THE QUALITY OF AIR
… WHAT WE CAN DO

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SUMMARY

Current Status

The downward spiral that epitomizes the current status of air pollution issues in Ontario is the consequence of government policies, or absence thereof. While imposing drastic funding cuts in environment, health and research activities, both provincial and federal governments are relying on voluntary measures to reduce pollution. Not only have such actions led to deterioration in essential monitoring and inspection programmes, they signal a lack of fortitude by governments to assume their role and responsibility to protect the environment for future generations.

Despite sizable reductions achieved in sulphur dioxide (SO_2) emissions over the last twenty years, acid rain continues to be a major concern. The recently introduced Ontario Smog Plan falls far short of being effective. Amongst other weaknesses, it fails to address the excessive and damaging levels of ozone and particulate matter that many communities are experiencing today. Climate change and greenhouse gas emissions do not even register on the provincial agenda, even though Ontario is a major consuming province. Emissions trading is currently becoming the favoured pollution reduction strategy on a global, national and provincial scale. Nevertheless, a cautious approach is warranted in adopting an untested market-based approach to emissions reduction that could result in environmental hotspots.

Federal-provincial initiatives such as the Acidifying Emissions Task Group and Sulphur Levels in Gasoline are examples of recent studies that compare various reduction scenarios in conjunction with the impact on human health, predicted cost benefits, and implicated expenses. However, lack of cooperation at the provincial level as well as some of the industrial sector often hamper implementation of the more stringent options or recommendations. Thus, the move to federal-provincial harmonization of regulations may well spell disaster for those provinces that display reluctance to institute meaningful regulations. In this respect, it remains to be seen how and what air quality objectives will be incorporated into current discussions on Canada-Wide-Standards for Particulate Matter and Ozone.

Cause of Problem

Lack of commitment, political will and funding is the root cause of inaction. The failure to use economic models that account for the true costs of environmental degradation is coupled with the failure to come to grips with the necessary changes or shifts in so many facets of our culture and lifestyles. Governments have not shown the leadership required to facilitate such changes nor have they addressed the challenge posed by the intrinsic relationship between jobs and the economy, and health and the environment. Existing taxation policies and subsidies are regressive, protecting the status quo. The deployment of green taxes and incentives for innovative techniques that address environmental issues is dismissed in a climate in which taxes of any sort are anathema to politicians. No public

education programme or active campaign is directed at reducing pollution. While media coverage of environmental issues has increased, it is at best sporadic and cannot be relied upon as the sole source of information. In Ontario, the educational sector is being pressured to deliver tangible employable skills, as determined by a market-driven consumer psychology. As a result, courses on environment are not expanding and are becoming optional. The level of public consultation and collaboration in assisting to formulate policy and regulations is token, if at all, in Ontario.

Agenda for Change

Ontario must alter course and direct its efforts to implement measures that improve air quality now. The setting of mandatory air quality standards along with stringent targets and timelines sends a clear signal of commitment to cleaner air and, at the very least, sets the stage for pollution reduction. An aggressive communication programme is needed to heighten public awareness as well as an increased level of public participation and consultation in decision-making and policy-setting processes. At the same time, government funding in environment must be enhanced to realize improvement in and support for monitoring programs and research. Creative new funding programs such as a provincial “Clean Air Fund” and/or “Atmospheric Fund” are needed to support and stimulate initiatives leading to emissions reduction, alternative energy sources, conservation projects, transportation strategies, and...cleaner air.

Key Recommendations

Major recommendations in this paper for government action include the following:

* The province should adopt the following air quality standards as mandatory objectives:
  a) place a cap on SO_2 emissions to ensure a 75% reduction of 1995 levels by 2015;
  b) set the air quality objective for ozone at 50 ppb (one-hr average) by year 2005;
  c) establish targets to reduce NO_X emissions by 75% of 1995 levels by 2010; and
  d) set objective levels at 25 $\mu g/m^3$ for PM_{10} and 15 $\mu g/m^3$ for $PM_{2.5}$ (24-hr average).

* The province should restore and enhance funding of monitoring and inspection programs and specifically promote the use of Personal Exposure Monitors for $PM_{2.5}$.

* The province should increase public participation in consultation processes, develop a communication strategy to heighten public awareness on air pollution issues and develop the mechanism to provide easy access to vital environmental information.

* The province should enact legislation that would:
  * reduce sulphur levels in gasoline to 30 ppm (maximum annual average) by 2002 and require sulphur content of gas to be posted at all filling stations; and
  * implement a mandatory vehicle Inspection Maintenance Program using up-to-date technology immediately in major urban areas and province-wide by April 19

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INTRODUCTION

General Comments

In the last few decades, there has been growing public awareness and concern with the increase in air pollution and its impact on human health and the environment. According to public opinion surveys, the environment is identified as the second most important risk factor to human health, just behind lifestyle.[1] However, the vast scale of problems associated with pollution is so overwhelming that people regard the future with apprehension and uncertainty, and feel powerless to change the course of events. Disasters such as the Plastimet fire in Hamilton in 1997 and the ice storms in Eastern Ontario and Quebec in 1998 serve as wake-up calls and galvanize the public and media to demand explanations, investigations and action. With time, these episodes fade from the spotlight leaving many issues unresolved.

Air quality advisories, UV indexes and smog alerts are now routinely issued along with weather reports. According to the level of the readings, such advisories warn of the need to remain indoors, protect against the sun's UV rays, avoid strenuous physical activity, minimize the use of motorized vehicles, and so on. These precautions are usually directed to vulnerable populations, that is children, allergy sufferers, people with respiratory problems and the elderly. There is no explanation as to what these readings signify or how accurately they represent air quality, nor is there any feedback whether these advisories are effective in altering people's habits. Often forgotten are those with increased risk of exposure due to their work environment or geographical location. Implied in these warnings is a tacit assumption that such advisories are to be expected as part of our modern-day lifestyle and that being indoors is somehow healthier. While these advisories serve to raise public awareness, it remains to be seen if they influence government action.

The current direction of federal and provincial governments has resulted in the weakening of regulations and enforcement, particularly in Ontario. Cuts in government funding in environment, health and research, downloading to municipalities, and the harmonization of environmental regulations are indicative of the low priority of Environment in the overall spectrum of governance. The deference of all issues to the need for economic recovery reveals a lack of political will to deal with the most problematic issues facing a society dependent on a healthy ecosystem.

Our society has become deeply polarized between the influential industrial sector and those concerned with social and environmental issues; the most vulnerable populations are marginalized in the process. Many industries question the cost-effectiveness of additional pollution control measures in light of the lack of conclusive evidence on the benefits to health, and the possible impact on jobs and the economy. Techniques such as risk management analysis are advocated in some quarters as a means of determining acceptable levels of exposure, despite studies indicating that there is no acceptable level or threshold value that will protect all of the population all of the time.[2]

Such sentiments are barriers to appropriately addressing the effects of pollutants on human health and the environment. The real economy operates within the constraints of the environment. Cleaner air, water and land inevitably leads to reduced health care costs and greater enjoyment of natural amenities, innovation and job creation.[3]

Provincial and federal environment commissioners have publicly criticized their respective governments for imposing funding cuts that ultimately endanger public health and for lack of concrete action to enforce pollution laws.[4] The Ontario Medical Association (OMA) has come out publicly in support of stronger action to fight air pollution and has attacked the government for promoting voluntary programs over mandatory standards.[5] Further fanning the flames, in a recent report on pollutant inventories Ontario was ranked as the third largest source of releases and transfers of pollutants among provinces and states in North America.[6]

It is time that government heeded their critics and re-assess their priorities. The consequences of inaction are far-reaching and may be irreversible.

Dynamics of Air Pollution

The very essence of pollutants is their non-static behaviour. Several pollutants released into the atmosphere cycle continuously among air, land and water. Once deposited on land or water, they bioaccumulate through food webs, reaching humans at highly concentrated and harmful levels. The cumulative impact of exposure to more than one medium is very likely to heighten the risk to human and ecological health. Furthermore, while small amounts of some pollutants may have low toxicity in themselves, their reactivity with other substances can lead to the formation of highly toxic pollutants.[7]

The designation of air pollution into air issues such as acid rain and smog reflects the manner in which this whole topic has evolved. These categories seem somewhat arbitrary in light of the complexity of this topic. At the same time, the various air issues are inherently linked in that they have common sources, emit common pollutants, have similar impacts on health and the environment, and require similar remedies.

This paper provides a synopsis of several key air issues, with emphasis on acid rain and smog. The sources, pollutants, and implications on human health and the environment are detailed. Government initiatives and programmes pertaining to these issues are reviewed and critiqued. Specific recommendations are made with respect to developing government policies and action that are directed toward an environmental agenda for Ontario. Strategies that could be implemented in the short term are explored. While the focus is on the provincial government, jurisdiction for many air issues resides at local, national, and international levels and recommendations and action need to be addressed accordingly.

ACID RAIN

Acid rain is caused by emissions of sulphur dioxide (SO_2) and nitrogen oxides (NO_X), mostly as a result of human activity. In the atmosphere, these pollutants are transformed into diluted acids and then fall to earth in the form of rain, snow, fog, and mist, as well as acidic dust and particles. In eastern North America, sulphur compounds account for approximately two-thirds of acid deposition while nitrogen compounds account for the remaining one-third. Emissions of these compounds can be transported long distances and adversely affect virtually anything that they contact, such as water, soil, plants and structural material.[8]

In the 1970's, acid rain became the environmental issue in Canada. In Ontario, losses of fish population along with other disturbing changes in lakes and forests signaled a problem; the source of the problem was found to be acid rain. The ominous prospect of dying lakes and forests struck at the very fabric of Canadian identity.

In response to mounting public pressure, the Eastern Canada Acid Rain Program was initiated in 1985 as a joint federal/provincial undertaking. The programme's objective was to reduce sulphur deposition to an amount that would protect moderately sensitive ecosystems. To achieve this objective, the plan committed Eastern Canada to cap SO_2 emissions at 2.3 million tonnes by 1994, a 40% reduction from 1980 emission levels. Other acid rain control programmes in Canada and the United States have since come into play, primarily focusing on SO_2. By 1996, SO_2 emissions dropped by 54% to 1.7 million tonnes. Yet acid rain continues to be a major concern for a number of reasons:[9]

- Emissions of nitrogen oxides (NO_X) are only holding the line; this may be undermining the benefits of reduction of SO_2. In fact, nitrate deposition has increased in the area from Lake Ontario to Quebec City.
- The acidity of precipitation has not decreased despite decreases in sulphate concentration, possibly as a result of the decrease in calcium and magnesium in precipitation, compounds that neutralize acid.
- Many of Canada's lakes, watersheds, soils, and forests have a natural tendency to be highly acid-sensitive and are not adequately protected by reductions alone.
- Fogs at high elevations are much more acidic than rain or snow, and more damaging to spruce trees and birches in these areas.
- More than 50% of acid deposition in Canada comes from sources in the United States.
- Emissions now reach higher altitudes, remain longer in the air, are spread more widely and are deposited much further from their source.[10]
- Higher levels of emission are now occurring in summer when increased electric power generation combined with more intense sunlight substantially increase the production of acid aerosols.[11]
- Deregulation of the electric industry leading to increased reliance on low-priced coal-

fired power plants will cause increases in SO_2 and NO_X emissions.[12]

While per cent reductions in emissions are given as indicators in the progress made in emission reduction, they should not mask the impact or significance of the total amount of emissions. Simply stated, the environment and effects on health respond to total pollutant loading**.** For example, in Ontario emissions for SO_2 and NO_X in 1995 were approximately 640 kilotonnes and 540 kilotonnes respectively (25% of the total emissions in Canada).[13] These amounts are highly significant in themselves.

Acid Rain Terminology

- ***Cap*** *is the maximum allowable level for emissions.*
- ***Critical load*** *measures the threshold above which pollutant load harms the environment. Different regions have different critical loads.*
- ***Target load*** *is the amount of pollution deemed acceptable, taking into account ethics, scientific uncertainties, social, economic and environmental factors, but not regional sensitivity. It is the driver used to reduce emissions.*
- ***Exceedance*** *describes the difference between acid deposition and critical load.*

A large area of Ontario receives depositions exceeding the critical load. Tens of thousands of lakes remain damaged by acid rain and acid rain remains a significant problem.[14]

Emission Sources (Canada)

- smelters, oil and gas processing of sulphur-rich ores;
- electric power plants: burning of sulphur containing coals, heavy oil;
- other industrial sources: pulp and paper, aluminum production, petroleum refining, iron and steel production, manufacturing of nitric acid or nitrated materials;
- transportation (fossil fuel consumption, sulphur-containing fuels); and
- volcanic eruptions (natural).

The following table gives the estimates of emissions for SO_2 and NO_X by source sector for Canada and United States for the year 1995:

Table 1: **Estimates for SO_2 and NO_X emissions, 1995:**[15]

Sector	**Canada**		**United States**	
	SO_2 - %	NOx - %	SO_2 - %	NOx - %
Electric Utilities	22	10	65	30
Industrial	**69**	25	28	17
Mobile	4	**60**	3	48

Other	5	5	4	5
Total (million onnes)	2.65	2.0	16.5	21.6

Note: In Canada, the mobile sector is the primary source of NO_X whereas the industrial sector is the major source of SO_2 emissions.

Human Health Effects [16]

SO_2 reacts with other chemicals in the air forming toxic pollutants. NO_X is a precursor for the formation of ground-level ozone, a major component in smog. Both SO_2 and NO_X contribute to the formation of fine particles suspended in air, known as acid aerosols. Sulphate aerosols, less than 1 micron in diameter, constitute a major fraction of smaller particles in the air and are particularly harmful to health because they readily penetrate the lungs.

The effects of acid rain on health include:
- cardiorespiratory damage;
- increased sensitivity for individuals with bronchitis and asthma;
- chronic bronchitis; and
- increase in premature mortality from cardiopulmonary diseases.

Environmental Impacts [17]

- acidification of lakes and soils;
- acceleration of metal corrosion;
- erosion of limestone, marble, and chalk building materials;
- decline in availability of nutrients in the soil;
- forest damage: leaf damage, reduction in tree vitality and regeneration (growth in hardwood forests reduced by 30%, coniferous forests by 10%);
- increased transparency to UV rays in lakes, harming fish species and aquatic life;
- mobilization of toxic heavy metals from soil and bedrock; and
- reduced visibility.

Acid Rain Control Programmes and Initiatives

"Towards a National Acid Rain Strategy", Acidifying Emissions Task Group (AETG), October, 1997 [18]

This multi-stakeholder task group, initiated by the National Air Issues Coordinating Committee (NAICC) in 1994, consisted of representatives from provincial and federal governments, industry, health and environmental groups across Canada. After nearly three years, the Task Group came to agreement on principles such as keeping clean areas clean, pollution prevention, and the need to develop a strategy to reduce nitrogen deposition, but failed to reach consensus on recommendations for targets and schedules.

Health and environment groups recommended emission reduction targets and schedules in stages that would result in a 75% reduction in SO_2 emissions below present caps by 2015**.** Ontario presented the greatest obstacle to proposed reduction scenarios and would not commit to keep their emissions from increasing**.** This was even more remarkable as emissions in Ontario are currently 25% below the cap. Representatives from industry were skeptical of the science and the validity of the cost benefits. They voiced concern about costs of implementation and losing the competitive edge, and questioned the merit of unilateral action by Canada.

The AETG report highlighted future potential cost benefits and human health effects associated with various SO_2 emission reduction scenarios, as shown in Table 2:

Table 2: **Cost Benefits and Human Health Effects Scenarios (2010- 2015)**[19]

Adverse Health Effects (adapted from the Health Effects Pyramid)	**Scenario 1 25% SO_2 reduction Canada & US No. of cases**	**Scenario 2(b) 50% SO_2 reduction Canada only No. of cases**	**Scenario 3 75% SO_2 reduction Canada & US No. of cases**
Mortality	200	200	830
Airway Obstructive Disease	710	730	2900
Hospital Admissions (respiratory & cardio)	230	240	950
Emergency Room Visits	560	580	2300
Asthma Symptom Days	77,300	79,300	316,900
Restricted Activity Days	110,270	113,500	451,800
Acute Respiratory Symptom Days	2,691,000	2,760,000	11,034,000
Child Bronchitis (cases)	9,600	9,800	39,400
Total Benefits($M)[1]	210-2000	220-2000	890-8000

[1] Total Benefits in $ Millions include an aggregate of environmental and social impacts, changes in well-being or damages and willingness to pay.

Scenario 3 was based on modeling predictions that indicated the need for 75% emission reductions of SO_2 in eastern Canada and the United States to fully protect the most sensitive areas and thereby achieve critical loads everywhere in eastern Canada.[20] The advantages of this Scenario over other options are evident.

The story on NO_X emissions is not encouraging. While smog plans in Canada and the US predict that reductions in the order of 45% in NO_X emissions would ameliorate acidification, the status of such plans is not clear. Furthermore, the benefits arising from reduction in nitrate deposition can not be quantified, as critical loads have not yet been established. At present, only an interim arbitrary target load of 10 kg/ha/yr exists. [21]

To date, no government has acted on the report's findings or conclusions.

Other Initiatives - Highlights

a) **US Clean Air Act (CAA):** The CAA, implemented by the Environment Protection Agency (EPA), was amended in 1990 to cut SO_2 emissions by 40% from 1980 levels by the year 2010 and NO_X emissions by 10% by 2000. The intention was to protect moderately sensitive ecosystems in the eastern United States. It introduced a SO_2 allowance trading system and called for regional control strategies, such as a NO_X trading programme and low-emissions vehicle programme.[22]

b) **Canada - US Air Quality Agreement, 1991:** This agreement was designed to control transboundary air pollution. The initial focus was on acid rain.[23]

Table 3: **Commitments under the Canada - United States Air Quality Agreement**

Commitment	**Compliance**
Canada	
Cap SO_2 emissions in 7 eastern provinces at 2.3 million tonnes by 1994 until 2000	24% under cap in 1996
Cap national SO_2 emissions at 3.4 million tonnes by 2000 onward	17% under cap in 1996
Reduce NO_X emissions from stationary sources by 10% (from year 2000 forecast)	On schedule
United States	
Reduce SO_2 emissions from 1980 levels by 9 million tonnes by 2000	On schedule
Reduce NO_X emissions from 1980 levels by 1.8 million tonnes by 2000	On schedule

c) **UN Protocols:** Signed under the auspices of the United Nations Economic Commission for Europe (UN ECE), these protocols addressed emissions caps for SO_2 and NO_X. The 1994 sulphur protocol set a cap on SO_2 emissions in sensitive regions of eastern Canada at 1.75 million tonnes by 2000. The NO_X Protocol committed to stabilize NO_X emissions.[24]

While these commitments represent an initial step in addressing air pollution issues and policies, they are relatively ineffective when one considers the severity of the problem, the level of commitment and the relative ease of achieving compliance.

Recommendations:

* Ontario, through the Ministry of Environment, should review and re-assess critical

loads and target loads to ensure that:

a) critical loads reflect the sensitivity of the watershed to the highest level of confidence and are routinely re-evaluated; and
b) target loads function as objectives and are set at or below critical loads.

* The province should enact measures that would:
  a) limit SO_2 emissions from exceeding current levels (now 25% below cap);
  b) establish stringent targets and schedules resulting in a 75% reduction in SO_2 emissions below current cap by 2015; and
  c) ensure that:
     1) critical loads for nitrogen deposition are established; and
     2) a strategy is in place by 2000 to reduce nitrogen deposition to critical loads.

SMOG

A term coined from smoke and fog, smog refers to the toxic soup we breathe, affecting our health and quality of life. Smog is the air issue with the greatest visibility and public awareness at this time. By addressing the sources and components of smog, significant improvements in air quality could be realized.

Smog is a complex combination of pollutants that is often found but not limited to large urban areas. The composition and concentration of smog vary with local conditions, sunlight, and other factors. These components can be transported downwind by air currents, affecting rural and other urban areas over distances that range from several hundred to a few thousand kilometres. While components of smog include ozone, particulate matter, gases such as sulphur oxides, nitrogen oxides, carbon monoxide and acid aerosols, the primary constituents are ground-level ozone and particulate matter.

Ozone

Ozone (O_3) is an odourless, tasteless, highly reactive and unstable form of oxygen. Ozone is formed by the reaction of nitrogen oxides (NO_X) with volatile organic compounds (VOCs) in the presence of sunlight. Given certain conditions such as warm sunny days, traffic, industrial emissions, slow moving air masses, and lack of precipitation, the formation of ozone and smog is greatly enhanced. Volatile Organic Compounds (VOCs) refer to organic compounds (hydrocarbons) that are highly reactive in sunlight, and generally short-lived. VOCs include substances such as benzene, acetone, propane, chloroform, and toluene. VOCs may be absorbed in particles, transported to rural areas, and released with temperature rise during the day, further enhancing ozone formation.

Since ozone and its precursors (NO_X and VOCs) can travel relatively long distances in the atmosphere, they can aggravate conditions in areas where local emissions may be only moderate. For example, some of the ozone created in the Ohio Valley by emissions of NOx and VOCs from the midwestern United States flows into Canada, raising ozone levels in Southern Ontario.[25]

Emission Sources

NO_x emissions are primarily associated with combustion of fossil fuels and industrial processes. Sources include the transportation sector (more than 60% of the emissions in Canada), electric power plants, and non-industrial fuel combustion. Natural sources are considered negligible.

VOCs are emitted primarily from natural sources (vegetation, forest fires, and animals). Anthropogenic sources are mainly from combustion, incineration, various industrial processes, evaporation of liquid fuels, paints and solvents, and organic chemicals. Transportation and industrial sources are the largest contributors. While biogenic emissions play an important role, anthropogenic VOCs emissions dominate during ozone episodes in the most populated smog-affected regions of Canada.[26]

Ambient Air Levels (ground-level ozone) [27]

Ground-level ozone occurs naturally, ranging anywhere between 25-45 ppb.

Currently, Canada has set an ambient air quality objective for ground-level ozone of 82 ppb as the maximum daily average over a one-hour period. This objective does not represent a mandatory standard. The Ontario guideline, or criterion, is 80 ppb. (The difference in these values is due to unit conversion and rounding and is insignificant.) More than half of all Canadians experience exceedances well beyond this objective, particularly in the summer months. Lakeshore sites in southwestern Ontario (e.g., Long Point) record the highest number of ozone exceedances, routinely experiencing levels greater than 120 ppb. Air quality at levels greater than 80 ppb is generally described as "poor" and is clearly associated with adverse health effects and related symptoms. An ozone level of 50 ppb is considered to represent "fair" air quality.[28]

Human Health Effects

Research in the US and Canada has repeatedly documented a strong correlation between high ozone levels and rates of hospitalization and worker absenteeism.[29] Ontario studies have shown that in the months May to August, approximately five per cent of daily respiratory hospital admissions are associated with ozone. Other findings have shown hospital admissions linked to ozone occurring at levels well below the current national air quality objective of 82 ppb, with the probability and severity of health effects increasing with increasing exposure.[30] Furthermore, it appears that there is no human health threshold for ozone, that is, there is no level that can be deemed safe.[31] Populations more sensitive to ozone exposure include young children, the elderly, people with respiratory problems, and people active outdoors, particularly in the summer.

Impacts on human health related to high ozone levels are summarized below:

- respiratory system:
  - lung functioning (coughing, shortness of breath, pain on inspiration, throat irritation, wheezing, chest tightness);
  - chronic and acute bronchitis, asthma; and
  - pulmonary emphysema;
- possible interference with the immune system; and
- headaches, burning eyes, irritated sinuses.

Environmental Effects [32]

- damage to lungs and respiration of animals;
- injury to foliage, reducing the yield in sensitive crops (observed at ozone levels of about 60 ppb);
- increased susceptibility to diseases and other stresses in plants and tree species; and
- increased mortality to individual trees and decline of species.

Particulate Matter (PM) [33]

Particles are a key component in many atmospheric processes and directly related to a number of critical environmental issues including smog, acid deposition, decrease in visibility, hazardous air pollutants, and climate change. Particulate matter (PM) describes microscopic airborne liquid and solid particles that range from approximately 0.005 μm to 100 μm in diameter. (A human hair is typically 70 μm.) These particles are classed as total suspended particulates (TSP), although PM is now the preferred term.

Size is the most important parameter in characterizing the behaviour of particulate matter. As more scientific information is obtained about PM, attention has focused on consecutively smaller particles. The tendency of these particles to remain in the air for days and even weeks and to penetrate into the lungs is indicative of the very significant impact of PM on health and ecosystems. Particles of greatest concern are those with a diameter less than 10 μm, referred to as PM_{10}.

PM_{10} is divided into two distinct modes or fractions of particles:

- Coarse mode includes particles with diameters between 2.5 μm and 10 μm. They include soil dust, inorganic and organic compounds and metals.

- Fine mode, or $PM_{2.5}$ are particles with diameter 2.5 μm or less. Components include sulphates, nitrates, ammonia, and VOCs, the most abundant being sulphates. Ultrafine particles (< 0.1 μm in diameter) behave like gases, do not settle and remain in the respiratory tract for lengthy periods.

Sources of PM: (illustrated in table below)

Table 4**: Sources of Particulate Matter** [34]

Particle size	**Natural**		**Anthropogenic**	
	Primary [a]	**Secondary** [b]	**Primary**	**Secondary**
Fine PM	Wildfires (high temp. sources)	Nitrates (natural NOx emissions, e.g., soil processes) VOCs (biogenic)	Fossil Fuels: power plants, vehicles industrial/residential boilers, heaters	VOCs: vehicles industrial processes solvents Sulphates, Nitrates: power plants, vehicles
Coarse PM	Windblown dust Mineral Particles Sea Salt Spray Volcanic Dust Forest fire debris		Road and construction dust Mineral dust (mining and extraction) Windblown agricultural soil	

[a] Primary particles: particles emitted directly into the atmosphere [b] Secondary particles: particles formed in the atmosphere

PM_{10} accounts for approximately 50% of Total Suspended Particulates (TSP), while $PM_{2.5}$ accounts for half of the total amount of PM_{10} (or 25% of TSP).

Ambient Air Levels of PM [35]

PM levels or concentrations are expressed in micrograms per cubic metre (μg/m^3) averaged over a 24-hour period. The range of background levels of PM_{10} is about 4 to 11 μg/m^3 and 1 to 5 μg/m^3 for $PM_{2.5}$ in remote sites in North America. In most urban sites across Canada, PM_{10} levels can range anywhere from about 20 to 42 μg/m^3 while $PM_{2.5}$ levels range from 8 to 20 μg/m^3. These ranges are substantially above background levels, indicating the significant influence of anthropogenic sources on ambient PM loadings. Current ambient levels of PM in most regions of Canada, particularly urban centres in summer months, exceed levels associated with adverse cardiorespiratory health problems on a regular basis.

There are no national or provincial air quality objectives that specifically address PM_{10} or $PM_{2.5}$. The current air quality objective in Canada related to particulate matter is only a guideline, expressed in terms of Total Suspended Particulates (TSP), and is set at a maximum 24-hour level of 120 μg/m^3. The level of TSP is not an appropriate indicator of PM in that it does not reflect particle size and it is the smaller particles that are the most detrimental to health and the environment**.**

Human Health Effects [36]

There is no doubt today that PM is emerging as a critical health issue. $PM_{2.5}$ penetrates deeply into regions of the lungs where there are no cilia and no mechanisms to remove contaminants. Low levels of ambient PM have been found to particularly affect susceptible individuals such as the elderly, children, and people with pre-existing disease. As PM levels rise, so do adverse health effects, placing healthy individuals at risk. In general, observed effects include:

- cardiorespiratory diseases: increase in mortality, hospitalization;
- decrease of lung function in children and in asthmatic adults;
- increase in respiratory stress, leading to restriction in physical activities, absenteeism from school and work; and
- increase in development of chronic bronchitis and asthma.

The epidemiological evidence for mortality and morbidity effects of current ambient levels of PM is strong, consistent and compelling. Hospitalization and mortality studies in southern Ontario and the U.S. have demonstrated a clear association between an increase in adverse health effects and PM. Increases in hospitalization and mortality rates were found to be significant at $PM_{2.5}$ and PM_{10} levels within the range of 15 µg/m^3 and 25 µg/m^3 respectively, with no evidence of a safe value or threshold.[37]

The lack of a threshold suggests that it is not possible to identify a level at which no adverse effects would occur as a result of exposure to PM. Furthermore, the long-term effects on the general population in health and quality of life from chronic exposure to PM may be far greater than has been considered.

Whether or not PM is the causal agent of the cardio-respiratory impacts, $PM_{2.5}$ is the most appropriate indicator at this time to which adverse health effects are attributed. Sufficient information exists to warrant strategies to reduce emissions of PM and its precursor gases.[38]

A recent in-depth study by the federal-provincial working group under the Canadian Environmental Protection Act has identified reference levels for PM to be "levels above which effects on human health and the environment can be demonstrated". Based on existing evidence, the recommended reference levels derived for PM are: 25 µg/m^3 for PM_{10} and 15 µg/m^3 for $PM_{2.5}$.[39]

Many urban sites experience maximum exposure values greater than 100 µg/m^3, particularly in the Windsor-Quebec City corridor. The following table highlights some of the hotspots in Ontario with respect to PM along with related mortality and hospital admission figures.

Table 5: **The Ontario PM Hotspots and related mortality and hospitalization** [40]

Location	PM_{10} 24-hour maximum µg/m^3	PM_{10} Impacts mortality (per	$PM_{2.5}$ 24-hour maximum µg/m^3	$PM_{2.5}$ Impacts Mortality (per million)	$PM_{2.5}$: Hospital Admissions (per million)

		million)			
Windsor Toronto Hamilton Walpole Is.	105 102 105 **150**	49 37 51 **80**	86 67 61 **127**	52 45 64 **41**	24 20 29 **35**

(Science Assessment Document, CEPA/WGAGOG August, 1997)

The maximum $PM_{2.5}$ 24-hour value across Canada is at Walpole Island, a native reserve in Lake St. Clair, and the highest urban site is at Windsor. Considering the evidence indicated, and that long-term chronic exposure is not known, levels of this magnitude are not tolerable.

Environmental and Other Impacts [41]

Animal Toxicity: Animals have exhibited reduction in lung clearance, alterations in immunological responses and have experienced a possible onset of chronic alveolitis, fibrosis and lung cancer.

Reduced visibility: PM refracts, reflects or absorbs light, creating a regional haze that reduces visibility both in urban environments and parks and wilderness areas. Reduced visibility is generally associated with poor air quality.

Vegetation: PM causes smothering of leaves by blocking stomata, biochemical interactions, soil effects, and susceptibility to disease.

Materials: Increased rates of physical and chemical degradation (accelerated rate of corrosion, erosion, soiling and discoloration) have been observed.

Government Plans and Initiatives

a) NO_X/VOCs Management Plan [42]

This plan was undertaken in 1990 to address the smog problem at a national level. Its objectives were to reduce ground-level ozone to ensure attainment of the objective of 82 ppb (maximum one-hour average) and to develop guidelines to reduce NO_X and VOCs emissions for the target years 2000 and 2005. Extensive consultations and scientific studies were utilized as a basis to formulate the plan.

In order to achieve the stated goals, reductions of NO_X and VOCs in the order of 50% would be needed.[43] In light of the slight decrease in annual NO_X emissions that occurred between 1990 to 1995 (from 2.1 to 2 million tonnes), the ability to achieve these reductions seems questionable. The government was to proceed into the next phase of a National Smog Management Plan. However, development of the plan was ended in 1997 as provinces, particularly BC and Ontario, indicated that they were unable to meet the time frame and would pursue their own response to the smog challenge.

b) Ontario Smog Plan [44]

The Ontario Ministry of Environment has estimated that that about 1800 premature deaths per year in Ontario can be attributed to smog (MOE, May 1997). Toronto residents faced 52 exceedances of the hourly ozone limits in 1995**.** The transportation sector is clearly identified as responsible for about 60% of local smog-causing emissions. After almost two years of consultation, in January, 1998, the provincial government released its response to the smog problem, namely the Ontario Smog Plan. The Plan is a voluntary agreement that sets an Air Quality Target for Smog representing a 75% reduction in the number of exceedances above the 80 ppb ozone criterion by the year 2015. There are several shortcomings to this plan:

- The Plan is not backed up with actions from other government departments, most notably the Ministry of Transportation nor are there any financial commitments from the MOE or the provincial government.
- The MOE has estimated that emissions of NO_X and VOCs will have to be reduced by 45% (from 1990 levels) to meet the goal of the Smog Plan. However, analysis of reduction plans indicate that they fall short of the 45% goal. Furthermore, the premise that a 45% reduction of NO_X and VOCs will be enough to improve air quality is doubtful.
- Smog-causing emissions from the US have not been taken into account.
- The Plan is drawn out over 17 years. This lax timetable reduces the emphasis on energy efficiency programs and commitment to renewable energy sources.
- The impact of Particulate Matter (PM) has been virtually ignored.
- No mechanism exists to set interim targets, monitor progress, or engage the public.

The Plan has been designed in a regulatory vacuum with no clear incentives to support voluntary action. Environmental and health groups have refused to sign the Smog Plan, as they say the reduction target is too low, the time frame too slow, and the Plan too weak to be effective. The Toronto Environmental Alliance has recommended that**:** "MOE adopt immediately an interim air quality standard for $PM_{2.5}$ of 15 $\mu g/m^3$. All health evidence points to the fact that while these interim standards may not be high enough to protect human health from fine particle pollution - the MOE risks little in introducing these standards." [45]

c) Canada-Wide Standards (CWS) for Particulate Matter and Ozone [46]

A federal/provincial/territorial development committee has been established to propose CWS for PM and Ozone by the fall of 1999. This latest initiative receives its mandate from the Canada-Wide Accord on Harmonization. The committee is to recommend targets and time frames that are "achievable...based on sound science and the evaluation of risk to human health and the environment, recognizing environmental and socioeconomic considerations". It remains to be seen if and how air quality objectives on ozone and PM will be incorporated into the new CWS, whether they are stringent enough to improve air quality, and what level of action or legislation would accompany such objectives.

Recommendations:

* In light of evidence that the current air quality criterion for ground-level ozone in Ontario does not adequately protect health or vegetation, the province should adopt the following policies and actions:
    a) replace its present air quality criterion of 80 ppb by an air quality objective of 50 ppb (one-hour average) as a mandatory standard;
    b) set a goal of zero exceedance across the province by 2005;
    c) accelerate timelines and establish more stringent targets in those communities with the highest level of exceedances;
    d) impose restrictions on the operation of facilities and activities that enhance ozone production and elevate ozone levels; and
    e) set mandatory targets and timetables to reduce NO_X emissions by 50% of 1995 levels in the year 2005, and by 75% no later than 2010.

* In light of the lack of any national or provincial standard for PM, the province should adopt the following policies and actions:
    a) adopt the reference levels of 25 $\mu g/m^3$ for PM_{10} and 15 $\mu g/m^3$ for $PM_{2.5}$ (24-hour average) as mandatory air quality objectives for PM in Ontario;
    b) establish more stringent targets with accelerated timelines in those communities with the highest levels of PM;
    c) support and fund studies that examine the effects of long term or chronic exposure to PM on health endpoints; and
    d) promote the use of personal exposure monitors to better characterize individual exposures to $PM_{2.5}$, particularly for vulnerable populations.

HAZARDOUS AIR POLLUTANTS (HAPs) [47]

HAPs, or air toxics, are atmospheric pollutants defined as "gaseous, aerosol or particulate contaminants present in the ambient air in trace amounts with characteristic toxicity and persistence so as to be a hazard to human health, or plant and animal life." HAPs include chemicals and families of chemicals, such as: PCBs, dioxins, benzene, heavy metals and compounds known as persistent organic pollutants.

Persistent Organic Pollutants (POPs) [48]

POPs are a diverse group of toxic organic compounds of natural or anthropogenic origin that share a number of generic characteristics. POPs degrade very slowly or not at all into the environment and their persistence is media-specific, in that they may degrade in the atmosphere in a matter of weeks, but their degradation in soils or sediments may take decades, if at all. POPs are present in the atmosphere both in gaseous form and associated with particles, and have the potential of being transported worldwide. POPs can re-evaporate after being deposited to the earth's surface, and cycle repeatedly between atmosphere and surface, eventually concentrating in water, soil and wildlife in cooler northern latitudes. This tendency to re-volatize many times is referred to as the grasshopper effect.[49]

Sources of POPs

POPs include chemicals deliberately produced as well as those generated as unintended by-products in production, combustion and breakdown processes and include:

- pesticides, e.g., DDT, chlordane, toxaphene, mirex, lindane;
- industrial chemicals, e.g., PCBs, hexachlorobenzene; and
- byproducts of industrial combustion processes, bleaching processes, diesel exhaust, incineration of municipal and medical waste - e.g. dioxins and furans, polycyclic aromatic hydrocarbons (PAHs).

Human Health Effects

POPs dissolve more easily in fat than water and accumulate in the fatty tissue of living organisms leading to their bioaccumulation in the food chain. The dominant route of human exposure is through eating fish and other wildlife. POPs can also accumulate via inhalation and skin exposure. Some POPs, such as dioxin, bioaccumulate through terrestrial food webs, concentrating in milk and other dairy products. POPs are a problem particularly to those populations (including indigenous peoples in the North) whose diet relies primarily on such foods and especially to pregnant women in those communities. The diversity of POPs and their toxicity contribute to a wide range of effects such as:

- immunosuppression;
- liver and kidney toxicity, neurotoxicity (effects in off-spring);
- cancer and mutagenicity; and
- diminished reproductive capacities, developmental abnormalities, and hormone disruption.

Further examples of the insidious nature of POPs are include:

*** Endocrine Disruption:**
The general population is at risk from exposure to POPs due to the ability of some POPs to act as endocrine disrupters, mimicking the body's hormones, turning on and off important development processes at critical times. It is believed that fetal exposure to endocrine disrupters or estrogenic chemicals (including 2,4-D, DDT, PCBs, dioxins and furans) may be responsible for declining sperm counts and the increase in abnormalities in the human male reproductive tract. Women and children are generally at special risk because of the transfer of these contaminants through the placenta and breast milk.[50]

* **PAHs (polycyclic aromatic hydrocarbons):**
Diesel exhaust is a major source of PAHs, chemicals known to cause mutations in cells and cancer in animals. In addition, diesel engines are a potent source of very fine particulates that are able to carry PAHs and easily penetrate the lung. People exposed to diesel exhaust in their occupations have an increased risk of lung cancer.[51]

* **Biological Effects** include compromising the ability of organisms to reproduce and develop normally, a decrease in egg production, eggshell thinning, embryonic deformities, gender blurring (or demasculinization), and growth retardation in birds and fish. The use of
pesticides stresses and weakens plants increasing susceptibility to insect and fungal damage.

Recommendations:

* The province should adopt measures to ensure that the deliberate manufacturing and use of POPs are phased out in stages with a goal of total elimination by the year 2010 or sooner and that the disposal of POPs is appropriately regulated.
* The province should support and promote non-polluting alternatives to POPs and provide the necessary public education and retraining programmes for affected workers.

MERCURY - MULTIMEDIA POLLUTANT [52]

While mercury falls under the classification of Heavy Metals, it was chosen as a focus for this category as an example of a substance pervasive in all media.

Mercury (Hg) is a highly volatile metal and is found in air, water, land, and biota. Mercury resides in the atmosphere in a gaseous form for a period ranging from three months to two years. In water, a significant fraction of inorganic mercury is transformed into an organic form, methylmercury (CH_3-Hg). This transformation has been increased by the acidified condition of many water bodies. Methylmercury is the most toxic and available form of Hg for living organisms and bioaccumulates through the food web to fish-eating mammals to levels thousands of times greater than in water.

In the last 100 years, the level of atmospheric mercury has increased by two to five times with anthropogenic sources accounting for anywhere from 50 to 70% of the total emissions. Approximately 60% of emissions are transported by long-range atmospheric processes. A major atmospheric pathway of mercury into Canada is from the Atlantic Coast of the US. The Great Lakes basin is also affected by the increased use of coal by electric utilities in the U.S. Midwest.

Sources

- coal-fired electric plants;

- waste incinerators (municipal, medical), and landfills;
- chlor-alkali facilities (mercury cell processes);
- copper and lead smelters;
- cement manufacturers; and
- products containing mercury (fluorescent light tubes, thermostats, thermometers, dental amalgams and batteries).

Human Health and Environmental Effects

- Exposure to inorganic mercury can cause liver and kidney damage.
- Methylmercury is a potent neurotoxic, causing impairment of the central nervous system leading to loss of sensation, tunnel vision, lack of coordination, impairment of speech, hearing and gait, tremors and hallucination. It is fetotoxic, affecting embryonic development and causing fetal malformations.
- Human populations at risk include pregnant women, developing fetuses, nursing infants, young children and populations where fish is a major food source.
- Environmental effects include the **i**nhibition of photosynthesis and growth in phytoplankton and reproductive failure and death in birds.

In recognition of the multi-media nature of the mercury problem and its global ramifications, numerous organizations are working collaboratively on developing a comprehensive assessment of the problems and strategies to address public health and environmental issues. A Heavy Metals Protocol was developed by the UN in 1996 to control emissions and an International Conference on Mercury as a Global Pollutant is scheduled for May, 1999. These efforts could influence provincial actions and strategies to aggressively address the mercury problem.

Recommendations:

* The province should enact the appropriate legislation to reduce mercury emissions and work toward its virtual elimination. In this regard, Ontario should:
  * improve monitoring programs to eliminate major discrepancies and information gaps; in particular, augment fish monitoring programs, fish consumption advisories and improve data collection on fish and wildlife;
  * cooperate with other jurisdictions on the effects of long-range transport and the ensuing impact on health, particularly for sensitive populations;
  * implement mandatory recycling, recovery and disposal programs to eliminate mercury in waste; and
  * identify and label products containing mercury and phase out their use.

RADIOACTIVE POLLUTION [53]

Like any other thermal energy-generating facility, nuclear plants emit pollutants into the atmosphere. The difference is that these releases contain radioactive particles, called radionuclides, the most common being tritium oxide and tritium gas. Tritium, a radioactive form (or isotope) of hydrogen and a known cancer-causing agent, is produced as an unwanted by-product in nuclear reactors and released into the air, water, and soil.

Exposure to ionizing radiation is a public health issue that is controversial partly due to assumptions and factors utilized in calculating exposure doses as well as the accuracy of the available data. The nuclear industry and the Atomic Energy Control Board (AECB) claim that public health impacts of radioactive pollution are negligible. However, any and all exposure to ionizing radiation can contribute to an increased risk of health problems such as cancer and birth defects.

Ontario Hydro monitors radioactive emissions and radiation levels in the local environment around their nuclear stations. In the case of airborne tritium, air samples are collected monthly at several boundary locations of selected nuclear facilities in Ontario. Table 5 shows the 1996 average annual tritium concentrations in air at boundary locations for 3 facilities.[54]

Table 6: **Tritium concentrations in air (1996)**
expressed in becquerels per cubic metre (Bq/m^3)

Boundary Locations	**Annual average**	**Highest average**
Pickering	4.9	11.9 (North-East)
Darlington	0.5	0.8 (east)
Bruce	2.8	3.3 (east)

Note: The provincial average for this year is 0.05 Bq/m^3.

As the table indicates, the Pickering Nuclear Station registered the highest average, well above the provincial average levels by a factor of 200. These levels were due to accidental and routine releases. While newer facilities (e.g., Darlington) may be better designed, resulting in lower tritium values, this should not detract from the overall issue of radioactive releases in any amount above background. These elevated levels could increase the risk of cancer and birth defects from contaminated drinking water, air, and food. Ontario Hydro has fought stricter tritium standards and has refused to use the best available technology to reduce emissions for cost reasons.

Jurisdiction over the nuclear industry in Canada resides primarily with the AECB, which is concerned with pollution that reaches the public and those workers at nuclear facilities. This leaves a void in regulation as far as controlling radioactive pollution in the environment. To date, other levels of government have avoided any involvement in radioactive pollution control.

One approach to deal with radioactive pollution is to adopt a strategy being championed by the International Joint Commission (IJC) that advocates the elimination of potentially harmful pollution at source, that is, zero discharge for persistent toxic substances.

Recommendations:

* Provincial and federal governments should incorporate those radionuclides that meet the definition of persistent toxic substances in their strategy for virtual elimination, in line with recommendations made by the IJC. [55]
* Ontario, in conjunction with the AECB and other levels of government, should implement mechanisms to measure and report on the environmental impacts of radioactive emissions on a routine basis.

GLOBAL ATMOSPHERIC CHANGE

Ozone Depletion [56]

The ozone layer in the upper atmosphere (stratospheric ozone) is the earth's protector against the sun's harmful UV radiation, acting as an invisible filter absorbing most of the UV-B rays. Reduction in the amount of stratospheric ozone inevitably leads to an increase in the intensity of UV-B radiation reaching the earth, inflicting damage to living organisms and materials as well as affecting air quality.

Over the past several years, stratospheric ozone has been diminishing, primarily due to the presence of substances such as chlorofluorcarbons (CFCs) in the atmosphere. CFCs and other such ozone-depleting substances are (or were) used in air conditioning, refrigeration, aerosols, extinguishers, as solvents and pesticides. These substances are very stable chemicals that do not break down in the lower atmosphere. When released, they drift into the stratosphere where they are broken down by ultraviolet radiation, releasing ozone-destroying chlorine and bromine atoms. Their long life spans, in some cases more than 100 years, allow them to continue their path of destruction well into the future.

In 1987, under the provisions of the Montreal Protocol, governments agreed to phase out CFCs; in 1995, production halted in developed countries.[57] However, other industrial chemicals that cause ozone depletion are in use, such as HCFCs (although they are slated for elimination by 2020). Even if CFCs in the atmosphere are held at their present levels, ozone will continue to be depleted into the next century.

Methyl bromide is 50 times more powerful in destroying ozone than CFCs. It is effective in getting rid of food pests by attacking their central nervous system and leaves no residue on food. Scientists estimate that up to 10% of the destruction of the ozone layer is caused by methyl bromide**.** There are organic alternatives that could be used to control insect infestation. Canada and the US have agreed to ban methyl bromide effective in 2001, except for critical use and quarantine.[58]

The global ozone layer has been reduced by about 3% between 1979 and 1991, with depletion being much more dramatic at the north and south poles. In 1993, the ozone layer over the Antarctic was sometimes less than one-quarter of that measured in the early 1970s. Thinning of the ozone layer will likely continue to worsen until the early 21st century and complete recovery may take up to 100 years.[59]

While ozone in the stratosphere is essential to the health of the planet, ozone at ground level is the main component of smog and extremely harmful to health.

Health Impact of UV-B radiation [60]

- sunburn, photoaging of skin, rise in skin cancer (enhanced for those on photosensitive drugs);
- increased risk of cataracts; and
- suppression of the immune system: possibly affecting severity and/or speed of infection of viral diseases, parasitic diseases, and bacterial and fungal infections.

Other Effects [61]

Terrestrial plants and aquatic ecosystems: Increased UV-B may reduce crop yields and disrupt marine food chains. The early growth stages of plants are likely affected. On older trees, the growing tips are most seriously affected before the bark is formed. High UV-B levels have been found to cause damage in the early development of fish and sea animals.

Air quality: Higher levels of UV-B radiation penetrating the lower atmosphere cause an increase in the chemical reactivity of several gases found in ambient air. Pollutants from vehicle exhaust, gasoline vapours, and industrial emissions interact with UV-B radiation leading to an increase in the production of ground-level ozone.

Materials: Increased UV-B levels can cause discolouration and loss of strength in wood and plastic materials, resulting in use of special treatments and more frequent replacement.

Recommendations

* In keeping with the principles of the Montreal Protocol of 1987, the province should regulate and phase out the use of ozone-depleting substances (ODS) in Ontario and implement measures such as:
  - ⇒ mandatory servicing of automobile air conditioners;
  - ⇒ mandatory recycling and recovery programs of ozone depleting substances;
  - ⇒ proper disposal of old appliances containing CFCs;
  - ⇒ proper labeling of equipment and products containing ODS;

⇒ appropriate training for equipment service providers; and
⇒ phasing out all use of methyl bromide and supporting safe organic alternatives.

Climate Change (The Greenhouse Effect) [62]

This has become the hot issue of 1997 to 1998, primarily due to publicity over the Kyoto Protocol. Climate change is a direct result of the increase of greenhouse gases in the atmosphere. "Greenhouse gases" such as carbon dioxide (CO_2), methane, and nitrous oxide, are naturally occurring gases. They are transparent, allowing sunlight in but absorbing the infrared radiation from the earth's surface, acting like a thermal blanket around the earth. However, human activity is thickening the blanket to the point where CO_2, the most abundant gas, is expected to double from pre-industrial levels over the course of a century, possibly raising global temperatures anywhere from 1° to 3.5° C.

Greenhouse gas emissions, primarily CO_2, come largely from the burning of fossil fuels (coal, oil, gas and diesel), industrial emissions, as well as changes in land use (land clearance, cutting and burning forests). Industrial gases such as CFCs are strong infrared absorbers, and further elevate the greenhouse effect. In Canada, the transportation sector accounts for approximately 26% of greenhouse gas emissions.

Kyoto Protocol:[63] A world-wide agreement to cut greenhouse gases was negotiated in December 1997 in Kyoto, Japan. While Canada signed the agreement on April 29, 1998, this is not ratification of the Protocol. The agreement would result in industrialized countries cutting their total greenhouse gas emissions by 5.2% of 1990 levels by the year 2010. Canada has committed to a 6% reduction (the US to 7%). The Protocol also provides for a market mechanism whereby parties will be able to buy emission credits from other parties. Ottawa has no plans to ratify the Kyoto agreement unless it gets consensus from the provinces and territories. The western provinces, notably Alberta, are major obstacles in achieving agreement. On April 24, 1998, at a provincial/federal environment and energy meeting, Environment Minister, Christine Stewart said: "We will not do anything to jeopardize our economy." The basic strategy employed to date by the Canadian government is to continue discussions and

Canada is the world's second highest greenhouse gas emitter on a per capita basis.

Health and Environmental Effects [65]

The gradual rise in temperatures as a result of climate change could disrupt weather patterns, increase the severity and frequency of adverse weather effects, melt polar ice, raise sea levels to swamp islands and low-lying areas and cause droughts in other regions. The long-term implications of climate change could lead to a number of possible consequences:

- increased famine and malnutrition;
- increasing numbers of eco-refugees from floods and other disasters;

- heightened risk of occurrence of tropical diseases spread by mosquitoes and other insects migrating into more temperate regions; and
- changes to existing habitat, and loss of plant and animal species.

Ontario, the major consuming province, which result in an interest in low energy prices, has made no public statements in favour of tough action. Yet Ontario is likely to experience increases of 3□C to 8□C in the annual average temperature in the last half of the next century if climate change is not halted.[66] Ontario's lack of response to the challenges of climate change is telling.

Recommendations

#11: Ontario should implement a province-wide strategy to reduce greenhouse gases (GHG) beyond the reduction targets in the Kyoto agreement and support a national program with similar objectives. This strategy should include the following actions:

a) establish mandatory GHG emission reduction targets and timelines on a local and regional basis;
b) support and promote research, through funding and other financial initiatives, activities that lead to increased energy efficiency, such as alternative fuel technologies, fuel-efficient vehicles, and retrofitting;
c) establish a provincial Ontario Atmospheric Fund (such as the Toronto Atmospheric Fund), that provides loans to projects that lead to reductions in GHG emissions and that can be adapted on a local or regional basis;[67]
d) implement a transportation strategy directed towards reduction in automobile use along with fiscal commitments to public transit and other such alternatives; and
e) develop a public education programme in cooperation with other levels of government, communities, and individuals and the general public that supports and addresses the role of communities and individuals to actions and initiatives dealing with climate change.

CURRENT PROGRAMMES AND POLICIES - HIGHLIGHTS

Emissions Trading Programmes

Emissions trading is rapidly becoming the favoured pollution reduction strategy on a provincial, national and global scale. The theory behind this marketable rights scheme is that a maximum pollution level (a cap) can be established and regulation can be put in place to achieve this level. A fixed number of allowances or credits representing emission amounts are meted out to facilities based on estimated usage. If the facility emits less than its cap, a surplus of allowances or credits is created. These allowances or credits may be bought, traded, sold or banked for future use just like any market commodity.[68]

The advantages of emissions trading must be weighed against the issues it raises:

- Emissions trading is only one tool to achieve emission reduction targets and should not take precedence over other pollution prevention measures.

- Emissions trading may obscure the importance of setting declining caps on emissions. If parties to the trade reduce emissions below levels required (as in the Kyoto Protocol), the excess reduction can be transferred to another party, permitting the latter to achieve its targets without actually reducing its own emissions to the mandated level.[70]
- The trading process could result in hotspots of environmental or health damage in sensitive areas and for vulnerable populations. It could further exacerbate inequities between developed and developing nations.
- The administration and cost of these programmes have not been adequately addressed.

Trading Allowances for SO_2, United States Acid Rain Program[69]
SO_2 allowances are allocated to utility-generating units on the basis of historical fuel consumption and specific emission rates. If SO_2 emissions are reduced more than required, the excess allowances can be banked and called upon in the future if necessary. In 1995, unexpected low prices for low-sulphur coal stimulated fuel-switching, resulting in a reduction of SO_2 emissions by 3 million tonnes more than was required by the US acid rain programme. Some utilities are expected to draw on these banked SO_2 allowances after 2000. As a result, the reduction goals

Emissions trading may be one avenue to reduce pollution, but it is not a panacea. Its use may not even be appropriate at a time when provincial and federal governments have minimized regulation and enforcement.

Recommendations:

* Ontario should ensure that emissions trading does not create environmental hotspots and does not impede reduction in cap values or jeopardize emission reduction goals.

* Ontario Hydro should be required to reduce its annual NO_X emissions limit by an additional 6,000 tonnes immediately.

A Balancing Act - Ontario Hydro and the Hartford Steam Boiler Co. [71]
As a result of closing a gas-fired cogeneration plant, this Hartford Connecticut power company opted to purchase electricity from other sources that were dirtier and likely to boost air pollution emissions. In order to comply with state environmental protection standards, the company needed to find parties from which they could purchase emission credits. One willing seller was Ontario Hydro, holding 6,000 tonnes in emission trading credits as a result of reductions in NO_X emissions at two of its plants. The deal - 500 credits sold for $500,000. And what benefits have

Cleaner Fuels

a) Sulphur Levels in Gasoline [72]

Canadian gasoline has amongst the highest sulphur levels in the world varying anywhere from about 785 ppm to 10 ppm, with an average of 340 ppm**.** Ontario has the highest average sulphur level at 540 ppm**.** Sulphur in fuels adversely affects emission control systems and is a barrier in the development of high efficiency engines. Reducing sulphur level in fuels would decrease emissions of other pollutants including particulate matter.

A recent study by Environment Canada on sulphur levels in fuels identified two possible options. Option A recommended reducing sulphur content in gasoline to an annual average of 30 ppm by the year 2002 with regional variations. Option B recommended a reduction to 150 ppm by the year 2003, with a provision to tie-in to US levels. (At present, there is no US standard, although California adopted the 30 ppm standard years ago.) Option A may cost refineries $1.8 billion, possibly result in one to three closures, and cost consumers about one cent a litre at the pumps. However, its impact on air quality as well as health benefits would be significant. The following table projects these benefits for the year 2020 for seven major cities across Canada, including Toronto.

Table 7: **Avoided Health Effects and Cost Benefits, Option A (30 ppm) in year 2020**[73]

Avoided Effect	Estimated Cases Avoided	Estimated Cost Benefits (1) ($ Thousands)
Premature mortality	82	329,000
Chronic respiratory disease	290	84,400
Hospital admissions	94	690
Emergency room visits	261	160
Bronchitis in children	3600	1,300
Restricted Activity Days	60,400	4,470
Asthma Symptom Days	127,500	6,240
Acute respiratory symptoms	435,600	6,100
Total (1) ($ Thousands)		432,000

(1) based on economic estimates of societal values

After much delay, on October 23, 1998, the federal government announced that sulphur levels in gasoline would be reduced to 30 ppm by the year 2005, with an interim reduction target of 150 ppm in 2002.[74] The issue of sulphur levels in diesel fuel has been put on hold awaiting further studies on adverse health effects of diesel fuel consumption.[75]

b) MMT: A Win for Ethyl Corporation - A Loss for Canadians [76]

The import and interprovincial trade of MMT, a gasoline additive manufactured by Ethyl Corporation, a US company, was banned by Canada based on its likelihood to damage emissions control equipment in automobiles and its possible effects on health and environment. MMT contains manganese, a known toxic linked to neurological and motor disorders. The effects of prolonged low-level exposure are not known. The US EPA has refused to approve MMT for sale and MMT is banned in California. On July 20, 1998, in fear of losing a $251 million dollar lawsuit filed by Ethyl Corporation under NAFTA provisions, Canada lifted its ban.

c) Benzene, a volatile and flammable liquid, is a known human carcinogen. Long-term exposure can cause various skin problems, bronchitis and pneumonia, and numerous other irritations. Most of the benzene emitted comes from transportation activities, with gas-powered vehicles emitting up to 80 times more benzene than diesels.[77]

Recommendations:

* In keeping with the need for cleaner fuels, Ontario should act without delay to:
  a) legislate the sulphur level in gasoline to an annual average of 30 ppm as a maximum by the year 2002;
  b) require all filling pumps in the province to post the sulphur content of gas;
  c) adopt a mandatory standard for sulphur level in diesel fuel at 400 ppm (or 0.04%) to replace the current level of 500 ppm;
  d) ban the use and sale of MMT; and
  e) set limits on emission standards for benzene and aim for zero discharge.

Inspection and Maintenance (I/M) Programmes

Mandatory I/M programs are a cost effective way of reducing tail pipe emissions and are widely supported by car manufacturers and owners alike. The experience of existing I/M programs (e.g., in the Greater Vancouver Area) has borne this out. Not only do such programmes result in fuel savings, they generate spin-off effects in jobs and investments.[78]

In August 1997, Ontario introduced its mandatory I/M emissions testing programme, namely Drive Clean, for trucks, buses, and cars**.** The programme projected reductions in emissions of NO_X and VOCs of 15 kilotonnes and 47 kilotonnes respectively by the year 2005 (this represents a mere fraction of the total emissions of these pollutants, roughly 2% and 5%).[79] The Drive Clean programme was to begin in the Toronto area by 1998, but its implementation has been delayed by a year, with no explanation. What's more, the automobile repair shops that form the front line of the programme have been directed to use outdated equipment for testing emissions, namely two-speed idle technology that does not measure NO_X , the key component of smog. While the testing and subsequent repairs can reduce emissions of other pollutants, the adjustments in the repairs are likely to cause increases in the emissions of nitrogen oxides.[80]

Recommendation:

* Ontario, through the Ministry of Environment, should implement the Drive Clean Mandatory I/M Program immediately in the major urban areas in Ontario and in the rest of the province by April 1999 and ensure that:
  a) testing centres use the most up-to-date technology available that detects the major components of smog; and

b) the current emission reduction targets for NO_X and VOCs are replaced with more rigorous targets and timelines in an overall shorter time period.

Deregulation and Ontario Hydro

Ontario Hydro has signed an option to purchase electricity from the largest single US utility source of sulphur dioxide emissions along the Eastern Canadian border. If this option is exercised, SO_2 emissions would rise significantly. In addition, the utility intends to bring back into service its mothballed oil-fueled and coal-power plants to replace lost power generation. Without appropriate protection in place, these actions, enabled by deregulation, will likely result in increased power production from low-cost, older coal-fired power plants that in turn emit significantly more pollutants than modern facilities.[81]

Recommendation:

* Ontario should not proceed with the introduction of competition in the electricity sector until measures are in place to ensure that emissions of smog and acid rain precursors will not increase as a result of this action**.**[82]

Public Relations and Communications

The complete absence of a public communication initiative to provide environmental information in an easy, readily accessible format sends a message in its own way. The public has a right to full disclosure of the presence of toxic substances in products and of those facilities that use, manufacture, and/or release pollutants into the atmosphere.

Recommendation:

* The province should develop a communication strategy specifically geared to providing the public with necessary environmental information in an easily accessible format. Such information should include a list of those facilities that use, manufacture and release pollutants into the atmosphere.

KEY FINDINGS AND RECOMMENDATIONS

Throughout this paper, emphasis has been placed on the need for significant reductions in emissions in all sectors if any real improvements in air quality are to be realized. This requires appropriate legislation that implements pollution prevention policies at the source along with mandatory standards and targets. The government cannot rely on voluntary efforts in the absence of a regulatory framework.

While acknowledging that major changes take time, short-term strategies that are in step with a long-term vision could be initiated with relative ease. At the same time, the inevitable shifts in the nature of employment that such strategies may cause must be accommodated.

It is not acceptable to continue to tolerate situations that lead to marginalization of communities and individuals and that treat vulnerable populations as a norm. Nor is it acceptable to delay measures that prevent environmental degradation on the basis of the lack of full scientific evidence. A vibrant economy is viable only within the constraints of a healthy environment. Cleaner air, water, and land will inevitably lead to reduced health care costs, a healthier future for our children, and opportunities for innovation and job creation.

Key Findings

1) Emissions:
Motor vehicle emissions are the largest single source of smog in Southern Ontario**.** On a provincial and national level, the transportation sector contributes to more than 60% of the total amount of NO_X emitted. To date, programmes to reduce NO_X emissions have been ineffective.

2) Health Effects:
- Pollutants affect the respiratory, reproductive and cardiac systems, as well as organs such as liver, kidneys, and glandular systems. Several are mutagenic, carcinogenic and affect reproductive and nervous systems.
- Adverse health effects have the greatest impact on vulnerable populations.
- There are no apparent discernible threshold levels for tropospheric ozone or PM.
- The long term effects of chronic exposure are not well known.

3) Governance:
Funding cuts have eroded inspection, monitoring and scientific research. Policies such as deregulation and harmonization have weakened control and enforcement of existing regulations. Emphasis on the voluntary approach is inappropriate in a regulatory vacuum.

4) Air Quality Standards and Objectives - Status:
- The current one-hour national objective (or provincial criterion) for ozone does not fully protect health and environment nor is it mandatory.
- There are currently no guidelines or objective levels for particulate matter.
- There is no further action on recommendations made in the Acid Rain Strategy Report with respect to the reduction of SO_2 and NO_X emissions.
- Critical loads for nitrate deposition have not yet been established.
- The lack of consistency and clarity in terminology related to standards is a barrier to public communication and comprehension of the issues in air pollution.

5) Monitoring, Science, and Research:
- The decrease in monitoring and inspection programmes is not only detrimental to tracking air quality; it compromises the ability to properly address problem areas. As a result, many air issues such as acid rain are slipping through the cracks.
- Cuts in the funding to science and research are likely to affect the ability to set sound policy and improve monitoring, and open the door to further criticism by industry on the inadequacies of science to provide convincing evidence on cause and effect.

6) Collaborative Approaches:
A large part of Ontario's air pollution problem comes from United States. Collaborative and concurrent actions are required to achieve the necessary large-scale reductions in NOx, VOCs, SO_2, PM and greenhouse gases.

7) Process and Consultation:
The representation and participation of non-governmental groups as stakeholders in government consultations is relatively small as compared to representatives from industry and government. The process and facilitation in these consultations are problematic; failure to reach consensus is a common outcome. In the past few years, the frequency and value of public and stakeholder consultation in Ontario has dwindled.

Key Recommendations:

In order for Ontario to realize improvements in air quality, a regulatory framework within a legislative context is necessary. Many recommendations for provincial action have been included in this paper. Key recommendations for immediate implementation include:

* enact the appropriate legislation and measures to implement policies directed to pollution prevention strategies accompanied by mandatory targets and timelines;
* adopt the following standards and practices:
    - set the one-hour air quality objective for ozone at 50 ppb as a mandatory standard;
    - set objective levels (24-hr average) for PM_{10} at 25 $\mu g/m^3$ and for $PM_{2.5}$ at 15 $\mu g/m^3$;
    - establish targets to reduce NO_X emissions by 75% (of 1995 levels) by 2010;
    - accelerate emission reduction targets and timelines to areas identified as problematic;
    - place a cap on SO_2 emissions that ensures a 75% reduction of the current cap by 2015; and
    - reduce sulphur levels in gasoline to 30 ppm by 2002.
- restore and enhance funding of monitoring and inspection programs and specifically;
    - ensure that there are sufficient monitoring stations for urban and rural sites;
    - investigate mechanisms that link monitoring and exposure to health endpoints;
    - increase ambient air monitoring of $PM_{2.5}$ as well as the use of personal exposure monitors to better characterize individual exposures to $PM_{2.5}$; and
    - issue air quality advisories indicating specific sources, locations and pollutants.
- support and fund scientific and epidemiological research in the public sector to ensure objectivity, accessibility, and strong, defensible standards;
- support and advocate joint programmes and collaborative action with other jurisdictions in Canada and the US in addressing transboundary issues, while at the same time not delaying action on the pretext of lack of action from others;
- adopt a collaborative approach to decision-making and ensure that the public is given fair and equitable opportunity to participate in consultations; and

- operate on the principle of full public disclosure of environmental information and publish such information in readily accessible easy format.

Recommended First Step

In the short term, a strategy needs to focus on priorities and have the tools, policies, and action plan in place to enable its implementation. The strategy must inform and engage the public, and provide the motivation to achieve its goals and objectives.

Key Issue - Smog: This issue receives the greatest media coverage and public attention, particularly in urban areas, and is a key indicator of air quality.

Key Pollutants:

- $PM_{2.5}$: PM is the penultimate link to the components in all the air issues; and
- NO_x: This is the most common element found in all air pollution issues.

Key Sector - Transportation: The automobile is the key target. Programmes and plans are readily available that can decrease emissions, use cleaner fuels, and reduce car use.

Action Plan - Key Tools:
1) Cleaner fuels and emissions reduction

2) Reduction in automobile use; and

3) Sustainable transportation planning policies.

Implementation of Strategy:
To guide and implement the strategy, requires that a provincially funded body, such as a smog steering committee, be established. Representation on the committee should be gleaned from a wide spectrum of the population including non-government groups in environment, health and transportation, as well as representatives from government ministries, the Ontario Medical Association, Worker's Health and Safety Centres, labour, environmental groups, and industry. The committee would form working groups to address specific issues. In all cases, decisions would be reached in a collaborative manner by consensus.

The tasks and responsibilities of the committee and any of its working groups should include:

- developing specific goals and timelines and identifying priority areas;
- coordination of regional projects in the province;
- allocation of resources to designated projects;
- periodic, public reviews to evaluate progress and effectiveness;
- ongoing public education and communication programmes;
- monitoring government actions and performance;
- establishing a mechanism for collection of data and any other relevant information

and ensure public accessibility; and

- exploring innovative methods in other jurisdictions that may be suitable in Ontario. Examples include the Clean Air Strategic Alliance in Alberta and the Air Care Program in British Columbia.

GLOSSARY

Acid aerosols: Acidic particles dispersed in gases. The combination of sulphur dioxide gas, sulphuric acid, liquid and solid particles creates an acid aerosol.

Acid deposition: Refers to deposition of acidic pollutants on biota or land or in waters of the earth's surface.

Acid Rain: a phenomenon associated with the emission of acidic substances and subsequent deposition in the form of precipitation.

Acute respiratory symptom days: Days when symptoms such as chest discomfort, coughing, wheezing, etc. are experienced.

Adverse effect: Impairment of quality of environment, injury or harm to plant or animal life, effect on human health.

Aerosol: A stable mixture of small particles suspended in gas.

Air Pollution Index: The basis of an alert and control system to warn of deteriorating quality (In Ontario it is the 24-hour running averages of SO_2 and suspended particles).

Air Quality Advisory (Ontario): A forecast advising of impending poor air quality due to photochemical smog (ground level ozone).

Air Quality Index: A system that provides hourly indications of air quality in major cities in Ontario based on six pollutants: sulphur dioxide, nitrogen oxides, ozone, carbon monoxide, suspended particles, and total reduced sulphur compounds.

Air Quality Objective (AQO): The air quality management goal for the protection of the general public and the environment in Canada, based upon consideration of scientific, social, economic and technological factors.

Ambient air: The open air, external to buildings.

Ambient Air Quality Criterion: A criterion developed by the Ministry of Environment that specifies the desirable maximum ambient air concentration of a contaminant. For example, the one hour ambient air quality criterion for ground level ozone in Ontario is 80 parts per billion. (The difference between the Ontario criterion and the national objective of 82 ppb is simply due to unit conversion from 160 $\mu g/m^3$ to ppb and rounding.)

Anthropogenic: Referring to alterations made to the environment due to human activity.

Asthma: A lung disease characterized by an inflammation, causing airways to respond to a variety of triggers.

Asthma Symptom Days: Days when asthmatics experience an increase in asthma symptoms.

Background radiation: The amount of radioactivity in a location due to naturally occurring radiation from the earth and space.

Becquerel (Bq): The system international (SI) unit describing the rate of radioactive disintegration of an element. One bequerel of radioactivity is one disintegration (by radioactive decay) per second.

Benzene: A volatile organic compound present in vehicle exhaust. It is carcinogenic and causes other severe health effects.

Bioaccumulation: The process by which contaminants in the environment accumulate in living organisms either directly through consumption of a food source or indirectly through the environment.

Biogenic: Referring to vegetative (natural) sources.
Biota/biotic: Relating to plants, animals and micro-organisms.
Cap: The maximum allowable level for emission of pollutants. The current cap for SO_2 emissions in Canada is 2.3 million tonnes.
Carcinogenic: An agent that incites the development of malignancy.
Chronic bronchitis: A chronic obstructive disease characterized by excess mucus production in the bronchial tree.
Contaminant: An unwanted and perhaps harmful physical, chemical or biological substance in the environment.
Critical load: A measure of how much pollution an ecosystem can tolerate before long term effects set in. Calculations of critical load are based on the ability of 95% of lakes in a region to maintain a pH of 6 or more. (In Ontario, critical loads for sulphate deposition can range from less than 8 kg/ha/year to greater than 20 kg/ha/year.)
Emission: Any pollutant that makes its way into the air.
Epidemiology: The study of distribution, determinants, and dynamics of health and disease.
Exceedance: Represents excess deposition above critical load.
Exposure: The result of being in contact with a contaminant in the environment.
Ground-level ozone: A colourless gas formed from chemical reactions between nitrogen oxide and hydrocarbons in air and the presence of sunlight.
Health Effects Pyramid: A pyramid that visualizes the relationship between the severity of health effects caused by exposure to a pollutant or class of pollutants:

Figure 1: **Health Effects Pyramid**

Inhalable particulate: Particles with a diameter less than 10 microns.
Ionizing Radiation: Any high-energy atomic, subatomic particle or electromagnetic wave that in its passage through matter causes the ejection of electrons from atoms resulting in the formation of ions (positively or negatively charged atoms).
Morbidity: various health effects, other than mortality; for example, hospital admissions.
Mortality: Loss of life, death.
Mutagenic: Capable of altering genetic material.
National Smog Management Plan: A series of preventative initiatives developed by the Federal Government.

Nitrogen Oxides (NO_X): Includes nitric oxide (NO) and nitrogen oxide (NO_2).
Ontario Smog Plan: A plan developed by the government of Ontario to address the smog problem in Ontario.
Ozone (O_3): A component of smog, ozone is a colourless gas formed from chemical reactions between nitrogen oxides and volatile organic compounds in the presence of sunlight in the lower atmosphere. Ozone also occurs naturally in the upper atmosphere, where it shields the earth from harmful rays.
Ozone Episode Day: A day on which widespread elevated levels of ozone occur.
Particulate Matter (PM): refers to any airborne solid or liquid material less than 100 microns in diameter. **PM_{10}** refers to PM less than 10 microns, known as coarse particles. **$PM_{2.5}$** refers to fine or respirable particles less than 2.5 microns.
Photochemical reaction: A chemical reaction influenced or initiated by light, particularly ultraviolet light.
Primary pollutant: A contaminant directly emitted into the atmosphere.
Radioactive: Having the property of emitting ionizing radiation.
Radioisotope: A radioactive form of an element.
Radioactive decay: The process whereby a radioactive element emits ionizing radiation while undergoing change (i.e. decay).
Reference Level (RL): A level above which there are demonstrated effects on human health and/or the environment. It provides a scientific basis for establishing goals for air quality management and is defined for all receptors for which information is available.
Secondary pollutant: A contaminant formed by reaction with other pollutants in the atmosphere.
Sievert (Sv): The system international (SI) unit describing the relative biological impact of absorbed doses of different types of radiation on various body organs and tissues.
Smog: A harmful mixture of gaseous and inhalable pollutants. The term comes from the words “smoke” and “fog”.
Stratospheric ozone: ozone in the atmosphere (10 to 40 kilometres above the earth’s surface) formed by the conversion of oxygen molecules by solar radiation. Stratospheric ozone absorbs most of the UV radiation before it reaches the earth.
Sulphur Dioxide (SO_2): A colourless gas with a strong odour, readily converted in the atmosphere to sulphuric acid and sulphate aerosols, a major concern of acid rain.
Target load: The amount of pollution deemed politically acceptable, taking into account factors such as ethics, scientific uncertainties, social, economic and environmental considerations. It is presently set at 20 kg/ha/year for wet sulphate deposition and arbitrarily at 10 kg/ha/year for wet nitrate deposition in Ontario.
Total Suspended Particulate: A generic term for airborne particles including smoke, fumes, dust, fly ash, pollen etc.
Toxics: a category of pollutants including VOCs, heavy metals, organic chemicals.
Toxic pollutant: A substance that can cause cancer, genetic mutations, organ damage, changes to the nervous system, or physiological harm from prolonged exposure, even to relatively small amounts.
Troposheric ozone: See ground level ozone.
Virtual Elimination: A term used to imply zero discharge, <u>not</u> total elimination.
Volatile Organic Compounds (VOCs): Any organic compound that participates in

atmospheric photochemical reactions.

ACRONYMS, ABBREVIATIONS AND UNITS

AECB	Atomic Energy Control Board
AETG	Acidifying Emissions Task Group
AQO	Air Quality Objective
Bq/m^3	Bequerels per cubic metre
CAA	Clean Air Act (U.S.)
CEC	Commission for Environmental Cooperation
CCME	Canadian Council of Ministers of the Environment
CEPA	Canadian Environmental Protection Act
CFCs	Chlorofluorocarbons
CO	Carbon monoxide
CO_2	Carbon dioxide
CWS	Canada-Wide Standards
GHG	Greenhouse gas
HCFCs	Hydrochlorofluorocarbons
kg/ha/yr	kilograms per hectare per year
ktonnes	kilotonnes = 1000 tonnes = 1 million kilograms
I/M	Inspection and Maintenance
□□□	Methylcyclopentadienyl manganese tricarbonyl
□g/m^3	Millionths of grams per cubic metre
□m	Micron, or one-millionth meter
MOE	Ministry of Environment (Ontario)
NAAQO	National Ambient Air Quality Objectives
NAICC	National Air Issues Coordinating Committee
O_3	Ozone
ODS	Ozone-Depleting Substances
OMA	Ontario Medical Association
PM	Particulate Matter
$PM_{2.5}$	Fine Particulate Matter
PM_{10}	Coarse Particulate Matter
ppb	Parts per Billion
ppm	Parts per Million
POPs	Persistent Organic Pollutants
NO_X	Nitrogen Oxides
SO_2	Sulphur Dioxide
SOMA	Sulphur Oxide Management Area
TSP	Total Suspended Particulates
UN ECE	United Nations Economic Commission for Europe
VOC(s)	Volatile Organic Compounds
WGAQOG	Working Group on Air Quality Objectives and Guidelines

ENDNOTES

[1] Doug Miller, Pollution Probe and the York Centre for Applied Sustainability, Transportation, Air Quality and Human Health Conference "*Clearing the Air*", York University, (April 1996): p.54.
[2] Government of Canada, *"Phase 2 Federal Smog Management Plan"*, (November 1997): p.13.
[3] Burgoa C. et al., Commission for Environmental Cooperation, *"Meeting the Challenges of Continental Pollutant Pathway Case Study, Pollution Prevention and Increased Regional Competitiveness through Technology Innovation",* (1997): p.10.
[4] Brian McAndrew, "*Cuts Doom Quality of Air*," The Toronto Star, (April 29,1998): p. A9.
Andrew Duffy, "*Canadians Too Complacent About Health*," The Ottawa Citizen ,(May 15, 1998): p. A3.
[5] Martin Mittelstaedt "*Breathing Can Be Bad For Health*," The Globe and Mail (May 13, 1998): p. A3.
[6] Commission for Environmental Cooperation, "*Taking Stock: North American Pollutant Releases and Transfers, 1994*", (1997): pp. 9,10,30.
[7] Commission for Environmental Cooperation. Continental Pollutant Pathways, "*An Agenda for Cooperation to Address Long-Range Transport of Air Pollution in North America",*(1997): p.17.
[8] ibid: pp. 8,9.
[9] Acidifying Emissions Task Group, "*Toward a National Acid Rain Strategy"*, (October, 1997): pp. 2,5,6,13,18,19,60.
[10] Commission for Environmental Cooperation,. Continental Pollutant Pathways, "*An Agenda for Cooperation to Address Long-Range Transport of Air Pollution in North America",* (1997): p. 17.
[11] Bascom R. et al., "*Health Effects of Outdoor Air Pollution*", American Journal of Respiratory Critical Care Medicine 153, (1996): pp. 3-50.
[12] Ontario Environmental Protection Working Group, "*Our Future/Our Health*, *The Consequences of Inaction*" (June 1998): pp.18,26,37.
[13] Acidifying Emissions Task Group, "*Toward a National Acid Rain Strategy*", (October 1997): pp.8,9.
[14] ibid: p. 63.
[15] ibid: pp. 8-10.
[16]Bascom R et al., "*Health Effects of Outdoor Air Pollution*", American Journal of Respiratory Critical Care Medicine 153 (1996): pp. 3-50.
[17] Acidifying Emissions Task Group, "*Toward a National Acid Rain Strategy*", (October 1997): pp.32-35.
[18] Vles, R.,. "*Towards a Post-2000 National Acid Rain Strategy Report*", sponsored by the Acidifying Emissions Task Group (May 1997).
[19] Acidifying Emissions Task Group, "*Toward a National Acid Rain Strategy*", (October, 1997): p. 50.
[20] ibid: pp. 41,43,55.
[21] ibid: p.53.
[22] ibid: pp. 9,10.
[23] ibid: p.11.
[24] ibid: pp. 11,12.
[25]Commission for Environmental Cooperation, Continental Pollutant Pathways, "*An Agenda for Cooperation to Address Long-Range Transport of Air Pollution in North America*", (1997): pp. 12,13.
[26] Government of Canada, "*Phase 2 Federal Smog Management Plan*", (November 1997): pp. 14,15.
[27] ibid: p.16.
[28] Pengelly LD., Taylor SM., Stieb D., "*Canadian Smog Advisory Health Matrices for Ozone and Suspended Particulates, Final Report*, *Hamilton and Toronto*", Institute of Environment and Health, prepared for Health and Welfare Canada: (1993).
[29] Dockery DW. et al., "*An Association between Air Pollution and Mortality in Six U.S. Cities*", The New England Journal of Medicine 329(24) (1993): pp. 1753-1759.
[30] Burnett RT. et al., "*Effects of Low Ambient Levels of Ozone and Sulphates on the Frequency of Admissions to Ontario Hospitals*", Env. Research 65 (1994): pp. 172-194.
[31] Government of Canada, "*Phase 2 Federal Smog Management Plan*", (November 1997): pp. 13-14.
[32] ibid: p. 13.
[33] Environment Canada and Health Canada, Federal Provincial Working Group on Air Quality Objectives and Guidelines. "*Particulate Matter - An Overview*", Brochure Draft (1997): pp. 1-4.

[34] ibid: p.3.
[35] Government of Canada, "*Phase 2 Federal Smog Management Plan*", (November 1997): p. 20.
[36] Pollution Probe and the York Centre for Applied Sustainability, Transportation, Air Quality and Human Health Conference. "*Clearing the Air*", York University (April 1996): pp. 34,42,52.
[37] Burnett et al, PM Science Assessment Document,(1994,95): pp. 14-1 to 14-3.
[38] Pollution Probe and the York Centre for Applied Sustainability, Transportation, Air Quality and Human Health Conference. *Clearing the Air*, York University (April 1996): p. 19.
[39] Health Canada, Environment Canada, National Ambient Air Quality Objectives for Particulate Matter, Executive Summary Part *1: Science Assessment Document*, a report by the CEPA Working Group on Air Quality Objectives (1998): p. 19.
[40] Health Canada, Environment Canada. Particulate Matter Air Quality Objectives Consultation Draft, CEPA Working Group on Air Quality Objectives (October 1997): pp. 28,29.
[41] Health Canada, Environment Canada. National Ambient Air Quality Objectives for Particulate Matter, Executive Summary Part *1: Science Assessment Document*, a report by the CEPA Working Group on Air Quality Objectives, Particulate Matter Air Quality Objectives, Science Assessment Document: (October 1998): pp.8-10.
[42] Environment Canada. *Summary for Policy Makers*, Canadian 1996 NO_X/VOCs Science Assessment Program (1996): 1.
[43] Acidifying Emissions Task Group, "*Toward a National Acid Rain Strategy*", (October 1997): p. 8.
[44] Toronto Environmental Alliance, "*What's Wrong with the Ontario Smog Plan*",(January, 1998).
[45] ibid: p. 5.
[46] Canada-Wide Standards Development Committee for Particulate Matter and Ozone Information Package for Consultations (June 1998).
[47] Definition from Organization of Economic Development (OECD) Particulate Matter Air Quality Objectives, Consultation Draft (1997): p. 2.
[48] Bidleman, T. et al., Commission for Environmental Cooperation, "*Meeting the Challenges of Continental Pollutant Pathway* Case *Study*", Persistent Organic Pollutants (1997): pp. 5-9, 14-17.
[49] Commission for Environmental Cooperation,. Continental Pollutant Pathways, "*An Agenda for Cooperation to Address Long-Range Transport of Air Pollution in North America*", (1997): p. 18.
[50] World Wildlife Fund Canada Publication, " *Toxics that Tamper with Hormones*", Eagle's Eye, (1995).
[51] Pollution Probe and the York Centre for Applied Sustainability, Transportation, Air Quality and Human Health Conference "*Clearing the Air*", York University (April, 1996): pp. 39-41.
[52] Pilgrim W., Lucotte M. et al., Commission for Environmental Cooperation, "*Meeting the Challenges of Continental Pollutant Pathway, CaseStudy"*, Mercury (1997): pp. 1-12, 23-32.
[53] Nuclear Awareness Project, Nuclear Hazard Report (1991-92), Nuclear Awareness News (1997-98)
[54] Nuclear Awareness Project, *Summary and Assessment of Environmental Radiological Data for 1996* (April, 1997): pp.15-23.
[55] International Joint Commission (IJC) Seventh Biennial Report on Great Lakes Water Quality, rec #12 (February 1994): p. 47.
[56] Environment Canada Stratospheric Ozone Bulletin No. 96-7 (Fall, 1996).
[57] Environment Canada, "*Canada's Ozone Layer Protection Program - A Summary*"(1997).
[58] Cameron Smith, " *Days of Arch Ozone Eater Numbered* ", Toronto Star, (May 23, 1998): p. E6.
[59] Pollution Probe and the York Centre for Applied Sustainability, Transportation, Air Quality and Human Health Conference "*Clearing the Air*", York University (April, 1996): p. 17.
[60] The UVB Impacts Reporter, "*Ozone Loss and Biologically Effective Dosages of UV-B"*,v 1(3): (1994).
[61] Environment Canada, *"Canada's Ozone Layer Protection Program - A Summary*",(1997): pp. 5,6.
[62] Patrick Monohan, "*What's in the Kyoto Protocol"* , Canada Watch, York University (January 1998): pp. 3,4.
[63] David Bell, " *Canada's Position on the Environment after Kyoto",* Canada Watch, York University (January 1998): pp. 3,4.
[64] Brian McAndrew, "*Canada Cool on Global Warming*", The Toronto Star,(April 25, 1998): p. A1.
[65] Pollution Probe and the York Centre for Applied Sustainability, Transportation, Air Quality and Human Health Conference "*Clearing the Air*", York University (April, 1996): p. 17.
[66] Doug Macdonald, "*Climate Change and the Biophysical Nature of Environmental Politics"*, Canada

Watch, York University (January 1998): pp. 8,9.
[67] Standing Committee on Environment and Sustainable Development, "*Kyoto and Beyond: Meeting the Climate Change Challenge"*, (December 1997): pp. 19,20.
[68] Joseph F. Castrilli, Interim Final Report *"Legal Authority for Emissions Trading in Canada"* submitted to Pilot Emissions Reduction Trading in Association with Pollution Probe (March 1998): pp.6-10.
[69] Acidifying Emissions Task Group, "*Toward a National Acid Rain Strategy*",(October 1997): p. 11.
[70] Patrick Monohan, "*What's in the Kyoto Protocol"* ,Canada Watch, York University (January 1998): p. 4.
[71] Brian McAndrew, "*Hydro Sells Pollution Credits for $500,000*", The Toronto Star(May 7, 1998):p. B9.
[72] Government Working Group on Sulphur in Gasoline and Diesel, "*Setting a Level for Sulphur in Gasoline and Diesel"*, Final Report (July 1998): pp.ii-x.
[73] ibid: pp. 13-14.
[74] Brian McAndrew, "*Canadians left in dark over fuel*", The Toronto Star (October 25, 1998): p. A7.
[75] Government Working Group on Sulphur in Gasoline and Diesel, "*Setting a Level for Sulphur in Gasoline and Diesel"*, Final Report (July 1998): p. 63.
[76] NDP Environmental News, "*MMT: Ethyl Corporation Wins - Canadians Lose*", (Summer 1998): pp.17-18.
[77] Pollution Probe and the York Centre for Applied Sustainability, Transportation, Air Quality and Human Health Conference. "*Clearing the Air*", York University (April 1996):pp. 39-41.
[78] Municipal "Clean Air Summit", June 1996. *Bad Air Alert: It's Killing Us*, Blue Ribbon Committee Report: 10-12.
[79] Ontario Ministry of the Environment, "*Ontario's Smog Plan"*, Steering Committee Report (January, 1998):pp. vi, 17.
[80] Alex Gillis, "*Has Ontario Taken U-turn on Smog Clean-up?* ", The Toronto Star, (August 30, 1998): p. A1.
[81] Ontario Environmental Protection Working Group, "*Our Future/Our Health*, *The Consequences of Inaction",*(June 1998): pp. 18,28,37.
[82] ibid: p. 42.