Ontario

Proposed Performance Indicators for Ontario's Anti-Smog Action Plan

A progress report developed by the Performance Monitoring and Reporting Work Group (PMRWG)

August 2000

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Cette publication technique
n'est disponible qu'en anglais.

ISBN 0-7778-9538-2

PIBS 3951E

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Executive summary

This report describes the development of appropriate performance indicators to be used in tracking and evaluating the progress made in the implementation of the Anti-Smog Action Plan (formerly called Ontario's Smog Plan). The performance indicators are components of the Plan's disciplined management system, which constitutes a framework for handling and tracking the overall progress of the Plan.

The task of developing such performance indicators was assigned to the Performance Monitoring and Reporting Work Group, which reports to the Plan's Operating Committee (formerly the Steering Committee). The Work Group is a multi-stakeholder group with representatives from the private sector, non-governmental organizations and the federal and provincial governments.

The Work Group identified a number of performance indicators – scientifically sound, reputable and quantifiable measurement tools – to track, measure or otherwise assess changes in:

- domestic emissions of nitrogen oxides (NO_x) and volatile organic compounds (VOCs), the primary ozone-producing precursors;
- domestic emissions of inhalable and respirable particulates (IP/RP), a major component of smog;
- the transboundary transport of smog, ground-level ozone and their precursors from the United States into Ontario;
- the human health and environmental effects of ground-level ozone and smog in Ontario;
- the degree of public and private sector participation in the Anti-Smog Action Plan;
- and, ultimately, any reduction in the incidence of ground-level ozone concentrations that exceed provincial air quality criteria.

The report sets forth the 13 proposed performance indicators to be used in Smog Plan reporting, as well as recommendations for the development or refinement of additional indicators for future application. Each of the proposed indicators has been allocated to one of two priority categories depending on its current availability for use, the development status of the necessary background science, and the extent of the supporting data collection infrastructure.

NO_x and VOC emission reduction

- Compile updated annual emissions inventory for the years 1990 to 2015 – **Level 1 Priority**.
- Report on how reductions have been achieved (anecdotal evidence in a format comparable to that acceptable under the National Pollutant Release Inventory- **Level 2 Priority**.

Reduction of inhalable and respirable particulates (IP/RP)

- Monitor ambient IP/RP concentration measurements at sampling stations – **Level 1 Priority**.
- Update annual emission inventory of IP/RP and precursors – **Level 1 Priority**.
- Evaluate sectoral contributions through the use of inventory data and atmospheric modelling – **Level 2 Priority**.

Ambient air quality monitoring

- Track number of exceedances of the ozone ambient air quality criterion (number of days) from Ontario Ministry of the Environment monitoring sites – **Level 1 Priority**.

Reduction of transboundary pollutants

- Compile inventories of emissions of NO_x, VOCs and IP/RP in states upwind of Ontario – **Level 1 Priority**.
- Track compliance activities under U.S. State Implementation Plans – **Level 2 Priority**.

Broad Involvement

- Track formal participation in the Anti-Smog Action Plan – **Level 1 Priority**.
- Develop quantifiable indicators with assistance from Public Engagement Work Group – **Level 2 Priority**.
- Track internal initiatives in place to reduce smog-related emissions from the institutional, commercial and industrial sectors (that are not made formal commitments under the Plan) – **Level 2 Priority**.

Health and vegetation impacts

- Develop appropriate indicators with assistance from the Health Work Group – **Level 2 Priority**.
- Use appropriate SUM60 indices to track agricultural impacts – **Level 2 Priority**.

The process and criteria used to develop these performance indicators are described in Chapter 2, while Chapters 3 through 8 address the application of these indicators to the evaluation of: NO_x and VOC emissions reduction (Chapter 3), the control of inhalable and respirable particulates (Chapter 4), air quality monitoring (Chapter 5), transboundary pollution (Chapter 6), the promotion of broad public involvement in the smog plan (Chapter 7), and human health impacts and vegetation impacts (Chapter 8). Recommendations concerning additional work needed to support the use or application of these indicators are presented in Chapter 9.

It should be noted that there have been certain difficulties in determining appropriate and meaningful performance indicators that can be used to evaluate the success of the Plan. Information gaps do exist and these have been identified.

1.0 Introduction

1.1 The Anti-Smog Action Plan

The first annual report was issued by what was then called the Ontario's Smog Plan Steering Committee in January 1998. (The plan became the Anti-Smog Action Plan [ASAP] in late 1999, and the committee is now the Operating Committee.) The document describes the fundamentals of Ontario's smog problem, sets forth the components of a process designed to address that problem, and establishes a management and organizational structure for implementing those components. The Smog Plan has been developed and is supported by a broad partnership of government, business and community representatives.

According to the 1998 report, the ASAP's primary target is to achieve, by the year 2015, a 75 per cent reduction in the number of times Ontario's one-hour air quality criterion for ozone is exceeded. This target is to be reached through a reduction in domestic emissions of total nitrogen oxides (NO_x), volatile organic compounds (VOCs) and fine particulates – the precursors of ground-level ozone and the main components of smog – as well as a reduction in the levels of transboundary pollution imported into the province from the United States. It has been estimated that a 45 per cent reduction in total NO_x and VOC emissions will be necessary to achieve the Plan's objectives, while the requisite reductions in particulates and transboundary pollution are currently under discussion. The ultimate success of the Plan will depend on the broad involvement of the public, business and government in smog reduction actions.

In order to co-ordinate activities, enhance communications and track progress, the Plan calls for the implementation of a "disciplined management process." Such a process entails the development of performance indicators and an annual reporting methodology to ensure that progress being made in improving Ontario's air quality can be objectively measured. Annual reporting will also allow sectoral adjustments to be made or regional targets to be established in response to advances in technology and/or improvements in the understanding of the smog problem in Southern Ontario.

Appendix A provides further details of federal and provincial smog control initiatives, such as Phase 1 and 2 of the Federal Smog Management Plan, the NO_x/VOC Management Plan, data management programs and emission inventories.

1.2 ASAP organization and management

The on-going development of the Anti-Smog Action Plan is being managed by a multi-sectoral operating Committee composed of leaders from business, government and non-governmental organizations. The committee has the responsibility for initiating the ASAP process, assembling working group plans, monitoring progress and reporting annually over the 20-year planning and emissions reduction process.

Through the Operating Committee, sectoral work groups have been established for the transportation, industrial/manufacturing and governmental sectors. Each of these groups (and such subgroups as have been set up) is responsible for collecting emission inventory data, preparing emission reduction plans for its sector, and implementing programs designed to contribute to the Plan's overall reduction targets. Sectoral work groups will report annually to the Operating Committee on their progress and performance.

These sectoral groups have been supported by four issue-based work groups (to address public acceptance concerns, transboundary issues, an inhalable/respirable particulate strategy, and incentives for participation in the Plan), as well as two support work groups (responsible for data management and technical support and liaison). The two support groups were eventually reconstituted as the Performance Monitoring and Reporting Work Group.

1.3 The Performance Monitoring and Reporting Work Group

A highly disciplined management system – which includes performance measurements and annual reporting – is being implemented to ensure progress is made toward improving Ontario's air quality and reducing the incidence of smog events. The mandate of the Performance Monitoring and Reporting Work Group (hereafter referred to as the Work Group in this report) has been to develop appropriate performance indicators and to recommend what tracking information (including emission inventories) should be provided in the form of an annual report.

The performance indicators identified by the Work Group will be used to track sectoral progress and constitute a framework for handling and reporting all the data generated during and in support of the ASAP. Subsequently, each sectoral and issues work group will track appropriate performance indicators as part of its reduction plan development and implementation.

The stated objectives of the Work Group are to:

1. provide recommendations on the evaluation of air quality targets and emission reduction goals;

2. support individual sector work groups on regional or sectoral air quality and inventory issues, and co-ordinate ASAP activities with other working groups and with industrial, provincial, federal and international activities; and,

3. report on the selection of overall performance indicators, the roll-up of emission reductions, and the performance evaluation of air quality goals.

The Work Group held its first meeting Feb. 2, 1998, and met a further eight times during 1998. Its membership includes representatives from government, the private sector and non-governmental organizations (the membership of the Work Group is provided in Appendix E).

The Work Group identified a short list of 13 proposed performance indicators – scientifically sound, reputable and quantifiable measurement tools – to gauge the progress and track the success in meeting the objectives of the Plan. The process and criteria used to develop such performance indicators are described in Chapter 2 of this report. The bulk of the report (Chapters 3 through 8) addresses the application of these indicators to the evaluation of: NO_x and VOC emissions reduction, the control of inhalable and respirable particulates, air quality monitoring, transboundary pollution, the promotion of broad public involvement in the Plan, human health impacts and vegetation impacts. Recommendations concerning additional work needed to support the use or application of these indicators are presented in Chapter 9.

2.0 Performance indicators

2.1 The role of performance indicators

With increasing frequency, performance indicators are being used to help companies, governments and organizations objectively evaluate their progress in meeting specific goals or objectives. In the past, such assessments could have been undertaken in a less than rigorous manner, using non-quantifiable, unscientific or otherwise subjective criteria. Such an approach often provided a skewed or misleading picture of what was actually happening. The use of well-defined performance indicators allows an organization to compare relative, year-to-year progress on a standardized basis.

Similarly, performance indicators can be used as a basis for benchmarking similar organizations or sectors against one another. This can be a useful exercise for identifying areas of weakness which may not otherwise become evident until too late in the development cycle. The application of performance indicators can also be used by companies or organizations that want to be considered as "leaders" in their sector. In such a situation, these measurements can serve as a catalyst for internal reorganization and help ensure that specified goals are achieved.

Public policy planning and reorganization strategies provide additional examples of the use of performance measurements to help administrators evaluate how well they are doing in meeting stated objectives.

Not surprisingly, a wide variety of performance indicators can be used, depending on the specific application or targets chosen; the targets selected in the auto manufacturing industry, for example, are likely to be significantly different from those used in the plastics or furniture industry. The question becomes: Which of the available measurement tools provide – in terms of their applicability, flexibility, and accessibility – the best and most accurate results?

In selecting relevant performance measures, the Work Group reviewed those in use elsewhere and in similar circumstances, such as those employed in other multi-stakeholder situations coupled with a public accountability component. An example of such an application is the performance monitoring undertaken by the International Joint Commission (IJC).

2.2 Criteria for selecting performance indicators

The task of developing suitable performance indicators to track and assess the progress made under the Anti-Smog Action Plan was undertaken by the Performance Monitoring and Reporting Work Group. The purpose of the performance indicators is to show objectively, over the years, how air quality in Ontario has been affected and could be improved by the various actions planned by the stakeholders under the Plan. These performance indicators would be employed to measure or otherwise assess changes in:

- domestic emissions of nitrogen oxides (NO_x) and volatile organic compounds (VOCs), the primary ozone-producing precursors;
- domestic emissions of inhalable and respirable particulates (IP/RP), a major component of smog;
- the transboundary transport of smog, ground-level ozone and their precursors from the United States into Ontario;
- the human health and environmental effects of ground-level ozone and smog in Ontario;
- the degree of public and private sector participation in the Plan;
- and, ultimately, any reduction in the occurrence of ground-level ozone concentrations that exceed provincial air quality criteria.

There were a number of additional issues that had to be considered by the Work Group in deciding which performance indicators would be the most useful and relevant in the execution of the Anti-Smog Action Plan:

- What are the needs of the individual stakeholders/partners in the Plan?
- What types of information will be acceptable in a public forum and meet the expectations and needs of the public?
- Are there any indicators compiled by other organizations or jurisdictions that can be used?
- What message(s) do we want to convey by using these indicators?

In developing a preliminary list of potential performance indicators, the Work Group concluded that if candidate indicators were to receive further consideration, they had to meet a series of both scientific and general criteria. The six criteria for evaluating candidate performance indicators are presented in Table 1.

Table 1
Criteria for evaluating candidate performance indicators

Criterion #1 Is the indicator necessary for characterizing the desired outcome properly and for evaluating progress? When deciding on an indicator, only those most relevant to measuring target objectives should be included. Non-essential indicators should be discarded.

Criterion #2 Is the indicator scientifically valid and of good quality, and can confidence be placed in it? In developing indicators, only those that have scientific validity should be included.

Criterion #3 Can the data and information be interpreted in terms of the desired outcome? A number of indicators could be developed, but it may be difficult to follow their relationship to the targets of the Anti-Smog Action Plan.

Criterion #4 Are the data and information readily available at a reasonable cost (including the value of both human and financial resources required)? One may be able to develop appropriate indicators, but if the cost to obtain the data is prohibitive, then in practical terms, the indicator is useless.

Criterion #5 Is the indicator timely? That is, does it provide data and information quickly enough? The results of any indicator selected should be timely enough so that corrective action can be taken if required.

Criterion #6 Is the indicator integrative and broadly applicable? Does it exhibit the capacity to combine a variety of diverse data and information? Rather than having a large number of different indicators, it would be more economical and efficient to develop single indicators that integrate the results from a number of different aspects. However, it is important that any integrative indicator doesn't oversimplify the complexity of the issue by ignoring some of the interrelationships.

2.3 Development of preliminary performance indicators

Based on the objectives of the Anti-Smog Action Plan and the selection criteria described above, the Work Group prepared a preliminary list of 34 potential indicators. These are listed in Appendix F.

2.4 Development of proposed performance indicators

Following preparation of the preliminary list of performance indicators, each member of the Work Group was then asked to rate each of these measures, on a scale ranging from "very high" to "very low", against the six selection criteria in Table 1. The results of this exercise resulted in the preparation of a shortened list of proposed performance indicators. (Note, not all members of the Work Group participated in this ranking exercise.)

The indicators were consolidated into the final list of 13 proposed performance indicators as presented in Table 2. Work Group members were also asked to list the anticipated results generated by each performance indicator and evaluate how the indicator would demonstrate that the commitments made under the Anti-Smog Action Plan had been fulfilled. These assessments are also summarized in Table 2.

Finally, in developing the performance indicators, a number of assumptions had to be made about the availability and applicability of the data. These assumptions have been documented in Table 2 and should represent critical factors in the final decision to adopt any of the individual performance indicators.

The complexity of this exercise should not be underestimated; it is important that all stakeholders are quite clear as to what can and cannot be obtained from these proposed indicators. For example, in proposing the use of an updated annual emissions inventory, it was assumed that this information could be obtained through an existing mechanism, such as the National Pollutant Release Inventory (NPRI). In order for this performance indicator to be an effective and useful option, duplication needs to be minimized to the extent possible.

TABLE 2 PROPOSED PERFORMANCE INDICATORS			
GOAL	**PERFORMANCE MEASURE**	**ANTICIPATED RESULTS**	**ASSUMPTIONS/ SUPPORTING REQUIREMENTS**
NO_x and VOC emission reduction	● Updated annual emissions inventory for the years 1990 to 2015.	Reports on the total annual domestic emissions of NO_x and VOCs in Ontario, emission reductions achieved from one year to the next, and up-to-date estimates on progress made in achieving the 2015 target for a 45% reduction in NO_x and VOC emissions.	● Develop baseline emission inventory of 1990 NO_x and VOC emission levels (or whatever base is selected for the measurement). ● Design comprehensive emission inventory to cover all sectors including the general public (e.g. area emissions from mobile and residential sources). Obtain general acceptance of methodology used for estimating emissions where not currently known. ● Include future projections to year 2015, based on current year's inventory and reductions from previous year. ● Base findings on monitoring data, such as stack testing and other applicable methodologies. ● Determine to what extent the inventory can be integrated with other environmental release questionnaires (e.g. NPRI, Statistics Canada, etc.). ● Increase responses to common air pollutant emissions survey (e.g. track number and percentage response rate). ● Ensure adequate resources allocated to collate and maintain database.
NO_x and VOC emission reduction	● Report on how reductions have been achieved (anecdotal evidence in a format comparable to that acceptable under NPRI)	A better understanding of how emission reductions were achieved.	● Implement a general checklist of how reductions are achieved to be voluntarily filled out and submitted to the "Smog Registry" (e.g. production, estimation methods in conformity with NPRI methods) supplemented by anecdotes. ● Associations can develop own questionnaire/checklist. ● Number of CCME codes/guidelines and similar instruments implemented. The greater the number of these implemented, the bigger the reductions.

TABLE 2
PROPOSED PERFORMANCE INDICATORS

GOAL	PERFORMANCE MEASURE	ANTICIPATED RESULTS	ASSUMPTIONS/ SUPPORTING REQUIREMENTS
Reduce transboundary pollutants	● Compile inventories of emissions of NO_x, VOCs and IP/RP in states upwind of Ontario. ● Track compliance activities under U.S. State Implementation Plans (SIPs).	Ontarians need assurance that the U.S. is helping to contribute to cleaner air in Ontario. There is a need to report on what is being achieved in the U.S.	● Track progress in meeting transboundary commitment (e.g., under the Canada-U.S. Air Quality Agreement) and participation in other activities designed to influence U.S. actions. ● Need agreement on what are considered background concentrations of ozone in Ontario and in the U.S. and agreement on where appropriate background monitoring sites will be located in Ontario. ● Measure levels of ambient transboundary pollutants (on an annual basis) in order to be able to distinguish between U.S. contributions and Ontario contributions. ● Track U.S. ambient air data and emissions inventories (on an annual basis). ● Compare Ontario's ambient air quality with equivalent U.S. data.
Broad involvement	● Develop quantifiable indicators with assistance from Public Engagement Work Group.	Reinforce message that "smog is everyone's problem" not just industry's. This indicator would measure the extent of the public "buy in" and assess whether we are able to influence actions that will result in reduction of smog-related pollutants.	● Track number of public education programs implemented on air quality and smog. ● Track number of energy efficiency regulations and estimate extent of emissions reduced by such programs. ● Develop other indicators, such as the distance driven by Ontarians (annual km. travelled, number of vehicle trips), degree of wood burning, public transit usage, home insulation upgrades, etc. ● Track extent of public concerns about air quality issues and/or local pollution sources.
Broad involvement	● Formal participation in Anti-Smog Action Plan	The Anti-Smog Action Plan is a partnership of public interest groups, businesses and government. Formal participation in the Plan or commitments through agreements are critical to the success of the overall Plan.	● Report participation in the Anti-Smog Action Plan. ● Report number of accord signatures, MOUs, etc. ● Report commitments made by ASAP partners and number of commitments actually implemented.

TABLE 2
PROPOSED PERFORMANCE INDICATORS

GOAL	PERFORMANCE MEASURE	ANTICIPATED RESULTS	ASSUMPTIONS/ SUPPORTING REQUIREMENTS
Broad involvement	● Internal initiatives in place to reduce smog-related emissions from the institutional, commercial & industrial sectors (that are not formal commitments under the Plan).	This report will measure the extent of informal corporate and government support and whether we are able to influence actions that will result in reduction of smog-related pollutants.	● Track number of Ecologo programs dealing with air quality. ● Track number of companies with green workplace programs with clean air components and/or smog advisory response components. ● Track number of municipalities that have implemented programs dealing with air quality (e.g. flex time, smog response time, employee education, etc.)
Reduction of inhalable and respirable particulates (IP/RP)	● Monitoring of IP/RP concentration measurements at sampling stations. ● Continued use of emissions inventories, with voluntary programs to try to increase sectoral participation in obtaining data for PM_{10} and pre-cursors. ● Continued evaluation of sectoral contributions by synthesizing inventory data with improved modelling requirements.	Actions taken by Ontarians will result in reduced IP/RP levels in the atmosphere. This figure should be reduced from one year to the next if actions are appropriate.	● Establish effective monitoring of ambient air levels of Ontario IP/RP and its precursors (such measurements must be scientifically defensible). ● Develop a comprehensive IP/RP emissions inventory for all sectors, based on a voluntary reporting mechanism. Current response rates for voluntary questionnaires are considered too low. Alternative voluntary mechanisms need to be developed to help smaller companies provide data. ● Apportion sources contributing to IP/RP (upstream of airshed) and assess sectoral contributions to total IP/RP emissions. ● Assess results of MOE IP/RP discussion paper and strategy. ● Track progress in reductions of IP/RP and precursors. Agreement on the modelling to be used as a basis is required, to help focus improvements.

TABLE 2 PROPOSED PERFORMANCE INDICATORS			
GOAL	**PERFORMANCE MEASURE**	**ANTICIPATED RESULTS**	**ASSUMPTIONS/ SUPPORTING REQUIREMENTS**
Ambient air quality monitoring	● Track number of exceedances of the ozone AAQC (number of days) from Ontario MOE monitoring sites	Ontarians need assurance that the plan is monitoring what is being achieved. This indicator will provide evidence that this is indeed occurring. The rating should improve with time as more partnerships become established.	● Install a defensible monitoring network in Ontario (how will this be defined? what model will be used? how will we know when we have such a system in place?). ● Track number of partnerships arranged for installing monitoring network sites. ● Develop future projections of air quality based on improvements in modelling efforts. ● Continue efforts to improve the model selected. Periodic upgrades may be required, as well as calibration testing against "real data".
Reduce health and vegetation impacts	● Develop appropriate indicators with assistance from the Health Work Group.	This report will give evidence that the actions under the Smog Plan will result in fewer Ontarians dying and suffering from respiratory symptoms.	● Track number of Ontarians with respiratory problems directly related to smog. Questions remain on how this number will be developed (based on hospital admissions? doctor visits? number of people using inhalers? number of deaths?) using statistical methods used in the Anti-Smog Action Plan. ● Establish verifiable statistical link between exposures to smog components and precursors and human health effects.
Reduce health and vegetation impacts	● Use appropriate SUM60 indices to track agricultural impacts.	This report will give evidence on the reduced losses to Ontario farmers resulting from air pollution exposure. Net losses should decrease with time.	● Track crop loss due to ozone. (How will this be done/estimated? Should losses be expressed in dollars or tonnes of crop lost? What baseline will be used?) ● Develop a methodology to track crop loss. ● Establish infrastructure needed to track losses (perhaps with the assistance of the Ontario Agricultural Institute).

3.0 NO_x and VOC emission reductions

3.1 Emission inventories and projected reductions

Emission inventories for nitrogen oxides (NO_x) and volatile organic compounds (VOCs) have been compiled by the Ministry of the Environment (MOE) for the years 1990 and 1995. The emissions data for stationary sources were as provided by the individual companies; in certain cases, the reported figures were weighted by the ministry's technical experts. Emissions for area and mobile sources were estimated from fuel and solvent usage and the Mobile-5C transportation model.

Emissions are projected to the year 2015 at five-year intervals by the National Emissions Inventory and Projections Task Group (NEIPTG) based on energy and economic growth and anticipated technological changes. The growth rates for emissions were calculated by NEIPTG in the early 1990s for the period 1990 to 2015 and are regularly reviewed and updated to include new information.

Historical NO_x and VOC emissions and the projected emissions for period 1990 to 2015 are presented in Appendix C (Tables 6a & b, and 7a & b). These tables also incorporate the NO_x and VOC emission reductions already achieved or committed to by various industrial sectors and other responsible parties. Reported emission reductions are cumulative and are shown in five-year intervals (although, in reality a reduction in emissions may have occurred earlier). Some years actually show smaller reductions in total reported emission reduction value for a particular sector owing to the effects of an increase in output and/or a lack of additional controls.

The reductions reported by the Anti-Smog Action Plan participants are assumed to be maintained through and up to the year 2015. This is a simplifying assumption employed to facilitate the projection of future reductions. It should be noted that some of the emission reductions identified in the Plan were not considered to be "firm" commitments for a variety of reasons; for example, no firm tonnage reductions were reported, no responsible parties were identified, and so on.

The emission reduction initiatives that have been identified by private and public sector organizations participating in ASAP, as well as information on technological options and other relevant details, are detailed in *Ontario's Smog Plan, Steering Committee Report* (January, 1998) and in the *Compendium Document* (1998) that supplements that report.

3.2 Emission reduction scenarios

The detailed information on future NO_x and VOC emission reductions are summarized in Figures 1 and 2. In addition to our best projections of NO_x and VOC emissions, the figures also show the impact of two variations in growth rate, as well as the projected emissions of NO_x and VOCs if no control actions were to be taken (for comparison purposes). NO_x and VOC emission projections are presented for the four scenarios at five-year intervals.

Scenario #1, in each figure, is based on zero increases over 1990 emissions and the timely and successful implementation of committed reductions by those industries and sectors contributing to the emissions. Scenario #4 , in each figure, shows the Plan's original NO_x and VOC emission projections based on estimated economic growth (and other factors discussed above in Section 3.1), and assumes no reduction in emissions by industrial, mobile and area sources. The remaining two scenarios incorporate growth in emissions at 50 and 100 per cent of the best estimates. These scenarios also assume that the reductions already committed under the Plan are achieved.

3.3 NO_x emission reduction scenarios

Scenario #1 shows NO_x emissions dropping steeply between 1990 and 2000 to 443 kilotonnes (kt), but thereafter the reductions are more modest and the target of 362 kt of total NO_x emissions is attainable by 2015. This will just about meet the ASAP objective of a 45 per cent reduction in NO_x emissions from 1990 levels (estimated at 659 kt). Note, this scenario is based on a zero growth rate over the period 1990-2015.

The other two scenarios show that if 50 per cent to 100 per cent of the assumed growth occurs and Ontario sources have no plans to reduce NO_x emissions further than that those actions already taken or committed to under the Plan, NO_x emissions are estimated to rise anywhere from 500 kt to 635 kt. Without any Smog Plan activities, Ontario's NO_x emissions are estimated to increase by 41.6 per cent from 1990 levels, as indicated in scenario #4 .

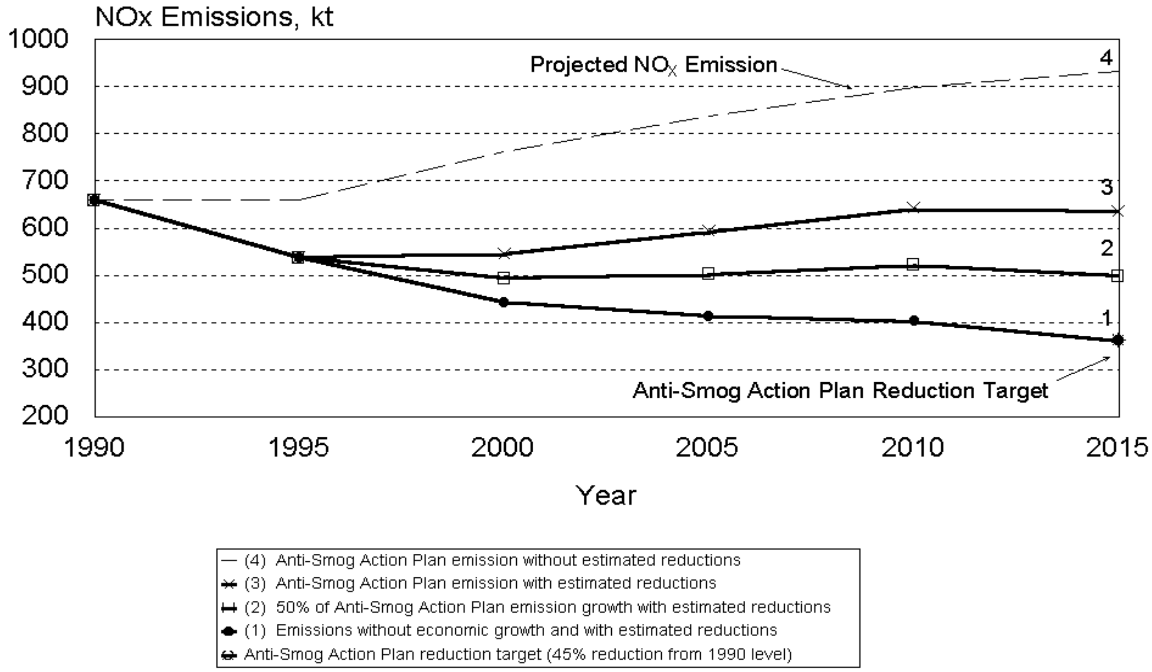
3.4 Analysis of NO_x scenarios

Canadian nitrogen oxide (NO_x) emissions are primarily associated with the combustion of fossil fuels and, secondarily, with high-temperature industrial processes. From 1990 through 2000 (estimated) , domestic NO_x emissions have been reduced by some 216 kilotonnes. If these reductions had not taken place, NO_x emissions in 2000 would have totalled an estimated 761 kilotonnes.

If no controls were to be implemented, the emissions of NO_x by the year 2015 are projected to total 933 kilotonnes. The firm reductions in NO_x emissions indicated in the Plan would reduce this amount by some 216 kilotonnes by 2000. Therefore, NO_x emissions are currently projected at 718 kilotonnes in the year 2015 if no further reductions are planned.

The target level for NO_x emissions in 2015 set under the Plan is 362 kilotonnes. Scenario #3 (the 100 per cent growth scenario) shows that a reduction in NO_x emissions of 571 kt (or 61 per cent) from the projected value of 933 kt in 2015 would be needed to meet the Plan's objective.

Figure 1
Historical and projected Ontario NO_x emissions, 1990-2015
(Projected growth with estimated reductions)



Notes to Figure 1:

1. Scenario #4 is an Anti-Smog Action Plan base case and assumes no emission reductions after 1990. Emissions are estimated to increase at an average annual compound growth rate of 1.42% over the 1990 to 2015 period.

2. Scenario #1 is based on a zero per cent increase in 1990 emissions, based on no economic growth over the same period and the premise that sources contributing to these emissions would be able to achieve additional committed reductions in Ontario NO_x emissions. NO_x emissions are estimated to decrease at an average annual compound rate of 4.0% (1990-2000) and 1.4% (2000-2015).

3. Scenarios #2 and #3 assume similar reductions in emissions, but use a set percentage of the growth rate of scenario #4 yielding average annual compound emissions changes between - 0.36% and +0.85% over the period 1995 to 2015.

It should be noted that there are uncertainties in the projections of future growth and emissions, and that some of the projected growth may not be realized. However, without additional commitments to emission reduction by stakeholders, NO_x emissions would rise owing to economic activity and changes in energy usage. The anticipated technological changes would not provide the large reduction in emissions required to meet the Plan's goals.

Since NO_x is considered the more important precursor pollutant in smog formation, Ontario will have to be more vigilant in monitoring progress in delivering the committed NO_x emission reductions by industries and other groups, and should plan new programs to offset future growth in NO_x emissions.

3.5 VOC emission reduction scenarios

Scenario #1 shows a significant drop in VOC emissions between 1990 and 2000 to 643 kilotonnes (kt), but thereafter the impact of the committed reductions is small. The VOC emissions in scenario #1 reach a level of about 600 kt in 2015. Again it is important to note that this scenario is based on a zero growth rate over the period 1995-2015.

Scenarios #2 and #3 show that if 50 per cent to 100 per cent of the assumed growth occurs and Ontario sources implement no additional plans to reduce VOC emissions (further to those committed so far under the Anti-Smog Action Plan), VOC emissions will rise anywhere from 771 kt to 944 kt. Even under a zero emission growth rate scenario (scenario #1), Ontario will fall short by an estimated 120 kt of its 45 per cent VOC emission reduction target (from 1990 levels of 868 kt) in 2015.

Without the implementation of any smog plan activities, Ontario's VOC emissions were estimated to increase by 40 per cent from 1990 levels, as indicated in scenario #4 .

3.6 Analysis of VOC scenarios

Volatile organic compounds (VOCs) include thousands of organic compounds, both natural and synthetic. Anthropogenic sources of VOCs include combustion, various industrial processes, and the evaporation of liquid fuels, solvents and organic chemicals.

Natural sources of VOCs include animals, plants and forest fires. Vegetation produces non-methane VOC emissions, also called biogenic emissions, which play an important role in the formation of ground-level ozone. However, it is important to note that anthropogenic VOC emissions tend to dominate during ozone episodes, both locally and in the most populous smog-affected regions of Canada.

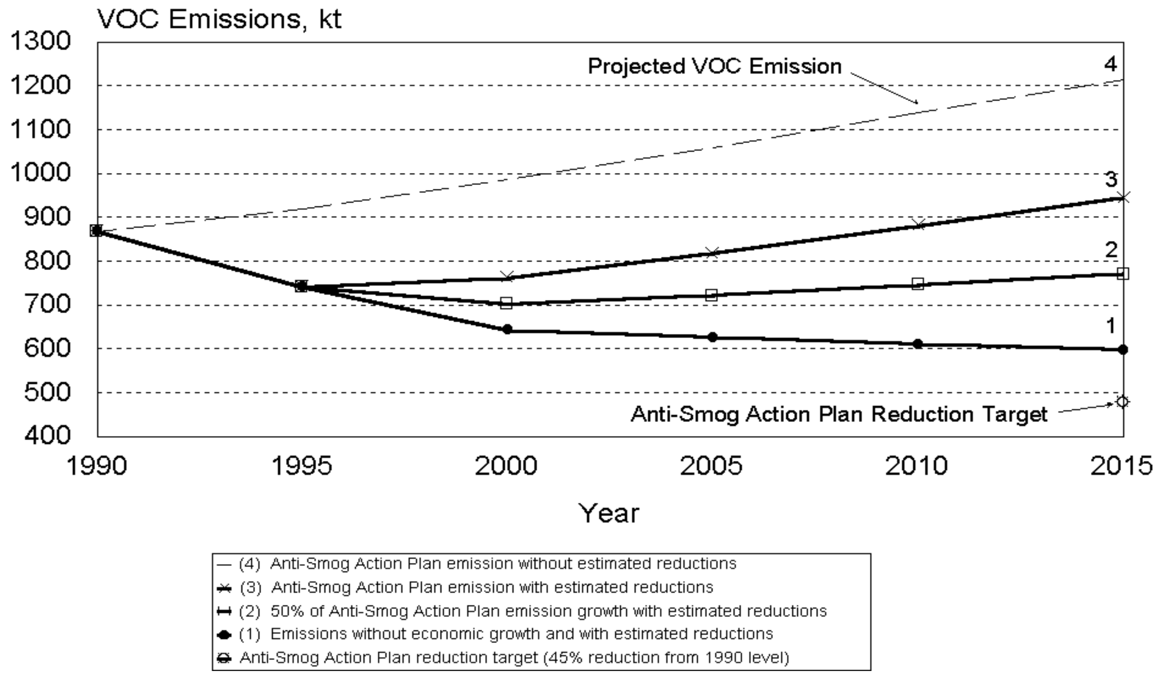
From 1990 through 2000 , domestic VOC emissions have been estimated to be reduced by some 225 kilotonnes. If these reductions had not taken place, VOC emissions in 2000 would have totalled an estimated 987 kilotonnes.

If no controls were to be implemented, the emissions of VOCs by the year 2015 would total a projected 1,215 kilotonnes. The firm reductions in VOC emissions indicated in the Anti-Smog Action Plan would reduce this amount by some 271 kilotonnes. Therefore, VOC emissions are currently projected at 941 kilotonnes in the year 2015.

The targeted level for VOC emissions in 2015, set under the smog plan to cut ground-level ozone exceedances by 75 per cent, is 477 kilotonnes. Scenario #4 (the 100 per cent growth scenario) shows that a reduction in VOC emissions of 738 kt (or 61 per cent) from the projected value of 1215 kt in 2015 will be needed to meet the ASAP objective.

It should be noted that there are uncertainties in the projections of future growth and emissions, and that some of the projected growth may not be realized. However, without additional commitments to emission reduction by the stakeholders, VOC emissions would rise owing to economic activity and changes in energy usage. The anticipated technological changes would not provide the large reduction in emissions required to meet ASAP Plan goals.

Figure 2
Historical and projected Ontario VOC emissions, 1990-2015
(Projected growth with estimated reductions)



Notes to Figure 2:

1. Scenario #4 is a base case and assumes no emission reductions after 1990. Under this scenario, emissions are estimated to increase at an average annual compound rate of 1.4% over the period 1990 to 2015.

2. Scenario #1 is based on a zero per cent increase in 1990 emissions, based on no economic growth over the period and the premise that sources would be able to achieve additional committed reductions in Ontario VOC emissions. Under this scenario VOC emissions are estimated to decrease at an average compound rate of 3.1% (1990-2000) and 0.5% (2000-2015).

3. Scenarios #2 and #3 assume similar reductions in emissions, but use a set percentage of the growth rate of scenario #4 yielding average annual compound emissions changes between - 0.2% and +1.25% over the period 1995 to 2015.

4.0 Inhalable and respirable particulates (IP/RP)

4.1 IP/RP Emissions

In order to identify the relative contributions to the IP/RP quotient, the Ministry of the Environment has developed an emission inventory based on voluntary industry surveys, emission data collected over past years, and available provincial statistics.

Average annual concentrations of inhalable particles (particulate matter measuring 10 microns or smaller, known as PM_{10}) for the period 1992 through 1996 ranged from 16 to 38 micrograms per cubic metre of air ($\mu g/m^3$) with most sites in the range of 20 to 30 $\mu g/m^3$. Over the short term, the concentration levels of PM_{10} can exceed the 24-hour interim ambient air quality criterion (AAQC). Similarly, the average annual concentration for respirable particulates (measuring 2.5 microns or smaller, known as $PM_{2.5}$) in urban air ranged from 12 to 18 $\mu g/m^3$.

4.2 IP/RP reduction options

In 1998, what was then known as the Steering Committee of the Ontario's Smog Plan decided to establish the Particulate Matter and Ozone Options Assessment Working Group to investigate the options available for reducing IP/RP. Broadly, this working group's mandate was to identify and assess strategic options to address the IP/RP problem in Ontario and to recommend preliminary options to the Steering Committee (now called the Operating Committee)..

To help meet this mandate, the Ministry of the Environment has prepared a lengthy report entitled *A Compendium of Current Knowledge On Fine Particulate Matter in Ontario,* dated December 1998, and a companion document entitled *Strategic Options To Address The Fine Particulate Issue in Ontario.* These two reports provide detailed scientific information and provide a basis for developing a strategy for IP/RP in Ontario. Both reports were reviewed and commented on by the particulates and ozone working group.

A total of seven potential strategic options were identified for possible use in Ontario. These are:

1. an interim ambient air quality criterion (AAQC) of 50 micrograms per cubic metre of air, with at least a 10 per cent reduction in emissions;
2. AAQC with interim and long-term target levels and dates;
3. long term AAQC (no target dates) and interim target levels or reduction percentages;
4. different AAQCs for designated Air Quality Management Areas;
5. different implementation dates for designated Air Quality Management Areas (same AAQCs across Ontario);
6. AAQC for PM_{10} with AAQC for $PM_{2.5}$ to follow; and/or

7. the adoption of the U.S. EPA standards for PM_{10} and $PM_{2.5}$.

No decision has yet been made as to which option(s) will be selected.

4.3 Proposed indicators to monitor IP/RP

The Performance Monitoring and Reporting Work Group has proposed three performance indicators for monitoring progress in reducing IP/RP levels in Ontario.

- Monitor ambient IP/RP concentration measurements at sampling stations to determine if/how concentrations are decreasing. Such measurements must be scientifically defensible in order to establish effective monitoring of ambient air levels of Ontario IP/RP and its precursors.

- Update annual emission inventory of IP/RP and precursors. In order to develop a comprehensive IP/RP emissions inventory for all sectors, based on a voluntary reporting mechanism, alternative voluntary mechanisms need to be developed to help smaller companies provide data. Current response rates for voluntary questionnaires are considered too low.

- Evaluate sectoral contributions through the use of inventory data and atmospheric modelling. To help focus on improvements and track progress in reductions of IP/RP and precursors, agreement is required on the modelling to be used. It is also important to be able to apportion sources contributing to IP/RP (upstream of airshed) and assess sectoral contributions to total IP/RP emissions.

5.0 Ambient air monitoring

5.1 Introduction

The Anti-Smog Action Plan has set an air quality target of a 75 per cent reduction by 2015 in the number of times the one-hour ozone criterion of 80 parts per billion is exceeded in a year. In order to achieve this target, the Ministry of the Environment has estimated that a 45 per cent reduction in NO_x and VOCs emissions from 1990 levels is needed, along with a corresponding reduction in transboundary pollution. (Note, the rationale for the 75 per cent reduction is presented in *Supporting Document for Towards a Smog Plan for Ontario,* June 1996.)

Part of the mandate of the Performance Monitoring and Reporting Work Group is to provide recommendations for measuring progress made in achieving the Plan's air quality targets and emission reduction goals. This requires defining a methodology for measuring the targeted reduction in the number of annual exceedances of the 80 ppb ozone air quality criterion.

In order to evaluate performance indicators that can be used for measuring the Plan's targets, the Work Group concluded that the following questions will have to be addressed:

- How can a 75 per cent reduction in the incidence of ground-level ozone exceedances be evaluated?
- What are the appropriate baseline years for estimating the 75 per cent reduction?
- What monitoring sites should be considered in defining the baseline?
- What future monitoring network/sites should be used in the evaluation?
- What is the most appropriate way to accommodate (or adjust for) the year-to-year variations in exceedances due to meteorological conditions?

The following section describes the Work Group's deliberations on these questions and its recommendations for performance indicators that may be used to evaluate the air quality target.

5.2 Ontario's ambient air monitoring network, ozone levels and trends

In 1995, ground-level ozone levels were monitored at 45 stations across Ontario. Figure 3 shows the locations of these monitors, as well as the geographic distribution of the number (of hours) of ozone exceedances. The results show a high number of exceedances at the stations located near the north shore of Lake Erie and the eastern shore of Lake Huron, primarily owing to the influence of transboundary pollution from the United States.

The 17-year trend of average ozone exceedances measured at 22 stations is shown in Figure 4. Interpretation of the 17-year trend is complicated by meteorological factors and changes in emissions. The high number of one-hour exceedances recorded in 1988 can be attributed, in part, to hot and dry weather that year, whereas the low numbers in 1993 reflect the cool and wet conditions that are less conducive to the production of ground-level ozone. There is no discernible trend in the number of ozone exceedances over the long term.

Figure 3
Geographical distribution of one-hour ozone concentration exceeding 80 ppb across Ontario, 1995

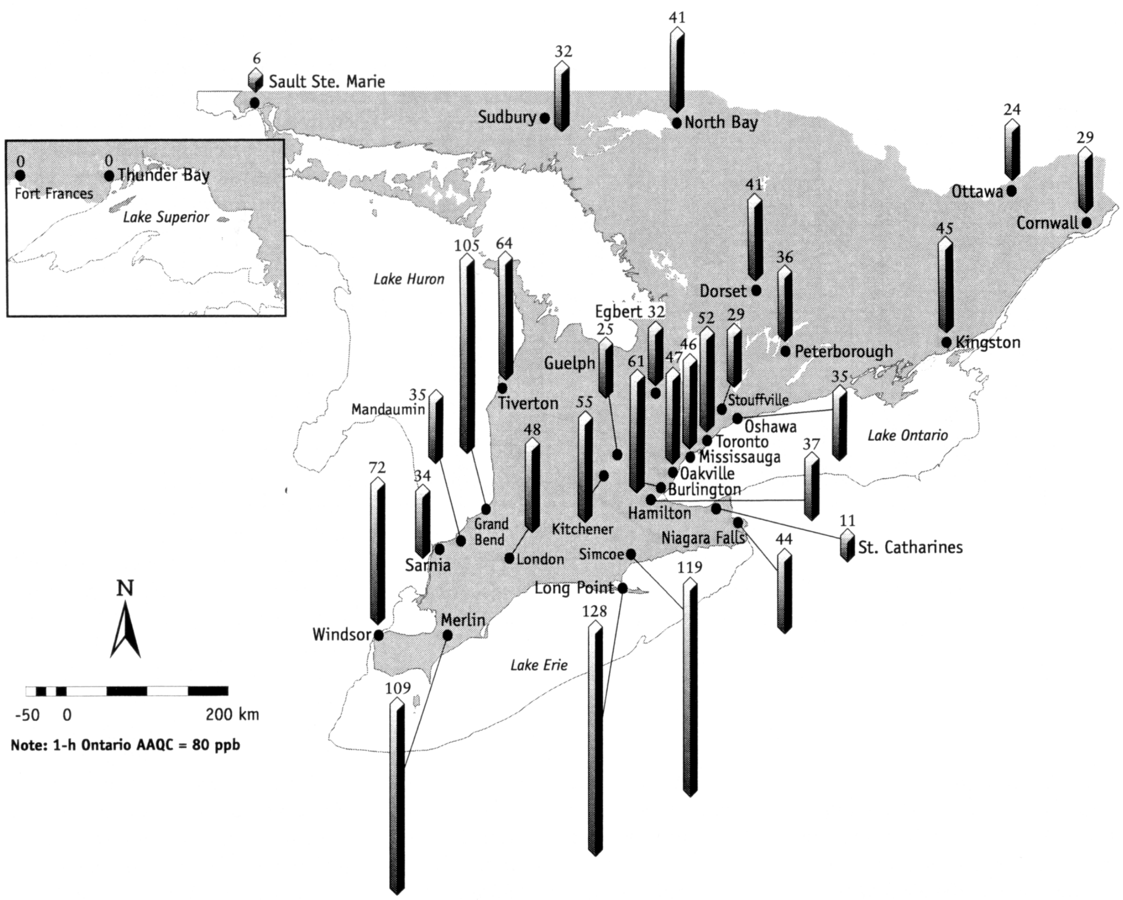
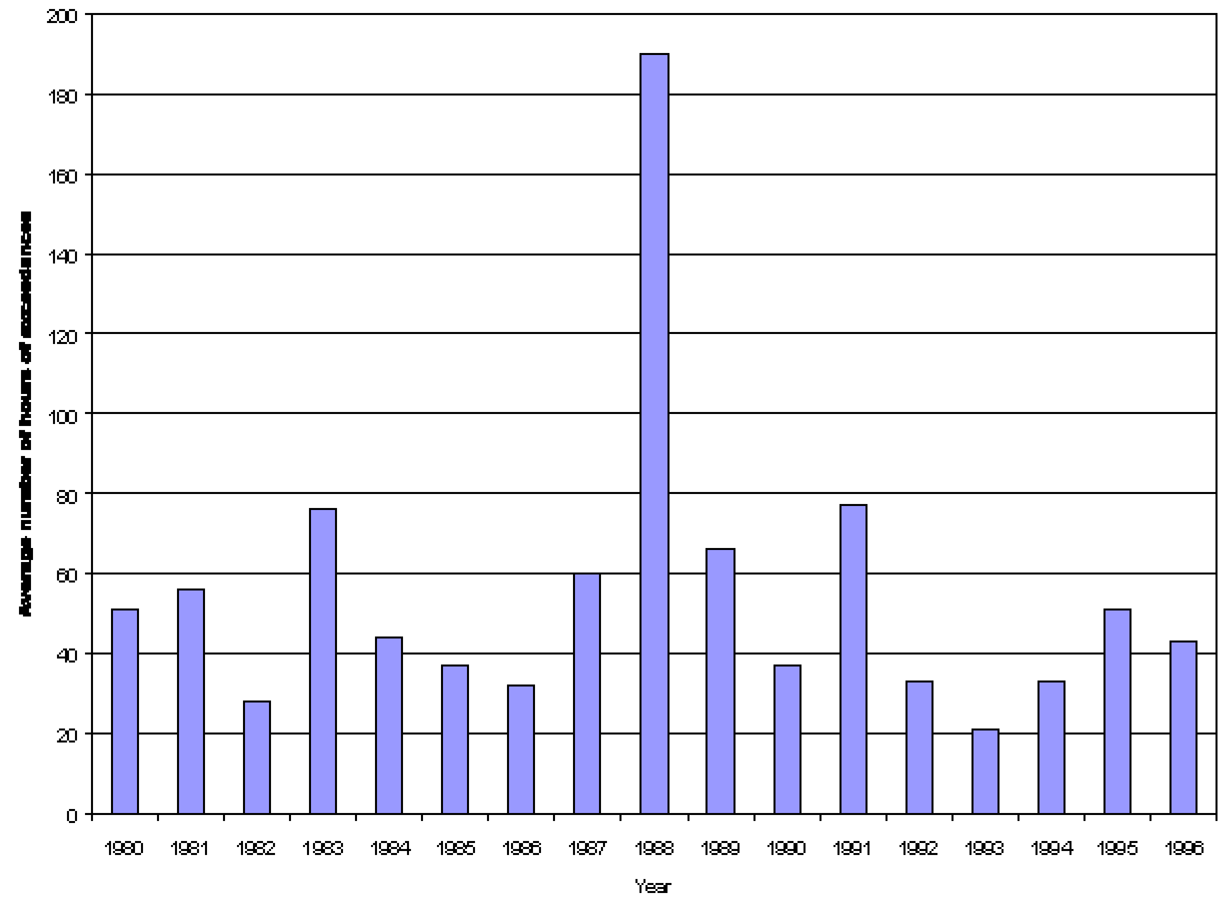


Figure 4
Average of ozone exceedance trends, 1980-1996



Note: 22 sites

5.3 Potential indicators for evaluating improvements in ozone exceedances

The Work Group established a number of criteria for assessing potential performance indicators. These considerations include:

- the measure should be relatively stable and show broad general trends in ozone exceedances;

- it should not take an excessively long time to determine whether the target has been met (for example, a five-year running average centred on 2015 means one may not be able to determine achievement of the target until 2019);
- the data have to be treated in a statistically and scientifically defensible manner; and
- where possible, the indicators should be able to distinguish between the impacts of domestic versus transboundary sources.

While there have been no obvious trends in the annual exceedances over the last 17 years, the Work Group further evaluated other statistical measures and geographic distributions to see whether it was possible to detect a pattern. A number of running averages and grouping by geographic areas were examined.

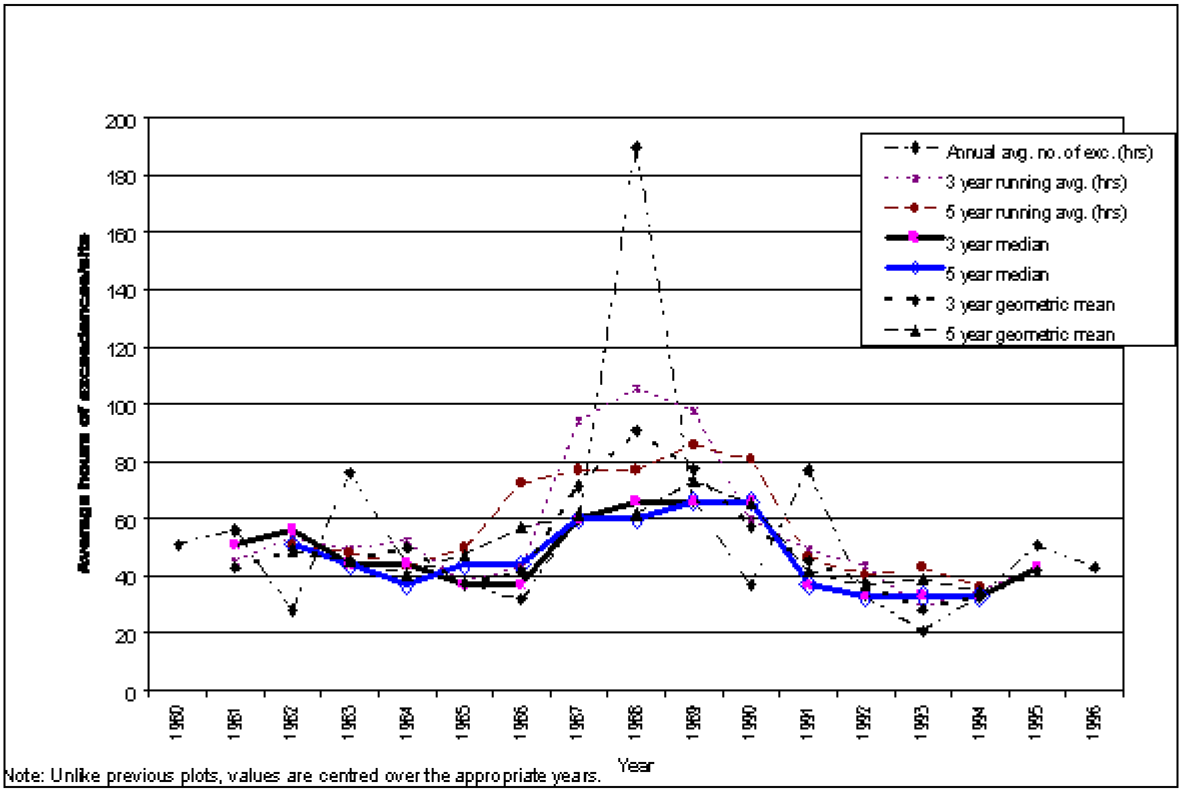
5.3.1 Indicators based on running averages

The Work Group looked at a variety of running averages (as shown in Figure 5) to see whether any trends were evident. As discussed previously, the annual average number of ozone exceedances is highly variable without any discernible trends. The three and five-year running averages are still highly variable, and the influence of the high values in 1988 and the low values in 1993 are still evident.

The three- and five-year median (i.e., the second-highest year in three years, and the third-highest year over five years) showed a more stable trend. Both trends are similar; they showed a slight decrease from 1980 to about 1984. This is followed by elevated levels in 1986 to 1990, and lower levels starting in 1991. Surprisingly, the three-year and five-year running geometric means showed a high degree of variability.

The average three-year median centred on 1990 (1989 to 1991) for the 22 sites is 66 hours per year per site. The average five-year median also happens to be 66 hours. If the three-year median is adopted as the measure for determining improvements, this means a 75 per cent reduction in ozone exceedances would result in a reduction of 50 hours in the number of ozone exceedances on average at the 22 sites in Ontario. It also means that, on average, the number of ozone exceedances at Ontario sites will have to be less than 17 hours per year in order to meet the ASAP target.

Figure 5
Annual and running averages of ozone exceedances in Ontario



5.3.2 Indicators based on the geographic grouping of sites

It was recognized that transboundary pollutants contribute significantly to the ozone exceedances in southern Ontario. There was general agreement among the members of the Work Group that it is important to distinguish between the impacts from transboundary sources and those from domestic Ontario sources. The first step in the examination of transboundary impacts was to analyze the geographic distribution of ozone exceedances and the trends. Figure 3 illustrates the ozone exceedances across Ontario in 1995.

Further analyses were undertaken to see whether there are any differences in the ozone exceedance trends over time and across the different broad geographic areas in Ontario. The monitoring sites were divided into the following zones (with each being influenced by different factors):

- southeast sites (Cornwall, Kingston, Ottawa, Peterborough), which are impacted more significantly by urban pollution from the Greater Toronto Area;
- central sites north of the urban centres (Dorset, North Bay, Sudbury, Sault Ste. Marie), which can be considered as typical background levels;
- south central sites in the urban areas (the Greater Toronto Area, Hamilton/Burlington, Niagara Falls, St. Catharines), which are impacted significantly by local Ontario sources, in addition to transboundary pollutants;
- southwest sites (Guelph, Kitchener, London, Parkhill), which are influenced significantly by transboundary sources, along with some local Ontario contributions; and
- transboundary sites along the northern shore of Lake Erie and the eastern shore of Lake Huron (Long Point, Mandaumin, Merlin, Sarnia, Simcoe, Tiverton, Windsor), which are primarily influenced by transboundary pollutants (although Windsor and Sarnia will have local influences).

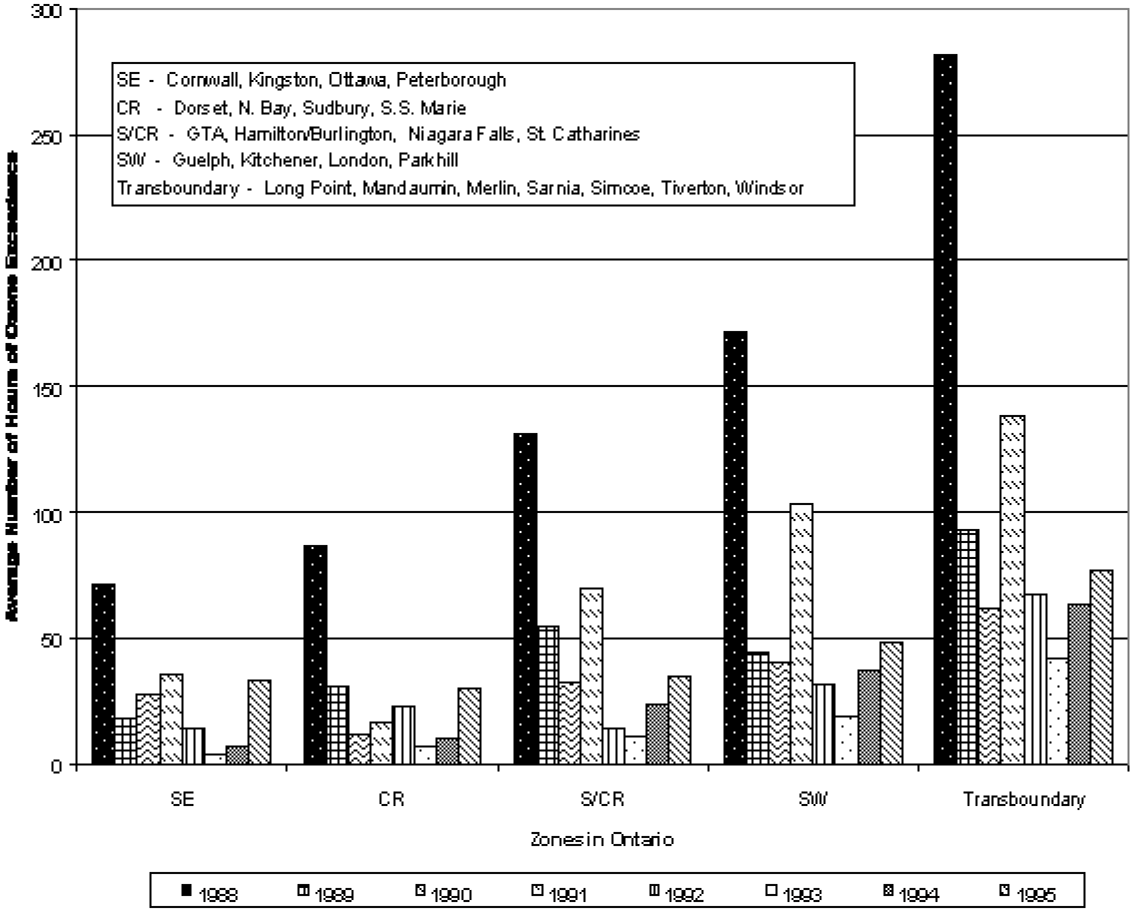
Figure 6 shows the average trends in ozone exceedances for the groups of sites in each zone in Ontario from 1988 to 1995. The analysis showed the ozone trends are similar in all geographic zones in southern Ontario. For example, the highest levels were experienced in all zones in Ontario in 1988, whereas the lowest levels were experienced in 1993 at all zones. In general, the transboundary sites experienced the highest number of exceedances over 1988 to 1995, while the southeastern and central sites experienced the lowest number of exceedances.

This analysis clearly highlighted the influence of transboundary pollution. However, as a performance indicator it offers only limited added value in terms of tracking improvements. It was concluded that it is sufficient to track the total ozone exceedances in southern Ontario rather than track the data across individual geographic areas.

5.3.3 Indicators based on source receptor relationships

The geographic distribution analysis illustrated the significant influence of transboundary pollution on the ozone problem in Ontario. A number of techniques and studies have been undertaken by various parties to explore the source contributions and receptor relationships. Much of this scientific data have been discussed in the 1996 *NO_x/VOC Science Assessment*. Some of the techniques, the findings and their limitations are summarized in Appendix D, “Summary of Techniques for Estimating Source Receptor Relationships”. The techniques ranged from a simple geographic association, which uses maps of ozone concentrations to show the continental ozone plume, to complex regional air quality modelling.

Figure 6
Ozone exceedances in different areas of southern Ontario



5.4 Recommended performance indicators for ozone exceedances

Based on the limited analysis of the ozone data, the Work Group recommends the use of three- and five-year medians as a practical, simple and stable indicator for evaluating the improvements in ozone exceedances on a preliminary basis. To complement the use of the median, the Work Group also recommends the monitoring of overall trends, perhaps on a longer time frame, along with good scientific judgment as to natural factors which influence the ozone levels.

The Work Group believes it is vital to be able to determine the improvements due to local Ontario actions and the contribution of transboundary pollutants. A limited examination of the data shows the importance of transboundary pollution.

Significant scientific efforts have already been devoted to this issue. It is beyond the technical capabilities and resources of the Work Group to undertake the type of analysis needed to address the issue of transboundary versus local contributions. It is recommended that further research be undertaken to distinguish between the changes resulting from local Ontario actions and those due to transboundary pollution.

6.0 Transboundary pollutants

6.1 Canadian and U.S. initiatives to reduce transboundary pollution

Under appropriate meteorological conditions, more than 50 per cent of Ontario's smog problems originate from U.S. sources of nitrogen oxides (NO_x) and volatile organic compounds (VOCs). (Provincial NO_x and VOC emissions, in turn, contribute to smog problems downwind of Ontario, particularly in the province of Quebec.)

Ontario and eastern Canadian provinces are concerned about the transboundary flows of ground-level ozone and particulate matter into and through eastern Canada, caused mainly by substantial NO_x and sulphur dioxide (SO_2) emissions in 18 states of the U.S. Midwest and Northeast. Canada is working to ensure that transboundary air issue concerns are heard in the United States. Existing Canada-U.S. intergovernmental mechanisms have facilitated official exchanges and work-sharing efforts. Canada and the U.S. continue to co-operate within the context of bilateral agreements, including the *Canada-United States Air Quality Agreement* and the *Canada-United States Great Lakes Water Quality Agreement*.

6.1.1 The Canada-U.S. Air Quality Agreement

Canada and the United States have successfully co-operated on acid rain reductions under the bilateral *Canada-U.S. Air Quality Agreement*, signed on March 31, 1991. Co-operative efforts under the Agreement address atmospheric modelling, emission inventories, effects research and monitoring, control technologies, and market-based initiatives. The reduction in SO_2 emissions achieved under these programs will also provide benefits to Canada in terms of decreased levels of particulate matter.

The *Canada-U.S. Air Quality Agreement* also provides the framework for co-operative action on smog. The *Canada-U.S. Program to Develop a Joint Plan of Action for Addressing Transboundary Air Pollution*, signed on April 7, 1997, will be implemented within the framework of the Agreement. The Joint Plan of Action constitutes a first step toward negotiating new Annexes on ground-level ozone and particulate matter in the atmosphere.

6.1.2 North American Research Strategy for Tropospheric Ozone (N ARSTO)

The international North American Research Strategy for Tropospheric Ozone (NARSTO) program was established on Feb. 13, 1995, as a non-binding public-private partnership; the membership of NARSTO includes governments, utilities, industry and academe in Canada, the United States and Mexico. NARSTO arose out of a 1991 report published by the National Research Council (U.S.) and titled *Rethinking of the Ozone Problem in Urban and Regional Air*

Pollution. In the beginning, NARSTO focused only on the tropospheric ozone problem, but since then has expanded its research interest to include fine particles as well. Its primary mission is to co-ordinate and enhance scientific research and assessment of tropospheric pollution behaviour in order to determine workable, efficient and effective strategies for local and regional air pollution management.

When completed, NARSTO's assessment document would recommend a strategic plan to remedy the tropospheric ozone problem, based on ozone science, aerosol science, VOC reactivities, model evaluations and quality systems management. To fulfil these goals, NARSTO has established several working groups and committees, and a number of meetings are planned in 1999 to develop the necessary information.

Some of the NARSTO activities in which Canada/Ontario is participating include the summer 1996 field study in eastern North America (which involved the collection of data on smog-related airborne chemicals) and meteorology for use in evaluating the regional oxidant model. The model evaluation and inter-comparison project is currently on-going. A number of regional models, including the Canadian CHRONOS model, are being evaluated using data from smog studies.

6.2 U.S. sources of NO_x, VOCs and particulate matter

Transboundary pollutant flows of smog occur across most of the Canada-U.S. border. However, the flows are especially significant in the region east of Lake Michigan. Reviews of back-trajectories for air masses involved in Canadian ozone episodes point to an 18-state region (including the District of Columbia) as the main area of focus. Targeting reductions in this U.S. region will have the greatest impact on air quality in southern Ontario, southern Quebec and the southern Atlantic Region.

The current (1995) emission levels of the three major smog precursors and constituents (NO_x, VOCs and PM_{10}) originating in the 18-state region are presented in Table 3. The table highlights the six states producing the largest emissions of all three pollutants: Ohio, Illinois, Indiana, Michigan, Pennsylvania and New York. The 1995 emissions from these six states totalled 4,589 kilotonnes for NO_x, 4,570 kt for VOC, and 5,788 kt for PM_{10}, and represented 69 per cent, 63 per cent and 70 per cent respectively of the total emissions for all 18 states.

In comparison, 1995 Environment Canada forecast emissions for Ontario and Quebec are: 537 kt and 273 kt, respectively, for NO_x; and 741 kt and 384 kt for VOCs. There are no comparable estimates available for Canadian PM_{10} emissions.

Table 3

Emissions of NO_x, VOCs and PM_{10} from the Eastern United States, 1995

State	**NO_X Emissions (kilotonnes)**	**VOC Emissions (kilotonnes)**	**PM_{10} Emissions (kilotonnes)**
Ohio	1,010	794	880
Illinois	798	827	1,487
Indiana	774	571	730
Pennsylvania	739	815	877
Michigan	668	686	747
New York	600	877	1,067
Other 12 states**	2,097	2,716	2,495
Total	**6,686**	**7,286**	**8,283**

** The other 12 states in the 18-state source region, listed in decreasing order of their NO_X emissions, are Virginia, West Virginia, New Jersey, Maryland, Massachusetts, Connecticut, New Hampshire, Maine, Delaware, Rhode Island, Vermont, and the District of Columbia.

Source: Table 3 is adapted from Table 12 in "National Air Pollutant Emission Trends, 1900 - 1995", U.S. EPA, EPA-454/R-96-007, October 1996 (figures converted from thousand short tons to kilotonnes).

6.3 On-going U.S. initiatives

A number of pending or on-going U.S. initiatives are expected to benefit Ontario and eastern Canadian provinces by reducing their smog problems in the long term.

6.3.1 Call for State Implementation Plans

The final rule promulgated by the U.S. Environmental Protection Agency (EPA) under the federal *Clean Air Act Amendments (1990)* requires 22 states and the District of Columbia to submit State Implementation Plans (SIPs) that address the regional transport of ground-level ozone. By improving air quality and reducing emissions of NO_x, the actions directed by these plans will decrease the transport of ozone across state boundaries in the eastern half of the United States. The rule requires emission reduction measures to be in place by May 1, 2003. The states that will be subject to this action are: Alabama, Connecticut, the District of Columbia, Delaware, Georgia, Illinois, Indiana, Kentucky, Massachusetts, Maryland, Michigan, Missouri, North Carolina, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, South Carolina, Tennessee, Virginia, Wisconsin, and West Virginia.

The rule does not mandate which sources must reduce pollution. States will have the opportunity to meet the requirements of this rule by reducing emissions from the sources they choose. However, utilities and large non-utility point sources would be among the most likely targets of NO_x emission reduction efforts. The rule includes a model NO_x Budget Trading Program that will allow states to achieve over 90 per cent of the required emission reductions in a highly cost-effective way.

This rule will reduce total summertime emissions of NO_x by about 28 per cent (1.2 million tons) beginning in the year 2003 in the affected 22 states and the District of Columbia. The U.S. EPA projects that these regional NO_x reductions will bring the vast majority of all new ozone nonattainment areas into attainment with the federal eight-hour ozone standard without having to implement more costly local controls. It will also help reduce ozone levels in the remaining nonattainment areas east of the Mississippi River. Responding to public comments, the EPA made several changes to the final NO_x SIP Call to make it more flexible and more cost effective, while preserving the environmental benefits.

6.3.2 Proposed U.S. Federal Implementation Plan

The U.S. EPA is also proposing federal requirements to reduce regional ozone transport in the event that any of the 22 states or the District of Columbia do not submit the required State Implementation Plan provisions in response to the NO_x SIP Call or fail to submit an approvable plan. The proposal includes NO_x reduction requirements for utilities and large non-utility point sources, including large industrial boilers and turbines, large internal combustion engines, and cement manufacturing. The proposed requirements use the same source cutoff levels, categories and control levels that were used to develop the final NO_x SIP Call budgets and require that the emission reduction measures be implemented on the same schedule (that is, by May 1, 2003).

6.3.3 Proposal related to Section 126 petitions

The U.S. EPA is also proposing action on petitions filed under section 126 of the *Clean Air Act* by eight Northeastern states seeking to reduce ozone transport across state boundaries through reductions in NO_x emissions. Each petition specifically requests that the EPA make a finding that NO_x emissions from certain stationary sources significantly contribute to ozone nonattainment problems in the petitioning state.

The EPA found that seven of the eight Section 126 petitions have technical merit and that sources in 19 states and the District of Columbia significantly contribute to nonattainment or interfere with the ability of states to maintain clean air in one or more of the petitioning states. For these sources, the EPA is proposing the control requirements that would apply if the agency makes a final finding. In selecting proposed requirements, the EPA relied on the analysis for the NO_x SIP call. The EPA is proposing to defer granting the approvable portions of the petitions until a later time. This deferral would allow the affected states and the District of Columbia an opportunity to respond to the NO_x SIP Call before the EPA would make any final finding.

7.0 Public, corporate and government involvement

7.1 Involving the General Public

In order for the Anti-Smog Action Plan to reach its maximum effectiveness in reducing air pollution in Ontario, the general public must first be made aware of the Plan's goals and objectives. Then they must be convinced to do their part – at home, work and play – in reducing the contaminants that contribute to polluting their air.

Before people are willing to change their habits, they must learn how their actions affect the environment and understand how a change in their lifestyle could improve their surroundings. There are many ways to reach and involve the public in furthering the objectives of ASAP, either directly by the provincial and local governments or through other agencies:

Municipal support Enlisting the support of every municipality in Ontario to inform their citizens about air pollution and to develop programs to ensure their residents' commitment and involvement would increase public commitment to the targets of the Anti-Smog Action Plan.

Non-governmental organizations Agencies, such as the Lung Association, are already in place in communities to spread the message about improving air quality. Relying on their expertise and resources to deliver a community-based education package will assist in reaching the public.

Media Using the media is the most effective way to reach the public. Through the use of public service announcements, press releases and paid advertisements, the Anti-Smog Action Plan will become better known to the public.

Financial support to develop and deliver programs The Ontario government should not be solely responsible for funding the development and delivery of public education and information programs. Partners, such as non-governmental organizations, municipal governments, corporate sponsors and others, have a role to play and should be approached.

Regional differences Every part of Ontario is impacted differently by air pollution and it is important to devise tailored programs that reach each community or area individually.

7.2 Measuring the public's involvement

It is difficult to establish a reliable performance indicator that would accurately determine the extent of the public's involvement in the Anti-Smog Action Plan. Surveys directed to the general public could be used to generate participation rates and other statistics. However, such surveys are expensive and it is a difficult challenge to create a survey that accurately measures increased knowledge about the Plan and, even more important, any behavioural changes made as a result.

Information such as increased transit usage, decreases in electricity consumption, increased bike sales and the creation of bicycle pathway networks could be used to indirectly measure the public commitment to improving air quality.

As residents become more aware of air issues, such as smog and ozone-related problems, they are likely to become increasingly active in identifying and raising concerns about local pollution sources, as well as transboundary contributions. Tracking these public air quality complaints or questions about smog levels could provide a measure of public involvement.

7.3 Involving the corporate and municipal sectors

While the industrial sector of Ontario is participating in the Anti-Smog Action Plan by providing reduction plans for smog-causing emissions from point sources, other business and government sectors can also participate through the development and implementation of non-point-source smog plans.

For example, the City of Toronto developed a corporate smog plan which consists of a set of measures that the corporation is taking to reduce its own emissions of smog-producing pollutants. Other municipalities in southern Ontario are interested in following Toronto's lead.

Such plans can provide guidance to other Ontario business. The Toronto Environmental Alliance (TEA) is currently conducting a pilot project, funded in part by Environment Canada, to test other corporate non-point-source response to a series of smog-reducing actions.

Corporate and municipal smog plans can include components that prepare in advance for poor air quality advisories by agreeing to, among other things:

- set up an in-house mechanism (usually a smog hot line) to inform employees of Smog Advisory forecasts;
- take actions that reduce the impact on employees' health (for example, reduced workload for employees who work outdoors, information displays at corporate run day-care centres, information to employees with respiratory problems, information at corporate fitness centres);
- suspend all non-essential vehicle use;

- suspend all activities that involve the use of high-VOC paints, solvents, and cleaners;
- suspend refuelling activities, at least until after dark;
- advise staff to dress casually and turn down air conditioning to reduce electrical demand;
- suspend activities requiring gas powered equipment (mowers, trimmers, etc.); and,
- suspend pesticide spraying.

Corporate and municipal smog plans can also be adopted that encourage businesses to:

- survey employee work-related travel patterns and develop comprehensive employee trip reduction plans;
- implement telecommuting options, car pooling, variable work hours, and walking and biking incentives;
- participate in employee awareness-raising programs (such as Pollution Probe's Clean Air Commute); and
- reassess employee parking policies and promote public transit alternatives.

Businesses can develop a "Green Fleet" program for their vehicles, in which they agree to:

- implement an enhanced inspection and maintenance program for the vehicle fleet;
- substitute currently used fuels with less polluting alternative fuels and energy sources, and replace vehicles with non-polluting alternatives (such as the successful Police on Bikes program of the Toronto Police Force); and,
- reduce mileage, operate fewer vehicles, improve route efficiency, and install vapour recovery systems at on-site pumping stations.

Corporations and municipalities can also reduce their use of electricity through enhanced energy efficiency programs, by agreeing to purchase "green power", and by encouraging employees to support non-polluting alternatives at home and at work.

7.4 Measuring corporate and municipal involvement

The overall goal is to obtain broad involvement by all sectors that contribute to or influence the generation of smog precursors and components. A number of performance indicators have been proposed for measuring the extent of support for the objectives of the Anti-Smog Action Plan and for monitoring the impact of programs designed to reduce smog emissions. The Performance Monitoring and Reporting Work Group has recommended the adoption and reporting of the following performance indicators:

- tracking the number of municipalities and corporations in Ontario that make a formal commitment to reduce emissions under the Anti-Smog Action Plan (i.e., the number of ASAP signatories, the number of Letters of Cooperation, and any Memorandums of Understanding or other agreements);

- tracking the number of municipalities and corporations in Ontario that adopt corporate or in-house smog plans (independently of ASAP) to reduce non-point-source emissions through workplace programs, alternative purchasing and changed practices; and

- tracking the number of municipalities and corporations in Ontario that use the workplace to inform workers about the impact of smog on human health, and work to protect employees during poor air quality advisory days.

7.5 Government greening programs

7.5.1 Federal Greening of Government Operations

Through the federal Greening of Government Operations initiative, the government has established guidelines for all federal departments to integrate environmental considerations into their operations. The main elements of the initiative are:

- a commitment to meet or exceed federal environmental statutes and regulations, and the emulation of best practices from the public and private sector;
- implementation of environmental management systems, starting with the principles of the Canadian Standards Association's Standard Z750-94; and
- inclusion in departmental sustainable development strategies of plans that incorporate principles for environmental management systems and best practices to improve environmental performance in procurement, construction and operation of buildings, fleet management and land utilization.

Appendix B presents the best practices guidelines that have been adopted by the federal government relating to practices that help in overall smog reduction.

7.5.2 Ontario's Green Workplace Program

Launched in 1991, the Ontario government’s in-house Green Workplace Program is designed to encourage staff to adopt environmentally responsible practices in offices, residential facilities and other buildings that are provincially owned and operated. The primary focus of the program is on waste management, with components that address waste recycling, reduction and reuse, as well as energy and water conservation, hazardous materials management, and the purchasing of “green” products and services. Features of the program include:

- environmental specifications for government tenders over $10,000 (see below);

- standards for purchasing many products, including fine paper, lubricating oil, paints, energy-efficient lamps and bulbs, garbage bags, toner cartridges, facsimile machines, systems furniture, and products registered under the federal Environmental Choice Program;
- a checklist of environmental factors to be used in writing specifications and evaluating purchasing options; and
- measures to reduce or reuse packaging.

The *Government of Ontario Environmental Procurement Policy and Operational Guidelines* provide guidance and assistance to purchasing officers, managers and administrators that are responsible for implementing environmental procurement policies and practices with the Ontario Public Service. The policy applies to all government ministries and Schedule 1 agencies, and to all government contracts over $10,000.

8.0 Health and vegetation impacts

8.1 Health impacts

Recent epidemiological studies have linked premature human mortality with exposure to inhalable particulates (PM_{10}). This association is evident in ambient air concentrations typical of metropolitan areas in North America, including Toronto, Detroit and Los Angeles. These studies illustrate that a reduction of inhalable particulates could reduce the total non-accidental mortality rate by one per cent.

Ambient levels of inhalable particulates and ground-level ozone have also been linked with the incidence of cardio-respiratory diseases. These studies showed:

- a reduction of 10 parts per billion in ozone concentration could reduce the existing respiratory hospital admission rate by 0.9 per cent; and

- a reduction in average 24-hour inhalable particulate concentrations of 10 micrograms per cubic metre of air could reduce the existing cardiac hospital admission rate by 0.6 per cent and the respiratory hospital admission rate by 0.8 per cent.

It is difficult to track health impacts directly because of the large number of confounding factors. One alternative is to use the ambient air data and established dose-response relationships to estimate the number of health impacts associated with exposures. This approach is recommended for tracking the health impacts of ozone and inhalable particulates in Ontario.

Simply tracking the number of inhalable particulate and ozone exceedances may not be a good indicator of health impacts. Health impacts can occur below the criterion levels of 80 ppb for ozone and 50 micrograms per cubic metre for inhalable particulate.

The current levels (1990-1995) of inhalable particulates are estimated to result in 1,700 premature mortalities and nearly 11 million restricted activity days per year in Ontario. Estimates of other health effects are summarized in Table 4. The health estimates were generated with the use of population-weighted ambient air monitoring data from 1990-1995 over 23 monitoring stations, and dose-response relationships from epidemiology studies.

Note, this table and the supporting discussion do not include recent data compiled during the preparation of the Health Canada-Environment Canada report *National Ambient Air Quality Objectives for Particulate Matter* (Cat. No.. H46-2/98-220, 1998), a science assessment document prepared by the CEPA Federal-Provincial Advisory Committee's Working Group on Air Quality Objectives and Guidelines.

Table 4

Estimated health effects* associated with current levels of PM_{10} in Ontario

Health Effect	Number of Cases per Year
Mortality	1,700
Adult chronic bronchitis	12,000
Hospital admissions**	1,400
Emergency room visits	62,000
Symptom days***	33.6 million
Restricted activity days	10.6 million
Bronchitis in children	114,000

* Airborne pollution always occurs as a mixture of agents of which particulate matter is only one. This mixture presents some uncertainty in drawing conclusions about the relationship of particulate matter to adverse health effects.
** Sum of respiratory and cardiac admissions
*** Sum of asthma and acute respiratory days

8.2 Vegetation impacts

According to studies conducted in 1989, crop and ornamental plant yields in Ontario could be increased by up to an estimated $70 million annually (*Towards a Smog Plan for Ontario, June 1996*) if Ontario achieved the existing ozone air quality criterion of 80 ppb. However, it is difficult to track directly the effects of vegetation damage due to ozone because of the many confounding factors.

A Vegetation Objective Working Group (VOWG) was established in 1992 as part of the federal NO_x/VOC Management Plan (see Appendix A) to re-evaluate the Canadian ambient air quality objective for ozone, based on vegetation response. In summary, the VOWG recommended that a peak-weighted cumulative index be selected as a reference level to provide crops and trees in Canada with long and short term protection from ozone exposure. This recommendation was based, in part, on findings that plant damage and losses in crop yield due to ozone exposures is cumulative.

The Performance Monitoring and Reporting Work Group has recommended that the Anti-Smog Action Plan Operating Committee adopt as a performance indicator a form of the SUM60 as an index for tracking the future impacts on vegetation. SUM60 is a cumulative index (the summation of hourly average ozone values exceeding 60 parts per billion for a given period) and uses an arbitrary threshold concentration of ozone equal to 60 ppb. Although the index value of 60 ppb is an arbitrary value, the SUM60 index of air quality was measurably better than hourly ozone exceedances (of the federal 82 ppb objective) in relating to crop yield loss. The average hourly ozone values cover only the daylight period (8 a.m. to 6 p.m.) during the crop growing season.

Table 5

One-day, three-day and three-month SUM60 indices

Reference Level	Proposed Form
6,600 or 7,400 ppb-h	a rolling three-month SUM60 during the daily 12-hour daylight period (08:00-19:59) for April to September
700 ppb-h	a rolling three-day SUM60 during the 12-hour daylight period (08:00-19:59) for April to September
500 ppb-h	a one-day SUM60 during the 12-hour daylight period for April to September

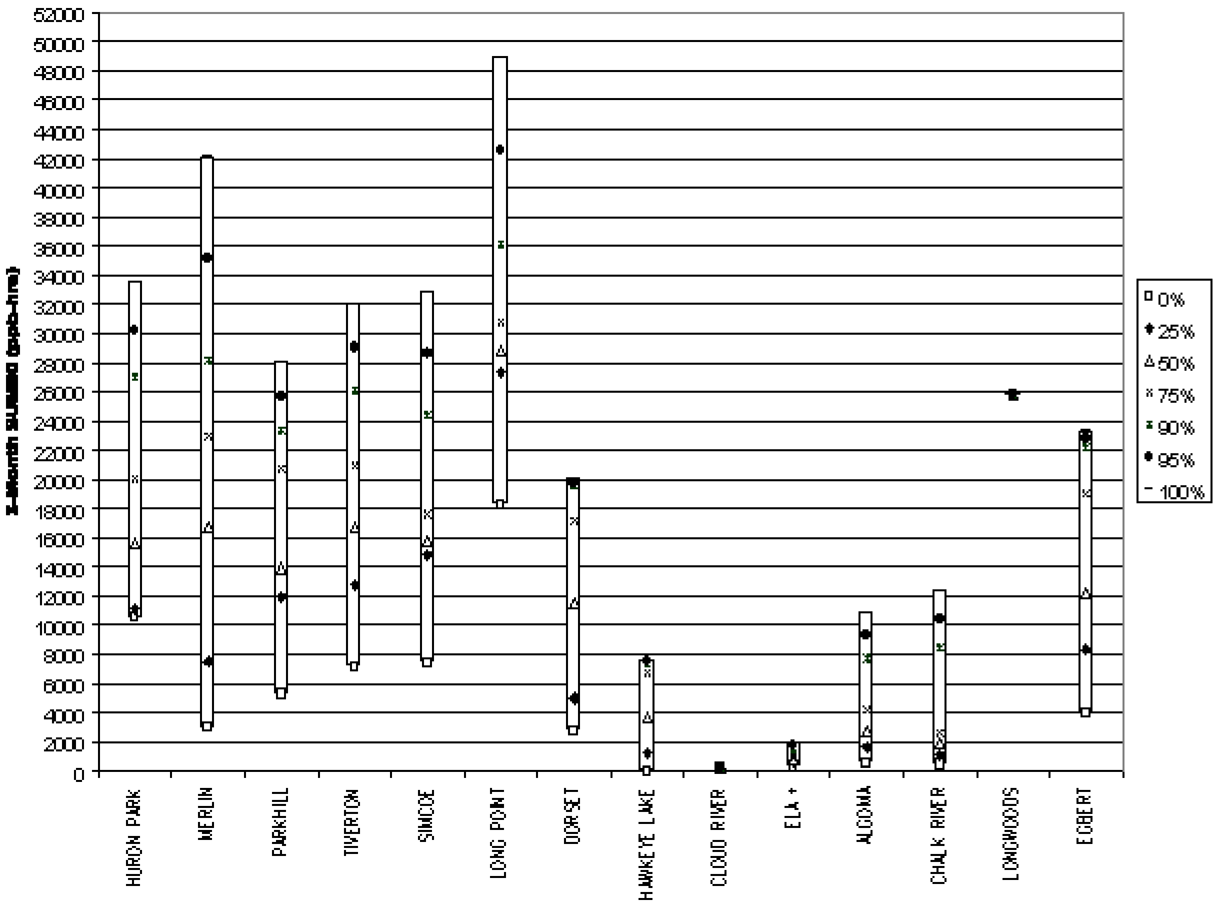
Ontario, the most severely impacted area in Canada, experiences maximum SUM60 values comparable with those of some areas in the United States. However, the minimum U.S. values are still significantly higher. The three-day and three-month SUM60 frequency profiles for Ontario are shown in Figures 7 and 8.

Spatial analysis of past ozone data (1988-1993) using three-month SUM60 median values indicate that greater than 50 per cent plant protection is possible in central and southern Ontario if SUM60 values are kept below 22,400 ppb-h. To provide protection from foliar injury to sensitive crops in Ontario, VOWG recommended that a short term index of 700 ppb-h (three-day SUM60) or 500 ppb-h (one-day SUM60) from April to September.

The National Crop Loss Assessment Network's (NCLAN) re-analysis of experimental crop exposure data from Ontario studies conducted over the past 15 years also confirmed that the seasonal SUM60 type air quality index resulted in an improved relationship between crop exposure and air quality when compared with the exceedance of an hourly ozone value.

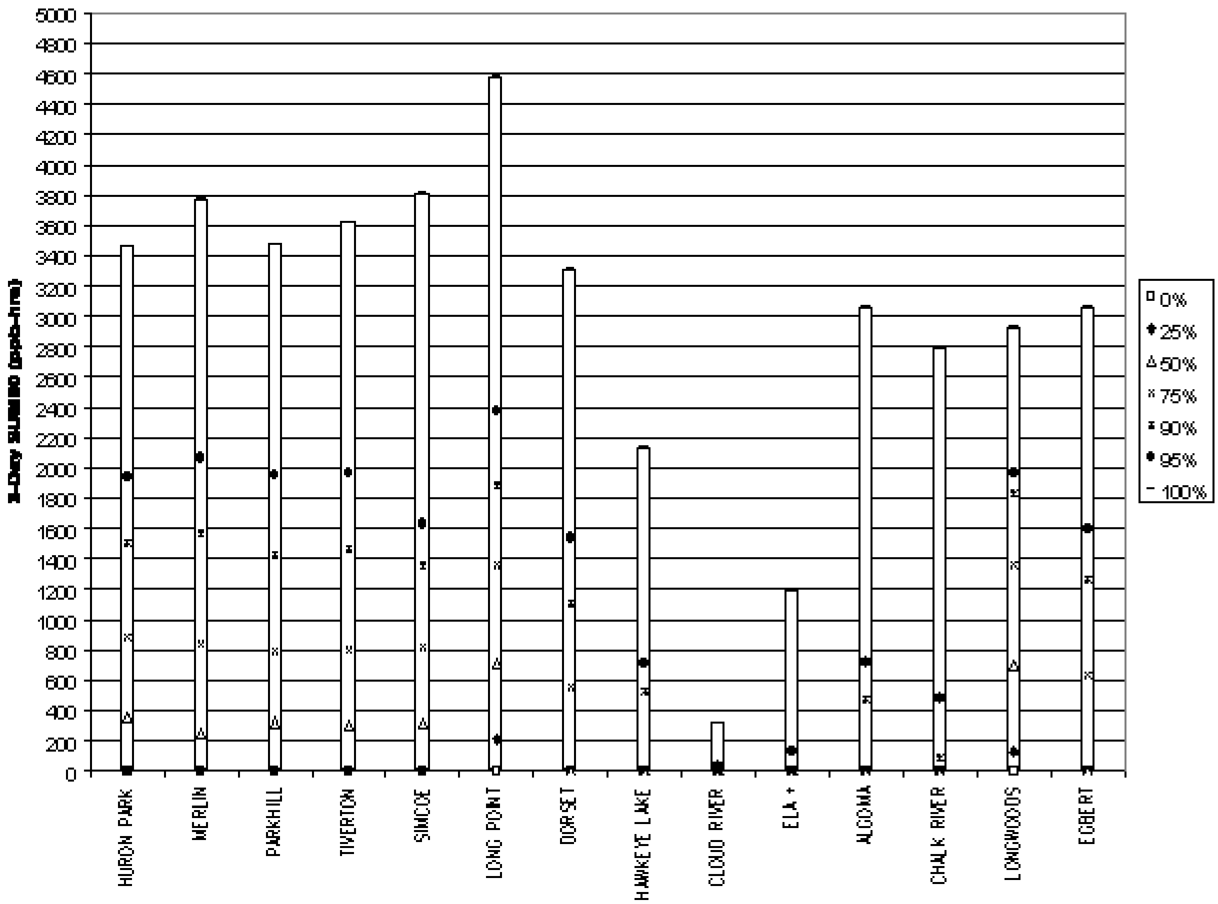
The three-day and three-month SUM60 values for rural and forest sites, based on combined rural monitoring data, should assist the Anti-Smog Action Plan in tracking effects on vegetation.

Figure 7
Frequency profile of three-month SUM60 values at rural and forest sites in Ontario, 1985-1993



* ELA is the Experimental Lakes Area operated by the Central and Arctic Region of the Candian Department of Fisheries and Ocean. ELA includes 58 small lakes (1 to 84 ha) and their drainage basins, plus 3 additional stream segments located in a sparsely inhabited region of southern Canada. It has been set aside and is managed through a joint agreement between the Canadian and Ontario governments. The ELA is relative unaffected by external human influence and industrial activities. Only research activities, or activities compatible with that research, are permitted within or adjacent to these watershed.

Figure 8
Frequency profile of three-day SUM60 values at rural and forest sites in Ontario, 1985-1993



* ELA is the Experimental Lakes Area operated by the Central and Arctic Region of the Candian Department of Fisheries and Ocean. ELA includes 58 small lakes (1 to 84 ha) and their drainage basins, plus 3 additional stream segments located in a sparsely inhabited region of southern Canada. It has been set aside and is managed through a joint agreement between the Canadian and Ontario governments. The ELA is relative unaffected by external human influence and industrial activities. Only research activities, or activities compatible with that research, are permitted within or adjacent to these watershed.

9.0 Recommendations of the Work Group

All members of the Performance Monitoring and Reporting Work Group agreed that adoption of the proposed performance indicators would be instrumental in tracking progress made in reducing smog and its precursors, and that this information should be disseminated in a publicly available report. The Work Group recommends development of an annual report, tentatively entitled *Performance Monitoring under Ontario's Anti-Smog Action Plan,* with chapters devoted to a discussion of each of the 13 proposed performance indicators. In addition, a rating could be assigned each performance indicator (using a standard A to F grading systems based on the components set forth in Table 2.

It is recommended that the Work Group should continue to meet, but with a revised mandate (the relevant details of which have been forwarded to the Anti-Smog Action Plan Operating Committee under separate cover). In general, responsibility for data compilation and analysis, as well as the preparation of the annual performance monitoring report would be the responsibility of the Work Group. In addition, the group would undertake internal quality assessment and quality control (QA/QC) functions in relation to the selected performance indicators.

However, it is evident that in order for a meaningful and objective report to be researched and written, certain action items must be undertaken by all stakeholders and ASAP partners. Chief among these is the collection of the required performance indicator data and their timely submission in an appropriate format. The allocation of adequate resources and secretariat services will also be necessary for the Work Group to fulfill its mandate.

The Work Group identified several additional areas, related to the proposed performance indicators, that would require further scientific study to improve their utility. It is recommended that these issues be assigned by the Operating Committee to the appropriate scientific authority for investigation and resolution. Among the additional work areas identified to date (note, this is not a comprehensive list of research needs) are the following:

- the development and/or refinement of emission inventories, with special emphasis on IP/RP emission inventories;
- the evaluation of background levels of NO_x, VOCs, ground-level ozone and IP/RP;
- a methodology for estimating transboundary contributions;
- the determination of appropriate monitoring sites to be used as background sites;
- a method for estimating emission reductions resulting from energy efficiency measures undertaken; and
- the determination of the appropriate “base year” for calculating the proposed ozone exceedance reductions (the options include three- and five-year median values of annual ozone exceedance hours, as alternatives to simply using the 1990 exceedances).

Appendix A

Federal smog control initiatives

A.1 Phases 1 and 2 of the Federal smog management plan

To address the issue of ground-level ozone, the 1990 Phase 1 NO_x /VOC Management Plan of the Canadian Council of Ministers of the Environment launched a program of more than 80 initiatives to reduce emissions of nitrogen oxides and volatile organic compounds. National, regional and study initiatives were undertaken. Accomplishments of national and federally led initiatives include completion of most of the 31 national pollution prevention initiatives:

- Initiatives to reduce emissions from autos and the Canadian rail system have resulted in government-industry agreements.
- National guidelines for new large stationary fuel-burning equipment such as power plants, combustion turbines and boilers will reduce future NO_x emissions.
- Codes of practice and new source performance standards for industrial printing and plastics processing will result in significant VOC reductions.
- a comprehensive science assessment on ozone provides important information for future actions to address NO_x and VOC.
- Actions to press the U.S. to strengthen its measures to reduce smog causing pollution and to set stricter air quality standards hopefully will reduce transboundary air pollution.
- Work with provinces to develop better monitoring reporting, emission tracking and emission projections will help measure progress.

The Phase 2 Plan brings together those "next step" actions by the Government of Canada which will help resolve the smog problem in Canada. It provides an improved national foundation of measures which will help provinces and territories in trying to resolve ground-level ozone and particulate matter problems in their respective regions.

The Phase 2 Plan carries forward gains made in national prevention initiatives under the Phase 1 Plan and studies and investigations on ground-level ozone. As well, the scope of work has been broadened to begin addressing the issue of particulate matter, in addition to ozone.

Under Phase 2, participants will continue to pursue the objective of consistently attaining Canada's one-hour ambient air quality objective for ozone (of 82 ppb) by 2005, and to establish the framework required to meet more stringent objectives in the future. Additional objectives for Phase 2 include: adopting a multi-pollutant approach (including incorporation of particulates), meeting Canada's international commitments, implementing a strong domestic national smog reduction program, assisting provinces in resolving regional smog problems across Canada, and coordinating and tracking results and progress against the NO_x /VOC Plan's objectives.

Further emission reductions from national and federally led Phase 2 Plan initiatives are expected to be relatively modest, when compared with the major achievements of Phase 1. However, only preliminary and conservative emission reduction estimates are available at present. These preliminary estimates indicate that additional emission reductions of about 47 kilotonnes for NO_x and 183 kt for VOCs can be expected by 2010.

Transportation sources are major contributors to PM loadings at urban sites. Estimated national reductions from lower sulphur levels in gasoline and diesel fuels of 20 to 36 kt (by 2020) represent an approximate reduction of 14 to 24 per cent from transportation sources by 2020. Therefore, by addressing vehicles and fuels, national and federally led initiatives on sulphur dioxide (SO_2) will impact significantly on a major source of emissions related to particulate matter in urban areas across Canada.

A.2 Initiatives of the NO_x /VOC Management Plan

The Phase 1 NO_x /VOC Management Plan comprised 82 specific initiatives and actions in three major areas: (1) national (prevention) program; (2) illustrative regional (remedial) initiatives; and (3) studies and investigations.

As outlined in the Phase 1 Plan (CCME, 1990), the national prevention program consisted of 31 initiatives, a combination of new source performance standards based on best available technology economically achievable, measures to control VOC emissions from products containing solvents, energy conservation and efficiency measures, and public education. These initiatives are of two types:

(1) those that would be implemented by the federal government, such as emission limits for mobile sources, energy efficiency standards for equipment and appliances, and product formulation; and

(2) those that would be developed nationally through federal-provincial co-operative programs, but implemented by provinces, such as new source performance standards for stationary sources of NO_x and VOCs.

A.3 Data management and emission inventories

Timely and accurate emissions inventories are essential for:

- the assessment of current emission levels;
- the development of forecasts and of air quality programs and policies;

- the development of emission reduction options for ground-level ozone, particularly since all the regional modelling systems currently employed are emission-based;
- reporting on Canada's compliance with commitments made under international agreements.

The Canadian Emissions Inventory of Criteria Air Contaminants (CEICAC) is a compilation of information on emissions from the 10 provinces and three territories in Canada. Emissions inventories have been maintained to date for five pollutants: total particulate matter (TPM), sulphur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), and volatile organic compounds (VOCs). The Pollution Data Branch of Environment Canada compiles the emissions inventory in collaboration with the provinces and territories through the National Emissions Inventory and Projections Task Group (NEIPTG) of the National Air Issues Coordinating Committee (NAICC).

From 1992 to 1996, there have been significant improvements in the emission data collection and dissemination process, which has enhanced both the timeliness and accuracy of the inventory for use in emission-based modelling systems and other analyses. For example, the development of a new national emissions inventory database system, called the Residual Discharge Information System II (RDIS II), has improved the tracking of all emission sources and emission modelling parameters. This system also provides improved links to other national release databases in both Canada and the United States. Other data collection and monitoring enhancements include:

- improved federal/provincial collaboration for the compilation of the emissions inventory, which has reduced the inventory reporting lag time to less than two years;
- the development of electronic data transfer software, which allows industries to report their emissions electronically and facilitates the efficient exchange of information between the federal and provincial governments;
- the addition of contaminants, such as ammonia and fine particulates (PM_{10}, $PM_{2.5}$), to the inventoried list of criterion air contaminants;
- improvements to the emission estimates, which have been achieved through direct measurements and detailed studies and have targeted sources such as the transportation sector, industrial and non-industrial solvent usage, residential fuel wood combustion, fugitive dusts, and biogenic emissions; and
- improved provincial emission reporting capabilities, both regional and urban, through the development of more accurate spatial allocation parameters and the use of geographical information systems (GIS).

Appendix B

Federal Greening of Government Operations: Best Practices

B.1 Procurement practices

- Evaluate potential purchase as outlined in the Treasury Board's *Material Management Environmental Guidelines.*
- Consistent with Canada's international trade obligations, purchase products and services that meet environmental specifications wherever these are available, and consider life-cycle costs. In some cases, this could involve a small price differential.
- Provide green procurement training to officers with purchasing authority to improve decision-making, such as *Implementing Environmental Purchasing Policies,* available from Environment Canada.
- Adopt just-in-time delivery of all standard items on a competitive basis.
- Phase out all warehousing space for standard items as the just-in-time system comes into place.

B.2 Energy use in federal buildings

- Review energy use in owned and leased facilities.
- Develop and implement energy management plans, including preventive maintenance.
- Assess the energy efficiency knowledge requirement for building operators and managers, and provide the required training.
- Implement all economically attractive energy retrofits.
- Take advantage of the Federal Buildings Initiative, which provides products and services in support of the above activities.
- Facilitate building occupant energy conservation, for example with bike racks, car pool parking privileges, and car pooling information.

B.3 Motor vehicle fleets

- Manage fleet vehicles in accordance with economic and environmental objectives of the Treasury Board's *Motor Vehicle Policy*.
- Maximize fuel efficiency and the use of alternative fuels to conserve energy and reduce emissions.

- Wherever possible, use low-sulphur diesel and ethanol-gasoline blends meeting environmental specifications.
- Purchase original equipment manufactured alternative fuel vehicles or retrofit vehicles where life cycle costs are comparable to gasoline or diesel-fuelled vehicles.
- Purchase vehicles of appropriate engine size to meet operational requirements.
- Reduce the number of vehicles for department use.
- Perform emission testing and regular maintenance on vehicles to ensure maximum operating efficiency.
- Recycle all used vehicle liquids, including oil, anti-freeze and CFCs.
- Conduct driver education for enhanced energy savings and safety.

Appendix C

NO_x and VOC emission projections and emission reductions

Table 6a Anti-Smog Action Plan – NO_x Emission Projections

NO_x Baseline Emissions (No New Reduction Activities after 1990), original Smog Plan

NO_x Emissions in kilottonnes

NO_x Baseline Emissions	Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Road Vehicles		267	*	*	*	*	221	n/a	n/a			322					348					376					376
Other Transportation		134	*	*	*	*	128	n/a	n/a			162					172					184					197
Other Sources		258	*	*	*	*	188	n/a	n/a			277					318					338					360
TOTAL		659	*	*	*	*	537	n/a	n/a			761					838					898					933

Note:

[1] The 1995 emissions were updated with the National Emission Inventory and Projections Task Group (NEIPTG) estimates, version 1, December 1998.

[2] * - The emissions for this years are being backcasted by the National Emission Inventory and Projections Task Group (NEIPTG).

[3] n/a - not available.

Table 6b Anti-Smog Action Plan - NO_x Emission Reductions

Cumulative Emission Reductions (Reduction Activities as per Smog Plan - Compendium Document, August 1997)

NO_x Emissions Reduction in kilotonnes

NO_x Emission Reduction	Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
INCO			43	>>>	>>>	>>>	43	>>>	>>>	>>>	>>>	43	>>>	>>>	>>>	>>>	43	>>>	>>>	>>>	>>>	43	>>>	>>>	>>>	>>>	43
Tier 1 Vehicle Standards							32	>>>	>>>	>>>	>>>	60	>>>	>>>	>>>	>>>	62	>>>	>>>	>>>	>>>	55	>>>	>>>	>>>	>>>	55
Light Duty Diesel Trucks							1	>>>	>>>	>>>	>>>	1	>>>	>>>	>>>	>>>	1	>>>	>>>	>>>	>>>	1	>>>	>>>	>>>	>>>	1
Heavy Duty Trucks							44	>>>	>>>	>>>	>>>	73	>>>	>>>	>>>	>>>	97	>>>	>>>	>>>	>>>	115	>>>	>>>	>>>	>>>	107
CCPA							3.9	>>>	>>>	>>>	>>>	3.9	>>>	>>>	>>>	>>>	3.9	>>>	>>>	>>>	>>>	3.9	>>>	>>>	>>>	>>>	3.9
Steel								2	>>>	>>>	>>>	2	3.5	>>>	>>>	>>>	3.5	>>>	>>>	>>>	>>>	3.5	>>>	>>>	>>>	>>>	3.5
Vehicle I/M Program												12	>>>	>>>	>>>	>>>	13	>>>	>>>	>>>	>>>	13	>>>	>>>	>>>	>>>	13
Ontario Hydro												19	>>>	>>>	>>>	>>>	19	>>>	>>>	>>>	>>>	19	>>>	>>>	>>>	>>>	19
Boiler I & M												2	3.5	>>>	>>>	>>>	3.5	>>>	>>>	>>>	>>>	3.5	>>>	>>>	>>>	>>>	3.5
Propane Vehicles																											5.1
Natural Gas Vehicles																											0.9
Demand Management																											10
Combustion Turbine																											29
Combustion Systems Std.																											4
TOTAL REDUCTIONS TO DATE (All Activities)																											
All Activities							124					216					246					257					298

Note:

[1] The emissions from other transportation will be updated with new statistics and methodologies by the National Emission Inventory and Projections Task Group (NEIPTG).

[2] The methodologies on the estimation of emissions from residential fuel wood combustion are being reviewed by NEIPTG and will be updated with new statistics.

[3] The projected emissions from years 1998 to 2015 are being reviewed by NEIPTG and will be updated when information is available.

Table 7a Anti-Smog Action Plan - VOC Emission Projections

VOC Baseline Emissions (No New Reduction Activities after 1990), original Smog Plan

VOC	VOC Emissions in kilotonnes																									
Baseline Emissions Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Road Vehicles	226	*	*	*	*	167	n/a	n/a			266					290					315					334
Other Transportation	61	*	*	*	*	64	n/a	n/a			58					59					65					72
Other Sources	581	*	*	*	*	510	n/a	n/a			663					711					758					809
TOTAL	868	*	*	*	*	741	n/a	n/a			987					1060					1138					1215

Note:

[1] The 1995 emissions were updated with the National Emission Inventory and Projections Task Group (NEIPTG) estimates, version 1, December 1998.

[2] * - The emissions for this years are being backcasted by the National Emission Inventory and Projections Task Group (NEIPTG).

[3] n/a - not available.

Table 7b Anti-Smog Action Plan - VOC Emission Reductions

Cumulative Emission Reductions (Reduction Activities as per Smog Plan - Compendium Document, August 1997)

VOC	VOC Emissions Reduction in kilotonnes																									
Emission Reduction Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Auto Manufacturing				12.1	>>>	12.1	>>>	>>>	>>>	>>>	12.1	>>>	>>>	>>>	>>>	12.1	>>>	>>>	>>>	>>>	12.1	>>>	>>>	>>>	>>>	12.1
Tier 1 Vehicle Standards						71	>>>	>>>	>>>	>>>	105	>>>	>>>	>>>	>>>	125	>>>	>>>	>>>	>>>	139	>>>	>>>	>>>	>>>	147
Heavy Duty Trucks						4	>>>	>>>	>>>	>>>	7	>>>	>>>	>>>	>>>	7	>>>	>>>	>>>	>>>	8	>>>	>>>	>>>	>>>	9
CCPA						6.8	>>>	>>>	>>>	>>>	11.8	>>>	>>>	>>>	>>>	11.8	>>>	>>>	>>>	>>>	11.8	>>>	>>>	>>>	>>>	11.8
Consumer Coatings						3.8	>>>	>>>	>>>	>>>	3.8	>>>	>>>	>>>	>>>	3.8	>>>	>>>	>>>	>>>	3.8	>>>	>>>	>>>	>>>	3.8
Adhesive						1.6	>>>	>>>	>>>	>>>	1.6	>>>	>>>	>>>	>>>	1.6	>>>	>>>	>>>	>>>	1.6	>>>	>>>	>>>	>>>	1.6
Rubber Products						1.2	>>>	>>>	>>>	>>>	1.2	>>>	>>>	>>>	>>>	1.2	>>>	>>>	>>>	>>>	1.2	>>>	>>>	>>>	>>>	1.2
Steel							0.3	>>>	>>>	>>>	0.3	0.9	>>>	>>>	>>>	0.9	>>>	>>>	>>>	>>>	0.9	>>>	>>>	>>>	>>>	0.9
Reduced RVP								18	>>>	>>>	18	>>>	>>>	>>>	>>>	18	>>>	>>>	>>>	>>>	18	>>>	>>>	>>>	>>>	18
Vehicle I/M Program											45	>>>	>>>	>>>	>>>	41	>>>	>>>	>>>	>>>	41	>>>	>>>	>>>	>>>	41
Stage I VRU									19	>>>	19	>>>	>>>	>>>	>>>	19	>>>	>>>	>>>	>>>	19	>>>	>>>	>>>	>>>	19
Auto Refinishing										0.5	0.5	>>>	>>>	>>>	>>>	0.5	>>>	>>>	>>>	>>>	0.5	>>>	>>>	>>>	>>>	0.5
Propane Vehicles																										2.4
Natural Gas Vehicles																										0.8
Demand Management																										1
Wood Treatment																										0.6
TOTAL REDUCTIONS TO DATE (All Activities)																										
All Activities						101					225					242					257					271

Note:

[1] The emissions from fuel marketing are being reviewed by the CPPI and will be updated when information is available.

[2] The emissions from other transportation will be updated with new statistics and methodologies by the National Emission Inventory and Projections Task Group (NEIPTG).

[3] The methodologies on the estimation of emissions from residential fuel wood combustion are being reviewed by NEIPTG and will be updated with new statistics.

[4] The projected emissions from years 1998 to 2015 are being reviewed by NEIPTG and will be updated when information is available.

Appendix D

Summary of techniques for estimating source receptor relationships

This table progresses from the simplest to the most comprehensive analyses/modelling techniques

Techniques	Description	Application/Results	Limitation of Method
Geographic Association	Uses geographic association to show regions of high emissions of precursors are close to the regions of high ozone concentrations	Results show high ozone episodes in Ontario are associated with episodes over much of the eastern U.S. A map of maximum ozone concentrations shows a "continental ozone plume" originating from around Texas, extending into the midwest and north Atlantic seaboard.	It suggests a substantial fraction of ozone in any location is due to precursors from within the very large region of the northeastern U.S. and southern Ontario. However, this analysis is only qualitative and by itself can't attribute the contributions of different sources or specific areas.
Local Wind Direction Sector Analysis	Analyzes the pollution concentration with different local wind direction. An example is the use of pollution roses to show the direction of the pollution sources. Pollution rose is a graph showing the measured pollutant concentration for each wind direction.	Results in the Windsor-Quebec Corridor show ozone episodes are usually associated with moderate southwesterly winds, with maximum daytime temperature of over 25 C and anticyclones.	It is ideal for identifying emissions from a single source or for sites at the periphery of emission zones. It is not possible to determine whether the source of the pollution is from sources close by or far away. Ozone and its precursors may have been transported over one to two days before it arrived in Ontario. Local wind data may not represent the true direction of that air mass. An example occurred for one of the highest ozone concentrations recorded in Sarnia (mid-day on Aug. 14, 1993) with winds coming from the north, off Lake Huron. However, over the previous two days, the polluted air mass had actually been transported from SW Michigan across the Greater Detroit area and then over Lake Huron. The wind direction shifted to a northerly flow, transporting the air mass over Sarnia and several hours later over Windsor.

Techniques	Description	Application/Results	Limitation of Method
Air Mass Trajectory - Climatological	The pathway or trajectory taken by the polluted parcel from distant sources is traced backwards from the receptor through the use of wind data (at different levels). Trajectory results are usually shown as a line or ensemble of lines linking the source of the pollution and the receptor.	Results for southern Ontario ozone episodes showed in more than 95% of the cases, the air parcel traversed the heavily industrialized and urbanized areas of the U.S. Midwest before it reached southern Ontario. The amount of ozone entering Ontario was quantified, using monitoring sites near the U.S.-Ontario border, by looking at the difference in concentrations with air flows from the U.S. versus background levels. The results indicated approximately an overall contribution of 50-60% from the U.S. during cloud-free summer days. For episode days, the U.S. contribution is expected to be much higher.	There are spatial and temporal limitations on meteorological data. Trajectories may traverse several source regions, with associated input of precursors and chemical transformation. This makes it hard to determine relative contribution of distant versus local sources. For locations away from the U.S.-Ontario border, this analysis can't separate the contribution of Ontario versus U.S. precursor gas emissions to observed ozone concentrations.
Air Mass Trajectories - Residence Time Analysis	Back trajectories are used to calculate the residence time of an air parcel before arriving at a receptor. This is summed for a number of ozone episodes across the region, and then plotted as isopleth maps showing the probability that a pollutant originated from that area before it arrived at the receptor.	Result in the Windsor-Quebec Corridor showed the highest number of residence hours coincided with sources to the south/southwest of the Windsor-Quebec Corridor.	Same as above.
Air Mass Trajectories - Simplified Modelling Analysis	Back trajectories can be coupled with emission injection along the trajectory and simple decay functions to represent the half life of the transported pollution. The half life represents all lost mechanisms including dry deposition, wet scavenging and photochemistry.	Back trajectories were combined with NO_x emissions input and decay rates to estimate the contribution of U.S. versus Ontario sources to NO_x in various Ontario cities.	The modelling of the combined effects of dry deposition, wet scavenging, mixing and atmospheric chemistry with a simple decay function is a very crude assumption. The use of different assumptions about the decay rate can change the U.S. contribution to NO_x by a factor of two. This simplified modelling approach can't be readily applied to ozone where both production and removal processes are occurring.

Techniques	Description	Application/Results	Limitation of Method
Special Studies - SONTOS	SONTOS (Southern Ontario Oxidant Study) has mounted three major field measurement campaigns, using ground-based and aircraft-borne instruments. A variety of analyses and interpolations of the data have been carried out, including the use of mathematical modelling.	Parameters measured include NO_x, O_3, SO_2, VOC, H_2O_2, proxy radicals, alkyl nitrates and meteorological parameters. Results have included: - the Great Lakes play an important role in storing and transporting high concentrations of ozone; - the atmospheric chemistry of ozone production in rural sites in southern Ontario is similar to what has been observed elsewhere. Ozone production is typically NO_x limited; - isoprene is the major contributor to VOC reactivity, although largely biogenic, it is also emitted from vehicle exhaust; - emission rates of some VOC species for Toronto may be seriously underestimated.	Expensive and labour intensive. However, yields results not accessible by other methods.
Regional Models	These are mathematical models which incorporate meteorological data, atmospheric chemical interaction and emissions to predict the formation and concentration of ground level ozone.	A suite of models have been used to simulate the ground level ozone episodes in eastern North America for the Canadian 1996 NO_x /VOC Science Assessments and for the U.S. Ozone Transport Assessment Group. Results of the models are compared with the actual monitoring data. Modelling has also been used to study the changes in ozone concentration due to different NO_x and VOC reduction scenarios. These results were used to estimate the emission reductions (45%) of NO_x and VOCs needed to meet the Smog Plan goal of 75% reduction in ground level ozone exceedances. Modelling can be used to determine the impact of Canadian versus U.S. emission reductions, as well as the importance of different source sectors.	Modelling is very resource intensive. There is still some uncertainty and limitations in the ability to simulate atmospheric chemistry and in estimates for emissions inventory.

Appendix E

Membership of the Performance Monitoring and Reporting Work Group

E.1 Members

Tim Adamson, Enbridge Consumers Gas (Co-chair)
Eric Loi, Ministry of the Environment (Co-chair)
Brenda Lorenz, Lorenz Environmental
Terry Mah/Jim Collins, Environment Canada
Michel Martin, Shell Canada
Peter Wong/Simon Wong, Ministry of the Environment

E.2 Corresponding or part-time members

Peter Baltais, Imperial Oil (CPPI/CCPA), replaced in January, 1999, by Michel Martin
Lois Corbertt, Toronto Environmental Alliance
Peter Mussio, Union Gas
Keith Madill, Canadian Motor Vehicle Manufacturers Association
Kathy Pritchard, Quebecor Printing Canada
Dave Yap, Ministry of the Environment

E.3 Technical writers/technical assistants

William M. Glenn
Arun Deshpande

Appendix F

Preliminary List of Performance Indicators

F.1 Indicators related to NO_x and VOC emissions reduction

(1) Develop a baseline emission inventory for 1990 levels.
(2) Update annual emissions with support from monitoring data.
(3) Develop a comprehensive emission inventory to cover all sectors, including the general public.
(4) Determine the emission reduction technologies used and how reductions are achieved (e.g., through anecdotal evidence acceptable under NPRI).
(5) Assess implementation of CCME codes and guidelines (e.g., the number of codes/guidelines implemented).

F.2 Indicators related to broad involvement in the Anti-Smog Action Plan

(6) Increase the response rate to the "Common Air Pollutant Emissions Survey" and track the number and percentage response rate.
(7) Track the number and scope of public education programs on air quality and smog.
(8) Determine the number of "Ecologo" programs that deal with air quality.
(9) Determine the number of energy efficiency regulations.
(10) Calculate the distance driven by Ontarians (e.g., vehicle kilometres travelled).
(11) Develop additional quantifiable performance indicators with the assistance of the Public Engagement Work Group (e.g., degree of wood burning, public transit usage, home insulation upgrades, etc.).
(12) Determine participation in the Anti-Smog Action Plan (e.g., the number of Accord signatures, MOUs, and other agreements).
(13) Determine the number of companies with a "Green Work Place" program that includes an air quality component.
(14) Determine the number of municipal programs dealing with air quality (e.g., flex time arrangements, smog response programs, etc.).

F.3 Indicators related to the reduction of transboundary pollutants

(15) Measure Ontario's ambient transboundary pollutants on an annual basis.
(16) Track U.S. ambient air data and emissions inventory on an annual basis.
(17) Track compliance activities under U.S. State Implementation Plans (e.g., OTAG, NARSTO).
(18) Track progress in meeting transboundary commitment under, for example, the *Canada-U.S. Air Quality Agreement*.
(19) Record the number of public "outcry" incidents from across the border.

F.4 Indicators related to the reduction of inhalable and respirable particulates

(20) Develop a comprehensive IP/RP emission inventory.
(21) Apportion sources upstream of airshed contributing to IP/RP levels (in order to better understand problem).
(22) Develop additional performance indicators with the assistance of the Particulate Matter and Ozone Options Assessment Working Group.
(23) Release MOE discussion paper and strategy to ASAP Operating Committee.

F.5 Indicators related to air quality monitoring

(24) Install a defensible network program in Ontario and maintain geographic coverage.
(25) Calculate number of exceedances of Ontario's ambient air quality criteria.
(26) Compare Ontario's ambient air quality with U.S. data.
(27) Document background levels for all applicable pollutants.
(28) Arrange a number of partnerships for ambient air monitoring.
(29) Project future air quality improvements through, for example, modelling of emission reductions.
(30) Continually upgrade and improve atmospheric models chosen.

F.6 Indicators related to reduced risk to human health and vegetation

(31) Calculate the number of Ontarians with respiratory symptoms related to smog, ground-level ozone and fine particulate exposure.
(32) Develop other health-related performance measures with the assistance of the Health Work Group.
(33) Track the value of crops lost due to ground-level ozone exposure.
(34) Develop a methodology to track crop/vegetation losses due to ozone.