Air Quality

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BACKGROUND

Air pollution, especially "smog," is a long-standing issue of environmental quality with a history of regulatory efforts to address air pollution dating back half a century. The two main types of air pollutants that make smog are airborne particulate matter and ground-level ozone. Trends in the levels of both these pollutants are shown in the two key indicators in this paper. Other air pollutants include sulphur oxides, carbon monoxide, nitrogen oxides, and heavy metals.

Ground-level ozone and $PM_{2.5}$ (particulate matter that is smaller than 2.5 micrometres in size) are of particular concern because no safe threshold for exposure has been found. This means that even low levels of exposure may pose a health risk. Because of their impacts on human health, both ground-level ozone and particulate matter have been added to the list of toxic substances under the Canadian Environmental Protection Act (CEPA). A BC Lung Association report (2003) identified particulate matter as the air emission of the most concern in BC from a human health perspective. In 2005, a study modelling the impacts on health of improving air quality in the Lower Fraser Valley reported that a 10% improvement in annual average $PM_{2.5}$ and mean daily maximum ozone concentrations would produce health benefits valued at approximately $195 million annually by 2010 (BC Lung Association 2005). The benefits should come from a reduction in acute and chronic bronchitis and asthma, hospital admissions, emergency room visits, and mortality.

In 2000, the Canadian Council of Ministers of the Environment (CCME) endorsed Canada-Wide Standards (CWS) for $PM_{2.5}$ and ground-level ozone that include targets for both pollutants. British Columbia supports the CWS agreement for $PM_{2.5}$ and ozone, which committed the province to do the following:

- Develop and implement plans to achieve the CWS by 2010
- Establish programs to ensure continuous improvement and to continue to keep existing clean areas clean, and
- Regularly report on progress made toward meeting the above targets.

In setting targets, the agreement recognizes that there are no "safe" levels for particulate matter or ozone.

INDICATORS

1. Key Indicator: Percentage of monitored communities that are achieving the Canada-wide standard for particulate matter ($PM_{2.5}$) in B.C.

Suspended particulate matter (PM) is composed of tiny, airborne solid or liquid particles (other than pure water). Particles larger than 10 micrometres (µm) in diameter settle to the ground relatively quickly. Particles this size are less of a health concern because they tend to collect in the throat and nose, where they are eliminated through the digestive system or by sneezing, coughing and nose blowing.

Particles of less than 10 µm can be inhaled. Previous state of environment reporting on air quality focussed on particulate matter of 10 µm or less (PM_{10}). It is now known that the portion of these particles posing the greatest threats to health are those 2.5 µm in diameter ($PM_{2.5}$) or smaller (Liu 2004) that penetrate deepest into the lungs. These fine particles ("respirable particulate matter") are less than 1/20th the width of a human hair. Although there are health risks associated with particles larger than $PM_{2.5}$, steps taken to reduce exposure to the $PM_{2.5}$ fraction also reduces exposure to the coarser particles in PM_{10}.

Once in the lungs, fine particulate matter affects pulmonary function. It contributes to the development of bronchitis and aggravates bronchial asthma and chronic bronchitis, pulmonary emphysema, existing cardiovascular disease, and other lung-related problems. Senior citizens and people with existing lung or heart problems are most at risk, but healthy adults and children can also be affected. Epidemiological studies show a relationship between exposure to fine particles and adverse effects on heath, particularly for the most susceptible groups in the population. This includes people who have had acute lower respiratory diseases, cardiovascular diseases, chronic artery diseases, congestive heart failure, or diabetes. This also includes children with asthma, children under 2 years of age and those who spend more time outdoors. A recent review of the scientific literature (Hrebenyk et al. 2005) showed that adverse health impacts have been found at exposure levels below the current Canada-Wide Standard (CWS) for $PM_{2.5}$, at levels observed in some communities in B.C.

In addition to naturally occurring dust, sources of PM include soot and smoke emitted by motor vehicles and other forms of transportation (including marine vessels), power plants, factories, construction, residential and forestry-related wood burning, and other activities. Particulate matter is categorized by how it is formed. Primary particulate matter is released directly into the atmosphere through processes such as erosion or direct emission from industrial or burning processes, including forest fires. Particles produced by erosion or by grinding are typically larger than 2.5 µm, whereas those produced by high-temperature combustion are predominantly less than 2.5 µm in diameter (i.e. $PM_{2.5}$). Based on the 2000 provincial emission inventory, the largest sources of $PM_{2.5}$ were controlled burning for forest management (29%), wood industries (18%), and residential wood combustion (15%), the latter reflecting the fact that a large proportion of homes burn wood for heating (BCMOE 2005). Secondary particulate matter is formed in the atmosphere through chemical or physical transformations of a large number of different chemicals, including gases such as sulphur dioxide, nitrogen oxides, volatile organic compounds, and ammonia. Secondary particles are typically less than 2.5 µm in diameter and can be a large part of total $PM_{2.5}$, contributing to reduced visibility and summertime (photochemical) smog.

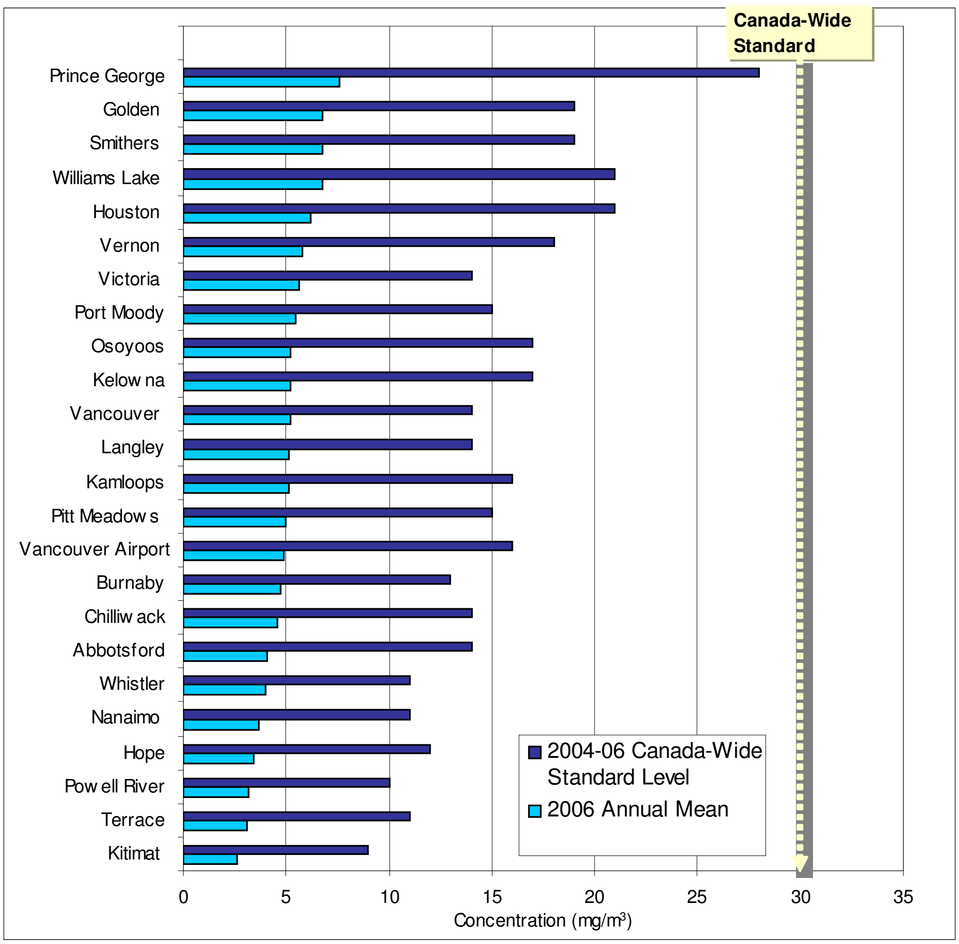
This indicator reports air quality with respect to achievement of the Canada-Wide Standard (CWS) for $PM_{2.5}$, as well as the annual averages for $PM_{2.5}$ in monitored communities. The annual averages are calculated as the average of all daily values available over the year. This differs from the way achievement of the CWS is calculated. Calculations for the CWS are based on the one daily value over the course of a year that is higher than 98% of all other daily values. These values are then averaged over three consecutive years.

Data and Methodology

Data for the $PM_{2.5}$ indicator (2004–2006) is gathered from a network of monitoring stations using continuous air samplers. The $PM_{2.5}$ monitoring network has expanded greatly over the past 6 years as the focus has shifted to monitoring smaller particles.

The Canada-Wide Standard (CWS) for $PM_{2.5}$ is 30 µg/m^3, averaged over a 24-hour period. Achievement of the standard is based on a 3-year running average of the annual 98th percentile ambient measurement. In the following analysis, the CWS is reported for continuous monitoring sites, irrespective of population. This reflects B.C.'s commitment to achieving the CWS in all monitored communities by 2010, and not just in communities larger than 100,000 population as specified in the CWS agreement.

Figure 1. Ambient levels of $PM_{2.5}$ at continuous monitoring stations across B.C. Annual mean for 2006 shown. Calculated Canada-wide Standard (CWS) value for 2004–2006 is also shown relative to the CWS (30 µg/m^3).



Source: B.C. Ministry of Environment.

Table 1. $PM_{2.5}$ concentrations (in µg/m^3) for sampling sites in B.C. using continuous (TEOM) samplers, 2004–2006.

	2004		2005		2006	
Site	Mean	CWS	Mean	CWS	Mean	CWS
Abbotsford Airport - Walmsley Road	5	15	5.2	15	4.1	14
Burnaby Kensington Park	4.9	–	4.9	14	4.5	13
Burnaby South	5.2	–	5.5	14	4.7	13
Chilliwack Airport	5	15	4.7	14	4.6	14
Golden Hospital	–	–	7.1	34	6.9	19
Golden Townsite	–	–	6.7	–	6.6	19
Hope Airport	–	–	4.5	–	3.4	12
Houston Firehall	6.2	22	6.2	22	6.2	21
Kamloops Brocklehurst	5.7	26	4.7	24	5.1	16
Kelowna College	5.8	25	4.6	23	5.2	17
Kitimat Rail *	4.1	12	3.7	12	–	–
Kitimat Riverlodge	2.9	11	2.7	10	2.6	9
Langley Central	–	–	5.6	17	5.1	14
Nanaimo Labieux Road	4.1	11	4.4	11	3.7	11
Osoyoos Canada Customs	–	–	4.1	–	5.2	17
Pitt Meadows Meadowlands Elem. Sch.	5.3	15	5.5	15	5	15
Port Moody Rocky Point Park	5.8	–	6	15	5.5	15
Powell River Cranberry Lake	3.2	10	3	10	3.2	10
Prince George Plaza 400	10.6	36	7.9	34	7.6	28
Quesnel Maple Drive	8.2	27	6.9	26	7.5	26
Quesnel Pinecrest Centre *	8.3	23	7.8	24	–	–
Quesnel Senior Secondary	8.9	27	7.3	25	8	24
Quesnel West Correlieu School	6.3	21	5.3	19	5.5	19
Saanich Stellys Cross Road	7.6	–	–	–	–	–
Smithers St Josephs	–	–	6.7	–	6.8	19
Terrace BC Access Centre	3.2	–	3.4	12	3.1	11
Vancouver International Airport #2	5.5	16	6	16	4.9	16
Vancouver Kitsilano	5.8	–	5.9	14	5.1	14
Vernon Science Centre	6.8	23	5.6	20	5.8	18
Victoria Royal Roads University	4.3	12	4.1	11	4	11
Victoria Topaz	5.6	16	5.4	15	5.6	14
Whistler Meadow Park	–	–	4	–	4	11
Williams Lake Columneetza School	7.2	24	6.7	22	6.8	21
Williams Lake CRD Library	6.5	19	5.6	18	5.6	18
Williams Lake Skyline School	7.5	22	6.7	21	6.5	21

Data Source: B.C. Ministry of Environment.

* Not shown in Figure 1; 2006 monitoring was not available.

Note: Mean = the annual average of all daily values for the year. CWS = calculated for achievement of Canada-wide Standards as one daily value that is higher than 98% of all other daily values (a running 3-year average).

Continuous measurements were obtained using a Tapered Element Oscillating Microbalance (TEOM). Continuous samplers use a heated inlet designed to exclude particles larger than 2.5 µm in diameter from the air sample stream. The air sample stream is drawn through a filter that sits at the end of a tapered tube. As the filter mass changes, the oscillating frequency of the tube changes. $PM_{2.5}$ concentrations can be determined through the corresponding frequency change.

The inlet air is heated to remove free water and to standardize sampling conditions. However, a drawback of this process is that a portion of the $PM_{2.5}$ may be volatilized by the high sampling temperature. Semivolatile materials such as ammonium nitrate and certain hydrocarbons are especially affected. Studies across Canada have indicated that annual average $PM_{2.5}$ concentrations may be underestimated by 1.5–3.0 µg/m^3, and annual 98th percentile concentrations underestimated by 4–15 µg/m^3 when compared with noncontinuous filter-based measurements (Dann and White 2005).

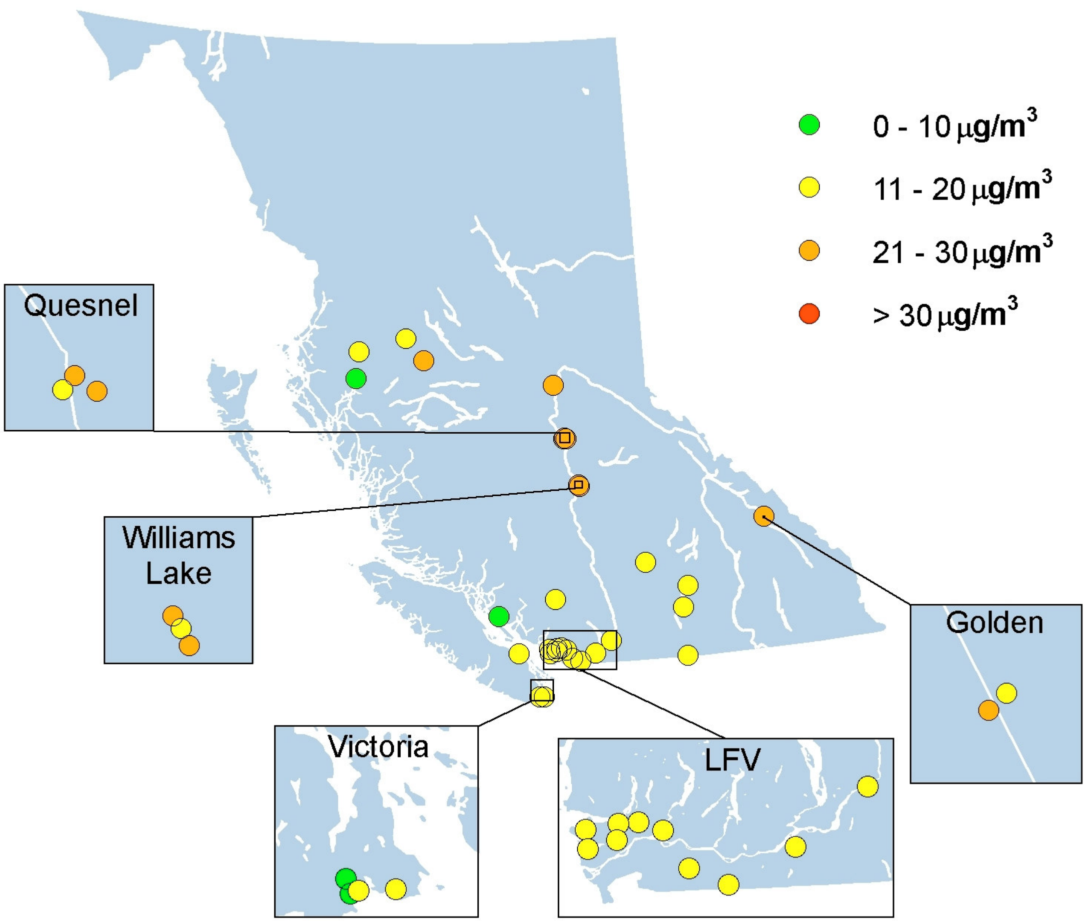
For the purposes of calculating achievement of the CWS, a daily value for $PM_{2.5}$ refers to the 24-hour average concentration of $PM_{2.5}$ measured from midnight to midnight (local time). For continuous monitors, at least 18 hourly measurements are required to calculate a valid daily value. An annual data set should be considered complete if at least 75% of the scheduled sampling days in each quarter have valid data.

Use of percentiles is a means of adjusting for differences in sample sizes and ensuring that the values used for determining achievement are not unduly affected by extreme events. The 98th percentile is the daily value out of a year of monitoring data below which 98% of all values fall. Jurisdictions calculate the 3-year average of annual 98th-percentile values, using the three most recent consecutive calendar years of monitoring data that meet annual data completeness criteria (CCME 2004).

Interpretation

Communities in the interior regions of the province typically have higher levels of $PM_{2.5}$ than coastal communities (Figure 2). This is due to a number of factors, including the large number of wood combustion sources and the greater frequency of light winds and inversions in interior communities. In 2006, all of the continuous monitoring sites in the province were below the CWS level.

Figure 2. Results of $PM_{2.5}$ continuous monitoring (TEOM sites) in 2006 compared to the CWS standard of $PM_{2.5}$ of 30 µg/m^3.



Source: B.C. Ministry of Environment.

Supplementary Information: Wood smoke in the air

A 1997 national survey of residential energy use found that about 40% of houses in BC had some type of wood-heating appliance or fireplace (NRC 1997). Smoke from wood heating and other types of wood burning contains fine particulate matter ($PM_{2.5}$) as well as larger particles, carbon monoxide, nitrogen oxides, sulphur oxides and volatile organic compounds. Table 2 shows the contribution to air pollution from residential wood burning alone in BC annually.

Table 2. Emissions from residential wood burning in B.C., 2003.

Emissions	Provincial total (tonnes/year)
CO	65,579
NOx	1,120
SOx	160
VOC	14,860
PM_{10}	10,632
$PM_{2.5}$	10,623

Source: BCMWLAP, 2005. Residential Wood Burning Emissions in British Columbia. *www.env.gov.bc.ca/air/airquality/pdfs/wood_emissions.pdf.*

In interior regions of the province, wood smoke is the largest contributor of fine particulate ($PM_{2.5}$) air pollution. There are an estimated 120,000 conventional wood burning stoves currently in use in BC (Xue and Wakelin 2006). Replacing these appliances with new, EPA/CSA-certified stoves would make a major difference to local air quality because certified stoves burn one-third less wood and produce 70% less smoke than older inefficient stoves.

A 1994 provincial regulation required that all new wood stoves installed in homes must be certified, and in 1995 the Ministry of Environment began a change-over program that gave incentives of $50 to $200 to replace older models with new technology. Despite this, a provincial survey in 2005 showed that only 1% of the existing stock of older stoves had been replaced despite local programs to encourage replacement (Gauvin and Wakelin 2005). Research showed that the barriers to success were the high cost of new stoves, accessibility of alternative fuels, and perception about wood smoke and wood burning (NRG Research Group 2006). To address these barriers in the Bulkley Valley-Lakes District, the province is partnering with Environment Canada, the Northern Health Authority, the regional district, and local retailers on a pilot program using community-based social marketing tools to encourage people to adopt clean burning technology. The pilot project combines education programs about operating wood stoves efficiently with funding incentives to exchange older models for new, low-emission appliances.

Regulatory requirements are also being brought in to speed replacement. In the Bulkley Valley-Lakes Regional District, Houston was the first jurisdiction to introduce a bylaw that requires residents to replace their non-certified woodstoves by 31 December 2010. Smithers and Burns Lake have also set target phase-out dates for conventional wood stoves of 2010 and 2012, respectively.

Ways to minimize the pollution from burning wood include the following:

- Burn only clean, dry wood. Never burn green, wet, painted, or treated wood or household garbage.
- Keep fires moderately hot, adding larger pieces of split wood as required.
- Avoid smoky, oxygen-starved fires by opening dampers enough to ensure the fire burns well.

- Don't burn on fair or poor air-quality days.
- Buy the right size of stove for the area to be heated. A stove that is too large will have to be damped down to maintain a comfortable temperature, creating more smoke.

2. Key Indicator: Percentage of monitored communities in B.C. that are achieving the Canada-wide standard for ground-level ozone

Ozone occurs naturally and is an important constituent of the upper levels of Earth's atmosphere, where it blocks harmful ultraviolet radiation from reaching the Earth's surface. However, at ground level ozone is an air pollutant harmful to human health and vegetation. Ground-level ozone is formed by chemical reactions between nitrogen oxides (NOx) and volatile organic compounds (VOCs) in the presence of sunlight (Warneck 1988). The component compounds ("precursors") may come from local emissions such as fossil fuels burned by vehicles and industry, or may be transported in the air from other regions.

Ozone concentrations vary with location and time of day, depending on the intensity of sunlight, weather conditions, and air movement. Hourly concentrations in urban areas are typically highest in the summer when temperatures are highest, the sun is most intense, and longer days enhance photochemistry. Strong daily patterns are observed during this period, with concentrations peaking in the afternoon and decreasing through the night, from lack of sunlight and other chemical reactions.

There are natural sources of the chemical precursors to ground-level ozone. These include soil microorganisms and lightning that contribute NOx emissions; vegetation that contributes VOC emissions; and wildfires that contribute both NOx and VOC emissions. Down mixing of ozone from the stratosphere is a direct source of ozone, most likely to be observed during the spring and at higher elevations when conditions favour such intrusions (Health Canada and Environment Canada 1999).

The risks to human health from ground-level ozone depend on the amount inhaled, and the probability of health problems rising as ozone concentrations increase. Ozone exposure can increase respiration and heart rates, aggravate asthma, bronchitis and emphysema, and pain during inhalation. In general, these effects are linked to more emergency room visits, hospitalizations, absenteeism, lower labour force participation, and higher health care costs, as well as premature death (Willey et al. 2004).

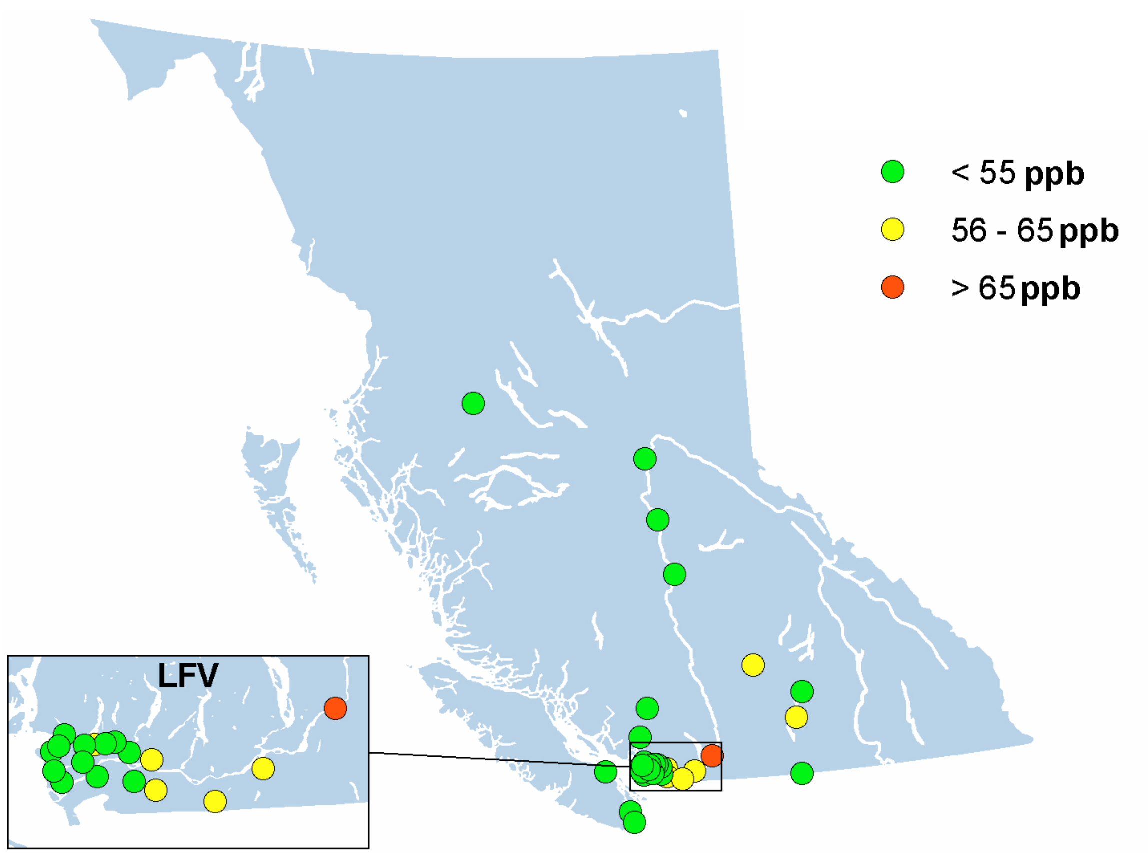
This indicator reports ground-level ozone concentrations with respect to achievement of the Canada-Wide Standard (CWS), as well as the annual averages in monitored communities. The annual averages are based on the average of all hourly values available over the year. This differs from the way calculations are done to show achievement of the CWS for ground-level ozone. This involves a series of calculations, in which the maximum 8-hour average concentration is determined for each day, then the 4th highest of these daily maximums is selected for each year. These values are averaged over 3 consecutive years.

Data and Methodology

The Canada-Wide Standard (CWS) for ground-level ozone is 65 parts per billion (ppb) averaged over an 8-hour period. Jurisdictions compute the 3-year average of the annual 4th-highest daily 8-hour average, using the three most recent consecutive calendar years of monitoring data that meet the annual data completeness criteria (CCME 2004).

Jurisdictions count a valid monitoring day as one in which 8-hour averages are available for at least 75% of the possible hours in the day (i.e., 18 of the 24 averages). However, if less than 75% of the 8-hour averages is available for a given day, it may still be counted as a valid day if the computed daily maximum 8-hour average is higher than 65 ppb. An annual data set is considered complete if daily maximum 8-hour average concentrations are available for 75% of the days during the period April to September.

Figure 3. Sampling sites (in red) in B.C. that exceeded the CWS standard for ground-level ozone (65 ppb) (2004–2006).



Source: B.C. Ministry of Environment.

Table 3. Ozone concentrations (in parts per billion, ppb) at sampling sites in B.C., 2004 to 2006.

	2004		2005		2006	
Site	Mean	CWS	Mean	CWS	Mean	CWS
Abbotsford Central	15	59	16	57	19	58
Burnaby	13	43	14	43	17	44
Burnaby Kensington Park	14	46	14	46	17	46
Burnaby Mtn	24	57	23	57	27	56
Campbell River	17	47	19	48	22	–
Chilliwack Airport	16	64	15	63	18	65
Coquitlam Douglas College	15	52	14	55	16	54
Eagle Ridge	–	–	–	–	–	–
Hope Airport	17	68	17	68	19	67
Kamloops Brocklehurst	19	60	20	59	22	57
Kelowna College	20	58	21	57	22	56
Langley Central	19	60	18	58	22	60
Maple Ridge Golden Ears Elementary School	16	60	16	59	19	62
Nanaimo Labieux Road	19	48	18	48	20	48
North Delta	15	48	14	48	17	48
North Vancouver Mahon Park	14	49	14	50	17	50
Osoyoos Canada Customs	–	–	27	–	30	53
Pitt Meadows Meadowlands Elem. Sch.	16	53	16	53	19	55
Port Moody Rocky Pt. Park	12	49	12	48	13	50
Prince George Plaza 400	20	55	18	53	19	51
Quesnel Senior Secondary	15	54	16	52	18	53
Richmond South	15	51	15	53	17	51
Saanich Stellys Cross Road	19	–	18	52	24	52
Smithers St. Josephs	18	50	17	52	19	52
Squamish	14	–	14	56	17	55
Surrey East	18	55	17	54	20	55
Vancouver International Airport	14	50	14	49	17	47
Vancouver Kitsilano	12	47	12	48	14	48
Vancouver Robson Square	7.5	36	7.5	37	8.9	36
Vernon Science Centre	12	45	12	44	14	43
Victoria Royal Roads University	20	50	21	51	–	–
Victoria Topaz	17	45	16	45	21	47
Whistler Meadow Park	18	54	18	54	20	54
Williams Lake Columneetza School	17	49	21	49	22	55

Source: B.C. Ministry of Environment.

Note: Mean = the annual average of all daily values for the year. CWS = calculated for the achievement of Canada-wide Standards from annual 4th-highest daily 8-hour average (3-year rolling average).

Interpretation

The highest annual mean concentrations of ground level ozone occur in the southern interior sites (e.g., Osoyoos and Creston), which experience very warm and sunny summers. In contrast, the lowest concentrations are measured in downtown Vancouver, where high NOx emissions remove the excess ozone (Table 3).

In calculating achievement of CWS, the highest concentrations of ozone were observed in the eastern Lower Fraser Valley. The monitoring site at Hope (Figure 3, in red) exceeded the CWS for ozone in each of the 3 past years, and Chilliwack has been within 2 ppb of the standard over the same time. Trends analysis shows that the maximum short-term (1-hour) concentrations have decreased in the Lower Fraser Valley between 1985 and 2000 (Vingarzan 2003), but it appears that annual mean concentrations in the western part of the valley are increasing. A contributing factor may be the increase in global background concentrations, including trans-Pacific transport of ozone from biomass burning and other human activities in Asia (McKendry 2005).

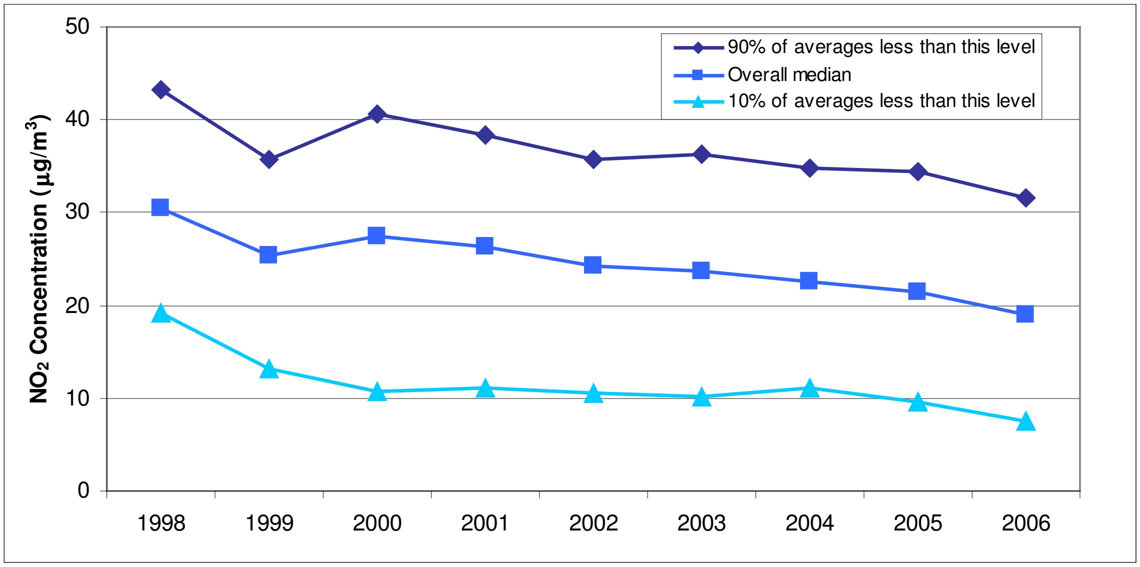
Supplementary Information: Trends in concentrations of nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) in B.C.

Nitrogen dioxide (NO_2) is one of the oxides of nitrogen (NOx), a group of highly reactive gases that form when fuel is burned at high temperatures. NO_2 is a very corrosive gas that contributes to ozone and secondary particulate formation and the reddish-brown haze associated with smog events. It is also harmful to health. NO_2 also reacts with water to form nitric acid, which is a component of acid rain. Most of the NOx emissions in BC come from transportation sources, such as vehicles and marine vessels, from non-road engines, the pulp and paper industry, and the oil and gas industry (BCMOE 2005).

The measurement of NO_2 is a 2-step process using the principles of chemiluminescence. First, the concentration of NO in the airstream is measured, using a gas-phase reaction of NO and ozone. This reaction gives off a quantity of light proportional to the concentration of NO. The second step involves passing the air stream over a heated catalyst to reduce all oxides of nitrogen to NO, then using the gas-phase reaction with NO and ozone to determine the total concentration of NO. The amount of NO_2 is the difference between the first measurement and the second measurement.

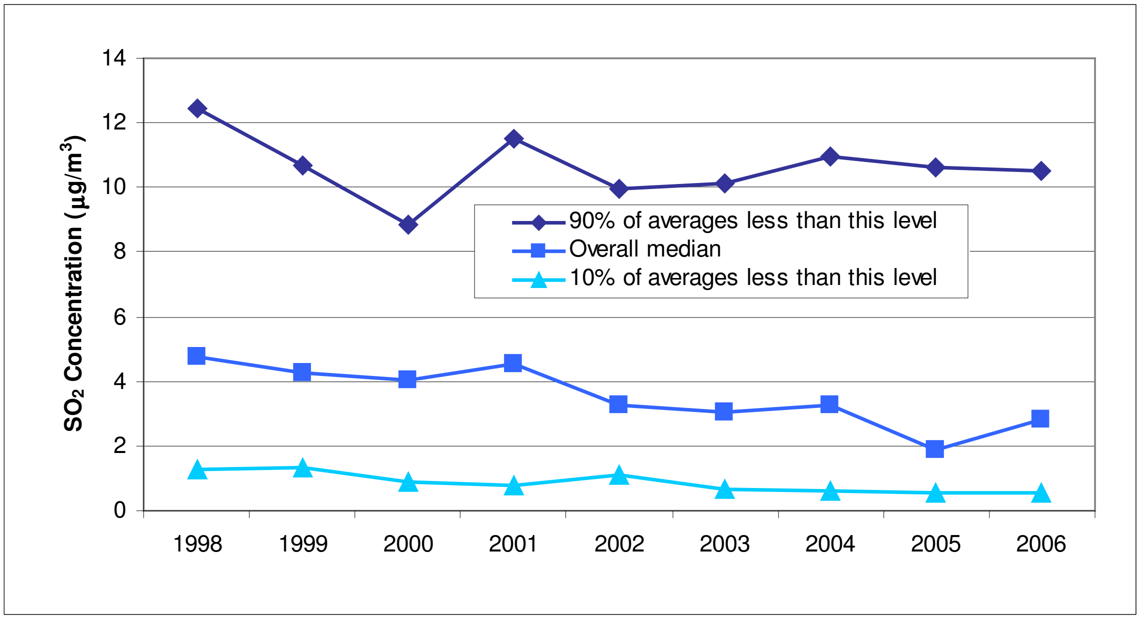
Urban areas tend to have higher levels of NO_2 as a result of the higher volume of traffic, as shown by the occurrence of the highest levels in Vancouver and Burnaby. The lowest levels were observed in areas such as Creston, Powell River, Kitimat, and Osoyoos. All BC communities monitored, however, met the Canadian annual objective for NO_2 of less than 60 $\mu g/m^3$. The graph (Figure 4) suggests that concentrations are declining, which would be consistent with an expected impact of more stringent emission standards for motor vehicles that have been adopted over the past decade.

Figure 4. Average NO_2 concentrations for sampling sites in B.C., 1998 to 2006.



Source: B.C. Ministry of Environment.

Figure 5. Average SO_2 concentrations for sampling sites in B.C., 1998 to 2006.



Source: B.C. Ministry of Environment.

Sulphur dioxide (SO_2) is a colourless gas that irritates the lungs and damages vegetation when it occurs in high concentrations. It comes from burning fossil fuels that contain sulphur and from processing ores that contain sulphur. The largest sources in the Lower Fraser Valley are marine vessels and the petroleum products industry, whereas in other parts of B.C., marine vessels, oil and gas and pulp and paper industries are the largest contributors (BCMOE 2005).

Monitoring for SO_2 is based on measuring fluorescent excitation of SO_2 by ultraviolet radiation. Where more than one monitor was located in a community, the one best representing regional air quality was presented. This may not include the site recording the highest concentrations in a community.

Trends in SO_2 concentrations are shown in Figure 5. In 2006, the highest annual average SO_2 concentration was in Trail, followed by Prince George, downtown Vancouver, and Kitimat. These are all communities with one or more industrial sources, or where marine, industrial, and motor vehicles are major sources. All B.C. communities except Trail met the B.C. annual objective for SO_2 of 25 $\mu g/m^3$.

WHAT IS HAPPENING IN THE ENVIRONMENT?

There has been a long history of monitoring and regulatory efforts to address the problem of "smog" and other forms of air pollution. B.C. now uses the Canada-Wide Standards (CWS) for fine particulate matter and ground-level ozone to measure achievement of objectives to improve air quality.

- In 2006, all communities with continuous air monitoring in B.C. were below the CWS for fine particulate matter (particles smaller than 2.5 micrometres). Only the levels in Prince George, which were the highest in B.C., approached the CWS threshold of 30 $\mu g/m^3$.
- Most communities in BC were below the CWS for ground-level ozone (65 parts per billion). The CWS for ozone was exceeded at Hope for the past 3 years, but readings at Chilliwack, Langley Central, and Maple Ridge were at or near the CWS threshold.
- In 2006 nitrogen dioxide readings in all communities were below the Canadian objective (60 microgram/m^3). In 2007, all communities, except Trail, met the BC annual objective for sulphur dioxide (25 microgram/m^3).

WHAT IS BEING DONE ABOUT AIR QUALITY?

Air quality management in B.C. is shared between federal, provincial, and local governments, with the provincial Ministry of Environment having the primary responsibility. Under the Canadian Environmental Protection Act (CEPA), the federal government sets National Ambient Air Quality Objectives (NAAQOs) as national goals for outdoor air quality. Provincial governments can adopt the NAAQOs or use them as benchmarks for setting provincial objectives or standards. Local and regional governments have the authority to restrict activities that emit air pollutants in their regions.

In 2000, the Canadian Council of Ministers of the Environment endorsed Canada-wide standards for ground-level ozone and fine particulate matter ($PM_{2.5}$). These standards set targets for ambient concentrations that have to be achieved by the year 2010.

Some key areas of work to improve air quality, such as programs to address diesel emissions, are jointly funded by several levels of government and the private sector working together. These include programs to retrofit school buses and municipal trucks with catalytic converters, replace diesel buses with natural gas buses, and encourage adoption of biodiesel fuel.

Federal Initiatives

Under the Canadian Environmental Protection Act (CEPA), the federal government assesses substances and controls their impact through national environmental quality objectives or regulations. The federal government regulates sources of air emissions such as motor vehicles and fuels, marine vessels, aircraft, railways, and other off-road engines, and is responsible for international agreements on air pollution.

Under CEPA, since 2002, emissions of air pollutants that affect human health and contribute to ground-level ozone, haze, and acid rain are tracked by Environment Canada in a national emissions inventory. The National Pollutant Release Inventory (available at www.ec.gc.ca/pdb/npri/npri_home_e.cfm) tracks emissions of particulate matter (total, PM_{10} and $PM_{2.5}$ sulphur oxides, nitrogen oxides, volatile organic compounds, carbon monoxide, and other pollutants).

Environment Canada is continuing to invest in new instruments to fill gaps in pollutant coverage at monitoring sites and to establish new monitoring sites. A priority is to upgrade the continuous $PM_{2.5}$ instruments and improve the monitoring of $PM_{2.5}$ during cold seasons (Environment Canada 2006). Increased monitoring in remote locations will improve the understanding of background air quality.

The federal government has also established new, more stringent engine and fuel standards for diesel engines. However, since these standards apply to newly manufactured engines, it will take 20 to 30 years to realize the full benefit of the reduced emissions as older engines are replaced.

Provincial Initiatives

The B.C. *Environmental Management Act* (EMA) gives the provincial government the authority to develop standards, objectives, and guidelines for protecting air quality. Under the EMA, air discharges must be authorized by the Ministry of Environment through permit, approval, order, or regulation. The legislation also includes provisions for area-based planning. Provincial legislation controlling particulate matter includes the following:

- Regulations limiting open burning of wood residues and emissions from wood stoves.
- Vehicle and fuel quality regulations.
- Regulations requiring the phase-out of beehive burners by the end of 2007.
- Emission limits for some industrial sources (e.g., coal-fired power plants).

The Open Burning Smoke Control Regulation is currently being revised (fall and winter 2007). The new regulation will be more protective of human health in community airsheds and more flexible in the working forests, while encouraging alternatives to open burning for disposing of woody debris.

Over the next three years, $13.5 million has been allocated to provincial clean air initiatives led by Ministry of Environment in partnership with industry, communities, and other levels of government. Planned initiatives include the following:

- Retrofitting diesel buses and heavy duty diesel vehicles (see text box).
- Providing incentives to reduce the use of conventional woodstoves.
- Encouraging industry to adopt better emission technologies.
- Eliminating beehive burners.
- Providing financial incentives to help municipalities shift to hybrids and retrofit diesel vehicles.
- Extending the $2,000 sales tax exemption on new hybrid vehicles.
- Creating electrified truck stops to reduce idling.
- Implementing elements of the BC Energy Plan (e.g., reduce emissions from oil and gas flaring).

The province has committed to achieve the CWS for $PM_{2.5}$ in all monitored communities by 2010. To support implementation of the CWS the province supports development of airshed plans in B.C. communities, and scientific studies (e.g. Golden, Prince George, and Kelowna) needed to support airshed decisions. Related activities in support of improved local air quality include:

- The Clean Air Toolkit, an online tool to help local governments develop emission reduction programs in their communities.
- Wood stove exchange programs and a pilot study in the Bulkley Valley-Lakes District to assess effective ways to encourage the exchange of conventional wood stoves with low-emission wood stoves.
- Increased biodiesel use in the province.
- Development of a GIS-based tool to produce local emission inventories for airshed planning.

DIESEL RETROFIT PROGRAM

On June 6, 2007, the provincial government announced that British Columbia would be the first province in Canada to make clean emission technology mandatory in older commercial transport diesel vehicles. The new regulation requires installation of Diesel Oxidation Catalyst (DOC) filters, or an equally effective technology, in about 7,500 older vehicles by 2009. In B.C., older on-road heavy-duty diesel vehicle (models from 1989 to 1993) are responsible for 6.8% of overall particulate matter pollution. This is a high proportion for a relatively small number of vehicles. Installation of each DOC unit costs about $1,200 to $2,500. DOC filters are one of the clean technology options that are easy to install on most vehicles and require virtually no maintenance. The filters do not affect vehicle performance or increase fuel consumption, and are compatible with biodiesel fuels. It is estimated that this new regulation will reduce particulate matter by up to 60 tonnes per year and contribute to improved local air quality.

British Columbia's AirCare® Program

In 1992, the British Columbia government initiated AirCare, a vehicle emissions inspection and maintenance program to reduce emissions from onroad motor vehicles. It was the first such program in Canada and it aimed to reduce smog-forming emissions from cars and light trucks in Vancouver and the Lower Fraser Valley. Under the program, vehicles are tested regularly (at 1- or 2-year intervals) and those identified with defective emission controls are required to be repaired. A later program, AirCare OnRoad for heavy duty diesel vehicles, was piloted in 1996 and re-launched by the Province in 2004.

A recent study of the impact of AirCare showed that over one inspection cycle (a 2-year period) the program reduces vehicle hydrocarbon emissions by 25%, carbon monoxide by 24%, and nitrogen oxides by 11% (Edwards et al. 2004). Together, the AirCare and AirCare OnRoad programs reduced regional air pollution by an estimated 5% fewer emissions (Edwards et al. 2004).

AirCare is now managed by TransLink, the transportation authority for the Lower Mainland. It is just one part of the broader Greater Vancouver Regional District Air Quality Management Plan. As a result of tighter federal emission standards for motor vehicles since 2004, AirCare, and other local emission reduction measures for point and area emission sources, Metro Vancouver accomplished the major objective of reducing total emissions of common air contaminants by 38% by 2000. (www.aircare.ca/)

The New Air Quality Health Index

After public testing in 2005, the Ministry of Environment began piloting a new Air Quality Health Index (AQHI) in 2006. The AQHI is a scale (1 to 10) developed by provincial and federal environmental and health professionals to inform the public of health risks from local air pollution conditions. It was designed to help people make decisions to protect their health (e.g., by limiting exposure or reducing activity when the levels are high).

The AQHI reports on the potential health effects as well as the quality of the air. This index is not the same as the Air Quality Index, which reports results of air quality monitoring but does not provide information on health risks. The AQHI is based on the relative risks of a combination of common air pollutants known to harm human health, including $PM_{2.5}$, ground-level ozone, and nitrogen dioxide. The AQI reports the index for the single pollutant with the highest concentration relative to environmentally-based regulatory criteria.

In the pilot phase (2006/07), the AQHI is provided for 14 communities around the province on a website that updates automatically. The website shows recent and current air quality conditions expressed on a scale of 1 to 10 in terms of the risks to health; it also provides predicted conditions for the next day. The website also provides specific health messages for people who are sensitive to air quality, thus the people most at risk. (www.airplaytoday.org)

In 2008 the AQHI for all monitoring locations in B.C. and across Canada will be provided from a national Environment Canada website (*http://WeatherOffice.gc.ca*).

Regional Initiatives

The provincial government has delegated authority for air quality management to the Greater Vancouver Regional District (Metro Vancouver). The Fraser Valley Regional District (FVRD) has been delegated the authority for air quality planning. Under the BC *Environmental Management Act*, the provincial government can designate an area or airshed for the purpose of developing area-based management plans, such as air quality management plans. However, to date all air quality planning efforts have been voluntary. Local air quality plans vary significantly from one area to another to take into account differences in the type of pollutants and sources, such as particulate matter from wood stoves and debris burning and SO_2 from industrial sources.

Table 4. Local air quality management programs and plans developed in B.C. (as of July 2007).

Plans in place	Drafted plans in progress 2007	Pre-planning stage
Metro Vancouver (Greater Vancouver Regional District)	Sea-to-Sky (will include Whistler)	Golden (intensive monitoring for source of PM)
Fraser Valley Regional District		
Whistler		
Regional District of Okanagan-Similkameen		
Regional District of Central Okanagan		
Regional District of North Okanagan		
Quesnel		
Williams Lake		
Prince George		
Bulkley Valley - Lakes District		
Merritt		

WHAT CAN YOU DO?

Any steps that you take to reduce the amount of fuel burned, whether it is in transportation, home heating, or other uses will help reduce the emission of air pollutants.

- Insulate your home and take other steps to reduce the use of home-heating fuels.
- Replace older wood stoves with EPA/CSA certified wood burning appliances. Keep smoke emissions low by burning only dry, well-seasoned wood in a moderately hot fire.
- Keep your vehicle tuned correctly to avoid excessive tailpipe emissions.
- Purchase a fuel-efficient car, use public transportation, bicycle or walk to reduce the amount of fuel burned.
- Avoid unnecessary vehicle idling. Idling a vehicle for longer than 10 seconds requires more fuel than stopping and restarting the engine.
- Use manual or electric lawn mowers, leaf blowers, and weed trimmers instead of gas-powered models. The small engines in yard equipment, particularly older 2-stroke models, emit high levels of air pollutants per litre of fuel burned.
- Instead of backyard burning, recycle or compost waste and yard debris. Not only does backyard burning contribute particulate matter to the air, it is now known to be a main source of new dioxin and furan contamination deposited in the local environment (Lemieux et al. 2000) (For more information see: www.env.gov.bc.ca/soe/bcce/02_industrial_contaminants/technical_paper/industrial_contaminants.pdf).

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