontariofirecode.ca/english/

Ontario Ministry of the Environment. 2004. Guideline G-2 Ontario Spills Action Centre Operations. www.ene.gov.on.ca/stdprodconsume/groups/lr/@ene/@resources/documents/resource/std01_079002.pdf

Ontario Ministry of the Environment. 2007. Spills Reporting - A Guide to Reporting Spills and Discharges. www.ene.gov.on.ca/stdprodconsume/groups/lr/@ene/@resources/documents/resource/std01_079165.pdf

Ontario Ministry of the Environment. 2007. Guidelines for Environmental Protection Measures at Chemical and Waste Storage Facilities. www.ene.gov.on.ca/stdprodconsume/groups/lr/@ene/@resources/documents/resource/std01_079136.pdf

Appendix D – Additional Resources

1. Canadian Environmental Protection Act Environmental Registry http://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=D44ED61E-1

2. Chemistry Industry Association of Canada. Responsible Care program. www.ccpa.ca/ResponsibleCareHome.aspx

3. Drinking Water Threat Contaminants Summary (DRAFT).

4. Environment Canada. Canadian Pollution Prevention Information Clearinghouse. www.ec.gc.ca/CPPIC/en/index.cfm

5. Ontario Ministry of the Environment. Environmental Leaders Program. www.ene.gov.on.ca/environment/en/funding/environmental_leaders_program/index.htm

6. Ontario Ministry of the Environment. Pollution Prevention Pledge Program. www.ene.gov.on.ca/environment/en/resources/STD01_076161.html

7. Ontario Ministry of the Environment Water Quality Risk Management Measures Catalogue (Version 2, 09/07/2010) **http://maps.thamesriver.on.ca/swpCAMaps/rmc/disclaimer.aspx**

8. Region of Waterloo. 2009. Water Resources Protection Master Plan. www.region.waterloo.on.ca/web/region.nsf/8ef02c0fded0c82a85256e590071a3ce/30be9624b64cc0f68525706d0055ee14!OpenDocument

9. United States Environmental Protection Agency. Pollution Prevention Resource Exchange. www.p2rx.org

Technical References:

1. www.clu-in.org/contaminantfocus/default.focus/sec/Dense_Nonaqueous_Phase_Liquids_%28DNAPLs%29/cat/Overview/

2. www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/tetrachloroethylene/index-eng.php

3. www.atsdr.cdc.gov/phs/phs.asp?id=263&tid=48

4. www.drycleancoalition.org/chemicals/ChemicalsUsedInDrycleaningOperations.pdf

5. http://en.wikipedia.org/wiki/Dry_cleaning

6. http://cgr.ebs.ogi.edu/schwillebook/

7. http://cgr.ebs.ogi.edu/dnaplbook/

8. http://www.clu-in.org/contaminantfocus/default.focus/sec/Dense_Nonaqueous_Phase_Liquids_%28DNAPLs%29/cat/Additional_Resources/