PRIMER ON

VOLATILE ORGANIC COMPOUNDS
(VOCs)
Pollution Probe is a non-profit charitable organization that works in partnership with all sectors of society to protect health by promoting clean air and clean water. Pollution Probe was established in 1969 following a gathering of 240 students and professors at the University of Toronto campus to discuss a series of disquieting pesticide-related stories that had appeared in the media. Early issues tackled by Pollution Probe included urging the Canadian government to ban DDT for almost all uses, and campaigning for the clean-up of the Don River in Toronto. We encouraged curbside recycling in 140 Ontario communities and supported the development of the Blue Box programme. Pollution Probe has published several books, including Profit from Pollution Prevention, The Green Consumer Guide (of which more than 225,000 copies were sold across Canada) and Additive Alert.

In the 1990s, Pollution Probe focused its programmes on issues related to air pollution, water pollution, climate change and human health, including a major programme to remove human sources of mercury from the environment. Pollution Probe’s scope has also expanded to new concerns, including the unique risks that environmental contaminants pose to children, the health risks related to exposures within indoor environments, and the development of innovative tools for promoting responsible environmental behaviour.

Since 1993, as part of our ongoing commitment to improving air quality, Pollution Probe has held an annual Clean Air Campaign during the month of June to raise awareness of the inter-relationships among vehicle emissions, smog, climate change and human respiratory problems. The Clean Air Campaign helped the Ontario Ministry of the Environment develop a mandatory vehicle emissions testing programme, called Drive Clean.

Pollution Probe offers innovative and practical solutions to environmental issues pertaining to air and water pollution. In defining environmental problems and advocating practical solutions, we draw upon sound science and technology, mobilize scientists and other experts, and build partnerships with industry, governments and communities.
October 2005

Pollution Probe is pleased to present this primer on Volatile Organic Compounds (VOCs). It is both a complementary primer to The Smog Primer and an introduction to some of the toxic VOCs that we encounter in everyday life.

As with other Pollution Probe primers, The Primer on Volatile Organic Compounds has been designed as an educational resource for people who want to understand this source of pollution and then take action to protect themselves and their children. In addition, the primer has been designed for use as an introduction to controlling VOCs from small- and medium-sized businesses. There are many opportunities in this sector to reduce VOC emissions and hence the unnecessary exposure of employees and surrounding communities to these pollutants.

Pollution Probe is dedicated to making positive, tangible progress in cleaning the air we breathe. This is essential to our health and well-being, and it is a goal that we can achieve. Please join us in advocating for a clean environment, and make personal choices that show your commitment to this worthwhile endeavor.

Ken Ogilvie
Executive Director
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Pollution Probe is solely responsible for the contents of this publication.

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Chapter One

What are Volatile Organic Compounds?

Almost everyone is familiar with the scent of a freshly mowed lawn and the distinctive odour of paint. Many people notice the wavy lines that rise in the air as they fill their cars at the gas station. However, what most people may not know is that they are smelling or seeing the effects of volatile organic compounds (VOCs).

VOCs are part of a large group of chemical substances called “organic compounds,” all of which contain at least one carbon atom in their molecular structure. There is a huge range of organic compounds — from the very simple molecule methane, which has one carbon atom and four hydrogen atoms, to the very complex DNA molecules that hold our genetic code. VOCs are the smaller, often simpler organic chemicals whose lower molecular weight allows them to evaporate (become a vapour) quickly at room temperature, which is why they are called “volatile.”
Some VOCs are a human health concern — either directly through their toxic properties or when they react with nitrogen oxides in the presence of sunlight to form ground-level ozone (a major component of smog). This Primer focuses on VOCs that are risky and harmful. It identifies major VOC sources, explains how they are controlled, and highlights what governments and industry are doing to reduce the level of VOCs in the atmosphere. The Primer also identifies what small- and medium-sized businesses can do to reduce VOC emissions, as well as what individuals can do in their homes.

### Major Sources of VOCs

#### Natural Sources

There is a diverse range of VOCs present in the environment — from both natural and human sources. Trees and plants (including those living, decaying and burning) are the largest source of VOCs in Canada, contributing five times more VOCs to the environment than do human sources, as noted in *Criteria Air Contaminants Emission Summaries, 2000*. VOCs are emitted mainly from foliage, but can also be released from woody tissue, flowers and buds. Isoprene and monoterpenes are two of the most common VOCs emitted by vegetation.

### Table 1-1: Biogenic Emissions from Several Vegetation Types in Alberta

<table>
<thead>
<tr>
<th>Forest Category</th>
<th>Isoprene (micrograms/m²/h)</th>
<th>Monoterpene (micrograms/m²/h)</th>
<th>Other VOCs (micrograms/m²/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boreal Forest</td>
<td>910</td>
<td>713</td>
<td>755</td>
</tr>
<tr>
<td>Hardwood Forest</td>
<td>8,730</td>
<td>436</td>
<td>882</td>
</tr>
<tr>
<td>Pine</td>
<td>79.3</td>
<td>2,380</td>
<td>1,295</td>
</tr>
<tr>
<td>Spruce</td>
<td>23,800</td>
<td>5,100</td>
<td>2,775</td>
</tr>
<tr>
<td>Aspen</td>
<td>29,750</td>
<td>42.5</td>
<td>693.7</td>
</tr>
</tbody>
</table>

Source: Geron et al., 1994; Guenther et al., 1994.
The rate of formation of these natural, or “biogenic” emissions (sometimes referred to as BVOCs) varies greatly and can be affected by sunlight, temperature, humidity and vegetation species. For example, isoprene emissions from spruce and aspen are more than 300 times those from pine (Table 1-1). Even related species of trees can vary widely in the amount of VOCs they emit. While natural sources of VOCs are significant, emissions from human sources are often larger in populated and industrialized areas, where there are fewer trees or open fields of crops.

**Human-made Sources**

The upstream oil and gas industry in Canada accounts for 27 per cent of VOC emissions, making it the largest contributor from human sources (Figure 1-1). This sector includes emissions that result from the exploration, production, processing and transmission of oil and natural gas. It should be noted that emissions from this source are largely regionalized. This industry is the dominant source of human-generated VOC emissions in Alberta and a significant source in Saskatchewan. In other areas of the country, the upstream oil and gas industry is not a significant contributor of VOC emissions.

**Transportation** and the related use of fossil fuels, such as gasoline and diesel, is the second greatest source of human-generated VOCs in Canada, accounting for 26 per cent of the national total. Vehicles release VOCs to the environment in a variety of ways. They are displaced into the air when the vehicle fuel tank is filled with liquid gasoline. As the vehicle heats up from running, more VOCs are released as raw gasoline and waste oil evaporate from

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**Figure 1-1: National VOC Emissions (2000) — Total 2,751 kilotonnes**

- Solvent Use — 17%
- Open Sources — 12%
- Transportation — 26%
- Upstream Oil and Gas — 27%
- Fuel Combustion — 6%
- Industrial Sources — 9%
- Fuel Marketing — 3%

www.ec.gc.ca/pdb/cac/ape_tables/canada2000_e.cfm
Industry activity is an additional source of VOC emissions. Releases of VOCs to the environment from industry usually come from process vents and storage devices or result from “fugitive” emissions (emissions in the form of leaks from process equipment, such as flanges, pump and compressor seals, valves and drains).

Poorly sealed fittings and gaskets, especially in older vehicles. Finally, as engines do not completely burn all the fuel, additional VOCs are released from vehicle tailpipes.

Approximately half of the total VOC emissions from the transportation sector come from on-road diesel and gasoline cars and trucks. The other half come from off-road vehicles (e.g., all-terrain vehicles and snowmobiles), as well as marine, rail and air transportation.

The use of solvents and solvent-containing products is also a major source of VOC emissions in Canada. According to Environment Canada, a solvent is generally defined as a substance (usually a liquid) that has the ability to dissolve one or more other substances. Solvents also aid in providing uniform dispersion and surface tensions appropriate for surface coverage. Solvents are commonly used in industry, homes and vehicles. In 2000 they accounted for 17 per cent of total VOC emissions in Canada.

Paints and coatings are the largest source of VOCs from solvent uses. Volatile solvents are used to dissolve or disperse pigment and resin in paints and coatings, thereby giving the desired consistency for application. Once paint is applied, the solvent, including potentially harmful VOCs, evaporates into the air, allowing the resin and pigment to produce a coat of paint.

Consumer products are the second largest source of VOCs from solvent uses. Within this sector, windshield washer fluids and hair sprays are the largest sources of VOC emissions (many aerosol containers use VOCs as propellants.) Although individually these sources are small emitters of VOCs, the large collective use of these products contributes significantly to overall emissions. Other common consumer products that release VOCs include air fresheners, cosmetics and antiperspirants. Because organic solvents are often able
to dissolve or suspend dirt and grease, they are also used in many household cleaning products.

Other common solvent-based products include printing inks, pesticides and chemicals used in dry cleaning. Building and household materials, such as new carpeting and adhesives, draperies, wood products that use certain glues, finishes and waxes in the manufacturing process, and vinyl type flooring may all release VOCs into the air. While car products, such as windshield washer fluids and de-icers, also emit VOCs, their value in improving road safety (by preventing the water in windshield washer fluid from freezing) makes them currently indispensable.

Other VOC sources include residential and commercial fuel use (especially wood burning, though this is a seasonal source with emissions occurring primarily during fall and winter), open sources (e.g., emissions from farming operations, forest fires, landfill sites and prescribed burning), and the storage and handling of fuel for distribution to markets.

Figure 1-2: Trend for Ontario VOC Emission Estimates (1991–2000)

The contribution to the atmosphere of various VOC sources has changed over the years. In Ontario, transportation and industrial emissions declined between 1991 and 2000 (see Figure 1-2), thus reducing total human-generated VOC emissions to the atmosphere. This was the case even as solvent use (and the population) continued to increase over this same period, with manufacturers developing new chemical and solvent uses and thus putting more products on the market each year.

Why are VOCs a Concern?

VOCs present in the environment vary widely in their properties and impacts. As with any substance, the impact of a given VOC on human health depends on both its concentration and the probability of exposure. Some VOCs are particularly toxic and can negatively impact human health, even at very low concentrations. Others, such as “smog precursors,” react to form ground-level ozone, or combine with other substances to form fine particulate matter, both posing a serious health threat to humans as smog.

Certain VOCs can harm human health if inhaled, ingested or absorbed through the skin. Common short-term health effects of VOC exposure include eye and lung irritation, headaches and nausea. Some compounds can cause longer-term effects, such as damage to the liver, kidneys and nervous system. Other VOCs, such as benzene, can cause cancer in humans and animals. It must be emphasized, however, that many VOCs are relatively harmless at concentrations typically found in the atmosphere.

Table 1-2 outlines the health effects of three potentially dangerous VOCs. While there are thousands of different VOCs, these examples illustrate the range of impacts that VOCs can pose to human health.
<table>
<thead>
<tr>
<th>VOC</th>
<th>What is it?</th>
<th>What are its health impacts?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzene (C₆H₆)</td>
<td>Benzene is a clear, colourless liquid with a strong, sweet odour. It occurs naturally in crude petroleum and is flammable.</td>
<td>Benzene is a human carcinogen (i.e., causes cancer) and is linked to specific types of leukemia. Short-term exposure causes depression of the central nervous system (CNS), marked by drowsiness, dizziness, headache, nausea, loss of coordination, confusion and unconsciousness. Benzene is also toxic to other organisms besides humans. Benzene is considered to be “toxic” under the Canadian Environmental Protection Act.</td>
</tr>
<tr>
<td>Toluene (C₆H₅CH₃)</td>
<td>Toluene is a clear, colourless, flammable liquid with a sweet, pungent odour. Toluene occurs naturally in crude oil and remains in the refined products. It is released in motor vehicle and aircraft exhausts, in losses during gasoline marketing activities, in spills and from processes in which toluene is used.</td>
<td>The main effects of inhaling toluene vapour are on the central nervous system (CNS). Symptoms range from slight drowsiness and headache (at lower concentrations around 50 ppm), through irritation of the nose, throat and respiratory tract, fatigue, dizziness, numbness and mild nausea, to mental confusion and reduced coordination. At higher concentrations around 10,000 ppm or more, further depression of the CNS occurs, leading to unconsciousness and death. Most serious incidences of exposure have occurred when vapours have accumulated in confined spaces or in cases of solvent abuse (glue-sniffing).</td>
</tr>
</tbody>
</table>
## Table 1-2: Characteristics of Selected VOCs and their Health Impacts (continued)

<table>
<thead>
<tr>
<th>VOC</th>
<th>What is it?</th>
<th>What are its health impacts?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toluene (C₆H₅CH₃)</td>
<td>Toluene is used in the production of other chemicals, in particular benzene, as a solvent carrier in paints, thinners, adhesives, inks, and pharmaceutical products, and as an additive in cosmetic products.</td>
<td>Toluene was not found to be carcinogenic in animal studies. The International Agency for Research on Cancer (IARC) has determined that there is inadequate evidence for the carcinogenicity of toluene in humans. After reviewing available scientific information, the Ministers of Environment Canada and of Health and Welfare Canada concluded that toluene should not be considered toxic under the Canadian Environmental Protection Act.</td>
</tr>
<tr>
<td>Tetrachloroethylene (also known as perchloroethylene) (Cl₂C:CCl₂)</td>
<td>Tetrachloroethylene is a clear, colourless liquid with an ether-like sweet odour. It is used primarily in dry cleaning facilities and as a degreasing (specifically metal cleaning) agent in industry. The main human exposures are through vapour inhalation and occasionally skin and eye contact at work. People living near such workplaces may be exposed to higher average levels than the general population.</td>
<td>Short-term exposure to tetrachloroethylene can result in eye, nose and throat irritation, nervous system depression and unconsciousness. Long-term exposure can result in liver and kidney damage in mice, but the level of exposure at which effects on the liver and/or kidneys might occur in humans is not clear. Tetrachloroethylene was found to be carcinogenic for mice, but not for rats. Evidence from epidemiological studies among dry-cleaning and laundry workers is insufficient to conclude that exposure to tetrachloroethylene causes cancer in human beings. Tetrachloroethylene was added to the CEPA 1999 list of toxic substances on March 29, 2000.</td>
</tr>
</tbody>
</table>

**VOCs and Smog**

VOCs are also a concern to human health due to their role in the formation of smog. In the presence of sunlight, VOCs react with nitrogen oxides (NOₓ) to create ground-level ozone (see Text Box 1-3).

Both human-made and biogenic VOCs condense (combine with other pollutants in the air) to form fine particulate matter (see Text Box 1-4). Ground-level ozone and fine particulate matter are major components of smog. To learn more about these pollutants and the health effects of smog, see *The Smog Primer* at www.pollutionprobe.org/Publications/Primers/htm.

Several factors affect the degree to which VOCs contribute to either ground-level ozone or particulate formation in an airshed (a geographic area that, because of landscape, weather patterns and/or climate, is frequently affected by the...
**Text Box 1-4**

**What is Particulate Matter (PM)?**

Particulate matter (PM) is made up of microscopic liquid droplets and particles of soot, ash, dirt, dust, metals and pollens. PM varies in size and chemical composition. The size of PM is of great importance, determining how far into the lungs it can go when inhaled. Particles directly emitted into the air from a source (e.g., smoke from a factory smokestack or dust from construction) are called “primary.” “Secondary” particles are formed in the atmosphere through chemical reactions involving gases (most commonly NO\(_x\), SO\(_2\), ammonia and VOCs). Secondary particles are typically of the type PM\(_{2.5}\) (meaning they are 2.5 microns or less in diameter, or about 1/30 the width of a human hair).

same air mass). These include the amount of VOCs emitted, the reactivity of the specific VOCs present in the atmosphere, and the sensitivity of the airshed to additional releases of VOCs.

The amount of a VOC emitted into an airshed is a significant factor in ground-level ozone formation. Even if a VOC is not very reactive (discussed below), it can still affect air quality if it is emitted in a large enough quantity.

All chemicals have different levels of reactivity (i.e., the rate at which a compound will undergo chemical changes), and VOCs are no exception. Some react easily to form ozone in the presence of sunlight, while others take longer or do not react at all. The more reactive a particular VOC or group of VOCs, the greater the potential to form ground-level ozone. Many natural VOCs released from plants are particularly reactive.

Ozone-forming reactions require both VOCs and nitrogen oxides (NO\(_x\)). The series of complex reactions between these groups of substances are limited by the amount of reactant in shortest supply. Across most of rural North America, VOCs from natural sources are plentiful. In these well-vegetated areas, the relatively smaller amount of available NO\(_x\) limits the production of ozone. These airsheds, where additional NO\(_x\) inputs will lead to higher ozone levels, are therefore said to be “NO\(_x\) sensitive.” Conversely, less densely vegetated urban areas that have higher relative NO\(_x\) emissions are more sensitive to increased VOC inputs. These airsheds are said to be “VOC sensitive.”
VOCs and Smog Management

For the purpose of smog management, Environment Canada defines VOCs as “volatile organic compounds that participate in atmospheric photochemical reactions.” Methane, ethane, methylene chloride, methyl chloroform, acetone and tetrachloroethylene are excluded due to their low ozone-forming potential. The definition also excludes a broad range of ozone-depleting substances, such as chlorofluorocarbons (CFCs), which are managed under different legislation.

The formation of VOC-bearing particulates is also affected by the abundance and chemical reactivity of various VOCs in the atmosphere. Scientists have made good progress in identifying a number of VOCs that contribute to the secondary formation of particulates. In addition, the chemical composition of the pre-existing mixture of gases and particles in the airshed is important, as is the volatility of the VOC mix. The blue haze seen over some similarly named “blue mountains” in the eastern United States and New South Wales, Australia, is the result of selective scattering of blue light by VOC-containing particulates.
Where are VOCs a Concern?

As mentioned earlier, VOCs are found throughout everyday life. In the following sections, areas where the average person may be exposed to VOCs are discussed.

**Indoors**

On average, Canadians spend about 90 per cent of their time indoors, making the quality of indoor air very important. Many sources of VOCs are found in homes, businesses, schools and shopping malls. They include scents and hair sprays, air fresheners, cleaning products, carpeting, upholstery, rug and oven cleaners, paints, thinners, dry cleaned clothing, photocopierns and printers, glues and adhesives, and markers. Tobacco smoke continues to contribute significant amounts of toxic VOCs, such as benzene, to indoor air in some communities. However, with ever-increasing restrictions on smoking in public places, exposure to this dangerous source of air pollutants is declining.

A study done by the US Environmental Protection Agency (EPA) found that levels of about a dozen common organic pollutants were two to five times higher inside homes than outside, regardless of whether the homes were located in rural or highly industrialized areas. Additional EPA studies indicated that, when people are using products containing VOCs, they can expose themselves and others to very high pollutant levels, and that these levels can stay in the air long after the activity is completed. For instance, during and after certain activities, such as paint stripping, indoor levels of VOCs may be 1,000 times those of outdoor levels.

It is not just human-made materials that produce VOCs in enclosed areas. Some moulds and fungi can emit VOC gases known as microbial VOCs (MVOCs). These MVOCs are responsible for the characteristic odours produced by moulds, which are often described as “musty” or “earthy.”

Levels of VOC exposure in homes, offices and other enclosed areas vary widely, depending on:
- the size of the room or building;
- the rate at which the VOCs are emitted;
- the rate of ventilation within the building;
- time spent within the building; and,
- outdoor concentrations of pollutants (e.g., if homes are located adjacent to a high traffic area, where VOCs may seep in from outside).

**In the Workplace**

Governments, under workplace health and safety legislation, closely regulate exposure to harmful pollutants in the workplace. Employers are required to ensure that airborne concentrations of numerous pollutants, including many VOCs, do not exceed safe levels and, where necessary, protective gear is made available to and used by employees.
**In Car Interiors**

VOCs in automobile exhaust can seep into a car’s cabin from the outside. This is particularly a problem when driving in congested traffic. As well, drivers of older cars are at greater risk since their vehicle cabins may not be as airtight as those of newer cars, and the emissions from older cars are higher than from newer cars. A 2001 study in *Environmental Health Perspectives* has shown that, when driving in heavy traffic, interior concentrations of certain VOCs can be up to 10 times greater than those of outside concentrations.

In addition to pollutants seeping in from the outside, VOCs can also be released from a new car’s interior, particularly from the vinyl, plastic, upholstery and carpeting (resulting in what has been termed “new car smell”). A 1995 study by Scientific Instrument Services reported that more than 100 VOCs were found in a new 1995 Lincoln Continental. The concentrations dropped significantly over a two-month period, but were still detectable and continued to increase from morning to mid-day as temperatures rose in the car. This study suggested that, while VOC emissions decrease in a new automobile over time, their concentration is dependent on the temperature within the cabin.

In early 2005, the Japan Automobile Manufacturers Association (JAMA) agreed to reduce the levels of 13 VOCs found in passenger vehicle compartments to levels that Japan’s Ministry of Health, Labour and Welfare has established for air quality in homes to combat “sick-building syndrome.” The Japanese auto manufacturers plan to apply the new standards starting with vehicles manufactured in 2007, but only to cars made and sold in Japan.

**In Water**

When chlorine, a commonly used disinfectant, is added to water that has high natural organic levels (such as decayed vegetation and human and animal wastes), a reaction can take place which creates a class of VOCs called trihalomethanes. Also known as “disinfection by-products,” many trihalomethanes are known to be harmful to human health. The main concern with disinfection by-products is human exposure, through either ingestion or inhalation (e.g., in the shower). For more information on this issue, see *The Drinking Water Primer* at www.pollutionprobe.org/Publications/Primers.htm.
Chapter Two

How VOC Emissions are Controlled

This chapter discusses ways in which VOC emissions from vehicles, consumer products and industrial sources can be controlled. Chapter Three presents VOC emissions reduction success stories.

Vehicle and industrial VOC emissions can be controlled through add-on controls and “pollution prevention” measures. VOC emissions associated with consumer products can be controlled by improving the handling of these chemicals and by reducing or eliminating VOCs used as ingredients in products.
Controlling VOC Emissions from Vehicles

As transportation emissions account for over one-quarter of total VOC emissions in Canada, it is important to control this source. Cars and trucks emit VOCs in several ways. When engines do not efficiently burn fuel, VOCs are emitted from tail pipes (see Text Box 2-1). VOCs are also emitted when vehicles are being fuelled and maintained, and even when they are inactive. Several basic factors affect the emission of VOCs and other pollutants from vehicles. These include engine design, engine condition and the type of fuel used.

For fuel to burn efficiently, the mix of air and fuel in an engine must be correctly balanced. When burning gasoline in cars, the ratio should be 14.7 parts air to one part fuel. To maintain this air-to-fuel ratio, vehicle manufacturers install oxygen sensors on vehicles that monitor the exhaust and signal the engine to adjust the amounts of air and fuel being burned. This, and other technologies to optimize combustion, reduces the amount of VOCs and other pollutants emitted from tailpipes. In turn, drivers save money because more of the fuel is converted into usable energy. For engines and emissions reduction systems to operate at peak levels of efficiency, engines must be properly handled and regularly maintained.

Add-on controls can also decrease the amount of VOCs released by vehicles. As an example, catalytic converters are mandatory on all Canadian cars. These pollution control devices burn (or “oxidize”) waste VOCs in exhaust, leaving mainly carbon dioxide ($CO_2$) and water vapour.
Fuel content affects both tailpipe emissions and evaporative emissions from vehicles. Reducing the VOC content of fuel lowers both of these. Over the past 15 years, fuel quality has improved significantly. In response to government pressure (namely the federal Benzene in Gasoline Regulations, which went into effect in 1999), refiners have reduced levels of benzene in gasoline. Federal regulations prohibit the sale of gasoline that contains benzene at a concentration exceeding 1.5 per cent by volume. This, plus additional cuts in benzene emissions from a number of industrial emitters, has resulted in major reductions of benzene levels in ambient air (see Figure 2-1). Fuel companies must also reduce evaporative losses of VOCs that occur when fuelling vehicles. They can do this by reducing the lower molecular weight VOC content of gasoline during the summer smog season.

Figure 2-1: Distribution of Annual Mean Benzene Concentrations in Urban (1990–2002) and Rural Locations (1994–2002)

National regulations have been passed that limit the amount of sulphur in gasoline. While not a VOC, sulphur in exhaust negatively impacts the functioning of catalytic converters. When sulphur levels in fuel are low, catalytic converters work better and last longer, thus reducing VOC emissions to the environment.

**Text Box 2-2**

**Sulphur Levels in Gasoline**

In 1998, the average sulphur level in Canadian gasoline was 350 parts per million (ppm). Legislation that came into effect on January 1, 2005 now dictates that sulphur levels in gasoline cannot exceed 30 ppm — a reduction of more than 90 per cent.
Reducing VOCs in Paints

Solvent-based paints (also known as “oil” or “alkyd” paints) dominated the home market for more than a century. These paints contain colour pigments, as well as agents that bind these pigments together. The pigments and binding agents are suspended in a liquid vehicle — usually an organic solvent that evaporates easily, releasing VOCs to the air. Recently, consumer concerns about the strong smell of solvent-based paints and health concerns about the vapours of these paints have prompted manufacturers to change their formulas. Today, paints are more often made using water as the vehicle and are known as latex paints. Latex paints contain different binding agents than do solvent-based paints. As a result, latex paints have a less intense odour and release fewer VOCs into the air than do solvent-based paints.

Reducing VOCs in Consumer Products

Many VOCs have properties that serve to dissolve and suspend grease and dirt. These qualities have made these compounds ideal for use in household cleansers. Though products using organic compounds with these properties still dominate the market, water-based soaps are becoming more accepted by consumers. Many cleaning products also contain fragrances composed of VOCs. Scent-free versions of many cleansers are becoming more popular as consumer demand for them increases.

Other commonly used consumer products that contribute to VOC emissions include air fresheners, perfumes, cooking sprays, fabric softeners, hair sprays, nail polish removers and antiperspirants. As the population grows in parallel with the creation of even more consumer products, the use of solvents and related releases of VOCs will also increase, unless consumers demand VOC-reduced or VOC-free products (or unless governments regulate the VOC content of these products).

The demand for reduced use of solvents in consumer products is coming not only from governments, but also from the people most affected by them. People with allergies and respiratory illnesses, such as asthma, often react strongly to VOCs. As the number of people diagnosed with these illnesses increases in Canada and other countries, manufacturers are responding by reducing the use of VOCs in products.
Reducing VOCs from Industrial and Commercial Sources

VOC emissions are controlled by industry in two basic ways — add-on controls and pollution prevention.

**Add-on Controls**

Historically, control efforts have emphasized add-on controls that incinerated, filtered or chemically reacted VOCs to reduce their concentrations in emissions to acceptable levels.

Since many VOCs are flammable, it is relatively easy to simply burn off unwanted waste VOCs, either by igniting the waste gas steam or, if the VOCs are insufficiently flammable or concentrated, adding more fuel, such as natural gas, to the waste stream prior to ignition. This has proven to be a cost-effective way to control VOC emissions, particularly when quantities are large.

Flare stacks are also an essential component of plant safety. In the event of an emergency, flaring allows an industry to safely burn off potentially dangerous quantities of pressurized process gases. Although significant efforts have been made by industries to reduce flaring (both to reduce costs and environmental impacts), it remains a concern. According to the World Resources Institute, flaring results in the annual release of more than four million tonnes of carbon dioxide (a greenhouse gas) in Canada. Industries are working to minimize flaring as part of their climate change programs and general air pollution reduction strategies.
Filtration has also proven to be an effective, but less desirable, way to remove VOCs from waste gas streams. Typically, gases are passed through layers of activated charcoal or comparable filtering material that adsorb VOCs. While VOC levels can be reduced to very low concentrations using this method, spent filters must be regularly replaced or regenerated, thus creating an environmental waste issue. Because filtration can be very efficient, however, it is often the most effective way to remove odoriferous VOCs.

The reaction of VOCs with other chemicals, often in the presence of a catalyst, such as platinum, has become an attractive option for the treatment of exhaust gases. The reaction process, known as catalytic thermal oxidizing, works much like that of the automotive catalytic converter discussed earlier. Ideally, the end products of catalytic reactions are little more than carbon dioxide and water.

**Pollution Prevention**

In recent years, the practice of “pollution prevention” has been embraced as the most environmentally and potentially cost-effective way to minimize VOC emissions. The Canadian Council of Ministers of the Environment (CCME) defines pollution prevention as “the use of processes, practices, materials, products and energy that avoid or minimize the creation of pollutants and wastes at source.” In other words, rather than investing significant resources to capture or destroy a pollutant after it is created, the production process is altered to reduce or eliminate the problem before it is created. For VOCs, this is commonly done by reducing the quantity of the VOC-producing substance, redesigning the manufacturing process to reduce the release of VOCs, eliminating VOCs from manufacturing or commercial processes, or substituting VOCs with less reactive or less toxic substances. Many industries have been successful in achieving significant emission reductions through such methods.

It is commonly recognized today that pollution prevention solutions should be evaluated and applied before add-on controls are used. Chapter Three presents examples of leading businesses that are practicing pollution prevention.
Chapter Two discussed the general principles of VOC control. Although there are notable exceptions, controlling VOC emissions in large industries, where mass production often results in lower per unit costs, is most commonly accomplished with the use of add-on controls. For small- and medium-sized enterprises (SMEs), in contrast, “pollution prevention” or “P2” strategies are more cost-effective when the necessary support is available.
As noted earlier, the CCME defines pollution prevention as “the use of processes, practices, materials, products and energy that avoid or minimize the creation of pollutants and wastes at source.” Many businesses have taken a proactive approach to reducing their VOC emissions. Many companies have also achieved financial savings that, in some cases, have more than compensated for the cost of reducing the emissions.

The following pages describe how several SME sectors have responded to the challenge of pollution prevention, and present some case studies in which the principle has been put to work successfully. Lessons learned in these case studies can be applied to businesses in similar sectors to reduce VOC emissions.

**SMEs and Pollution Prevention**

**Automobile Painting**

Painting an automobile, whether new or refurbished, involves several coats of paint. Coatings may include a pre-treatment wash primer or pre-coat, a primer surfacer, a primer sealer and a topcoat, each of which contains solvents. VOC emissions from painting occur during surface preparation, coating application and clean-up.

Some actions that this sector has taken to reduce VOCs include

- Leading auto body repair shops have changed the way they apply paint to automobile body surfaces by using high-volume, low-pressure spray guns. The low velocity of application from these guns prevents the rapid expansion of spray and results in less over-spray and lower VOC emissions.
- Automakers have changed the paints they use from high solids solvent-based enamels to water-based paints and powder coatings, and thus reduced VOC emissions.
- Automakers have minimized the frequency of colour changes. This reduces VOC emissions generated when cleaning equipment with solvents between applications.
**Printing and Graphics Industry**

The primary source of VOC emissions within a printing plant is the pressroom where there are three main sources of VOCs: solvent-based inks, solvents used to clean presses after print runs, and isopropyl alcohol used in fountain solutions (solutions used in lithographic printing).

Other VOC sources within a printing and publication facility include pre-press and the bindery. Pre-press is the location where printing plates are created for use during printing, and the bindery is the location where materials are bound together to create a finished product.

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**Text Box 3-1**

**CleanPrint Canada**

The CleanPrint Canada initiative, created by printers, suppliers, associations and government, assists and educates the printing industry on reducing VOC emissions. CleanPrint Canada has developed a *Checksheet/Guidebook for Printers*, which includes checklists and tips for reducing pollution within a printing facility. The guide, initially written for the Ontario market, was adapted for facilities across Canada and is used by regional CleanPrint groups. The CleanPrint project also provides auditing services to help printers identify areas of potential improvement. For more information visit the CleanPrint Canada website at www.cleanprint.org.
Some actions that this sector has taken to reduce VOCs include
- using water- and vegetable oil-based inks;
- reducing or eliminating the use of organic solvents, such as isopropyl alcohol, in lithographic printing fountain solutions;
- capturing and recycling used solvents; and,
- reducing VOC emissions through improved housekeeping (for example, ensuring solvent containers are closed when not in use and placing used solvent rags and wipers in closed containers for future recycling).

**Dry Cleaners**

Tetrachloroethylene, also known as perchloroethylene, has been declared toxic under the Canadian Environmental Protection Act. This liquid solvent is used in dry cleaning to clean clothes and remove stains.

Some actions that this sector has taken to reduce VOCs include
- Use of closed-loop (non-vented) “dry-to-dry” refrigerated machines. In this technology, all dry cleaning steps are performed in a single unit, hence containing the perchloroethylene within the unit. The drying air continuously circulates within the closed system and a refrigerated condenser removes solvent vapour from the circulated air.
- Use of sealed delivery systems for adding perchloroethylene to dry cleaning machines.
- Phasing out the use of perchloroethylene by cleaning clothes with soap and water solutions.

**Case Studies of Pollution Prevention**

Some Canadian companies have successfully implemented pollution prevention strategies. Below are just a few of many examples.

**Reducing VOCs in the Printing Industry**

**Hemlock Printers** is a commercial offset printing company located in Burnaby, British Columbia. Hemlock Printers has taken steps to meet and exceed the Greater Vancouver Regional District (GVRD) stringent environmental standards regarding air and water quality and waste disposal limits. Hemlock was the first printer in the industry to become completely alcohol-free. The majority of the inks used in its printing processes are vegetable-based, which greatly reduces VOC emissions. In the press room, specially designed paper towels are used to clean the presses. These towels are collected and used as fuel, with minimal VOCs being released. The remaining ash is used in cement products. Minimal ink waste is generated at Hemlock. All inks are pre-measured for each project to reduce excess, and when there is ink left over it is re-mixed and used in another printing job. Electronic technology has eliminated requirements for film, and therefore film waste, in 100 per cent of projects. This change includes reduced chemical...
use and handling. Hemlock has reduced VOC emissions 50 per cent by changing to an alcohol-free printing process and reducing the number of chemicals and solvents used by 65 per cent (from *Pollution Prevention Canadian Success Stories*, www.ec.gc.ca/pp).

At **Bowne of Canada** a number of pollution prevention opportunities were identified in plant operations, several of which addressed VOC emissions. In the pressroom, spent waste fountain solution generated an estimated 53,000 litres of hazardous liquid waste per year that was disposed of at a cost of $30,750. Additionally, used rags and wipers, saturated with solvent and ink residue, were stored in drums that lacked tight-fitting lids; as a result, they were sources of VOC emissions. Upon full implementation of pollution prevention initiatives, Bowne expects to achieve annual aggregated reductions of 29.3 tonnes of VOCs, 6.6 tonnes of greenhouse gases, and 51.6 tonnes of process wastes, while saving 2.7 kilotonnes of water. This amounts to an overall savings of $133,000 and a payback period of seven months (from *Toronto Region Sustainability Program: Pollution Prevention Initiatives at Bowne Canada*, www.oceta.on.ca/TORSUS/bowne.pdf).

**Reducing VOCs in the Paint and Stain Business**

**CAN-LAK Inc.**, which employs 60 people, manufactures paints, stains and lacquers. Due to the nature of its business, the evaporation of solvents and subsequent release of VOCs into the atmosphere is a significant issue. Recognizing inefficiencies, CAN-LAK has undertaken operating improvements to prevent solvent losses. Improvements include increasing ventilation to eliminate solvent vapours in the workplace. CAN-LAK stores its basic solvents in tanks outside the plant. The vapours of the solvents stored in outside tanks are subjected to expansion and contraction cycles that vary with daily temperature changes. As a result, it was recommended that the tanks be filled more frequently during the summer, thereby reducing the headspace where evaporation occurs and reducing the quantity of VOCs released into the air. Within the plant, operating procedures were modified to isolate tank washing activities, minimize evaporation and optimize the collection of solvent vapours during the mixing and packaging of finished products. Since organic solvent fumes are generally heavier than air, intake nozzles were re-positioned to allow for the natural flow of the vapours towards the floor, thereby optimizing ventilation. These new measures have reduced VOC emissions by 4,125 kilograms per year (from *Pollution Prevention Canadian Success Stories*, www.ec.gc.ca/pp).
Reducing VOCs in Other Processes

Steelcase Canada Ltd. is a designer and manufacturer of products used in work environments, including desks, seating, work surfaces, storage systems and lighting. Headquartered in Markham, Ontario, the company employs more than 500 people at its manufacturing facility. On September 29, 2004 the Ontario Ministry of the Environment introduced Steelcase Canada as the first company to be accepted under the province’s new Environmental Leaders Program. By endorsing the leadership agreement, Steelcase Canada has pledged to eliminate emissions of VOCs from all liquid painting processes (in 2003, Steelcase emitted nine tonnes of VOCs during these processes). This will be achieved by replacing all solvent-based liquid operations with powder coating operations.

Interface Flooring Systems in Belleville, Ontario is another SME that is putting pollution prevention strategies to work. Interface manufactures nylon carpet tiles. It has lowered emissions of VOCs by reducing the use of polymer on the backing of carpet tiles.

Canadian Auto Collision Inc. in Brantford, Ontario has also succeeded in lowering VOC emissions through the use of high-solids and water-based paints. On-site recycling of cleaning solvents has resulted in 88 per cent recovery and reuse of solvents, reducing waste to a small concentrated sludge. A procedure for capturing and reusing solvents was developed that redirected 22 litres of chemicals away from landfill sites. Major emission reductions have also come from upgrading equipment, such as spray guns, which has improved transfer efficiency by 40 per cent.

Lord and Partners of Huntsville, Ontario manufacture low-VOC solvents and cleaners that are used in a variety of industries, including automotive, aviation, mining, oil exploration, pulp and paper, and transportation. Successful tests of its products have been done for paint removal, parts cleaning and degreasing applications by National Defence Canada at the Trenton Air Force base in Ontario.
Small- (fewer than 50 employees) and medium-sized (50–500 employees) enterprises are a large and diverse sector of the Canadian economy (Canada currently has 2.6 million SMEs, and this number is growing). Individually their environmental impact may be small, but cumulatively they generate a substantial amount of pollution that impacts the quality of air, water and land. Businesses can draw on a range of best practices to reduce VOCs, and can also assist their customers in doing the same. Three organizations, in particular, offer assistance, information, and/or case studies that can be helpful to businesses interested in practicing pollution prevention:

**The Ontario Centre for Environmental Technology Advancement (OCETA)** is a private sector, not-for-profit Ontario corporation with a mandate of providing business services to entrepreneurs, start-up companies and SMEs to help commercialize new environmental technologies and to support sustainable economic development, both domestically and internationally. One component of OCETA’s work is the organization and delivery of workshops, under the Natural Resources Canada energy efficiency program, to plant managers, energy managers and company executives in a variety of sectors. OCETA’s Toronto Region Sustainability Program provides pollution prevention technical assistance to SME manufacturers in the Greater Toronto Area. [www.oceta.on.ca/toronto.htm](http://www.oceta.on.ca/toronto.htm)

**The Canadian Centre for Pollution Prevention** website provides access to information, tools and networks for the purpose of improving the environmental performance of SMEs. Through the site, users have access to information on environmental compliance, pollution prevention techniques, management tools, on-line training, success stories and industry-specific resources, as well as a list of support programs available to SMEs. [www.c2p2online.com](http://www.c2p2online.com)

**The Canadian Pollution Prevention Information Clearinghouse (CPPIC)** is a database providing Canadians with information they need to practice pollution prevention. More than 1,200 references, ranging from fact sheets to case studies, are available on the website. Searches can be done through simple text searches, advanced searches or more specific industrial sector searches. [www.ec.gc.ca/cppic](http://www.ec.gc.ca/cppic)
Chapter Four

What Governments are Doing to Reduce VOCs

The previous chapter looked at some ways that unwanted VOC emissions can be controlled. This chapter considers specific ways in which three levels of government in Canada are requiring or encouraging reductions of these emissions.

Governments face major challenges in reducing VOC emissions. Because the majority of VOCs are released by natural sources (i.e., living and decaying plants, including trees), it is difficult or impossible to make significant reductions from those sources. However, populated urban areas — where most VOC emissions originate from human sources — are amenable to controls. VOC emission reductions can be achieved by taking action on emissions from transportation, industry and consumer products.
What the Canadian Government is Doing

The Canadian government has various means at its disposal to limit VOC emissions. Among them, it can control airborne releases of substances it considers toxic. The federal government sets national product standards and oversees the negotiation and implementation of binding international agreements related to transboundary air pollution. It is also able to promote best practices within federal departments. With these mandates, the federal government is able to significantly contribute to the control of VOCs, both as toxics and as smog precursors.

**VOCs as Toxics**

Under the *Canadian Environmental Protection Act (CEPA)*, the federal government is required to assess the potential toxicity of thousands of chemicals, including numerous VOCs. Through this assessment process, if a chemical is deemed “toxic” (see Text Box 4-1), Environment Canada may be obligated to propose and finalize, within strict timelines, control measures to reduce risks associated with the substance. These measures can include regulations, guidelines or other policy “instruments,” and can apply to toxic VOCs at any stage of their life cycle. The measure selected can affect the research, development, manufacture, use, storage, transport or disposal of toxic VOCs. The measures often include the development and implementation of plans for pollution prevention, response to environmental emergencies and codes of practice. See Text Box 4-2 for examples of risk management measures that can be used to control toxic VOCs.

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**Text Box 4-1**

**What is “CEPA-toxic”?**

Section 64 of CEPA 1999 defines a substance as “toxic” if it is entering or may enter the environment in a quantity or concentration or under conditions that

a. have or may have an immediate or long-term harmful effect on the environment or its biological diversity;

b. constitute or may constitute a danger to the environment on which life depends; or

c. constitute or may constitute a danger in Canada to human life or health.

Under the *Canadian Environmental Protection Act (CEPA)*, the federal government is required to assess the potential toxicity of thousands of chemicals, including numerous VOCs. Through this assessment process, if a chemical is deemed “toxic” (see Text Box 4-1), Environment Canada may be obligated to propose and finalize, within strict timelines, control measures to reduce risks associated with the substance. These measures can include regulations, guidelines or other policy “instruments,” and can apply to toxic VOCs at any stage of their life cycle. The measure selected can affect the research, development, manufacture, use, storage, transport or disposal of toxic VOCs. The measures often include the development and implementation of plans for pollution prevention, response to environmental emergencies and codes of practice. See Text Box 4-2 for examples of risk management measures that can be used to control toxic VOCs.
VOCs as Smog Precursors

In 2000, Canada signed the Ozone Annex to the Canada–US Air Quality Agreement. The annex defines a transboundary region in each country. The states and provinces within the regions represent the areas within which emission reductions will have the most impact on the flow of transboundary ozone and its precursors. In the United States, the region covers 18 states and the District of Columbia (together these comprise 40 per cent of the US population). In Canada, the region includes central and southern Ontario and southern Quebec (together these include more than 50 per cent of the Canadian population).

Figure 4-1: Ozone Annex Pollutant Emission Management Area

Text Box 4-2

Examples of Risk Management Tools for Toxic VOCs

- **Instruments authorized under CEPA 1999:** regulations (including deposit refund and trading system regulations), pollution prevention plans, environmental emergency plans, administrative agreements, codes of practice, environmental quality objectives or guidelines and release guidelines
- **Voluntary approaches:** Environmental Performance Agreements, Memoranda of Understanding
- **Non-CEPA 1999 economic instruments:** financial incentives and subsidies, environmental charges and taxes
- **Joint federal/provincial/territorial initiatives:** Canada-wide standards, guidelines, codes of practice
- **Provincial/territorial Acts:** regulations, permits, or other processes
- **Other federal Acts:** e.g., Fisheries Act, Pest Control Products Act, Hazardous Products Act.
As part of this agreement, Canada is committed to reducing VOC emissions from transportation. To accomplish the goal of reducing transboundary ozone, new regulated standards have been put in place to reduce VOC emissions from vehicles and fuels. These standards cover cars, vans, light-duty trucks, off-road vehicles, small engines and diesel engines, as well as fuel. Implementation of measures under the *Federal Agenda on Cleaner Vehicles, Engines and Fuels* is expected to achieve significant VOC reductions from the transportation sector by 2010. As well, VOCs from consumer products are being addressed through the CEPA 1999 *Guideline for Reducing Emissions of Volatile Organic Compounds from Consumer Products*. This guideline lists VOC content limits for 22 consumer product types, including hairsprays, household cleaning products, automobile cleaning products and insecticides.

On March 27, 2004, the Ministers of Environment and Health published a Notice of Intent entitled, *Federal Agenda on the Reduction of Emissions of Volatile Organic Compounds from Consumer and Commercial Products*. This document outlines a series of measures to be developed and implemented between 2004 and 2010 to reduce emissions of VOCs from consumer and commercial products. (Information on actions being taken by Environment Canada to address VOC emissions resulting from the use of consumer and commercial products in Canada can be found at www.ec.gc.ca/nopp/voc.)

**Text Box 4-3**

**Reduction of VOC Emissions through the Development of Two Regulations**

In 1993, the VOC tetrachloroethylene (more commonly called perchloroethylene or PERC) was assessed and declared “toxic” under CEPA. As a result, on February 27, 2003, the federal government passed into law the *Tetrachloroethylene (Use in Dry Cleaning and Reporting Requirements) Regulations*. The regulations apply to PERC as it is used by dry cleaners, set standards for its handling and disposal, and specify safety measures to be followed in case of spills. These regulations were expected to result in a 70 per cent reduction of PERC releases at dry-cleaning facilities from 1994 levels by August 2005. Eventually, the regulations will phase out the use of PERC in all dry cleaning equipment except machines that are fully enclosed and re-use PERC.

The Solvent Degreasing Regulation went into effect on July 24, 2003, to control the VOC trichloroethylene. This regulation is expected to result in a 65 per cent reduction in consumption of trichloroethylene in solvent degreasing by 2007.
The federal government also initiated the “Environmental Choice Program,” which encourages the supply of and demand for products and services deemed to be environmentally responsible. According to a report published by Environment Canada in 2003, “companies must comply with stringent environmental criteria that are established in consultation with industry, environmental groups and independent experts, and that are based on research into the life-cycle impacts of a product or service” to obtain environmental certification of their products and services. The Environmental Choice Program currently sets VOC content limits for the following products: consumer, industrial and/or institutional cleaning products, biologically-based cleaning and degreasing compounds, industrial hand cleaners, paints, surface coatings, printing inks, adhesives and personal care products. For more information, see www.environmentalchoice.com.

Although many VOCs that form smog are not particularly toxic on their own, VOCs were added as a group to the list of CEPA toxics in July 2003. This means that Environment Canada can now apply regulations and guidelines to the entire range of smog-forming VOCs.

**Text Box 4-4**

**Tracking VOC Emissions**

In 1992, the Canadian federal government created the National Pollutant Release Inventory (NPRI). Any facility in Canada that “manufactures, processes or otherwise uses” one or more of the NPRI-listed substances in excess of a certain “threshold” must submit an annual report to Environment Canada on the releases and transfers of those substances (in 2002, the threshold for VOCs was 10 tonnes). As of 2002, the number of substances for which releases and transfers must be reported was 273, many of which are VOCs. More than 3,000 facilities across Canada report to the NPRI on a yearly basis. For more information, visit the website at www.ec.gc.ca/pdb/npri.

Another method of tracking VOCs is through the Criteria Air Contaminants (CAC) database. The CAC inventory conveys data on the actual emissions of various air pollutants (measured in tonnes per year) that originate from a number of sources located across the country. These sources are organized in categories that include industrial production, fuel combustion, transportation vehicles and incineration, among others. Every five years, Environment Canada issues a national inventory of air contaminant emissions from polluting sources in Canada of the five common smog pollutants, which include VOCs. A separate category of biogenic VOC emissions categorized by province is also given. Summary data for CAC can be found on Environment Canada’s GreenLane website at www.ec.gc.ca.
What Provincial Governments are Doing

Issuing Permits

Provincial governments control pollutant releases from commercial and industrial sources mainly by requiring that site-specific permits be obtained for those releases. These permits set limits on how much of each pollutant the source may release. In setting these limits, provincial governments, similar to US state governments, focus on protecting the “most sensitive receptor,” which is most often humans, but can be plants or animals inhabiting the natural environment. Governments do this by using mathematical models to calculate the potential worst-case concentration of each pollutant, usually at ground level, around the source. If the calculated concentrations are below the applicable air quality standards in the jurisdiction, the company is issued a permit to operate the processes under review.

Provincial governments either develop independently, or adopt from other jurisdictions, the air quality standards used in their permitting processes. Beginning in the late 1990s, Ontario embarked on a plan to review and, where necessary, update many of its standards, including those for such commonly found VOCs as acetone, hexane, tetrachloroethylene, toluene and xylene.

In August 2005, the government of Ontario introduced new and updated standards for 40 pollutants, including some for VOCs, into the regulation to protect Ontario communities from the impacts of air pollution. For a list of the new standards, see www.ene.gov.on.ca/envision/AIR/airquality/standards.htm.
Air Quality Monitoring

To support air management policy and enforcement of air pollution regulations in general, provinces maintain air quality monitoring networks. In areas of Canada where smog is a problem (i.e., the Windsor–Quebec City “corridor”; the Greater Vancouver area, also known as the Lower Fraser Valley; and the lower St. John area of New Brunswick), provincial governments operate smog monitoring networks, which continuously measure ground-level ozone, NO$_x$, particulate matter and VOCs.

Provincial governments also encourage individuals to change their smog-related lifestyle habits through various programs, such as Ontario’s “Air Quality Ontario” (www.airqualityontario.com) and New Brunswick’s “Index of the Quality of the Air” (www1.gnb.ca/0355/0003/0000.asp), which monitor and report air quality readings. By informing the public of air quality conditions and what they mean, these programs enable people to take actions to protect themselves from poor air quality and to reduce their own emissions.

Vehicle Emissions Testing Programs

Both British Columbia and Ontario have vehicle emissions testing programs. AirCare in British Columbia and Drive Clean in Ontario require vehicle emissions to be tested on a regular basis. Among other pollutants, such as NO$_x$, these tests measure hydrocarbons emitted by a vehicle’s exhaust system. If a car fails the emissions test, the goal is to have the car repaired to reduce its emissions before it goes back on the road. According to an independent analysis by Stewart Brown Associates, Drive Clean has reduced smog-causing emissions by more than 81,200 tonnes of NO$_x$ and hydrocarbons from 1999 through 2003. In 2003 alone, smog-causing emissions were reduced by the equivalent of removing more than 600,000 typical light duty vehicles from Ontario’s roads. For more information, see www.driveclean.com.
Four Codes of Practice related to on-road vehicles and handling of fuels have been developed through the CCME:


Eleven codes, guidelines, standards and Memoranda of Understanding (MOUs) to control solvent use have been completed and endorsed by the CCME. These are listed below in order of publication year:


In addition, CCME has developed two national plans to reduce emissions from VOC-containing products:

1. A Plan to Reduce VOC Emissions by 20 per cent from Consumer Surface Coatings (2005).

For more information on the Canadian Council of Ministers of the Environment, and to access these documents, visit their website at www.ccme.ca.
Joint Federal/Provincial/Territorial Actions

The Canadian Council of Ministers of the Environment (CCME) is the “major intergovernmental forum in Canada for discussion and joint action on environmental issues of national and international concern.” Environment ministers from the federal, provincial and territorial governments meet regularly to discuss environmental priorities and work to be carried out under the guidance of the CCME. Through this national forum, the CCME has overseen the development of nationally consistent environmental standards, strategies and objectives. This includes the 15 VOC-focused guidelines, codes of practice and MOUs listed in Text Box 4-6.

What Municipal Governments are Doing

Although municipal governments across Canada generally lack extensive powers to enact laws to manage VOC emissions, they have often proven to be effective messengers of sound environmental advice. The following are some examples of bylaws and initiatives that can be found across Canada.

Montreal and the Former Montreal Urban Community

The Quebec government delegated significant environmental management powers, including those over air pollution, to the Montreal Urban Community (MUC), now re-structured as the City of Montreal. The MUC’s By-law pertaining to air purification (By-law 90-1), which has been amended several times since its first passage in 1986, sets out extensive rules covering a range of air pollution sources. By 2001, its powers had been extended to cover VOC-emitting activities or facilities as diverse as:

- dry cleaning;
- wire stripping;
- floating roof tanks;
- incineration of sewage sludge, biomedical, hazardous and wood waste;
- crematoria;
- application of paints;
- degreasing of metal parts;
- mixing of asphalt;
• cleaning and storage of skins;
• vapour recovery during fuel distribution; and,
• leak detection and repair programs at refineries, petrochemical plants, organic chemistry plants and petroleum terminals over a specified size.

Greater Vancouver Regional District (GVRD)

Through an air quality regulatory program similar to Montreal’s, the Greater Vancouver Regional District (GVRD) sets allowable emission levels for industries and businesses. The sources currently permitted by the GVRD include numerous solvent-use sub-sectors, such as cabinet manufacturing plants, furniture manufacturing plants, polyurethane foam manufacturing plants, metal container manufacturing plants, aerospace component manufacturing facilities, auto dewaxing/body shops, web press printing, boat manufacturing plants, custom refinishing and restoration plants, industrial rubber rebuilding plants, wood preservation facilities and industrial laundry facilities.

The two VOC emissions regulations that the GVRD has developed and adopted are for the solvent use sub-sectors: automotive refinishing, and reinforced plastics and composites industries.

For other commercial and industrial operations, voluntary emissions reduction guidelines and educational programs are provided to help reduce air pollution.

Toronto and the Surrounding Region

Municipalities in Ontario are subject to Ontario’s Municipal Act 2001. Under this Act, municipalities have specific powers that either fall within 10 service delivery areas or, in more limited terms, fall outside these “spheres” of jurisdiction. Included in the latter are provisions in three areas: health, safety, well-being and protection of persons and property; nuisances; and the natural environment. In no case can municipal by-laws conflict with federal or provincial statutes. Using these powers, in 2004 the City of Toronto passed a by-law limiting the use of herbicides and pesticides on private property.

Although to date Ontario municipalities have not sought to regulate an extensive range of activities, as have Montreal and the GVRD, some notable initiatives have emerged to reduce transportation emissions, including VOCs:

Anti-idling by-laws: These by-laws, which limit the length of time that vehicles can idle unnecessarily, are being passed or considered across the Greater Toronto Area (GTA). In 1998, the City of Toronto passed an idling by-law that — with some exceptions — limits idling to no more than three minutes in a given sixty-minute period.
**GTA Clean Air Council (GTA-CAC):** Since the spring of 2000, an annual “Smog Summit” has been convened in Toronto, organized through the inter-governmental GTA Clean Air Council. In 2001, the Council’s mandate was expanded to share best practices among the participating governments. In particular, the GTA-CAC was encouraged to extend participation to all regional, city and town governments in the Greater Toronto Area and to explore coordination of smog reduction initiatives.

Most GTA-CAC initiatives focus, in some way or another, on energy efficiency and conservation, each of which may assist in reducing VOC emissions.

**Toronto Atmospheric Fund (TAF):** Using $23 million from the sale of surplus property in 1988, Toronto City Council established TAF in 1991 to finance local initiatives to combat global warming and improve air quality in Toronto. TAF’s stated mandate is to help reduce greenhouse gas emissions, such as CO$_2$ and methane; improve local air quality; promote energy conservation and efficiency; improve public understanding of global warming and its implications for the urban environment; expand “carbon sinks,” such as Toronto’s urban forest that absorbs CO$_2$ from the air; support related scientific research and technology development; and develop partnerships with non-governmental organizations, other levels of government, businesses and academic institutions.

Although most of the initiatives funded by TAF are now focused on renewable energy, energy conservation and efficiency, as well as reducing the fossil fuel content of energy sources, some of its initiatives, particularly those related to transportation, will result in VOC emission reductions.
Chapter Five

What You Can Do to Reduce VOCs and Your Personal Exposure

VOCs are released from industries, transportation and consumer products. The choices you make can increase or decrease emissions from these sources. By making changes in home, vehicle and consumption habits, you can choose to limit and reduce VOCs in the atmosphere while protecting yourself and others.
<table>
<thead>
<tr>
<th>What you can do</th>
<th>Why?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drive less, especially during peak traffic periods or on hot, sunny days.</td>
<td>Transportation emissions account for 26 per cent of the total national human-generated VOC emissions in Canada (<em>Criteria Air Contaminants Emission Summaries, 2000</em>).</td>
</tr>
<tr>
<td>Get engine tune-ups and car maintenance checks as advised by your mechanic or</td>
<td>If all drivers maintained their cars regularly, VOC emissions from this source could be reduced by 30 per cent.</td>
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<td>the car manufacturers’ maintenance schedule.</td>
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<td>Consider fuel efficiency when purchasing a vehicle, and keep your vehicle</td>
<td>Small engines make a significant contribution to Canada’s air pollution problems. In 2000, VOC emissions from these sources in Canada totalled 58.9 kilotonnes.</td>
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<td>well maintained. Check out the AutoSmart website (<a href="http://oee.nrcan.gc.ca/">http://oee.nrcan.gc.ca/</a></td>
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<td>vehicles) to find out which vehicles are most fuel efficient.</td>
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<td>Cut down on the use of small engine motors. These engines, which usually</td>
<td>The new technologies are more fuel-efficient, consume less lubricating oil and reduce emissions of toxins, such as benzene and toluene, compared to the two-stroke options.</td>
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<td>run on gasoline, are used primarily in lawn and garden equipment, such as</td>
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<td>lawnmowers, leaf blowers, chain saws, and lawn and garden tractors. Take</td>
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<td>advantage of programs, such as the Clean Air Foundation’s <em>Mow Down Pollution</em></td>
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<td>program that, in partnership with several government and industry sectors,</td>
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<td>encourages recycling and replacement of old polluting gasoline-powered</td>
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<td>lawnmowers and trimmers.</td>
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<td>Replace conventional two-stroke recreational outboard marine engines with</td>
<td>Products that may be hazardous should have warnings on them.</td>
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<td>new four-stroke or direct fuel injection (DFI) two-stroke technologies.</td>
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<td>Read and follow the instructions on labels on home products. Familiarize</td>
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<tr>
<td><strong>What you can do</strong></td>
<td><strong>Why?</strong></td>
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<td>Buy and use non-VOC containing products and support businesses that do the same. Old-fashioned cleaning products based on common household substances, such as vinegar and baking soda, have many appropriate applications. Many cleaners are now available that use soaps instead of organic compounds.</td>
<td>These alternatives release few or no VOCs into your home. Some dry cleaners are moving away from the use of perchloroethylene. By supporting these businesses you provide more incentive for others to reduce their VOC emissions as well. As in industry, however, the choices are not always easy or straightforward. A less toxic product on a volume-for-volume basis might be a greater burden on the environment than a more toxic product if proportionately more of the less toxic substitute is required to get the job done.</td>
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<td>Properly store and seal containers that are VOC based (e.g., paints). Properly dispose of partially full containers of old or unneeded products. Do not dispose of them with your regular garbage. Put them out on collection days for the disposal of hazardous household waste. If your community does not have this service, take the containers to a disposal site recommended by your municipality.</td>
<td>VOCs may leak from closed containers. Getting rid of them can help lower VOC concentrations in your home.</td>
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<tr>
<td>Buy limited qualities of VOC-containing products and buy only what you will be able to use right away.</td>
<td>This eliminates the need to store products that would otherwise release VOCs into your home.</td>
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<td>Time your use of products. Try to avoid using paints, cleaners and other solvents during the summer high smog season, especially if there is a smog advisory in effect. Fill your vehicle’s gas tank during cooler evening hours to cut down on the formation of ground-level ozone.</td>
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</tbody>
</table>
References

Reports


**Websites**


Health Canada. Existing Substances Division — www.hc-sc.gc.ca/hecs-sesc/exsd

International Programme on Chemical Safety (IPCS). INCHEM — www.inchem.org


US Environmental Protection Agency. Sources of Indoor Air Pollution — Organic Gases (Volatile Organic Compounds — VOCs) — www.epa.gov/iaq/voc.html

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Pollution Probe’s Primer Series

Pollution Probe has prepared a series of educational Primers on environmental topics. The goal of the Primers is to inform Canadians about current environmental issues by setting out the scientific basis for concern, potential solutions and the policy tools available. Each Primer focuses on what is being done, and what more can be done, by governments, businesses and individuals on these issues. Designed to be used by the general public, the Primers are produced in full-colour with an easy-to-use layout. The Primers all include a reference section that acts as an additional resource to help users continue to improve their understanding of the subject.

Each Primer is researched and written under the direction of Pollution Probe’s Executive Director. Before publication they are reviewed by scientists, non-profit organizations, industry experts, policy makers and others who have technical expertise on the issue to ensure that they are factually correct and reflect current thinking on the topic.

For more information, or to see the Primers on-line, please visit our website at www.pollutionprobe.org/Publications/Primers.htm.

**Child Health and the Environment — A Primer** (August 2005) provides an introduction to what makes children healthy, explains why children are more vulnerable than adults and examines health effects and exposures of concern for children.

**Primer on Bioproducts** (November 2004) provides an overview of the ways bioproducts are made and highlights some of the issues that bioproduct technologies might raise for Canadians.

**The Source Water Protection Primer** (May 2004) explains the water cycle, identifies threats to water sources, focuses on watersheds as the ideal management unit and identifies steps to consider when developing local source water protection plans.

**Primer on Climate Change and Human Health** (April 2004) describes the ways in which a warmer and more variable climate may impact Canadians’ health, reviews actions taken by Canadian governments and industries, and examines what individuals can do to reduce greenhouse gas emissions.

**Emissions Trading Primer** (November 2003) explains the concepts behind emissions trading, describes the ways in which it works and provides examples and case studies.

**Primer on the Technologies of Renewable Energy** (September 2003) explains the concept of renewable energy and the rationale for shifting energy generation towards cleaner and less greenhouse gas-intensive sources.

**Mercury in the Environment: A Primer** (June 2003) provides an overview of the mercury cycle, releases to the environment, transportation and deposition around the world and the uptake and accumulation of mercury in the food chain.

**The Drinking Water Primer** (June 2002) examines the two sources of drinking water — groundwater and surface water — and the extent to which Canadians depend on them.

**The Smog Primer** (June 2002) explains what smog and the pollutants that create it are and highlights the major sources of these pollutants (i.e., transportation and the burning of fossil fuels for energy).

All of Pollution Probe’s Primers are available for $20.00 per copy, plus postage (Cdn. $2.50, US $4.50, Int. $10.50).