TORONTO **STAFF REPORT**

May 18, 2000

To: Board of Health

From: Dr. Sheela V. Basrur, Medical Officer of Health

Subject: Air Pollution Burden of Illness in Toronto – Summary Report

Purpose:

To report on the key findings of Toronto Public Health's research study that estimates the number of premature deaths and hospitalizations that occur in the City of Toronto each year because of air pollution, and to provide policy recommendations for further action to improve air quality.

Financial Implications and Impact Statement:

This report has no direct financial implications. Financial implications are related to the implementation of Toronto's Environmental Plan, for which resource requirements are currently under discussion by the Toronto Interdepartmental Environment Team.

Recommendations:

It is recommended that the Board of Health:

(1) Request that the Medical Officer of Health:

(a) Investigate the policy options available to the City to reduce air pollution from key contributors within Toronto such as diesel fueled vehicles;

(b) Report back through the 2001 budget process on the benefit and feasibility of creating a Clean Air Advocate position to work with other municipalities and health units to advocate for the regulations, standards, policies and budget allocations needed from senior levels of government to improve regional air quality in southern Ontario; and a Clean Air Campaign Co-ordinator position to work with corporate staff, other government agencies, community groups and the private sector to implement a Greater Toronto Area-wide social marketing

program to shift individual and institutional practices towards air quality improvement;

(2) Encourage City Council:

(a) In keeping with the Strategic Transportation Plan prepared by the Greater Toronto Services Board and the sustainable transportation recommendations contained in Toronto's Environmental Plan, to advocate to the Federal Ministers of Finance, Revenue, Transportation and Environment, and the Provincial Ministers of Finance, Municipal Affairs, Transportation and Environment for the funding to implement a sustainable transportation plan for the Greater Toronto Area;

(b) To encourage the Federal Ministers of Environment and Health to establish sulphur levels in diesel that maximize health benefits for residents across Canada and harmonize standards for off-road and on-road diesel;

(c) Advocate to the Ontario Ministers of Environment and Energy, Science and Technology to:

(i) Make the selling of Lakeview Generating Station conditional upon its conversion to natural gas;

(ii) Establish for Ontario's electrical sector, the air emission caps recommended by the Ontario Clean Air Alliance that have been endorsed previously by both the Board of Health and City Council;

(iii) Establish for coal-fired power plants serving Ontario, an air emission rate for nitrogen oxide emissions that matches the rate contained in the recently affirmed rule developed by the United States Environmental Protection Agency; and

(iv) Revise the Air Quality Index to incorporate health based criteria that reflect the most recent scientific evidence for the six air pollutants identified in this report;

(d) Encourage the Federal Ministers of Environment and Health and the Canadian Council of Ministers of Environment to:

(i) Establish health protective Canada-wide Standards for carbon monoxide, sulphur dioxide, and nitrogen dioxide; and

(ii) Establish Canada-wide Standards of 50 ug/m^3 (24-hour) for inhalable particulates, 25 ug/m^3 (24-hour) for respirable particulates, and 60 ppb (8-hour) for ozone to be attained by the year 2010; and

(iii) Review the Canada-wide Standards for ozone and particulates on a regular basis to continually strengthen the standards towards the lowest adverse health effect level and/or naturally occurring background levels in the region to which they apply.

(e) Ensure that adequate and sustained funding is provided in a timely fashion to implement the recommendations contained in the Environmental Plan that are directed at the improvement of air quality in Toronto;

(f) Forward this report to the Greater Toronto Services Board, Toronto Transit Commission, GO Transit, Works Committee, Planning and Transportation Committee, Sustainability Roundtable, and the Toronto Interdepartmental Environment Team;

(g) Forward this report to the Prime Minister and the Federal Ministers of Finance, Revenue, Health, Transportation, and Environment;

(h) Forward this report to the Premier of Ontario and the Provincial Ministers of Finance, Health, Transportation, Environment and Energy, Science and Technology;

(i) Forward this report to all municipalities with a population greater than 50,000 in Ontario, all health units in Ontario, the Association of Municipalities of Ontario and the Federation of Canadian Municipalities, the Ontario Public Health Association, Association for Local Public Health Agencies and the Canadian Urban Transit Association for information; and

(j) Forward this report to the U.S. Environmental Protection Agency and the New York Attorney General's office as information relevant to their legal action against coal-fired power plants in the mid-western United States.

Background:

The City of Toronto has dedicated considerable staff resources towards the development of policies and plans to reduce both the Corporation's and the City's impact on air quality. Most notable among these plans is Toronto's Environmental Plan that was endorsed by City Council in April 2000. The City has also been active in advocating to the provincial and federal levels of governments for the standards, regulations, policies and budget allocations needed to improve air quality in Toronto and the rest of Ontario.

To date, the City has based its actions on air quality improvement on air monitoring data that indicate that Toronto residents are frequently exposed to air pollutants above levels known from the scientific literature to produce hospitalizations and premature deaths, and on provincial and federal estimates of premature deaths and hospitalizations related to air quality for Ontario and Canada. While air pollution-related estimates of the number of premature deaths and hospitalizations are available for Ontario, this information did not exist for Toronto. Toronto-

specific burden of illness information is essential to support local air quality improvement initiatives, and to understand the significance of air pollution as a determinant of health for Toronto's 2.4 million residents. Consequently, a research study was undertaken by Toronto Public Health to provide reliable estimates of the number of people seriously affected by air pollution in the City.

The methodology and results of this research are detailed in the attached technical report entitled, *Air Pollution Burden of Illness in Toronto* (Appendix 1). The study was conducted by a project team that included the internationally recognized air expert, Dr. David Pengelly, and staff from Toronto Public Health, the Ontario Ministry of Environment and the Central East Health Information Partnership. The study has been peer reviewed by four prominent scientists (Dr. Rick Burnett, Dr. David Steib, Dr. Donald Cole and Dr. Akos Szakolcai) who have strong expertise in air quality research. Some funding support was received from the Walter and Duncan Gordon Foundation.

Comments:

This report summarizes the key findings of the *Air Pollution Burden of Illness in Toronto* research study (Appendix 1), comments on the major sources of air pollution that lead to adverse health effects, and provides policy recommendations for further action to improve air quality.

Key Messages:

There are several key messages that arise as a result of the burden of illness study. The study suggests that:

(a) Toronto residents experience a substantial burden of illness because of the quality of Toronto air. In any given year, approximately 1,000 Toronto residents die prematurely, while another 5,500 are hospitalized, as a result of six air pollutants that are common in Toronto's air. These severe health outcomes are the tip of the iceberg; they represent a much larger number of less severe health effects such as respiratory infections and reduced lung function that can affect all members of the population.

(b) Illness and premature death occur at levels below those that trigger Smog Alerts. (Smog Alerts are triggered when ozone levels exceed 80 ppb.) Typically, Toronto has 5 to 10 Smog Alert days per year, all triggered by ozone. However, ozone is responsible for less than 5% of the premature mortality and about 30% of cardiorespiratory hospitalizations attributable to air pollution.

(c) The remaining illness and death result from exposure to other critical pollutants such as particulates, nitrogen dioxide, sulphur dioxide and carbon monoxide. Advising the public to take steps to protect themselves during extreme air pollution episodes is important, however, it is essential to understand that taking protective action only on Smog Alert days is not enough. The total level of all fossil fuel emissions from gasoline, diesel, oil and coal burned for the operation of cars, trucks, furnaces, and industrial operations must be reduced throughout the year.

(d) Toronto residents are being harmed by air pollution year round. Three of the six air pollutants -- ozone, inhalable particulates and sulphates -- are present at higher levels in the warmer months in Toronto, while the other three – nitrogen dioxide, carbon monoxide and sulphur dioxide – are present at higher levels in the colder months.

(e) The burden of illness documented in Toronto is occurring at exposure levels well below existing air quality standards set by the Canadian and Ontario governments. This is particularly true for the three primary air pollutants -- carbon monoxide, nitrogen dioxide and sulphur dioxide -- that have not received regulatory attention for many years. But it is also true that the Canada-wide Standards recently proposed for inhalable particulates (PM_{10}) and ozone will do little to reduce the burden of illness in Toronto. Stated in very approximate terms, only about 1% of premature mortality and less than 3% of respiratory hospital admissions in Toronto would be averted with full compliance of the newly proposed standards for ozone and particulates.

(f) The air emission inventory prepared by the Ministry of Environment for Toronto demonstrates that the transportation sector is the largest source of air emissions from human activity within the City. In 1995, the transportation sector was responsible for about 90% of carbon monoxide, 83% of nitrogen oxides, and 60% of sulphur dioxide emissions in the City. The emission inventory points to automobiles, heavy duty diesel trucks, and off-road diesel vehicles as the most significant contributors of air pollutants within the City.

(g) This report acknowledges that there are important industrial sources located outside of Toronto that can have a significant impact on Toronto's air quality. Among those that have been documented by Toronto Public Health previously are coal-fired electrical generating plants in the mid-western United States and in Ontario. Of particular concern is the Lakeview Generating Station that is located just west of Toronto in Mississauga. In 1995, when it was operating at very low capacity, it emitted as much sulphur dioxide as all sources within the entire City of Toronto.

(h) Action is needed to reduce air emissions on many different fronts. Within the City, adequate and sustained funding must be provided for the implementation of the air quality improvement recommendations contained in Toronto's Environmental Plan. Resources must also be allocated for the advocacy and educational outreach that is needed to secure action on air quality issues from other levels of government and the public.

(i) Public transit needs preferential funding support compared with highway construction if air quality is to be improved significantly. The federal and provincial governments must fund the implementation of a sustainable transportation plan for the Greater Toronto Area. The Toronto Transit Commission and GO Transit are among the least supported transit systems in North America. The fare box represents about 80% of revenues. This compares with the United States, where on average, 40% of revenues are collected from fares and both the federal and state governments provide financial grants for operating

and capital expenses. Improvements in public transit capacity and service could yield relatively rapid improvements in Toronto's air quality.

(j) The federal and provincial government must establish stringent sulphur standards for on-road and off-road diesel, and ever decreasing air emission caps for coal-fired electrical generating stations and other industrial point sources. They must also establish health protective air standards that will drive the development of new technologies that are environmentally sustainable and economically viable in all sectors of the economy.

Study Methodology

The *Air Pollution Burden of Illness in Toronto* study is based on the methodology first developed for the Hamilton Air Quality Initiative (HAQI) under the leadership of Dr. David Pengelly. Air pollutants were included in this study if there was sufficient information in the scientific literature to estimate how an increase in their levels in the air could increase adverse health outcomes in the population. This study therefore focussed on six common air pollutants -- carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), ozone (O_3), inhalable particulates (PM_{10}) and sulphates (SO_4). All of these air pollutants are prevalent in industrialized societies because they are emitted when fossil fuels such as gasoline, diesel, oil and coal are burned in the operation of cars, trucks, furnaces, power plants and other industrial operations.

Using the most recent scientific literature, risk coefficients were calculated for each air pollutant for three broad categories of health outcomes – premature mortality, respiratory hospital admissions and cardiac hospital admissions (Table 1). The risk coefficients describe the increase in specific health outcomes for every unit increase in a pollutant. Through the use of risk coefficients, it is possible to calculate the air pollution-related morbidity and mortality in a given community, provided that health outcome data (such as indicated in Table 1) and specific air pollution levels are available for that community.

Table 1. Indicators of Health Outcome

Health Outcome	Examples	Definition
Premature mortality	Heart failure Chronic pulmonary heart disease Viral pneumonia	All causes of non-traumatic early death.
Respiratory hospital admissions	Pulmonary congestion Pneumococcal pneumonia Asthma	Hospital admission as a result of diseases of the respiratory system.
Cardiac hospital admissions	Acute myocardial infraction Congestive heart failure Cardiac dysrhythmias	Hospital admission as a result of diseases of the circulatory system.

To estimate the health outcomes that can be attributed to air pollution, the risk coefficients for each air pollutant were multiplied by the number of premature deaths, and respiratory and cardiac hospitalizations, recorded in Toronto in 1995, and by the air levels recorded for each of the air pollutants in Toronto in 1995. Calculations were based on 1995 data because it was the

most recent complete set of air quality monitoring data available from the Ministry of the Environment at the time of the investigation. Air monitoring data came from six sampling stations in Toronto; two located in Etobicoke, one in York, one in Toronto, one in Scarborough and one in North York

Most of the risk coefficients were derived from many published, peer reviewed epidemiological studies. Therefore, there is a good deal of confidence in the numbers calculated for premature deaths and respiratory admissions. However, for cardiac hospital admissions, the risk coefficients were derived, in some cases, from only one study so there is lower confidence in the numbers calculated for cardiac admissions.

In order to strengthen the information upon which the cardiac hospital admissions were based, the burden of illness estimates were calculated a second time using the risk coefficients derived from a single, multi-pollutant study that was carried out for Toronto using 15 years' worth of air quality and health data by Burnett et al. (1999). Although the Burnett study is a single study, it has the advantage of relating specifically to Toronto, it uses a large data set, and a multi-pollutant approach. By using the two methods (one based on HAQI and the other based on the risk coefficients of Burnett et al, 1999), our study resulted in a range of health outcome estimates. The results of the two methods provide a lower and upper estimate of the burden of illness.

In addition to estimating the total air pollution burden of illness due to premature mortality and hospitalizations, this study sought to assess the relative importance of each of Toronto's critical air pollutants in contributing to ill health. It is recognized that there is some uncertainty in attributing illness rates to each pollutant, and that consequently, the reader should consider such outcomes as estimates, rather than precise accounts of exactly how many people are affected by a given pollutant. Given that the purpose of doing so is to better identify reasonable policy responses to reduce air-related illness, the approach is justified. For example, if one finds that a large amount of illness is associated with a pollutant known to come from a specific source, then it makes sense in terms of risk management to strategically direct control measures towards that source. It is for this reason that we calculated and documented the illness outcomes for each key pollutant. To reduce confusion for the reader, this summary report profiles the burden of illness values as determined through the HAQI method, rather than reporting each value as a range that included the values derived through the Burnett coefficients.

Air Pollution Results in a Significant Burden of Illness in Toronto

The *Air Pollution Burden of Illness in Toronto* study demonstrates that air pollution related to burning of fossil fuels results in a significant burden of illness in Toronto. In 1995, the six common air pollutants were responsible for between 730 and 1,400 premature deaths and between 3,300 and 7,600 hospital admissions in Toronto.

For the purpose of communicating these results in a more public, policy-making forum, it is reasonable to express the air pollution burden of illness in Toronto as resulting in about 1,000 premature deaths and about 5,500 hospitalizations each year. Although the calculations were based on 1995 data, air quality in Toronto has not shown any significant improvement since then, so it is reasonable to expect these illness estimates reflect the current situation as well.

Table 2 summarizes the mortality and hospitalization rates based on the HAQI approach, and indicates the relative importance of each of the key air pollutants in contributing to ill health.

Table 2. Burden of Illness Summary for Toronto (Based on HAQI approach, 1997)

Pollutant	Estimated Number of People with Adverse Health Outcome[b]			
	Non-traumatic Mortality	Respiratory Hospital Admissions	Cardiac Hospital Admissions	Congestive Heart Failure in Elderly
PM_{10}	226	555	812	
SO_4	119 [a]	170	169	
CO	441		274	439
NO_2	511	1,234	2,207	
SO_2	119	172		
0_3	59	199	2,155	
Total (SO_4 excluded)[c]	1,356	2,160	5,448	

[a] 405 when based on chronic exposure, rather than 24 hr exposure

[b] Blanks indicate no coefficients available to enable estimates to be calculated. Health outcomes for O_3 and PM_{10} based on excess morbidity and mortality beyond that associated with 'background' levels.

[c] SO_4 excluded because it is a component of PM_{10}.

These estimates, while dramatic, represent only the most serious health effects resulting from air pollution. For the last 15 years, it has been well recognized that air pollution produces a "pyramid" of health effects, with the rare but most serious health outcomes such as premature deaths and hospitalizations at the peak of the pyramid, and the less serious but more numerous health outcomes such as asthma symptom days and respiratory infections appearing in progressive layers below that peak. The premature deaths and hospitalizations documented in our burden of illness study represent only the peak of the pyramid of health effects that are related to poor air quality in Toronto. Table 3 was prepared to illustrate (for one pollutant - inhalable particulates) the increasing prevalence of less serious health outcomes that affect a larger portion of the population.

Table 3. Pyramid of Health Effects – Inhalable Particulates (PM_{10})

Health Outcome	No. of People Affected/Adverse Events
Mortality	226
Respiratory hospitalizations	555
Cardiac hospitalizations	812
Adult chronic bronchitis*	1,514
Emergency room visits*	7,639
Bronchitis in children*	15,322
Asthma symptom days*	91,982

* Values for these outcomes are calculated for Toronto based on relationship identified in Supporting Document for "Towards a Smog Plan for Ontario: A Discussion Paper". June 1996. OMOE.

The number of serious adverse health outcomes due to air pollution in Toronto is cause for considerable concern, however, it is useful to compare these estimates with morbidity and mortality rates due to other causes. As seen in Table 4, air-pollution related premature mortality is quite significant, even when compared with other major causes of death.

Although the improvement of air quality is a complex and difficult undertaking that will take years to implement, what is important to remember is that the mortality and morbidity estimates provided in this study represent health outcomes attributable to air pollutants occurring above "background" or naturally-occurring levels. Consequently, they represent the preventable adverse health outcomes. It is the reduction of these preventable outcomes that needs to be the focus of the City's air quality improvement initiatives.

Air pollution can affect all members of society, but children, the elderly and those with predisposing respiratory conditions (such as asthma) or heart conditions (such as congestive heart failure) are most vulnerable. An Ontario study demonstrated that 15% of respiratory admissions to hospital of children under two was due to ozone and sulphates in the air. Premature deaths occur mostly in the elderly with pre-existing health conditions whose life expectancy can be shortened by months or years.

Table 4. Comparative Health Outcome Statistics for Toronto Population (1995)

Health Outcome	Cause	Number People Affected
Mortality	Heart attack	3,160
	Stroke	1,347
	Lung cancer	1,048
	Air-pollution related*	1,000
	All other heart diseases	897
	Breast cancer (female)	432
	AIDS	414
	Tuberculosis	2
Morbidity	Air-related hospital admissions*	5,500
	Reported foodborne illness (all settings)	1,700
	New tuberculosis cases	486
	Reported foodborne illness (restaurants)	210

* Calculated in the *Air Pollution Burden of Illness in Toronto* study.

Human Health Affected Year Round

Contrary to popular belief, poor air quality is not only a summer time health concern. The six air pollutants responsible for the burden of illness documented in this report are present in Toronto's air all year round. In fact, three of the six air pollutants -- nitrogen dioxide, carbon monoxide, and sulphur dioxide -- are present at higher levels in the colder months than in the summer months, and these three air pollutants are responsible for almost 80% of air pollution-related premature deaths in Toronto.

Summer time air pollution has received much more attention because of the influence of ozone on the province's Air Quality Index. Smog alerts in Ontario are called most frequently when the

ozone levels exceed the province's hourly criterion of 80 ppb. Because ozone is a secondary air pollutant that is formed in the atmosphere in the presence of sunlight, ozone levels are much higher in the warmer months than in the colder months. While ozone is an important air pollutant, it is only one of six air pollutants that contribute to premature mortality, hospitalizations and illness in Toronto. (Ozone is responsible for only 5% of the premature deaths and 30% of the hospitalizations attributable to air pollution.)

The fact that smog alerts are triggered solely by ozone in Toronto points to weaknesses in the Air Quality Index. Currently, the Air Quality Index is based on air quality criteria that do not reflect the most recent evidence of adverse health effects for all the criteria pollutants. The Air Quality Index is a tool to educate and warn the public when air quality is poor. Therefore, it should incorporate health-based criteria and should not be based on air quality standards that incorporate economic and technical considerations.

Nitrogen Dioxide (NO_2) – Greatest Impact on Human Health in Toronto

Based on this study, nitrogen dioxide is the air pollutant with the greatest adverse impact on human health, responsible for almost 40% of air-related premature mortality and 60% of cardiorespiratory admissions to hospital. These health effects were documented at nitrogen dioxide readings that ranged from 17.5 to 30.1 ppb (24-hour) across the City, levels that are well below Ontario's air quality criterion of 200 ppb (1-hour) (see Table 5). These findings indicate that the air quality criterion for nitrogen dioxide should be reviewed by both the provincial and federal governments immediately.

The transportation sector is by far the greatest source of nitrogen dioxide within Toronto, releasing more than 80% of the nitrogen oxides emitted by human activity within the City. In 1995, heavy duty diesel vehicles and off-road diesel vehicles were responsible for about 40% of the nitrogen oxide emissions while automobiles and light duty gasoline trucks were responsible for 33% (see Table 6). Air monitoring data indicate that nitrogen dioxide levels are higher in the cold months than in the warm months, suggesting that heating and electrical sector are major contributors as well.

Carbon Monoxide (CO) – Air Quality Criterion Not Protective

The current air quality criterion for carbon monoxide is not protective of human health. The burden of illness study demonstrates that carbon monoxide has a significant impact on premature deaths in Toronto. In 1995**,** carbon monoxide was responsible for about 30% of the premature deaths attributed to the six common air pollutants. These health effects occurred at carbon monoxide levels (24-hour) that ranged from 530 to 1,020 ppb, levels that are well below Ontario's current air quality criterion of 13,000 ppb (8-hour).

The transportation sector is by far the most significant source of carbon monoxide within the City of Toronto. In 1995, it was responsible for about 90% of the 447,000 tonnes of carbon monoxide emitted by human activity within the City. Automobiles are the greatest contributors, responsible for about 60% of the carbon monoxide emissions from transportation.

Ozone (O_3) – More Protective Air Standards Needed

The burden of illness study demonstrates that, next to nitrogen dioxide, ozone is the air pollutant that has the greatest impact on hospitalizations in Toronto. In 1995**,** ozone was responsible for about 2,300 hospital admissions**.** While there is less confidence in the number of cardiac hospital admissions estimated for ozone with the HAQI-based approach compared with the use of Burnett's coefficients, the Burnett-based estimates confirm the importance of ozone's contribution to health outcomes in Toronto.

These health estimates are based on ozone exposures in excess of 30 ppb only. While there appears to be no safe level of exposure to ozone, there are natural or background levels of ozone that would be present without air pollution from human activity. For the purposes of this study, the background level for ozone in Toronto was assumed to be 30 ppb, and was subtracted from all of the monitoring data before the health outcomes were estimated.

The substantial burden of illness estimated for ozone occurred at average daily maximum ozone readings that ranged from 30.9 to 37.1 ppb across Toronto. These readings are well below the national air quality objective that currently applies to ozone (82 ppb, 1-hour) and the Canada-wide Standard recently proposed by the Canadian Council of Ministers of the Environment (CCME). The CCME has recently proposed an 8-hour standard of 65 ppb for ozone to be attained by 2015, which is similar to the existing objective.

Given the burden of illness associated with ozone at levels well below the existing standard, it is essential that the CCME set a standard that reduces exposure to ozone in the near future. Toronto Public Health has recommended that the CCME should establish an 8-hour ozone standard of 60 ppb to be achieved by 2010, with review on a regular basis to continually strengthen the standards towards the lowest adverse effect and/or background levels.

Air monitoring data from 1995 indicate that ozone levels in Toronto's air vary substantially from one hour to the next, particularly during the summer months. The monitoring data also indicate that ozone levels in the warmer months are about double the levels in the colder months. Ozone levels tend to be lower in downtown Toronto because of higher levels of nitrogen oxides from the high traffic density. Nitric oxide (NO) scavenges ozone to produce oxygen and nitrogen dioxide thereby reducing ozone levels somewhat.

Ozone is a secondary air pollutant that is formed when nitrogen oxides react with volatile organic compounds in the presence of sunlight. Because volatile organic compounds are released from vegetation in warmer months, as well as from human activities, it has been determined that the most effective way to reduce ozone is to reduce emissions of nitrogen oxides. As discussed in the section on nitrogen dioxide, the transportation sector is by far the greatest source of nitrogen oxides within Toronto.

Because ozone can take several hours to form in the atmosphere and can travel hundreds of kilometres, distant sources of nitrogen oxides can have a significant impact on ozone levels in Toronto. Modeling has demonstrated that about 50% of the ozone that affects southern Ontario in the summer arises from nitrogen oxides emitted from coal-fired electrical generating stations

in the mid-western United States. Coal-fired power plants in Ontario, such as Nanticoke and Lakeview, and steel plants in Hamilton, may also be important contributors of the ozone experienced in Toronto.

Inhalable Particulates (PM_{10}) – More Protective Air Standards Needed

Inhalable particulates (PM_{10}) are responsible for a substantial burden of illness in Toronto. In this study, close to 20% of the air pollution-related premature mortality and hospitalizations were attributable to PM_{10}.

Inhalable particulates include fine dusts, metal fumes and acid aerosols that are formed in the atmosphere from gases such as sulphur dioxide and nitrogen oxides. These particulates are all small enough to be inhaled into the lungs. While it appears that there is no safe level of exposure to inhalable particulates, health outcomes were calculated for only that portion of the exposure that is greater than the background level. Deciding what level of inhalable particulates is background or natural is subject to debate. For the purposes of this study, 5 ug/m^3 was used as the background level and health outcomes were only calculated for air levels that exceeded this value.

In 1995, the annual average of the 24-hour readings for inhalable particulates ranged from 19.7 to 23.9 ug/m^3 in Toronto. The interim 24-hour air quality objective of 50 ug/m^3 has been applied to inhalable particulates in Ontario since 1996. The CCME has recently proposed a Canada-wide Standard of 30 ug/m^3 (24-hour) for respirable particulates ($PM_{2.5}$) to be attained by 2010, which is approximately equivalent to a 24-hour standard of 60 ug/m^3 for inhalable particulates (PM_{10}). This would suggest an increase over Ontario's existing (interim) criterion, resulting in less health protection.

Given the burden of illness associated with inhalable particulates, it is essential that the CCME move to establish a standard that will require reductions in air levels of PM_{10} in the near future. Toronto Board of Health has recommended a Canada-wide Standard of 50 ug/m^3 for inhalable particulates (PM_{10}) to be attained by 2010, and a standard of 40 ug/m^3 to be attained by 2015. For respirable particulates ($PM_{2.5}$), the Board of Health recommended that a standard of 25 ug/m^3 should be attained by 2010 while a standard of 20 ug/m^3 should be attained by 2015.

With respect to emissions arising from human activity within Toronto, wood fireplaces/stoves appear to be a large source of inhalable particulates in the City, based on the Ministry of Environment's 1995 emission inventory. In 1995, they were responsible for about half of the inhalable particulates emitted directly within Toronto. Heavy duty diesel trucks and off-road diesel equipment such as construction equipment, operating inside Toronto were also identified as important contributors of inhalable particulates. Toronto Public Health should investigate the policy options available to the City to reduce air emissions from both wood-fueled fireplaces and diesel-operated vehicles operated within the City.

Because inhalable particulates are composed of secondary air pollutants such as sulphates and nitrates that can be formed in the atmosphere, distant sources of their precursors can contribute significantly to levels measured in Toronto's air. Modeling indicates that transboundary air

pollution is responsible for a significant portion of the particulates that affect southern Ontario. The Acidifying Emissions Task Group has estimated that 90 to 95% of the sulphates that are deposited on southwestern Ontario, and which contribute to inhalable particulates in Toronto, originate in the United States. Coal-fired power plants in the mid-western United States are the most significant source of the sulphates crossing the international border.

Major industrial point sources on this side of the border are also likely contributors of inhalable particulates in Toronto's air. For example, the Lambton and Nanticoke electrical generating stations are two major point sources of the precursors of inhalable particulates that are upwind from Toronto (see Table 8).

Sulphates (SO_4) – Significant Component of Particulates

A significant component of particulates in air are sulphates. Estimates indicate that about 25% of the inhalable particulates and 40% of the respirable particulates in Ontario are sulphates that have formed in the air from sulphur dioxide. Although sulphates are a component of inhalable particulates, health outcomes were calculated for them separately as well. In 1995**,** sulphates were responsible for about 120 premature deaths, 170 respiratory hospital admissions and 170 cardiac hospital admissions in Toronto.

Air monitoring data demonstrate that air levels of both inhalable particulates and sulphates are higher in the warmer months than in the colder months. This may reflect a variety of factors including: long-range transport; drier ground conditions; and increased transformation of sulphates from sulphur dioxide because of the higher levels of ozone present in the summer. The annual average of daily sulphate levels in Toronto ranged from 3.0 to 3.5 ug/m^3 in 1995. There is currently no air quality criterion for sulphates in Ontario.

Sulphur Dioxide (SO_2) – Air Quality Criterion Not Protective

Sulphur dioxide is well known as a precursor of sulphates that have long been associated with human health effects. More recent studies have demonstrated however, that sulphur dioxide itself can have a substantial impact on human health. Sulphur dioxide was responsible for about 120 premature deaths and 170 respiratory hospital admissions in Toronto in 1995. These health effects were demonstrated at average (24-hour) air levels of sulphur dioxide that ranged from 2.4 to 4.1 ppb across the City. Ontario's current 24-hour air quality criterion for sulphur dioxide is 100 ppb; 25 to 40 times higher than average air levels in Toronto in 1995.

The Lakeview coal-fired electrical generating station located just west of Toronto in Mississauga emitted as much sulphur dioxide in 1995 as all sectors within the City of Toronto. Since then, air emissions from Lakeview have increased dramatically. In 1998, for instance, Lakeview emitted 1.5 times as much sulphur dioxide as the entire City of Toronto (see Table 8). Within the City of Toronto, the transportation sector and the heating of buildings were important contributors of sulphur dioxide.

Need for More Protective Ambient Air Quality Standards

This research study revealed that air-pollution related morbidity and mortality occur for all six pollutants prevalent in Toronto's air, even at levels well below Ontario's existing air quality criteria, and at levels below the new federal-provincial Canada-wide Standards proposed for ozone and particulates. Table 5 shows the range in average pollutant levels at the various monitoring stations throughout Toronto. With the exception of ozone exceedances during smog alert days, pollutant levels in Toronto typically fall below allowable air quality criteria/standards. Despite this, as shown in Table 2, there is considerable premature mortality and illness associated with existing pollutant levels.

Table 5: 1995 Air Pollution Levels in Toronto and Applicable Criteria (Standards)

Air Pollutant	Range in Annual Averages Across Toronto Monitoring Stations	Current Ontario Air Quality Criteria	Proposed Canada Wide Standards
NO_2 (ppb)	24.6 – 30.1 (24-hr)	200 (1-hr)	
CO (ppb)	530 – 1,020 (24-hr)	13,000 (8-hr)	
O_3 (ppb)	36.9 – 41.2 (1-hr)	80 (1-hr) 82 (national)	65 (8-hr) [a]
SO_2 (ppb)	2.4 – 4.1 (24-hr)	100 (24-hr)	
PM_{10} (ug/m^3)	19.7–23.9 (24-hr)	50 (24-hr)	(60 ug/m^3)(24-hr) [b]
SO_4 (ug/m^3)	3.0 – 3.5 (24-hr)		

a Approximately equivalent to 87 ppb when averaged over 1 hour

b A standard has been proposed for $PM_{2.5}$ of 30 ug/m^3 which is approximately equivalent to a PM10 standard of 60 ug/m^3

Our calculations suggest that even if air levels of ozone and particulates were reduced below Ontario's existing criteria, very few premature deaths and hospitalizations in Toronto would be avoided. If ozone levels in Toronto's air were restored to background levels (30 ppb), approximately 59 premature deaths and 199 respiratory hospitalizations could be avoided each year, whereas full compliance with Ontario's current ozone standard would result in the avoidance of only about 2 premature deaths and 7 respiratory admissions.

The situation for PM_{10} is similar (Table 6). If PM_{10} were restored to background levels (5 ug/m^3), one could avoid approximately 226 premature deaths and 555 respiratory hospitalizations every year. However, even with full compliance with the existing Ontario criterion for PM_{10} (50 ug/m^3), it is expected that only about 3 premature deaths and 7 respiratory hospital admissions would be avoided. Stated in very approximate terms, only about 1% of premature mortality and less than 3% of respiratory hospital admissions attributed to air pollution are averted with full compliance with current criteria. This is of concern, considering that the new Canada-wide standards proposed are quite similar to Ontario's existing criteria for ozone and particulates. This analysis demonstrates the urgent need to ensure that air standards are set at levels that drive improvements in air quality and advancements in technologies.

Table 6. Particulate Standards and Avoidable Health Outcomes in Toronto

Health Outcome	Adverse Health Outcomes Avoided With Different PM_{10} Standards[a]		
	If PM_{10} = 50 [b]	If PM_{10} = 25	If PM_{10} = 5 [c]
Premature mortality	3	47	226
Respiratory hospitalization	7	113	555

a Based on 1995 health outcome rates; PM expressed in ug/m^3.
b Equivalent to the existing Ontario interim Air Quality Criteria
c Background level

Sources of Air Pollution in Toronto

An inventory of air emission generated by human activity in the City of Toronto was provided by the Ontario Ministry of Environment for 1995 (see Table 7) . While this inventory is based on incomplete records for industrial air emissions and on rough estimates for vehicle use in the City, it does provide useful information on the relative contribution of different sources for the common air pollutants generated within Toronto (see Table 7).

Within Toronto, transportation is the most significant source of the six air pollutants discussed in this report. In 1995, transportation was responsible for 91% of carbon monoxide, 83% of nitrogen oxides, 60% of sulphur dioxide, 33% of particulate matter and 30% of volatile organic compounds emitted through human activity within Toronto. Automobiles are the most significant sources of carbon monoxide, while automobiles, heavy duty diesel trucks, and off-road diesel vehicles such as construction equipment, are the most significant sources of nitrogen oxides and sulphur dioxide in the City.

The emission inventory demonstrates that the heating of homes, offices and industry was responsible for 57% of inhalable particulates and 33% of sulphur dioxide emitted within the City in 1995. Wood used in residential fireplaces/stoves appears to be the most significant contributor of air pollutants within the heating sector.

The emission inventory for Toronto demonstrates the need for:

(a) Improved vehicle emission standards for automobiles, for trucks and off-road equipment;
(b) More stringent fuel standards for gasoline, on-road diesel and off-road diesel;
(c) A significant modal shift from automobiles to public transit, bicycles and other less polluting forms of transportation;
(d) Fuel switching from diesel and gasoline to alternative fuels;
(e) Greater energy efficiency in buildings that are heated and air conditioned;
(f) Shifting away from the use of coal for electrical power generation; and
(g) Shifting away from the use of wood as a fuel in residential settings.

Table 7. Sources of Air Pollution Emissions Due to Human Activity Within Toronto[a]

Category/Sector	Estimated Emissions (tonnes)				
	NOx	VOC	CO	SO_2	PM
Industrial (total)	5,200	12,500	1,400	900	1,100
Fuel Combustion					
Residential fuel-wood	400	21,500	38,800	60	5,400
Total[b]	8,000	22,000	40,700	3,700	6,500
Transportation					
Automobiles	20,200	25,000	255,400	1,200	400
Heavy Duty Diesel	14,500	1,900	8,700	2,300	1,500
Off-road diesel	17,300	1,400	5,000	1,600	700
Total[b]	62,500	40,300	405,100	6,800	3,700
Miscellaneous		57,500			
Total	75,600	132,300	447,400	11,400	11,400

a Based on data for 1995 from OMOE.

b Includes other sources not itemized because of comparatively small contribution.

Sources of Air Pollutants Beyond Toronto

Emissions from major industrial point sources and mobile sources beyond Toronto are not included in the emission inventory, even though it is recognized that they may have a significant impact on air quality in Toronto. Toronto Public Health does not have sufficient information to comment on all major sources beyond the City. However, comments are offered on the contribution of coal-fired power plants based on previous research.

Modeling has demonstrated that coal-fired power plants in the mid-western United States have a significant impact on air quality in southern Ontario. Estimates suggest that about 50% of the ozone that affects southern Ontario in the summer, and about 90 to 95% of the sulphates that fall on southwestern Ontario, originate as nitrogen oxides and sulphur dioxide in the mid-western United States. This is why City Council has recommended that the City should seek standing as a "Friend of the Court" in the legal action being taken by the U.S. Environmental Protection Agency (EPA) and the New York Attorney General's Office against U.S. coal-fired power plants that are alleged to be out of compliance with the U.S. Clean Air Act.

Three coal-fired electrical generating stations operating in Ontario are also upwind from Toronto. The Lakeview Generating Station, located just west of Toronto in Mississauga, has a very direct impact on Toronto because of its close proximity. In 1995, Lakeview emitted as much sulphur dioxide as all sources within the City of Toronto. In 1998, its air emissions increased dramatically so that it was emitting 1.5 times as much sulphur dioxide as all sources within Toronto in 1995 (see Table 8).

The Nanticoke Generating Stations is located a few hundred miles upwind of Toronto near Lake Erie. In 1995, it emitted 3.5 times as much sulphur dioxide and one third as much nitrogen oxides as the entire City of Toronto. In 1998, it emitted 7 times as much sulphur dioxide and 1.5 times as much nitrogen oxides as all sources within the City of Toronto in 1995. The Lambton Generating Station, located in Sarnia, emitted almost 1.5 times as much sulphur dioxide as Toronto in 1995 and 2.5 times as much in 1998.

Table 8. Pollutant Emissions from Coal-Fired Generating Stations Upwind of Toronto

Power Plant	Estimated Emissions (tonnes)			
	SO_2		NOx	
	1995	1998	1995	1998
Lakeview	11,490	18,820	6,600	12,000
Lambton	16,300	29,230	11,800	22,100
Nanticoke	37,360	78,450	24,000	42,200

Actions Needed - Greater Support for Public Transit

The Greater Toronto Services Board in its January 2000 report “Removing Roadblocks” noted that transit is the key to reducing traffic congestion in the region. Reduced congestion will bring about a number of direct and indirect benefits, which include more efficient movement of goods, cleaner air and reduced urban sprawl. The 20% increase in air pollution levels in Hamilton during its 1998-99 transit strike is an indication of the contribution of transit to cleaner air in that city.

Greater investment in public transit is essential for the continued prosperity of Toronto and the surrounding areas. In recognition of the importance of transit in fostering economic development and reducing pollution, it is common for public transport to receive government support for its operations. The Toronto Transit Commission and GO Transit are among the least supported transit systems in North America. The fare box represents about 80% of revenues. This compares with the United States where on average, 40% of revenues are collected from fares, and both the federal and state governments provide financial grants for both operating and capital expenses.

In February 2000, the Canadian Minister of Finance announced a $2.75 billion allocation over six years to improve provincial highways and municipal infrastructure. It is essential that the federal and provincial government allocate a substantial portion of these funds to improve public transit. Public transit needs preferential funding support compared with highway construction if air quality is to be significantly improved.

Given that so much of the burden of illness in Toronto is associated with pollutants arising from the transportation sector, improvements in public transit capacity and service can provide relatively rapid relief to Toronto’s air pollution problems. There needs to be serious consideration given by both the federal and provincial levels of government towards sustained funding for public transit in Canada’s major cities, similar to the situation in the United States. Given that improved public transit would greatly reduce air pollution, it would also reduce the enormous health care costs associated with air pollution-related burden of illness that are currently borne by provincial and federal governments. Staff will monitor the estimated health care costs attributable to air pollution and report back to the Board of Health as these costs become known.

Action Needed - Improved Fuel and Vehicle Emission Standards

In 1998, the Government Working Group convened by Environment Canada demonstrated that significant health benefits would be associated with reductions in the sulphur levels in gasoline, on-road diesel and off-road diesel. The federal government has since moved to significantly reduce sulphur levels in gasoline to 30 ppm by 2005 with the Sulphur in Gasoline Regulations. This move could reduce sulphur dioxide levels in Toronto air by 29%, and air levels of carbon monoxide, nitrogen dioxide and sulphates by 6% - 7%. The federal government has not yet moved to act on the findings related to on-road or off-road diesel.

In 1998, the average sulphur levels in on-road diesel were about 270 ppm, while the average sulphur levels in off-road diesel were about 2,200 ppm. The Government Working Group demonstrated that by lowering the sulphur levels in on road-diesel and off-road diesel, air levels of sulphur dioxide, respirable particulates ($PM_{2.5}$) and sulphates could be substantially reduced in Toronto. It estimated that a 50 ppm sulphur standard for on-road diesel could result in $1.2 billion worth of health benefits in seven Canadian cities, including Toronto, over a 20 year period, while a 400 ppm sulphur standard for off-road diesel could result in $2.9 billion worth of health benefits.

On the basis of the Government Working Group report, Toronto's Board of Health and City Council recommended in 1998 that the federal government should establish sulphur levels for on-road diesel that maximize the health benefits for residents across Canada before the year 2000, and that standards for off-road should be aligned with those for on-road diesel.

Canada has traditionally aligned its vehicle emission standards with those developed by the U.S. EPA, because of the integrated nature of the automobile industry in North America. Under the U.S. Clean Air Act, the U.S. EPA has established a progressive agenda for the development of stringent vehicle emission standards for light duty and heavy-duty gasoline and diesel operated vehicles, including off-road vehicles. The federal government should continue to align its vehicle emission standards with those being developed in the U.S. This is particularly important for heavy-duty diesel trucks and off-road diesel vehicles such as construction equipment that are important contributors to Toronto's air pollution.

Actions Needed – Coal-Fired Plants

In January of this year, Ontario Power Generation (previously part of Ontario Hydro) announced its intention to sell the Lakeview Generating Station. Under a new owner, and in a privatized electrical system, it is possible that Lakeview's operating capacity could increase from 15% to as much as 80% in the future. If Lakeview were operated at full capacity (an 80% increase) as a coal-fired plant, sulphur dioxide emissions from the plant could increase by almost five times the 1995 levels to 53,000 tonnes per year. If however, the plant were converted to natural gas, sulphur dioxide emissions from the plant could be eliminated entirely. For these reasons, Toronto City Council (April 11-13, 2000 meeting) endorsed a resolution requesting that the Ontario Government make the selling of Lakeview conditional upon its conversion to natural gas.

Air emissions from the Nanticoke, Lambton and other coal-fired electrical generating stations in Ontario will depend greatly upon the new regulatory scheme being developed for Ontario's electrical sector by the Ontario Ministry of Environment. The Ministry is developing a regulatory scheme that is based on emission trading and emission caps for air pollutants such as nitrogen oxides and sulphur dioxide. With health protective air emission caps and a properly designed emission trading system, air emissions from plants such as Nanticoke and Lambton could be substantially reduced. However, with the regulatory scheme currently proposed by the Ministry, air emissions from these plants could actually increase in the future.

Toronto's Board of Health has previously recommended that the province's emissions trading system should be designed to encourage development of low impact and renewable technologies in the electrical sector. It has also recommended that the province should work towards achieving the air emission caps recommended by the Ontario Clean Air Alliance that have been endorsed by both the Board of Health and City Council. Given the results of this air pollution burden of illness study, there is a need to reiterate Toronto's previous recommendations.

Toronto's Environmental Plan

The results of the burden of illness study provide evidence of the urgent need to improve air quality in Toronto. They also support many of the initiatives recommended in Toronto's Environmental Plan *Clean, Green and Healthy: A Plan for an Environmentally Sustainable Toronto,* which was adopted in principle by City Council in March 2000. Many of the recommendations contained in the plan address air quality. They include:

(a) Development of a comprehensive air quality strategy which would set priorities for City action and could include an expansion of the smog reduction plan to the private sector, the use of zero emission fleets and promoting employer trip reduction programs;

(b) Reduction of air emissions through adoption of stricter standards and by exploring the feasibility of a by-law to restrict point source emissions;

(c) Integration of the City's efforts on air quality with regional, provincial, federal and international bodies;

(d) Coordination of sustainable energy efforts in the City;

(e) Increasing energy efficiency in City operations and facilities to achieve a 15% reduction in energy use;

(f) Commitment to purchase 25% of the City's energy needs through green power;

(g) Encouraging energy efficiency in new developments through improved building design;

(h) Focusing education and community-based marketing on key areas such as air issues;

(i) Development of a comprehensive sustainable transportation plan which includes strategies for reducing the need to transport people or goods, giving priority to sustainable transportation in land use decisions, addressing biases that favour automobile users and encouraging a seamless multi-modal transportation network within the region.

Further Actions Possible by Toronto Public Health

Within Toronto Public Health, the Health Promotion and Environmental Protection Office is responsible for applied research, policy development, advocacy and health promotion on aspects that relate to how the biophysical environment might adversely affect human health. At present, the equivalent of only 2.5 Public Health staff persons are available to address air quality issues, given competing priorities for other environmental issues that arise in Toronto. However, two new initiatives are under development that could be considered further in the year 2001 budget cycle.

One initiative involves the creation of a specialized position within Toronto Public Health that is conceptualized as a Clean Air Advocate. The intent of this position is to collaborate with other municipalities to advocate for health-protective regulations, standards, policies and budget allocations by provincial and federal levels of government to improve air quality. There would also be substantial collaboration with community partners, including environmental, health and community groups active on air quality advocacy. Given that much of the authority for the actions needed to improve air quality in Toronto rests with senior levels of government, a Clean Air Advocate is needed to influence Provincial and Federal decision-making.

A second initiative involves the development and implementation of a major social marketing campaign to combat air pollution and global warming. A campaign framework has been developed and proposals for external grants have been submitted to bring the campaign from concept to reality. The campaign, branded as *20/20: A Clear View to Clean Air*, targets two key behavioural areas that influence air quality: transportation and energy use. The campaign is focused on promoting and enabling attainment of a collective (Greater Toronto Area-wide) and individual (household level) goal of 20% reduction in air emissions. Positive, direct and forward-looking, 20/20 is about creating a sense of possibility. The campaign has a dual role: (a) it acts as a hub for collaboration and joint promotion by supporting existing corporate and community efforts; and (b) it fills key programming gaps with new tools (including educational resources) and approaches. Toronto Public Health is well situated to take a leadership role on a clean air campaign because it has the credibility and expertise to deliver compelling health-based reasons for action on air quality improvements. To ensure success of this emerging program, there is a need to create a new position within Toronto Public Health for a Clean Air Campaign Co-ordinator.

Conclusions:

The *Air Pollution Burden of Illness in Toronto* study has demonstrated that air pollution associated with the burning of fossil fuels has a significant impact on human health in the City of Toronto, and that air pollution is a problem year round. The study indicates that each year about

1,000 Toronto residents die prematurely and about 5,500 are admitted to hospital as a result of air pollution in this City.

The study identifies nitrogen dioxide as the air pollutant with the greatest impact on premature mortality and hospitalizations in the City. It also demonstrates that carbon monoxide, ozone, inhalable particulates, sulphur dioxide and sulphates are important air pollutants that each contribute substantially to premature mortality and hospitalizations.

The study demonstrates the inadequacy of existing air quality criteria for carbon monoxide, nitrogen dioxide and sulphur dioxide. It also highlights the limitations of the Canada-wide Standards recently proposed by the CCME for ozone and particulate matter. The study demonstrates the need for health protective air standards that drive the development of new technologies that are environmentally sustainable and economically viable.

The air emissions inventory provided for Toronto identifies that the transportation sector is the most significant source of air pollution from human activity within the City. Automobiles, heavy-duty diesel trucks and off-road diesel vehicles are identified as the greatest contributors of nitrogen oxides, carbon monoxide and sulphur dioxide within the City.

This report acknowledges that air pollution sources beyond Toronto also have a significant impact on Toronto's air quality. Coal-fired power plants in the mid-western United States are identified as significant contributors of ozone and inhalable particulates that affect Toronto. The Nanticoke, Lambton and Lakeview coal-fired electrical generating stations in Ontario are also identified as major point sources that likely contribute to ozone, particulates and/or sulphur dioxide levels in Toronto's air.

Urgent action is needed from all levels of government to improve air quality in Toronto and in the rest of southern Ontario. Within the City, adequate and sustained funding is required for the implementation of Toronto's Environmental Plan, particularly with respect to the City's air strategy, sustainable energy and sustainable transportation plans. Action is also needed from the provincial and federal governments on issues related to public transit, land use planning, fuel and vehicle standards, air quality standards, and regulations for Ontario's electrical sector. The City of Toronto can not operate on its own. It must collaborate with other municipalities and senior levels of government. To facilitate this collaboration, there is a need to adequately resource air-related health advocacy and promotion initiatives by Toronto Public Health staff, including through creation of new positions through future budget cycles.

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