Air Quality Agreement

2002 Progress Report

THE INTERNATIONAL JOINT COMMISSION REQUESTS YOUR COMMENTS ON THIS REPORT

The Canada-United States Air Quality Agreement is now 10 years old, a new annex has been added, and reporting of the Air Quality Committee routinely includes information on sulphur dioxide and nitrogen dioxide reductions, cooperative air quality programs, notification and assessment actions, and research efforts related to aquatic environment, forest, materials and human health effects.

- Do you feel the agreement has been successful?
- Are there other transboundary air quality issues that should be addressed through this agreement?
- Are the progress reports useful?

The International Joint Commission (IJC) is responsible for inviting public comment on the Air Quality Agreement Progress Reports and for providing a synthesis of the comments to the governments to assist them in implementing the agreement. Comments on any aspect of the agreement would be appreciated.

Written comments on this report should be sent by February 28, 2003 to:

Secretary, Canadian Section
International Joint Commission
234 Laurier Avenue, West
22nd Floor
Ottawa, Ontario K1P 6K6

Fax: (613) 993-5583
Email: commission@ottawa.ijc.org

Secretary, United States Section
International Joint Commission
1250 23rd Street, NW
Suite 100
Washington, DC 20440

Fax: (202) 467-0746
Email: commission@washington.ijc.org

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Acronyms and Abbreviations

ACDEP	Atmospheric Chemistry and Deposition model
AIRMoN	Atmospheric Integrated Research Monitoring Network
AQC	Air Quality Committee
AQI	Air Quality Index
ARNEWS	Acid Rain National Early Warning System
AURAMS	A Unified Regional Air Quality Modelling System
BACT	Best Available Control Technology
BART	Best Available Retrofit Technology
BAT	Best Available Technology
BC	British Columbia
BDPS	Boundary Dam Power Station
CAPMoN	Canadian Air and Precipitation Monitoring Network
CASTNet	Clean Air Status and Trends Network
CCME	Canadian Council of the Ministers of the Environment
CEM	continuous emissions monitoring or monitors
CEPA	Canadian Environmental Protection Act
CFS	Canadian Forest Service
CHRONOS	Canadian Hemispheric and Regional Ozone and NO_x System
CL	critical loads
CO	carbon monoxide
CO_2	carbon dioxide
CMAQ	Community Multiscale Air Quality model
CUTA	Canadian Urban Transit Association
CWS	Canada-Wide Standards
E-GRID	Emissions and Generation Resource Integrated Database
EPA	U.S. Environmental Protection Agency
eq	equivalence
FHM	Forest Health Monitoring
FRM	Federal Reference Method
g/bhp-hr	grams per brake horsepower hour
g/mi	grams per mile
IMPROVE	Interagency Monitoring of Protected Visual Environments
km	kilometres
kt	kilotonnes
LRTAP	Long-Range Transboundary Air Pollution Protocol
MACT	maximum achievable control technology
mm	millimetre
MERS	Multi-pollutant Emission Reduction Strategies
MOU	Memorandum of Understanding
MRP	Materials Research Program
NAAQS	National Ambient Air Quality Standards
NADP/NTN	National Atmospheric Deposition Program/National Trends Network
NAMS	National Air Monitoring Stations
NAPS	National Air Pollution Surveillance
NARSTO	North American Research Strategy for Tropospheric Ozone
NCPTT	National Center for the Preservation of Technology and Training
NEG/ECP	New England Governors and Eastern Canadian Premiers
NERAQC	Northeast Regional Air Quality Committee
NESCAUM	Northeast States for Coordinated Air Use Management
NH_4	Ammonium
NO	nitrogen oxide
NO_x	nitrogen oxides
NO_2	nitrogen dioxide
NPRI	National Pollutant Release Inventory
O_3	Ozone
OTC	Ozone Transport Commission
PEMA	Pollutant Emission Management Area
PM	particulate matter
PM_{10}	particulate matter less than or equal to 10 microns
$PM_{2.5}$	particulate matter less than or equal to 2.5 microns
ppb	parts per billion
ppm	parts per million
PSD	prevention of significant (air quality) deterioration
REMSAD	Regional Modelling System for Aerosols and Deposition
RESEF	Quebec Forest Intensive Monitoring Network
RPO	Regional Planning Organization
SIP	State Implementation Plan
SLAMS	State and Local Air Monitoring Stations
SMB	simple mass-balance
SO_2	sulphur dioxide
SO_4^{2}	sulphate ion
SPM	special purpose monitors
SUV	sport utility vehicle
TEOM	Tapered Element Oscillating Microbalance
USFS	U.S. Department of Agriculture Forest Service
VOC	volatile organic compound
μm^3	cubic micrometres

Introduction

The 2002 Progress Report is the sixth report under the 1991 Canada—U.S. Air Quality Agreement and the first to address new requirements under the Ozone Annex (Annex III), signed by Canada and the United States in Washington in December 2000. This report highlights actions undertaken by Canada and the United States in the last two years to address transboundary air pollution under the Agreement—namely, acid rain and ground-level ozone. The report, prepared by the bilateral Air Quality Committee (AQC), builds on previous progress reports and includes the second five-year comprehensive review of the Air Quality Agreement.

Actions to address acid rain in the last two years have been significant both in the United States and in Canada. In Canada, total sulphur dioxide (SO_2) emissions are already 20% below the national emission cap commitment of 3.2 million tonnes. New emission reduction targets have been set for SO_2 under the Canada-Wide Acid Rain Strategy for Post-2000. In addition, the Canada-wide Standards for Particulate Matter (PM) will result in further reductions. The United States has achieved a reduction in SO_2 emissions of about 35% when compared with 1980 levels. Full implementation in 2010 will result in a 10-million-ton reduction of SO_2 emissions, approximately 40% below 1980 levels.

The amendments to the Air Quality Agreement to address ground-level ozone were comprehensive and far-reaching. Based on the domestic legislation adopted by each country to achieve long-term ozone reduction, the amendments committed the Parties to aggressive measures to reduce emissions of nitrogen oxides (NO_x) and volatile organic compounds (VOCs), the precursors to ground-level ozone and contributors to transboundary air pollution. To track progress and report to the public, the Ozone Annex set in place commitments to report the ozone air quality levels from ambient air quality monitors within 500 kilometres (km) of the U.S.—Canada border starting in 2002 and industrial facility emissions starting in 2004. The first of these air quality reports is contained on pages 26-28 and 56-58 of the 2002 Progress Report. Finally, the Ozone Annex made new commitments to undertake joint research and technical work that will support the reduction of emissions and the achievement of the air quality standards.

Joint work resulting from the 1997 Joint Plan of Action for Addressing Transboundary Air Pollution on ground-level ozone and particulate matter (PM) led to the Ozone Annex. Cooperative efforts to address transboundary PM are now underway and are reported in the 2002 Progress Report. The Report also outlines cooperative efforts on acid deposition monitoring, emissions inventories and forecasts, and air quality programs in both countries.

The second five-year comprehensive review of the Air Quality Agreement is set in the context of an amended, enhanced cooperative Agreement. Clearly, the fact that the Ozone Annex was negotiated and addresses an issue of concern to both Parties demonstrates that the Agreement can be a valuable instrument for bilateral cooperation. The review addresses issues raised in 1996 when the first review was undertaken, outlines where progress has been made, and indicates where challenges continue to exist.

Note: *Canadian spelling is used throughout. Future reports will alternate the use of Canadian and American spelling.*

Progress and Commitments

This section focuses on Canadian and U.S. progress in meeting commitments under Annex 1, the Acid Rain Annex, and Annex 3, the Ozone Annex, of the Air Quality Agreement.

Acid Rain Annex

SULPHUR DIOXIDE REDUCTIONS

Canadian Commitment

- Sulphur dioxide (SO_2) emissions reduction in the seven easternmost provinces to 2.3 million tonnes[1] by 1994.
- Maintenance of 2.3 million-tonne annual cap for eastern Canada through December 1999.
- Permanent national cap for SO_2 emissions of 3.2 million tonnes by 2000.

Canada is committed to reducing acid rain in all parts of the country to levels below those that cause harm to ecosystems. In the year 2000, total Canadian sulphur dioxide (SO_2) emissions were 2.5 million tonnes, which is about 20% below the national cap of 3.2 million tonnes and a 45% reduction from 1980 emission levels. The 1.6 million tonnes of emissions in the seven easternmost provinces in 2000 were 29% below the eastern Canada cap of 2.3 million tonnes. Forecast of emissions developed by the federal—provincial Emissions and Projections Working Group indicate that emissions will remain below all applicable caps well into the future.[2] Significant further reductions of SO_2 will result from reduction initiatives not included in the forecasts, those coming into effect after 2000, such as the new SO_2 targets under The Canada-Wide Acid Rain Strategy for Post-2000,[3] and federal and provincial implementation activities to achieve the Canada-Wide Standards for particulate matter (PM).

Measures to implement the permanent national cap of 3.2 million tonnes per year by 2000 and the 2.3 million-tonne eastern Canada cap were initially undertaken through the Eastern Canada Acid Rain Program, under bilateral agreements between each respective province and the federal government. This program, which ended in 2000, is being succeeded by the Canada-Wide Acid Rain Strategy for Post-2000. This strategy calls for a number of actions designed both to deal with the continuing acid rain problem in eastern Canada and to prevent the problem from occurring in other parts of the country. In particular, the Strategy calls for further emission reductions in the provinces of Ontario, Quebec, New Brunswick, and Nova Scotia. In fulfillment of this commitment, each of these provinces has announced a 50% reduction in its existing emissions cap established under the Eastern Canada Acid Rain Program. Quebec, New Brunswick, and Nova Scotia are committed to doing so by 2010. Ontario committed to meet its new cap in 2015; however, a proposal to advance the timeline to 2010 is under consideration (see provincial updates, pp. 14-16).

U.S. Commitment

- SO_2 emissions reduction of 10 million tons[4] from 1980 levels by 2000, taking into account credits ("allowances") earned for reductions from 1995 to 1999.
- Permanent national cap of 8.95 million tons of SO_2 per year for electric utilities by the year 2010.
- National SO_2 emissions cap of 5.6 million tons for industrial sources beginning in 1995.

In 2001, the second year of Phase II of the Acid Rain Program, all participating sources achieved a total reduction in SO_2 emissions of about 32% when compared to 1990 levels and over 35% from 1980 levels. Compared with 2000 levels, these sources reduced SO_2 emissions by 5%, or 572,000 tons. In 2000, sources emitted approximately 10.6 million tons, some 1.08 million tons more than the allowances granted for the year, reflecting the use of banked allowances. The bank of allowances used in 2000 was less than in 2001; however, it is expected to decrease as sources continue to comply with stringent Phase II requirements. The number of participating units in 2001 was 3,065. Full implementation of the program in 2010 will achieve a 10 million-ton reduction of SO_2 emissions, about 40% below 1980 levels.

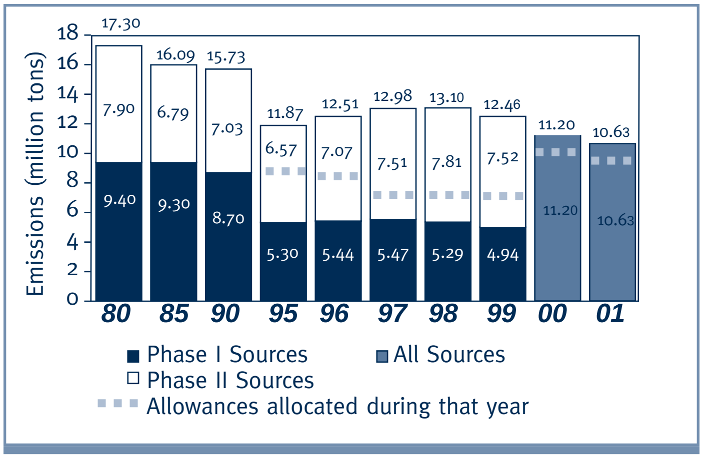
During Phase II, allowance market trading under the SO_2 Allowance Trading Program continues to increase steadily

1 One tonne is equal to 1.1 short tons.

2 Forecast emissions are interim estimates using 1999 values reported by the provinces and territories. The forecasts are projected with growth factors calculated from total provincial changes in emissions found in the Emissions and Projections Working Group Consensus National Base Case Forecast, 2002.

3 The Canada-Wide Acid Rain Strategy for Post-2000 can be found at http://www.ec.gc.ca/acidrain/done-canada.html.

4 One (short) ton is equal to 0.907 tonne.



U.S. SO_2 Emissions for Phase I and Phase II Units *Figure 1*

among all participants, contributing to lower than expected costs for reducing emissions. SO_2 allowance trading is the centrepiece of the Acid Rain Program, under which all affected utility units are allocated a specific number of allowances authorizing the emission of one ton of SO_2. The allowances are tradable, and utilities may buy, sell, or bank them for future use. Every year each individual source must hold allowances that equal or exceed its annual emissions.

The Online Allowance Transfer System (OATS), introduced by the Environmental Protection Agency (EPA) in December 2001, is expected to further accelerate trading of SO_2 as well as NO_x allowances (see p. 13 for NO_x budget trading information). OATS enables participants to record trades directly on the Internet rather than submit paper forms to EPA for processing. By the end of April 2002, the monthly record of SO_2 and NO_x transfers using the system was 94.5%.

Industrial SO_2 emissions from stationary sources continue to remain below the 5.6 million-ton cap and are projected to remain below for at least the next 10 years. Should emissions from these sources exceed the cap, EPA is authorized to establish regulations to reduce emissions to below 5.6 million tons.

NITROGEN OXIDE REDUCTIONS

Canadian Commitment

- By 2000, reduce stationary source emissions 100,000 tonnes below the forecast level of 970,000 tonnes.[5]
- By 1995, develop further annual national emissions reduction requirements from stationary sources to be achieved by 2000 and/or 2005.
- Implement an NO_x control program for mobile sources.

Nitrogen oxide (NO_x) emissions have been reduced by more than 100,000 tonnes below the forecast level of 970,000 tonnes at power plants, major combustion sources, and metal smelting operations.

In relation to further reducing annual national emissions, Canada is developing programs to reduce NO_x emissions in a number of areas (see section III, p. 14). The provinces and the federal government are working together to achieve multi-pollutant emission reductions for pollutants contributing to PM and ozone for key industrial sectors. Through analytical studies, pollutants that cause PM and ozone (including NO_x) will be characterized and best available technologies (BAT) identified to assist jurisdictions in developing plans to meet the Canada-wide Standards for PM and Ozone by 2010. These plans are expected to include measures and actions to reduce emissions of NO_x.

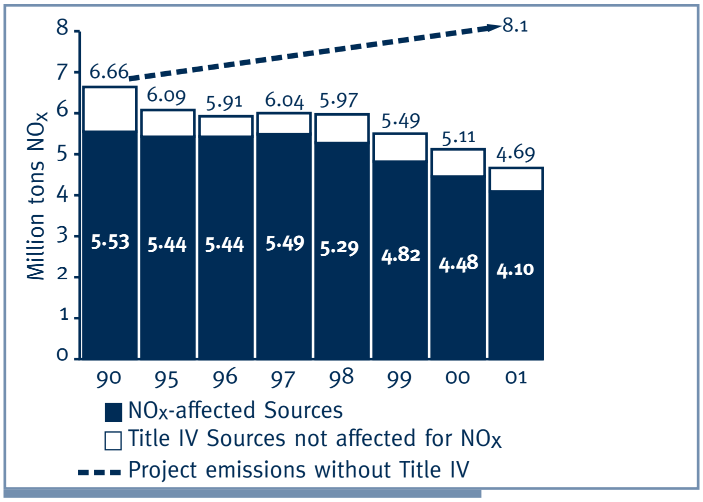
The proposed On-Road Vehicle and Engine Emission Regulations and Sulphur in Diesel Fuel Regulations, in combination with current regulations and programs, will result in a 60% reduction in NO_x emissions from on-road vehicles in the year 2010 compared with the year 2000.

U.S. Commitment

- By 2000, reduce total annual emissions of NO_x by 2 million tons.
- Implement stationary source control program for electric utility boilers.
- Implement mobile source control program.

Reductions in NO_x emissions have significantly surpassed the two-million-ton reduction for stationary and mobile sources mandated by the 1990 Clean Air Act. Under the Acid Rain Program alone, NO_x emissions in 2001 continue to be about three million tons below what they would have been. In 2001, NO_x emissions for the 2,626 affected sources were 4.69 million tons, which was

[5] The 970,000 tonnes is forecast for 2005 in the NO_x/VOC Emission Forecast 90-B from the 1990 NO_x/VOC Management Plan.



U.S. NO_x Emissions for Phase I and Phase II Electric Generating Sources *Figure 2*

0.42 million tons, or 8.2%, lower than 2000 levels and 1.97 million tons, or 30%, lower than in 1990.

Under continuing implementation of the Clean Air Act Amendments (CAAA) requirements for mobile sources, EPA announced in December 2000 a major program to significantly reduce emissions from heavy-duty engines and vehicles. The program will reduce precursor emissions from trucks and buses by 95% beyond current levels. This comprehensive 50-state control program regulates the heavy-duty vehicle and its fuel as a single system. New emission standards will begin to take effect in 2007 and will apply to heavy-duty highway engines and vehicles operated on any fuel. The program will reduce emissions in 2030 of NO_x by 2.6 million tons and nonmethane hydrocarbons (NMHC) emissions by 115,000 tons per year. Particulate emissions from these vehicles would be reduced by 109,000 tons per year in 2030.

The particulate matter (PM) emissions standards for new heavy-duty engines of 0.01 grams per brake horsepower hour (g/bhp-hr) will take effect in the 2007 model year. Standards for NO_x and NMHC are 0.20 g/bhp-hr and 0.14 g/bhp-hr, respectively. These standards will be phased in together for diesel engines between 2007 and 2010 on the same schedule as standards for complete heavy-duty vehicles. For vehicles between 10,000 and 14,000 pounds, the standards are 0.4 grams per mile (g/mi) for NO_x, 0.02 g/mi for PM, and 0.23 g/mi for NMHC. Standards for diesel fuel specify that beginning in June 2006 fuel sold to consumers for use in highway vehicles have a sulphur content no greater than 15 ppm (parts per million). Current sulphur content in fuel is about 500 ppm.

The United States is also moving forward with implementing December 1999 tailpipe emissions and low-sulphur fuel standards for light-duty vehicles (Tier 2). These standards, will take effect in 2004 and include new requirements for sport utility vehicles. The new standards will require passenger vehicles to be 77% to 95% cleaner than those on the road today and will reduce the sulphur content of gasoline by up to 90%.

Additional NO_x reductions will be achieved as a result of efforts to meet the National Ambient Air Quality Standards (NAAQS) for ozone (see p. 12) and for PM (see p. 16).

Since 1999, EPA's work with nine northeastern states and the District of Columbia in the Ozone Transport Region to implement a trading program for NO_x, known as the NO_x Budget Program, has led to reductions of NO_x emissions by more than 50% from 1990 levels. In 2001, sources emitted approximately 193,000 tons, 11% below the allocation for that year.

Furthermore, EPA has finalized the NO_x SIP Call to reduce ozone in the eastern United States. This topic is discussed under the Ozone Annex subsection of this report (see pp. 12-13).

MONITORING OF EMISSIONS

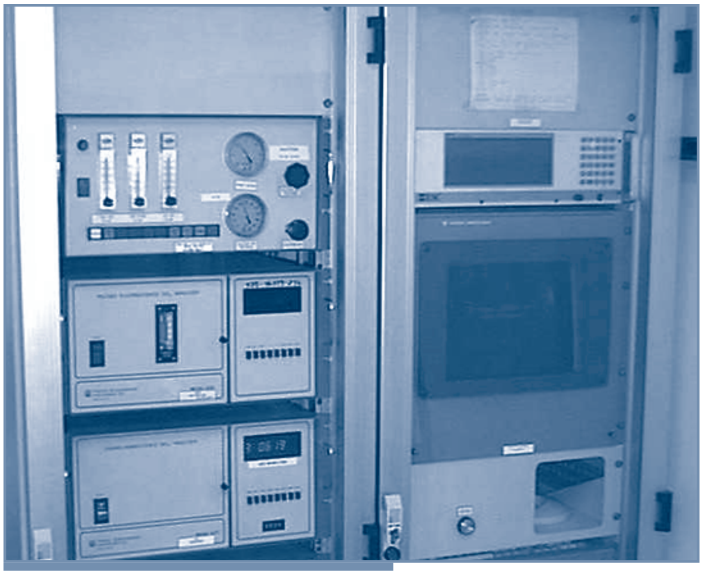
Canadian Commitment

- By 1995, estimate emissions of NO_x and SO_2 from new electric utility units and existing electric utility units greater than 25 megawatts electric (MWe) using a method of comparable effectiveness to Continuous Emissions Monitors (CEMs).
- By 1995, investigate feasibility of using CEMs.
- Work toward comparably effective methods of emission estimation for SO_2 and NO_x emissions from other major stationary sources.

Having met the existing Air Quality Agreement commitments, Canada is studying the use of continuous emissions monitoring (CEMs) in the context of the implementation of market-based control programs such as emissions trading. Under the Ozone Annex, both governments agreed to cooperate and exchange information with respect to their analysis of and experience with market-based mechanisms, including emissions trading. Emission trading programs have been successful in the United States in providing flexibility to industrial emission sources regarding their reduction options while achieving substantial emission reductions and improved ecosystem and human health.

At this time, reviews of CEMs undertaken in Canada have revealed that the Environment Canada 1993 guidelines for CEM systems, "Protocols and Performance Specifications for Continuous Monitoring of Gaseous Emissions from Thermal Power Generation," Report EPS 1/PG/7, compare favourably with the U.S. 40 Code of Federal Regulations (CFR) Part 75 specifications for CEMs in accuracy and precision of data. At the same time, the EPS 1/ PG/7, allows the use of calculations for determining emission flow rather than requiring the installation and use of flow monitors at each industry source. This facilitates an uncertainty that the U.S. Part 75 monitoring requirement would not permit in an emissions trading program.

Furthermore, a U.S. requirement that all industrial sources involved in emissions trading must report their data electronically



CEM monitor for SO_2, NO_x and CO_2

to the U.S. EPA in electronic data report format is not mirrored in Canada.

At this time, the preliminary conclusions of the Canadian reviews are that EPS 1/PG/7-compliant CEM systems in Canada would meet Canadian monitoring requirements for domestic purposes but that these might have to be enhanced to meet the needs of transboundary emissions trading if such a joint program were to be developed in the future.

U.S. Commitment

- By 1995, new electric utility units and existing units greater than 25 MWe operate CEM systems.

CEMs are widely used in the United States. All affected utilities under the Acid Rain Program installed the required CEMs by 1995, and CEMs continue to provide some of the most accurate and complete data collected from utility units. All coal-fired units must use CEMs to measure concentrations of SO_2 and NO_x as well as volumetric flow to determine hourly mass emissions of SO_2 and NO_x. Those natural gas and oil-fired units that do not use CEMs use fuel flow meters and frequent fuel sampling and analysis to determine mass SO_2 emissions for conservative emission factors. These units must also use CEMs with volumetric flow to determine NO_x mass emissions.

Relative accuracy standards for CEMs at Phase I and Phase II units remained at continuing high levels in 2001. These standards were met respectively by 96.7%, 93%, and 99.2% of the SO_2, NO_x, and volumetric flow CEMs. In 2001, availability of data exceeded 99% for coal-fired units and approximately 98% for oil and gas units. In 2001, for the second year, 100% of affected sources were reporting hourly emissions electronically. Electronic reporting allows immediate quality assurance analyses by EPA's Emissions Tracking System, feedback to utilities, and verification of quarterly data compiled from hourly data on SO_2, NO_x, and carbon dioxide (CO_2). Quarterly emissions reports for every affected unit are available to the public on the Internet at www.epa.gov/airmarkets.

Data from CEMs provide the foundation for the SO_2 Allowance Trading Program as well as the NO_x Budget Trading Program and are used to determine compliance with both the SO_2 and the NO_x reduction programs.

PREVENTION OF AIR QUALITY DETERIORATION AND VISIBILITY PROTECTION

Canadian Commitment

- By 1995, develop and implement means (comparable to those implemented in the United States) for prevent air quality deterioration and to ensure visibility protection for sources that could cause significant transboundary air pollution.

Canada

Canada is addressing this commitment to prevent deterioration of air quality and to ensure protection of visibility through the implementation of Canada-wide Standards for PM and Ozone and through the Canada-Wide Acid Rain Strategy for Post-2000.

In addition to achievement of the Standards for PM and Ozone by the 2010 target date, implementation of principles such as pollution prevention, continuous improvement (CI), and keeping clean areas clean (KCAC) are part of the Canada-wide Standards and will prevent the deterioration of air quality and address the pollutants involved in impairment of visibility. The KCAC principle recognizes that polluting "up to a limit" is not acceptable and that the best strategy to avoid future problems is to keep clean areas clean. CI applies in areas with ambient levels below the levels of the standards but still above the levels associated with observable health effects. Jurisdictions are encouraged to take remedial and preventive actions to reduce emissions from anthropogenic sources to the extent practicable. Over the next year, jurisdictions will be cooperatively developing a national guidance document on CI/KCAC.

Federal, provincial, and territorial governments will work with stakeholders over the next several years to establish implementation plans and programs for $PM_{2.5}$ and Ozone Canada-wide Standards that apply pollution prevention and best management practices. These practices could include ensuring that new facilities and activities incorporate the best available economically feasible technologies to reduce PM and ozone levels and reviewing new activities that might contribute to PM and ozone level increases.

The largest contributor from stationary sources is the electric power sector. Therefore, the Government of Canada is taking steps to tighten emission limits for key air pollutants from new fossil fuel power plants. Following consultations with partners and stakeholders, Environment Canada plans to issue revised emission guidelines under the Canadian Environmental Protection Act (CEPA) during fall 2002.

The "Thermal Power Generation Emissions - National Guidelines for New Stationary Sources" are intended to provide national emission standards for application by the provinces to new coal, oil, and gas-fired steam-electric power plants.

The revised guidelines include emission limits for SO_2, NO_x, and total PM consistent with the performance capability of current economically feasible best available technologies. This is based on information from the United States, Germany, and other western European nations on emission requirements being applied to power plants and on the demonstrated performance capabilities of best available technologies in these jurisdictions. In particular, the proposed revisions will align with U.S. standards and best available control technology (BACT) determinations.

U.S. Commitment

- Maintain means for preventing significant deterioration of air quality and protecting visibility as required under the Clean Air Act for sources that could cause significant transboundary air pollution.

The U.S. Prevention of Significant Air Quality Deterioration (PSD) program is designed to protect public health from any adverse effects that might occur from the addition of new sources of air pollution, even at levels lower than the National Ambient Air Quality Standards (NAAQS). The program is also a means of preserving, protecting, and enhancing air quality in Class I areas, such as large national parks and wilderness areas, by assessing impacts on visibility and other air quality-related values before construction permits are issued. These reviews and procedures ensure that economic growth occurs in harmony with the preservation of clean air.

The PSD program sets limits on air quality degradation to ensure that air quality in many areas of the country remains better than levels mandated by the NAAQS. The program establishes three classes of land areas that require BACT for all new sources.

EPA has issued visibility protection rules for federally designated Class I areas. The original rules issued in 1980 focused on the impacts of new and existing "nearby" sources. Regulations issued in 1999 address visibility impairment by many sources located across broad geographic areas. States are now working together in five regional planning organizations to develop strategies to address haze. Individual states will then develop implementation plans designed to achieve "reasonable progress" toward the national visibility goal of no human-caused impairment in the 156 mandatory Class I Federal areas across the country.

Glacier Lake National Park: good to poor visibility day at the same location

Source: National Park Service

States are required to establish goals to improve visibility on the 20% worst days and to allow no degradation on the 20% best days for each Class I area in the state. In establishing progress goals, states must analyze the rate of progress for the next 10-to-15-year implementation period that, if maintained, would achieve natural visibility conditions within 60 years from the baseline period of 2000 through 2004. In addition, State plans must, among other things, include requirements for Best Available Retrofit Technology (BART) on certain large existing sources (or use of an alternative emissions trading program). In 2001, EPA issued draft guidance for implementation of BART requirements, tracking progress, and estimating "natural conditions." A portion of the regional haze rule, the BART provisions, was vacated by the U.S. Court of Appeals for the District of Columbia Circuit in June 2002, although other portions were ratified.

Regional haze plans are due in the 2005 to 2008 time frame for most states. The states and regional planning organizations (RPOs) collected monitoring data and emissions inventory data and assessed regional modelling tools in 2001. (For information on RPOs, see p. 17). Technical assessments will continue for the next few years. One provision of the regional haze rule allows nine Grand Canyon Visibility Transport Commission States (i.e., Arizona, California, Colorado, Idaho, Nevada, New Mexico, Oregon, Utah, and Wyoming) to submit initial plans in 2003 to implement their past recommendations within the framework of the national regional haze program. Many of these states are pursuing that option.

The new regional haze regulations require ambient monitoring representative of each of the Class I areas to track progress toward the U.S. national visibility goal. Required regional haze trend assessments will be based on changes in visibility expressed in deciviews.[6] To facilitate these assessments, the aerosol portion of the Interagency Monitoring of Protected Visual Environments (IMPROVE) visibility network was expanded from 30 to 110 sites in 2001. The expanded network is representative of all Class I areas where monitoring can be practicably implemented. IMPROVE sites are collecting speciated fine particle sampling on a schedule matching that of the ambient air quality monitoring network known as State and Local Air Monitoring Stations (SLAMS) (see section IV, p. 25).

Implementation of the PM and ozone NAAQS, in conjunction with the regional haze program, is expected to improve visibility in urban as well as rural areas across the country. Other air quality programs that are expected to bring about reductions in emissions will also improve visibility. The Acid Rain Program, by achieving significant regional reductions in SO_2 emissions, is expected to reduce sulphate haze, particularly in the eastern United States. The ozone transport reduction rule, or NO_x State Implementation Plan (SIP) Call, which will cut emissions from sources of NO_x to reduce the formation of ozone, should also improve regional visibility to some degree.

In addition, visibility in Class I areas should improve as a result of a number of other programs, including mobile source emissions and fuel standards, certain air toxics standards, and the implementation of smoke management and woodstove programs to reduce fuel combustion and soot emissions. Under the visibility protection program, state and Federal land managers are exploring options for management of smoke from wildfires to help achieve health and visibility requirements.

NOTIFICATION, ASSESSMENT, AND MITIGATION OF SIGNIFICANT TRANSBOUNDARY AIR POLLUTION

Joint Commitment

- Each party shall notify the other concerning a proposed action, activity, or project that would be likely to cause significant transboundary air pollution.

Notification

Canada and the United States have ongoing notification procedures, established in fall 1994, to identify possible new sources and modifications to existing sources of transboundary air pollution within 100 kilometres (km)—62 miles—of the border. Each government is also notifying the other of new sources or modifications of concern beyond the 100 km limit. Since the last progress report, Canada has notified the United States of 6 additional sources, for a total of 26. The United States has notified Canada of 9, for a total of 23. Transboundary notification information is available on the Internet sites of the two governments at:

Canada: www.ec.gc.ca/pdb/can_us/canus_applic_e.cfm
U.S.: www.epa.gov/ttn/gei/uscadata.html

Canada and the United States are reporting significant continuing progress on joint monitoring efforts arising from successful, ongoing consultations on the Boundary Dam Power Station (BDPS), near Estevan, Saskatchewan, and the Algoma Steel Plant, near Sault Ste. Marie, Ontario. In 2000, a binational consultation group of Federal, State, provincial, and BDPS authorities developed a five-year monitoring plan for the Estevan community, an area around the power station on both sides of the border.

SaskPower, the operator of BDPS, is installing electrostatic precipitators (ESPs) on the stacks at the power station over a five-year period beginning in October 1999. By the end of 2001, ESPs were installed and operational at three 150 MW units. The last two

6 A measure of visibility that captures the relationship between air pollution and human perception of visibility. When air is free of particles that cause degradation, the Deciview Haze Index is zero. The higher the deciview level, the poorer the visibility.

66 MW units will be worked on next. Unit 6, which is 300 MW, was originally built with an ESP.

Boundary Dam Power Station

As a result of the installation of ESPs on the power station, the monitoring network will capture changes in air quality before and after the complete installation of this control technology. The first report of ambient air monitoring data from the network will be completed this year and posted on the Internet. Data from 1999 to 2000 showed no exceedance of any ambient air quality standards at any of the sites.

In continuing consultation regarding the Algoma Steel Mill, Canadian and U.S. representatives of the Federal, State, and provincial governments, the Inter Tribal Council in Michigan, the Ontario provincial regional health unit, and the Algoma Steel company met to discuss transboundary issues of concern in the common airshed in October, 2001. Ontario gave a detailed air quality monitoring report for the airshed, using data from both Canada and the United States. There were exceedances of air quality standards for total dustfall and fine particulate on the Ontario side (Bonney St. site near the steelworks). There have been only two exceedances of total dustfall at one site in Sault Ste. Marie, Michigan, and both were the result of road dust and natural sources. So far, the dustfall monitoring results on the U.S. side show only traces of coarse particulate matter (coal, coke, kish, coal soot, iron oxide) normally associated with steel mill/works emissions.

To enhance air quality monitoring in the transboundary airshed and to help develop comparable Canada—U.S. air quality data for use in reporting information to the public, a Canadian and U.S. ambient air quality monitor had been installed earlier in the year at a location downwind of the Algoma Steel plant, at the Lake Superior State College complex in Sault Ste. Marie, Michigan. The installation was reviewed at the October, 2001 meeting. The consultation will continue among the governments and other interested groups within the context of the guidelines set by the Canada—U.S. Air Quality Committee for such discussions.

Assessment and Mitigation

The benefits of progress made by Canada and the United States in assessment and mitigation have continued despite different interpretations of the commitment under the Air Quality Agreement (see 1996 Progress Report and Five-Year Review). Joint intergovernmental information sharing and cooperation between the United States and Canada continue, as demonstrated by Windsor—Detroit issues such as the Minergy proposal and the Detroit Incinerator permit. For example, when the Detroit Incinerator permit was under review for Title 5 requirements, both countries, including Federal, State, and provincial representatives, participated in a joint teleconference call to exchange information on the facility and on the results of air quality studies that had been completed in the study area surrounding the incinerator. The teleconference call concluded with the creation of joint information distribution lists for the Windsor—Detroit notification area.

The United States has continued to improve and update the electronic database—The Emissions and Generation Resource Integrated Database (E-GRID)—that reports publicly available emissions and generation data for virtually every power plant and company that generates electricity in the United States. E-GRID was initiated in 1999 in response to the Federal Energy Regulatory Commission's adoption of the open access transmission policy and Canada's concerns about possible increased transboundary flow of emissions. The current version, E-GRID 2000, reports plant-specific emissions and emission rates for mercury for the first time. E-GRID 2002, which is expected to be available in the latter part of 2002, will create an interactive on-line version allowing data to be more easily accessed. The E-GRID Web site is located at www.epa.gov/airmarkets/egrid.

Ozone Annex

OVERVIEW

The Ozone Annex to the Air Quality Agreement was signed by Canada and the United States in December 2000 in Washington, D.C. (See Appendix B for complete text.) The Annex is expected to result in significant reductions of emissions of NO_X and VOCs, the precursor pollutants to ground-level ozone, the major component of smog. It defines a transboundary region in each country most associated with flows of ozone pollution. In Canada, the region includes central and southern Ontario and southern Quebec (more than 50% of Canada's population). In the United States, the region covers 18 states and the District of Columbia (approximately 40% of the U.S. population).

The Annex commits to emission reductions from the major sources of NO_X and VOCs, thereby helping both countries attain their air quality goals to protect human health and the environment. These key reduction commitments are summarized below. In addition, the monitoring and reporting requirements in the Annex commit the Parties to reporting annual emissions from major source categories beginning in 2004; reporting ambient air quality within 500 km of the border between Canada and the lower 48 U.S. states beginning in 2002; improving public access to information on emissions and air quality; and consulting and sharing respective information on data, tools, and methodologies and developing joint analyses on ground-level ozone and precursors. The Annex also requires the Parties to revisit the agreement in 2004 to review progress in implementing their respective commitments, with a

view to negotiating further reductions. At the same time, Parties can add new transboundary regions.

KEY EMISSION REDUCTION COMMITMENTS

Canada

Canada estimates that total NO_x reductions in the Canadian transboundary region will be 44% year-round by 2010.

- Aggressive annual caps by 2007 of 39 kilotonnes (kt) of nitrogen dioxide (NO_2) emissions from fossil-fuel power plants in central and southern Ontario and 5 kt of NO_2 in southern Quebec aligned with U.S. standards year-round.
- New stringent emission reduction standards regulated to align with the United States to reduce NO_x and VOCs from vehicles and fuels including cars, vans, light-duty trucks, off-road vehicles, small engines, diesel engines, and fuel.
- Measures required to attain the Canada-wide Standard for Ozone to address NO_x emissions from industrial boilers and to address VOCs emissions from solvents, paints, and consumer products.

United States

The United States estimates that the total NO_x reductions in the U.S. transboundary region will be 36% year-round by 2010 and 43% during the ozone season.

- The NO_x emission reduction program, known as the NO_x SIP Call, is expected to reduce summertime NO_x emissions in the U.S. transboundary region by about 35% in 2007. EPA expects that this will be achieved by a more than 70% reduction in summertime emissions from power plants and major industrial sources.
- NO_x and VOC reductions are associated with existing U.S. vehicle and fuel quality rules and standards for new and modified stationary sources. VOC reductions are associated with standards for stationary sources of hazardous air pollutants, consumer and commercial products, architectural coatings, and automobile repair coatings.

DOMESTIC PROGRESS AND UPDATES

Joint Efforts

The Ozone Annex commits Canada and the United States to reporting ozone, VOC, and NO_x ambient air concentrations within 500 km of the border. The two governments are meeting this commitment. Air quality reporting data is provided on pages 26-28 and in Appendix C, pages 56-58.

Canada

In February 2001, the Canadian government announced an implementation plan and a funding package toward the costs of implementing measures committed in the Annex (http://www.ec.gc.ca/press/2001/010219_n_e.htm). The highlights of the package include the following measures:

- Canada will implement new emissions standards for vehicles and engines and the fuels that power them over the next four years.
- Environment Canada will expand and refurbish federal and provincial networks of air quality monitoring stations across Canada in the next five years.
- Canada will expand the National Pollutant Release Inventory (NPRI) in 2002 to include annual public reporting of precursors of ground-level ozone and components of smog such as NO_x, VOCs, SO_2, PM_{10}, $PM_{2.5}$, and CO.
- Canada has committed further investments toward industrial programs to reduce NO_x and VOC emissions from industrial sectors and to address regional risk analyses to characterize major sources of smog in Canada and assess progress to meet the Canada-wide Standards with modelling of transboundary air pollution.

Since 2000, Canada has made progress in meeting all of the commitments included in the Ozone Annex.

Vehicles, Engines, and Fuels

The Sulphur in Gasoline Regulations were passed on June 23, 1999. Starting in 2005, low-sulphur gasoline will be required throughout Canada. Low sulphur gasoline has an average sulphur level of less than 30 parts per million (ppm). As an interim step, starting in July 2002 gasoline with an average sulphur level of not more than 150 ppm will be required.

The proposed Sulphur in Diesel Fuel Regulations were published in the *Canada Gazette*, Part I, on December 22, 2001. A 15-ppm maximum limit for on-road diesel fuel sulphur content is proposed to come into effect in 2006. This standard will enable new technology that will be used in heavy-duty on-road vehicle engines to meet emission control standards that come into effect in 2007. The final regulations are being developed for publication in the Canada Gazette, Part II, in early fall 2002.

The proposed On-Road Vehicle and Engine Emission Regulations were published in the *Canada Gazette*, Part I, on March 30, 2002 and had a 60-day comment period. A final regulation will be developed for implementation in the 2004 model year. The proposed regulations align Canadian emission standards for on-road vehicles and engines with the Tier 2 levels in the United States

The On-Road Vehicle and Engine Emission Regulations are the first of a series of planned regulations for vehicles and engines. Off-road vehicles and engines are being addressed for the first time in Canada, and a discussion draft of the Small Spark Ignition Engine Emissions Regulations is the subject of consultation with major stakeholders before formal proposal in the *Canada Gazette*, Part 1, scheduled for fall 2002. These proposals will be followed by proposals for off-road diesel engines, marine engines (outboards and personal watercraft), large spark ignition engines (engines above 19 kW), and recreational vehicles (such as snowmobiles and ATVs).

The proposed regulations are consistent with Environment Minister David Anderson's 10-year Plan of Action for Cleaner Vehicles, Engines and Fuels announced on February 19, 2001. The plan includes Canadian emission standards for vehicles and engines aligned with those of the United States in EPA measures targeted at improving the quality of diesel fuels and gasoline.

Pending the final implementation of the proposed vehicle and engine regulations, memoranda of understanding have been signed with automobile and engine manufacturers covering on-road vehicles and selected categories of off-road engines. The memoranda provide for vehicles and engines for the Canadian market to have the same emission controls as those for the U.S. market. In the case of on-road vehicles, the memorandum of understanding complements existing emission regulations under the Motor Vehicle Safety Act.

With respect to fuels, Canada is proposing to reduce sulphur in fuel oils with the view to matching the requirements set by the European Union (1% by weight sulphur in heavy fuel oil and 0.1% by weight sulphur in light fuel oil). Once implemented, this initiative will result in the reduction of SO_2 and wet sulphate deposition concentrations, mostly in eastern Canada.

Stationary Sources of NO_x Emissions

Canada will comply with its commitment to achieve a 39 kt NO_2 emission cap in the Ontario portion of the Pollutant Emission Management Area (PEMA) by 2007 from fossil fuel-fired electricity generators with capacities larger than 25 megawatts.

New regulated electricity sector emission caps in Ontario took effect January 1, 2002. At the same time, the province introduced an emission reduction trading system, a new environmental

assessment regulation for electricity sector activities, and requirements for Lakeview Generating Station to cease burning coal by April 2005.

Discussions are underway between the federal government and the Quebec provincial government regarding compliance with the commitment to cap NO_2 emissions in the Quebec portion of the PEMA at 5 kt by 2007.

On December 8, 2001, Canada published a notice in the Canada Gazette initiating a public comment period on the proposed Renewable Low-Impact Electricity Guideline, the purpose of which is to update criteria under s.54 of CEPA, 1999, for the certification and labelling of renewable low-impact electricity under the government's Environmental Choice Program. The Government of Canada has committed to purchase, by 2006, 20% of its electricity consumption as emerging renewable low-impact electricity having an acceptable environmental certification.

Sources of VOCs

Paints, solvents, and other industrial, commercial, and consumer products are major sources of VOCs that contribute significantly to air pollution. A 10-year federal agenda is being developed to reduce VOCs emissions from consumer products and from paints, solvents, and other products used in industrial and commercial processes. Development of foundation information is being completed and includes an analysis of U.S. measures, refinement of inventory information, and a review of temporal factors relating to VOCs emissions from solvents. Proposed elements of the agenda are taking shape and will be discussed with affected stakeholder groups starting in spring 2002. Broad multi-stakeholder consultations will begin in fall 2002 with the distribution of a discussion document outlining all elements of the proposed federal agenda. A multi-stakeholder workshop is scheduled for early 2003, and consultations will wrap up by the end of 2003. Following these consultations, the measures for the federal agenda will be finalized and published as a Notice of Intent in the *Canada Gazette*, Part I.

In addition, Canada is developing two regulations that will reduce VOCs: The Degreasing Regulation is currently being reviewed and publication in the *Canada Gazette* is anticipated in 2002. The Dry Cleaning Regulation was published in the *Canada Gazette* I on August 18, 2001 and is expected to come into force later in 2002 with the publication of the *Canada Gazette* II notice.

Measures for NO_x Emissions based on Multi-Pollutant Emission Reduction Strategies

Certain industrial sectors will be important contributors to the achievement of the Canada-wide Standards for PM and Ozone. Canada is preparing foundation analysis reports for key sectors: pulp and paper, lumber and allied wood products, concrete batch and asphalt mix, base metal smelting, and iron and steel. The information is being prepared in consultation with provinces and stakeholders and is expected to be completed by fall 2002. The reports will contain a description of the sector, emissions released, performance standards, available pollution prevention and control techniques, and preliminary analyses of technically feasible emission reduction options. Provinces and territories will use the reports in preparing their implementation plans.

Quebec

The Province of Quebec made progress in meeting its commitments in the Ozone Annex. Amendments to Le Règlement sur la qualité de l'atmosphère du Québec ("Québec's Regulation respecting the Quality of the Atmosphere") have been proposed to reduce NO_x emissions from new and modified industrial and commercial boilers in accordance with the Canadian Council of the Ministers of the Environment (CCME) code and measures requiring the replacement of burners on an existing unit by low NO_x burners. The proposed amendments also include measures to reduce VOC emissions from surface coatings, commercial printing, dry cleaning, and above-ground storage tanks.

Currently, Quebec is implementing the existing Règlement sur les produits pétroliers du Québec ("Quebec's Regulation on Petroleum Products") concerning gasoline volatility for the summer months in the Montreal Urban Community's territory and for the Hull-Pointe-aux-Trembles part of the Windsor—Quebec corridor with a mandatory initiative for lower gasoline volatility.

With respect to amendments to "Quebec's Regulation on Petroleum Products" to reduce VOC emissions from gasoline distribution networks, Quebec has implemented a mandatory program for the Montreal Urban Community territory. The regulation will address stage I initiatives including gasoline storage and transfer depots for new installations in the Windsor—Quebec corridor and for existing installations in the Hull-Pointe-aux-Trembles part of the Windsor—Quebec corridor.

Ontario

Ontario has made progress toward its commitments under the Ozone Annex. The province's Drive Clean program is expected to reduce CO2 emissions by 100,000 tonnes once fully implemented and has already achieved a reduction in smog-causing pollutants of 11.5% in the first phase. Drive Clean initially applied to owners of designated passenger and light-duty vehicles registered in the Greater Toronto Area (City of Toronto and the regions of Halton, Peel, Durham, and York), the City of Hamilton, and other urban centres and their commuting zones from Peterborough to Windsor. On July 1, 2002, the program expanded across southern Ontario's smog zone and now includes vehicles registered in centres such as Ottawa, Kingston, and Cornwall in eastern Ontario and Chatham-Kent in southwestern Ontario.

Stage II of the vapour recovery regulation is not required at this time, since new vehicles now have an onboard canister for collecting vapour during filling. Similarly, Ontario has been implementing its regulation of volatility of gasoline at 9 pounds per square inch (psi) during the summer months in southern Ontario and 10.5 psi in northern Ontario for a number of years. No additional activities are required at this time. The Ontario Ministry of the Environment is currently updating the Dry Cleaners Operators course to provide comprehensive environmental training for dry cleaners.

Ontario has also implemented the CCME guidelines on turbines and boilers and the CCME guideline for new and modified commercial/industrial boilers and heaters.

The Ozone Annex calls for a regulation (Ontario Environmental Protection Act Regulation 227/00) to be applied to the electricity sector requiring annual monitoring and reporting of 28 pollutants of concern along with a commitment to extend the monitoring requirements to other industry sectors. Regulation 127/01, effective May 1, 2001, covers 358 pollutants and applies to electricity, industrial, commercial, and institutional facilities.

United States

Revised Ozone Standards

The revised ozone[7] and PM standards (for PM, see section III, p. 16) had been challenged in 1997 by various industry groups, based in part on the claim that the EPA interpretation of the Clean Air Act in setting these standards represented an unconstitutional delegation of authority. In February 2001, the U.S. Supreme Court upheld the constitutionality of the Clean Air Act as EPA had interpreted it,

[7] The revised primary (health-based) and secondary (welfare-based) ozone standards are based on 8-hr average ozone concentrations to protect against longer exposure periods of concern for human health and the environment. The 8-hr ozone standards are set at a level of 0.08 ppm and are met when the three-year average of the annual fourth highest daily maximum 8-hr concentration is less than 0.08 ppm.

reversing a 1999 opinion issued by the U.S. Circuit Court of Appeals for the District of Columbia and reaffirmed that EPA must set air quality standards at levels necessary to protect public health and welfare without consideration of economic cost. In March 2002, the U.S. Circuit Court of Appeals for the District of Columbia rejected all remaining challenges to EPA 1997 8-hr ozone standard relating to whether the standards were arbitrary and capricious by unanimously finding that EPA engaged in "reasoned decision-making" in establishing the standard. In its initial 1999 decision, however, the court directed EPA to consider any potential beneficial health impacts from ground-level ozone. EPA's proposed response to this directive was published on November, 2001, in the *Federal Register*. The directive concluded that no revision to the 8-hr ozone standard was warranted. A final response is anticipated in August, 2002.

8-Hour NAAQS Implementation

EPA plans to propose an implementation program in July 2002 and take final rulemaking action on designating areas for the eight-hour (8-hr) standard a year later. EPA plans to designate 8-hr ozone nonattainment areas in mid-2004. EPA has posted a variety of materials regarding implementation options on the following website: www.epa.gov/ttn/rto/ozonetech/o3imp8hr/o3imp8hr.htm

The Ozone Transport Reduction Rule and Related Actions

In September 1998, EPA finalized the Ozone Transport Reduction Rule, known as the NO_X SIP Call, which addresses the regional transport of ground-level ozone. By improving air quality and reducing NO_X emissions, the actions directed by the required state SIPs will decrease the transport of ozone across state boundaries in the eastern half of the United States. The final rule does not mandate which sources must reduce pollution; states will have the ability to meet the rule's requirements by reducing emissions from the sources they choose. However, utilities and large non-utility point sources would be the most likely sources of NO_X reductions. The final rule includes a model NO_X Budget Trading Program which will allow states to achieve more than 90% of the required emissions reductions in a highly cost-effective way.

EPA's final action was subject to legal challenge by a number of parties. In March 2000, the U.S. Court of Appeals for the District of Columbia Circuit issued a 2-to-1 ruling in favour of EPA on all major issues associated with the NO_X SIP Call. The court remanded several issues to EPA for further consideration. As a result, EPA split the NO_X SIP Call into two phases. Nineteen states and the District of Columbia (D.C.) are now required to submit SIPs under Phase I.[8] (The original NO_X SIP Call included the 19 states and Wisconsin, Georgia, and Missouri.) The rule now requires emission reduction measures to be in place by May 2004. As of June 2002, EPA has published final approval for SIPs submitted by 15 states–Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Maryland, Alabama, Delaware, Pennsylvania, Illinois, Indiana, Kentucky, West Virginia, South Carolina, and the District of Columbia.

Phase I is expected to achieve 90% of the emission reductions required under the original NO_X SIP Call. Phase I will reduce total summertime NO_X emissions in the affected 19 states and the District of Columbia by about 23% from 1996 levels (approximately 900,000 tons) beginning in 2004. This will help reduce ozone levels in the remaining nonattainment areas east of the Mississippi River.

EPA issued a proposed rulemaking addressing the issues remanded by the court (Phase II of the NO_X SIP Call) in February, 2002 and expects to complete the final action later in 2002. The EPA proposal addresses definitions for electric generating units and nonelectric generating units, the control level for stationary internal combustion engines, how cogenerators should be included, emission limits for Georgia, Missouri, Alabama, and Michigan, the removal of Wisconsin from the SIP Call, and due dates for Phase II for all affected states.

In January 2000, EPA issued the Section 126 Rule for the purpose of reducing the interstate transport of ozone. EPA developed this rule in response to petitions from eight states asking that EPA find that NO_X emissions from certain utilities and other industrial sources in 30 upwind states and the District of Columbia are significantly contributing to their ozone nonattainment problems. EPA partially granted petitions from Connecticut, Massachusetts, New York, and Pennsylvania under the 1-hr ozone standard.[9] As

8 The 19 states are Alabama, Connecticut, Delaware, Illinois, Indiana, Kentucky, Massachusetts, Maryland, Michigan, North Carolina, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, South Carolina, Tennessee, Virginia, and West Virginia.

9 All eight petitioning states (Connecticut, Maine, Massachusetts, New Hampshire, New York, Pennsylvania, Rhode Island, and Vermont) requested findings under the 1-hr ozone standard. EPA denied petitions for the one-hour standard filed by Maine, New Hampshire, Rhode Island, and Vermont because these states no longer had areas that were not attaining the 1-hr standard. Five states also requested findings under the 8-hr standard. For each petition, EPA made separate technical determinations for the 1-hr and 8-hr ozone standards. EPA has stayed its action under the 8-hour standard.

a result, 392 facilities, located in 12 states and the District of Columbia, will have to reduce ozone season NO_X emissions by a total of about 510,000 tons from projected 2007 levels. All of the sources affected by the Section 126 Rule are located in states subject to the NO_X SIP Call. EPA promulgated a Federal NO_X Budget Trading Program as the control remedy. This trading program is integrated with the trading program that states may choose to adopt to meet the NO_X SIP Call requirements.

The Section 126 Rule was also legally challenged by a number of parties. The court subsequently suspended the compliance deadline for the majority of sources subject to the rule until EPA resolved one of the remanded issues related to emissions growth factors. The administrator signed the EPA response to that remand in April , 2002, at which time EPA established a new compliance date of May 2004. EPA is coordinating the two ozone transport rules such that if a state controls its transported NO_X emissions under the NO_X SIP Call, EPA will withdraw the requirements for sources in that state under the Section 126 Rule.

Other Regulatory Efforts

Other NO_X reductions under the ground-level ozone provisions of the CAAA that are expected to significantly lower future emission levels—the heavy-duty diesel rule, Tier 2, and vehicle fuel standards—are reported in section II, p. 4 as part of mobile sources regulatory efforts. In addition, EPA is implementing rulemaking on smaller sources of VOCs, including consumer and commercial products, that contribute approximately 28% annually to VOC emissions for areas in the United States that do not meet the ozone NAAQS. VOC, along with NO_X, are the major contributors to ground-level ozone.

Under EPA's final rules issued in 1998 and effective in 1999, the following VOC reductions were achieved: consumer products, 20% from 1990 emission levels; architectural and industrial maintenance coatings, 20% from 1990 levels; and automobile refinishing coatings, 33% from current levels.

State Efforts

Attainment Demonstrations

The Clean Air Act requires each state containing an area designated nonattainment for ozone to submit an attainment demonstration plan to meet the ozone standard. EPA recently approved attainment demonstration plans for 10 major urban areas: Atlanta, Baltimore, Houston, New York, Philadelphia, Chicago, Milwaukee, western Massachusetts, greater Connecticut, and Washington, D.C. Attainment demonstrations for these areas will involve 13 states and the District of Columbia.

The Clean Air Act specifies certain measures that must be adopted in nonattainment areas—reasonably available control technology on major sources and vehicle inspection and maintenance, for example; however, each state can choose the additional measures needed for attainment. The rulemaking action for each plan provides details of the control measures the plan relies upon.

Northeast Ozone Transport Region

The 1990 Clean Air Act Amendments established the Northeast Ozone Transport Region (OTR) and the Ozone Transport Commission (OTC) in recognition of long-standing regional ozone problems in the northeastern United States. The OTC comprises the governors or their designees and an air pollution control official from Connecticut, Delaware, Maine, Maryland, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, and the District of Columbia. Administrators for three northeastern EPA regions also participate. The purpose of the OTC is to assess the formation and transport of ground-level ozone in the OTR and develop strategies for mitigating the interstate pollution.

The OTC states have decided on a number of steps to reduce regional ozone pollution; for example, they have agreed to significantly reduce NO_X emissions throughout the region from large stationary sources such as power plants and other large fuel combustion sources using market-based approaches. This program is expected to reduce 1990 baseline emissions by 52%. The OTC has developed several model rules for states to adopt to control VOC and NO_X emissions and has also focused on reducing emissions from mobile sources.

Additional Air Quality Programs

This section focuses on the expanding cooperative efforts the United States and Canada have undertaken and the progress they have made on air quality issues, including particulate matter (PM). Other air quality efforts undertaken internationally, through provincial—state cooperation and public/private partnership, are also reported.

COOPERATION ON PARTICULATE MATTER

Cooperative Efforts

Canada and the United States have continued their cooperative efforts to address PM as an outgrowth of the Joint Plan of Action signed in April 1997 by the environmental ministers and the ministers' 1998 report characterizing transboundary issues. Over the past two years, the two governments have undertaken cooperative modelling, monitoring, and data analysis and developed a work plan to characterize transboundary contributions of PM. Their objective is to issue a report on transboundary PM issues by the end of 2003 that will be the focus of decision-making on whether to develop a PM annex to the Air Quality Agreement (for more detail, see section IV, p. 28).

DOMESTIC PROGRAMS TO ADDRESS PARTICULATE MATTER

Canada

Federal Initiatives

The federal government of Canada has identified clean air as a national priority. In May 2000, Canada announced the development of a Clean Air Agenda aimed at improving air quality in Canada and reducing negative impacts on human health and the environment. The federal government's action on PM_{10} and ozone is one of a number of immediate and long-term efforts developed under the Clean Air Agenda.

In May 2001, the federal government added PM_{10} to the List of Toxic Substances in Schedule 1 of the Canadian Environmental Protection Act 1999 (CEPA 1999). Efforts are also being undertaken to address the precursor pollutants to PM and ozone. In July 2000 and June 2001, respectively, the federal government announced its intention to recommend to the Governor in Council that the principal precursors to PM (SO_2, NO_x, VOCs, and NH_4) and ozone and its precursors (NO_x and VOCs) be added to Schedule 1 of CEPA. These announcements launched 60-day periods during which interested parties had the opportunity to provide the ministers of Environment and Health with comments regarding the proposals. The comments are currently being considered by the ministers prior to their recommendation to the Governor in Council, which will initiate an additional 60-day comment period under CEPA. In April, 2001, the federal government of Canada published its Interim Plan 2001 on Particulate Matter and Ozone which outlines the initial strategies the government will pursue to reduce levels of PM and ozone and meet the targets agreed to under the Canada-Wide Standards process.

Specific areas identified for action in the Interim Plan include transportation and petroleum fuels as well as stationary sources. The plan also provides for further scientific research and analysis of the smog problem, better ambient air monitoring and reporting, and public education.

Furthermore, Canada is expanding the National Pollutant Release Inventory (NPRI) in 2002 to require industries to report on their emissions of several criteria air contaminants, including PM, NO_x, SO_2, and VOCs, and, under the Interim Plan, Canada is also implementing multi-pollutant emission reduction strategies for key industrial sectors.

Provincial/Regional Air Management Initiatives

British Columbia

British Columbia (BC) continues to identify PM and ozone as key air quality issues and to work actively with other levels of government to address them. A separate section of this report addresses the Canada—U.S. Georgia Basin Initiative, which provides a context for actions in the Canadian portion of this airshed (referred to as the Lower Fraser Valley). See p. 19.

The Lower Fraser Valley Air Quality Coordinating Committee actively coordinates the efforts of the federal and provincial environmental agencies with those of the Greater Vancouver Regional District (GVRD) and Fraser Valley Regional District (FVRD), each of which has an air quality management plan aimed at maintaining and improving air quality in the region. The committee also provides a mechanism for informal coordination with the Northwest Air Pollution Authority (the local air quality authority for Whatcom County in Washington State). The GVRD has been delegated provincial powers for air quality management (one of only two such regional agencies in Canada), and the FVRD has been delegated planning powers for air quality. Detailed information on air quality management efforts in both regions can be found at www.gvrd.bc.ca/services/air/index.html and www.fvrd.bc.ca/home.html.

The Lower Fraser Valley coordinating mechanism has been effective in cooperatively addressing a number of issues, including an assessment and update of BC's AirCare light-duty vehicle inspection and maintenance program; an evaluation of the mandatory AirCare OnRoad testing program for heavy-duty diesel vehicles; and a joint technical assessment of major new sources such as the Sumas 2 power generation proposal, including an inter-agency air quality report.

In transportation, BC remains committed to adopting the U.S. Tier 2 new vehicle standards, preferably by harmonizing them with national standards; BC is providing a fuel tax exemption to encourage the use of natural gas, propane, and high-level alcohol blends to help reduce emissions related to smog, fine particle formation, and greenhouse gases. BC has also established a Voluntary Scrapping of Older Vehicles Program (SCRAP) which provides financial incentives to take older polluting vehicles off the road and, in addition, provides support to enhanced transit under a province-wide cost-sharing program for cycling infrastructure and a network of high-occupancy vehicle lanes in the Greater Vancouver area.

Provincial efforts are currently focused on improving understanding of $PM_{2.5}$ sources and levels and developing a framework for airshed planning that can be applied to threatened airsheds and to helping keep clean areas clean.

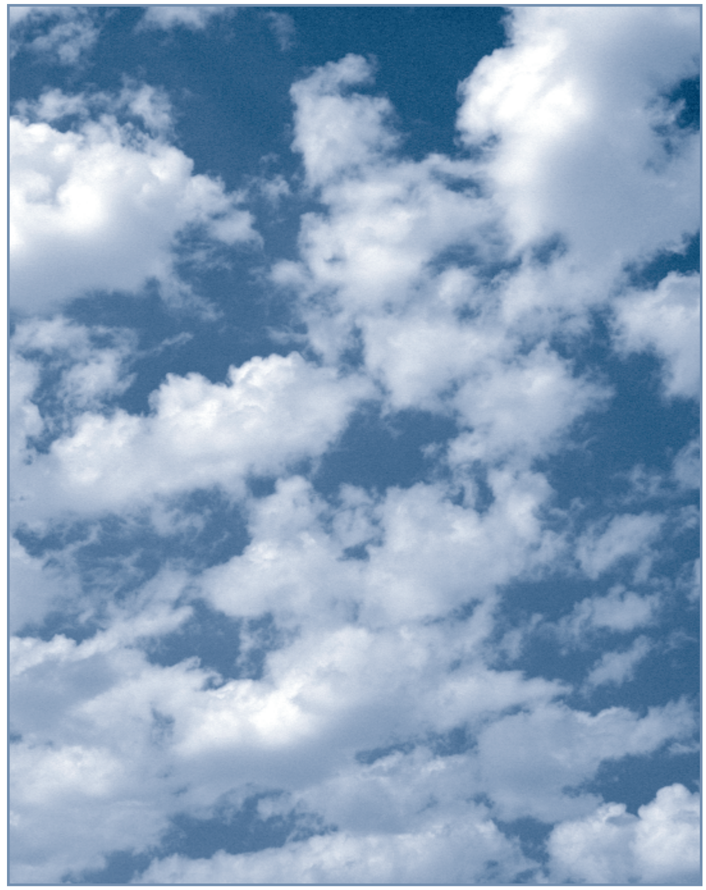
Nova Scotia

Nova Scotia released an Energy Strategy in December 2001 that includes commitments to reduce emissions of SO_2 and NO_x and to promote the production of renewable energy. The province has committed to a 25% reduction of its existing SO_2 cap, to 142,000 tonnes, by 2005 and has a 2010 target of reducing SO_2 emissions from existing sources by 50% to 94,500 tonnes. The gap between the emission target for existing sources and the 142 kt target established in 2005 is to establish a reserve that could be used to reduce the cap if further studies show that such a reduction is necessary. In addition, the reserve could be used to provide room for new facilities (i.e., related to Nova Scotia's growing offshore industry) without compromising the environment. All new facilities will be expected to operate using best available, proven technologies to minimize emissions. The province has also committed to a 20% reduction from 2000 NO_x levels by 2009.

The Energy Strategy also includes a short-term renewable energy target totalling 2.5% of Nova Scotia Power's current generation capacity. This target will be monitored for three years, at which time a longer term mandatory renewable energy portfolio standard will be established.

Ontario

Ontario has committed to reducing the province's SO_2 emissions 50% beyond the Countdown Acid Rain Program cap of 885 kt per year by 2015 under the strategy. Under the Anti-Smog Action Plan (ASAP), Ontario committed to reducing NO_x and VOC emissions by 45% below 1990 levels by the year 2015.



Ontario announced several other initiatives during the 2001-2002 period, including those presented in section I, under the Ozone Annex (see p. 11), and the following:

- Consultation is ongoing for a "Clean Air Plan for Industry" to develop options for addressing NO_x and SO_2 reductions from selected industry sectors. This could include emission caps for major industrial emitters, including sectors such as pulp and paper, cement, iron and steel, petroleum refineries, chemicals, and non-iron metal smelters.
- The Ontario government has also proposed to consult on reducing the sulphur content in fuel oil and coal used by industry, commercial, institutional, and residential sources to further reduce provincial sulphur dioxide emissions.
- Ontario will continue to work with the federal government and Ontario stakeholders to adopt process-specific CCME "codes of practice" for VOC, a key component of smog.
- In 2002 Ontario will revise an order to Inco and Falconbridge to reduce the allowable limits of annual emissions of SO_2 by 34% by 2007.

Quebec

Since 1998, the Communauté Urbaine de Montréal (Montreal Urban Community), the Département de santé publique de Montréal–centre (Department of Health - Montreal Centre), and Environment

Canada have been working together to determine the impact of wood heating on air quality in a residential neighbourhood. The results will be used to help develop a Quebec-wide educational campaign to improve wood stove use to reduce emissions of pollutants in general and of fine particulate matter ($PM_{2.5}$) in particular.

In 1994, Environment Canada, the Ministère de l'Environnement du Québec (Quebec Ministry of the Environment), the Département de santé publique du Québec (Quebec Department of Public Health), and the Communauté Urbaine de Montréal, now the City of Montreal, established the INFO-SMOG program as a way of advising the public to limit its activities and take measures to reduce smog-producing emissions on days when ozone levels are high. The program has been extended to the entire southwestern part of Quebec.

Through a partnership among two industry associations in the Montreal area, the Ministère de l'Environnement du Québec, and Environment Canada, a 60% drop in benzene and a 40% drop in VOCs were measured in the ambient air, the results of voluntary adjustments to equipment in Montreal refineries, the introduction of gasoline vapour recovery equipment as required by municipal by-laws, and the reduction of benzene content and the gasoline dispensing flow rate, as required by regulations enacted under the Canadian Environmental Protection Act.

In addition, partnerships (EnviroclubMO) have been formed between small and medium-sized manufacturing companies to demonstrate the benefits of pollution prevention and help them implement a technical source reduction program. In 2001, 18 small and medium-sized enterprises (SMEs) joined EnviroclubMO, and the environmental results have been highly encouraging, consisting of a 4,396 kilogram (kg) drop in VOCs emissions and a 59,117 tonne drop in greenhouse gas emissions.

United States

Revised PM Standards

In July 1997, EPA established revised national ambient air quality standards for PM and ozone (for ozone, see section II, p. 12), having concluded in the last reviews of these standards that further protection from adverse health effects was needed. Two new $PM_{2.5}$ standards were added to provide protection from fine particles. New annual and 24-hour primary $PM_{2.5}$ standards were set at 15 micrograms per cubic metre ($\mu g/m^3$) and 65 $\mu g/m^3$, respectively. Secondary $PM_{2.5}$ standards were made identical to the primary standards and will be implemented in conjunction with a revised visibility protection program to address regional haze in Federal Class I areas. EPA is currently conducting the next periodic review of the PM standards, which is now targeted for completion in late 2003/early 2004.

In 1997 various industry groups and others challenged the revised PM (and ozone) standards, in part based on the claim that the EPA interpretation of the Clean Air Act in setting the standards represented an unconstitutional delegation of authority. In February 2001, the U.S. Supreme Court upheld the constitutionality of the Clean Air Act as EPA had interpreted it, reversing a 1999 opinion issued by the U.S. Circuit Court of Appeals for the District of Columbia, and reaffirmed that EPA must set air quality standards at levels necessary to protect public health and welfare without consideration of economic cost. On March 26, 2002, the U.S. Circuit Court of Appeals for the District of Columbia rejected all remaining challenges to the EPA 1997 revised PM standards relating to whether those standards were arbitrary and capricious by unanimously finding that EPA engaged in "reasoned decision making" in establishing those standards.

As a result of the court decisions, EPA is continuing to implement the 1987 PM_{10} NAAQS and will begin the process of designating areas that do not meet the 1997 $PM_{2.5}$ NAAQS this year. Implementation of the PM_{10} NAAQS means continuing to apply the regulatory and statutory requirements of the 1990 Clean Air Act to existing PM_{10} nonattainment and attainment areas. This includes requiring additional emission reductions and establishing new attainment dates in nonattainment areas. The latest attainment date that can be established under the Clean Air Act is December 31, 2006. For those PM_{10} nonattainment areas that have attained the NAAQS, EPA continues to encourage states to pursue redesignation to attainment to ensure that the NAAQS can be maintained into the future. For attainment areas, EPA wants to ensure that attainment of the NAAQS is maintained and that existing regulatory programs remain in place unless a persuasive demonstration is made that would allow the state to modify existing requirements.

In conjunction with state and local agencies, EPA began ambient monitoring of $PM_{2.5}$ in 1999 (see pp. 29 and 31) and will have three years (1999–2001) of quality assured $PM_{2.5}$ air quality data by the summer of 2002 for many areas in the United States. The first step in the implementation process will be to designate geographic areas within the United States as attainment, nonattainment, or unclassifiable according to their air quality data and other factors. Preliminary analyses of the data show that areas not meeting the $PM_{2.5}$ standard are likely to be located primarily across a broad region of the eastern United States and in California. States have up to one year (by the summer of 2003) to make recommendations regarding attainment and nonattainment areas using the first three years of data. EPA will then proceed to finalize designations by the summer of 2004.

Based upon the final EPA designations, states will have up to three years (summer 2007) to submit SIPs, which will outline the control strategies necessary to attain the NAAQS. Attainment of the NAAQS is to be as expeditious as practicable but no later than five years from the date of designation, or summer 2009. If the state is unable to demonstrate attainment by summer 2009, then EPA can extend the attainment date up to another five years to summer 2014. Similarly, for the 2000-2002 data, EPA expects to have three years of complete quality-assured $PM_{2.5}$ data for the entire United States in the summer of 2003; that states will make

designation recommendations in the summer of 2004; and that EPA will finalize those designations in late 2004.

Since $PM_{2.5}$ is a regional problem, the United States is concerned about the issue of interstate transport. Under the Clean Air Act, the SIP for any state must demonstrate that sources within the state do not contribute significantly to violations of the $PM_{2.5}$ NAAQS in another state. Therefore, EPA will begin work shortly on an analysis of the regional transport of $PM_{2.5}$ that may be used to support development of a rule to address the interstate transport of $PM_{2.5}$ and its precursors. EPA expects to begin technical analyses to support the rule in 2003, with completion of the technical work in 2004 and proposal of the rule in 2005-6. This rule is expected to go forward whether or not President Bush's Clear Skies Initiative (see p. 20) is enacted in legislation and will provide reductions needed to ensure attainment of the $PM_{2.5}$ NAAQS.

Implementation of PM SIP programs as well as current plans to develop a regional haze rule to return visibility in Class I areas to natural conditions (see pp. 6-7). are very closely related and will enhance efforts to improve visibility throughout the country. Many of the milestones in the regional haze rule are triggered by the designation process for $PM_{2.5}$.

Regional Haze/Regional Planning Organizations

Since the pollutants that lead to regional haze can originate from sources located across broad geographic areas, EPA has encouraged the states and tribes across the United States to address the impairment of visibility from a regional perspective. Congress provided the first funding in 1999 to establish RPOs to address regional haze on a multi-state level, rather than state-by-state. Five organizations were initially designated as funding organizations: the Ozone Transport Commission for the Northeast; the Southeast States Air Resources Management (SESARM) for the Southeast; Lake Michigan Air Directors Consortium (LADCO) for the Midwest; Central States Air Resources Agencies (CenSARA) for the central states; and the Western Regional Air Partnership (WRAP) for the West.

As they worked to organize in their initial grant year, four of the newly identified organizations (all but WRAP) created new organizations to accommodate changes in state alignment and to separate the regional haze funds and work from their other funding and work. The RPOs for regional haze are as follows:

- The Mid-Atlantic/North East Visibility Union (MANE-VU) includes Connecticut, Delaware, the District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and Washington, D.C. The Northeast States for Coordinated Air Use Management (NESCAUM) and Mid-Atlantic Regional Air Management Association (MARAMA) are working in cooperation with the OTC on regional haze issues.
- The State and Tribal Association of the Southeast (VISTAS) includes states that are also members of the Southern Appalachian Mountain Initiative (SAMI): Alabama, Georgia, Kentucky, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. Formed in 1992, SAMI is working to complete a regional strategy to protect the Southern Appalachian environment from the adverse effects of air pollution, including visibility impairment, ground-level ozone effects on plants and trees, and acid deposition effects on water bodies and vegetation.
- The Midwest Regional Planning Organization includes five state — Ohio in addition to Illinois, Indiana, Michigan, and Wisconsin from LADCO.
- The Central States Regional Air Partnership (CENRAP) includes nine states — Nebraska, Kansas, Oklahoma, Texas, Minnesota, Iowa, Missouri, Arkansas, and Louisiana. This is a new grouping of states without a prior history of working together on regional haze or ozone issues.
- The Western Regional Air Partnership (WRAP) is the successor organization to the Grand Canyon Visibility Transport Commission. The Commission was formed in 1991 and issued recommendations to EPA in 1996 for improving the air quality in the 16 Class I areas on the Colorado Plateau. The Western States Air Resources Council (WESTAR) is working in cooperation with WRAP. WRAP states now have the option of implementing many of the commission's recommendations within the framework of the national regional haze rule.
- EPA manages the RPO project on a national level to ensure consistency. The lead EPA regions manage the specific grants for their individual RPOs. National meetings of the RPOs with EPA, State, and tribal representatives and Federal Land Managers have been held in various locations throughout the country since spring 2000.

The RPOs are first evaluating technical information to better understand how their states and tribes have an impact on national park and wilderness areas (Class I areas) across the country. RPOs will then pursue the development of regional strategies to reduce emissions of particulate matter and other pollutants leading to regional haze. All of the new RPOs have begun technical assessment work as they completed their organizational development.

The RPOs have each held their own technical work group sessions at meetings throughout the country to make decisions on joint technical work, including the location of new monitors, development of common protocols for emissions inventories, identification of data gaps, and assessment of modelling resources. This effort is designed to lead to SIPs for regional haze, which are due in 2007—2008.

Although the RPOs are funded specifically to develop regional haze plans, they will also study the precursors of haze, develop strategies for reaching haze goals through the control of a variety of pollutants, and account for pollutants from outside their borders, from either another state or another country. To this end, CENRAP will host a meeting in fall 2002 for all RPOs to begin to discuss international issues.

OTHER COOPERATIVE AIR QUALITY EFFORTS

United Nations Convention on Long-Range Transboundary Air Pollution

The United Nations Economic Commission for Europe's Convention on Long-Range Transboundary Air Pollution (LRTAP), signed in 1979, was the first international agreement recognizing environmental and health problems caused by the flow of air pollutants across borders and the need for regional solutions. On LRTAP's 20th anniversary, in December 1999, Canada and the United States signed the Protocol to Abate Acidification, Eutrophication, and Ground-Level Ozone. The signing of this agreement initiates a new phase within LRTAP to increase emphasis on implementation, compliance, review, and extension of existing protocols.

To accommodate the domestic and bilateral agreements in place or currently underway in both countries, Canada and the United States will incorporate their emission reduction commitments for SO_2, NO_x, and VOCs into the protocol at the time of ratification. The Ozone Annex will be the basis for both countries' emission reduction commitments for the protocol.

Emission reduction commitments relate to: (1) limits for emissions from new and existing stationary sources and new mobile sources; (2) application of BAT; and (3) measures to reduce VOC emissions associated with the use of products. There are no Canadian or U.S. commitments related to ammonia. For further information on the LRTAP Convention and protocols, see www.unece.org/env/lrtap.

New England Governors and Eastern Canadian Premiers

In 1998, the Conference of New England Governors and Eastern Canadian Premiers (NEG/ECP) developed Action Plans to coordinate research, public outreach, and action for both mercury and acid rain. In 2001, the NEG/ECP developed a Climate Change Action Plan along these same lines. The NEG/ECP has also recognized the links between air issues and the energy sector and, where appropriate, is involving both its Environment Committee and its Energy Committee. Work underway includes the development of a communications plan and the continuation of the Forest Mapping Project.

A significant part of the NEG/ECP's work focuses on a survey aimed at gauging public understanding and attitudes toward acid rain and mercury. The Acid Rain Partnership: Data Without Borders, released in August 2001, highlights both the progress and the future requirements to address the acid rain issue.

The Forest Mapping Project aims to generate maps of eastern Canada and the northeastern United States that identify the areas most sensitive to acid deposition. More specifically, the project will estimate acid deposition rates that would maintain forest ecosystem health and related productivity indefinitely based on sulphur and nitrogen deposition inputs. A Protocol for Assessing and Mapping Forest Sensitivity to Atmospheric Sulphur and Nitrogen Deposition has been developed and is being used as the foundation for the Forest Mapping Project.

Harmonization and presentation of data from both sides of the border is continuing through participation in the AIRNOW real-time ozone map program (see p. 27). Plans are underway to have a Canada—U.S. map included as a supplement to air quality and weather forecasts in the region. Work is also progressing on the development of a similar mapping program for $PM_{2.5}$. The NEG/ECP has also collocated a number of $PM_{2.5}$ monitors to help harmonize that data while a regional temporal network has been developed to assess water quality trends over time.

Recognizing the links between the emissions that cause acid rain and those that cause smog, the NEG/ECP is increasing its emphasis on the health effects of acidifying emissions. A conference in Quebec in May 2002 brought together scientists to discuss the links between health and air pollution.

NEG/ECP recognizes the importance of using a more harmonized approach when addressing air issues. More details on NEG/ECP work are available at http://www.cmp.ca/en-main1.html.

Canada—U.S. Georgia Basin/Puget Sound Initiative

More than six million people live in the Georgia Basin region of southwestern British Columbia and the Puget Sound region of northwestern Washington State. The Canadian cities of Vancouver and Victoria and the U.S. cities of Seattle and Tacoma are located here. This international region shares a common geography, climate, ecosystem, and strong social and economic links. These factors, combined with the rapid growth of population and significant motor vehicle use on both sides of the border has led to joint efforts to address shared air quality issues and concerns.

Air quality in the Georgia Basin and Puget Sound International Airshed generally meets Canadian standards north of the Canada—U.S. border and U.S. standards south of the border as a result of actions taken by various levels of government including: (1) regional air quality agency emission control programs for commerce and industry; (2) provincial and state initiatives for early action on cleaner vehicles and fuels, on motor vehicle inspection and maintenance programs, and on woodstove emissions; and (3) more stringent federal government standards for vehicle emissions and fuel quality. However, there is concern that the continuing rapid growth in the Georgia Basin and Puget Sound area may result in more industrial and motor vehicle emissions and worsening air quality in the future.

In February 2001, Environment Canada and the EPA initiated a collaborative process to develop a Georgia Basin/Puget Sound International Airshed Strategy, which will include early action to address some high-priority air quality issues, an airshed characterization to provide a good understanding of present and future air quality issues and challenges, and a strategic plan to address air quality problems that are identified in the scientific studies. Participants in the process include provincial and state governments, regional air quality management agencies, local governments, and First Nations and tribes from both sides of the international border.

The goal of the international airshed strategy is to protect air quality and address concerns about the impacts of air pollution on human and environmental health. This supports the commitment under the Ozone Annex to the 1991 Canada—U.S. Air Quality Agreement to determine if air quality issues along the border between British Columbia and adjacent U.S. states should be considered when the Annex is assessed in 2004. A final draft report on the Georgia Basin International Airshed Strategy will be ready for review in fall 2003.

Considerable progress has been made in the Georgia Basin/Puget Sound International Airshed Strategy. Since February 2001, two meetings of the coordinating committee have been held in the United States and two in Canada. Participating agencies have broadly supported the bilateral draft Statement of Intent on areas of future cooperation between the EPA and Environment Canada, and work is underway on six early action items, including an issue-ranking information system, a transboundary air quality data exchange, a Web-based information clearinghouse, an improved transboundary new source review process, and activities relating to clean vehicles and fuels.

NARSTO

NARSTO,[10] a North American consortium for support of atmospheric research in support of air quality management, is a public/private partnership whose membership spans government, the utilities, industry, and academia throughout Mexico, the United States, and Canada. NARSTO's primary mission is to coordinate and enhance policy-relevant scientific research and assessment of tropospheric pollution behaviour including PM and ozone. Its activities provide input for science-based decision making and determination of workable, efficient, and effective strategies for local and regional management of air pollution. NARSTO coordinates tri-national research under four broad technical program areas: (1) atmospheric chemistry and modelling research; (2) emission research; (3) observations research; and (4) integrated analysis and assessment. More information on this organization, its plans and progress, and recent science assessments is available at http://www.cgenv.com/Narsto/.

The NARSTO state of science assessment on ozone, An Assessment of Tropospheric Ozone Pollution—A North American Perspective, June 2000, is available in print, on the Internet (see above address) or can be dowloaded on Adobe Acrobat. The document synthesizes the policy-relevant science insights from 24 critical review papers spanning the atmospheric science and source-to-receptor relationships of ozone and its precursor gases. An executive summary presents answers to policy questions such as (1) Are existing control measures helping to bring the ozone problem under control? and (2) What are alternative approaches for reducing current and future ozone concentrations?

A comparable assessment of PM science for ambient PM management is being developed and is available in draft form through the NARSTO Web site. The document is scheduled to complete tri-national scientific peer review in September 2002 and

10 Formerly an acronym for "North American Research Strategy for Tropospheric Ozone," the term NARSTO has come to signify this tri-national, public--private partnership for dealing with multiple features of tropospheric pollution, including ozone and suspended particulate matter.

will be available to the general public in March 2003. The authors prepared this assessment to assist policy makers. Topics covered in the document include meteorological and chemical processes, emission estimations, ambient measurements, source attribution, air quality modelling, and their health and visibility context. In addition, chapter 10 and the appendix present summary conceptual descriptions of what is known about PM over nine major urban and regional North American areas.

NARSTO has also undertaken a comparison of air quality models currently in use in the United States and Canada. Comparative and operational evaluations of the modelling systems will be performed using configurations and inputs currently in use for air quality assessments. The focus will be on ozone. Model outputs from a common domain and time period will be compared among the modelling systems and with selected observations, including those made during the summer of 1995. The models' relative and absolute abilities to simulate observed conditions will be evaluated and their comparability established, at least for the conditions simulated. The models will also be compared to determine if they suggest the same emission-control directions to policymakers for some simple control scenarios—50% across-the-board cuts in VOC and NO_x emissions.

EMERGING COUNTRY ISSUES

Canada

Air pollution continues to be a serious threat to Canada's health and environment, despite improvements to air quality. It is clear that human health is a key factor in reducing air pollution. To further improve air quality and human health, there is a need to reduce emissions of particulate matter, sulphur and nitrogen dioxides, mercury, and persistent organic pollutants.

Health science has shown that particulate matter and ozone are linked to serious health effects including chronic bronchitis, asthma, and premature death. $PM_{2.5}$ has been recognized to have the potential for the greatest health impact on a larger segment of the general population.

Although Canada has made significant progress on acid rain, Canadian scientists believe that lakes and forests need further protection. As Canada moves forward to encompass other pollutants such as fine PM, this is expected to have a positive impact on acid rain issues.

Mercury is a significant health and environmental concern and Canada is involved in several international initiatives, many regionally with the United States, as well as domestic programs that address mercury in the environment. Domestic programs include the Canada-wide Standards for Mercury and the Collaborative Mercury Research Network.

Persistent organic pollutants (POPs) are toxic chemicals that pose a significant health concern for Canadians. Over the past years, Canada has taken strong actions domestically to deal with POPs, but more work is necessary to deal with the long-range atmospheric transport of these pollutants.

United States

Since the last Progress Report, there has been increasing interest in both the public and the private sector in a multi-pollutant approach to reducing air pollution. In February 2002, President Bush proposed an Administration plan, The Clear Skies Initiative, which would significantly reduce power plant emissions of three of the worst air pollutants—SO_2 , NO_x, and mercury.

The initiative would establish national enforceable emission caps on all the pollutants (placing the first national cap on mercury emissions) and reduce emissions of all three pollutants by approximately 70%. If passed by Congress, The Clear Skies Initiative would provide the following reductions: (1) a cut in SO_2 emissions of 73%, from current emissions of 11 million tons to a cap of 4.5 million tons in 2020 and 3 million tons in 2018; (2) a cut of NO_x emissions by 67%, from current emissions of 5 million tons to a cap of 2.1 million tons in 2008 and 1.7 million tons in 2018; and (3) a cut of mercury emissions by 69% from current emissions of 48 tons to a cap of 26 tons in 2010 and 15 tons in 2018. Emission caps for NO_x would be set to account for different air quality needs in the East and West. The caps for all three pollutants would be reassessed by 2010.

The initiative builds on the Acid Rain Program under the CAAA, using a market-based approach to clean air and encouraging the use of new pollution control technologies.

Scientific Cooperation

This section focuses on U.S. and Canadian progress under Annex 2 of the Air Quality Agreement to cooperate and to exchange scientific information related to transboundary air quality issues.

Data Measurement and Analysis

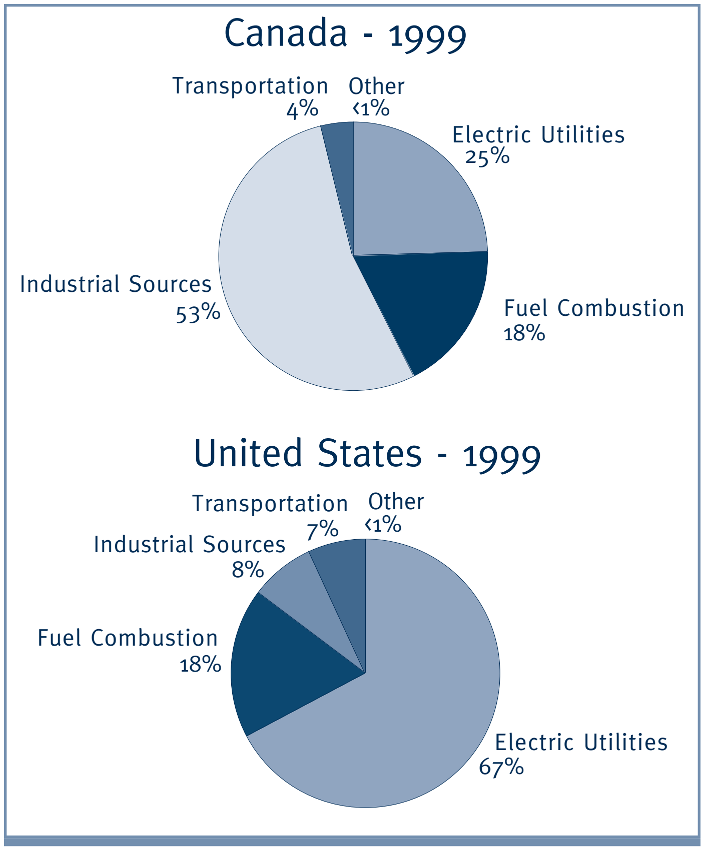
EMISSIONS INVENTORIES

Emissions inventories provide the foundation for air quality management programs. They are used to identify major sources of air pollution, provide data to input into air quality models, and track the progress of control strategies. This section addresses mainly SO_2, NO_x, and VOCs. SO_2 and NO_x emissions are the dominant precursors of acidic deposition; NO_x and VOCs are primary contributors to the formation of ground-level ozone; and all three pollutants contribute to the formation of PM.

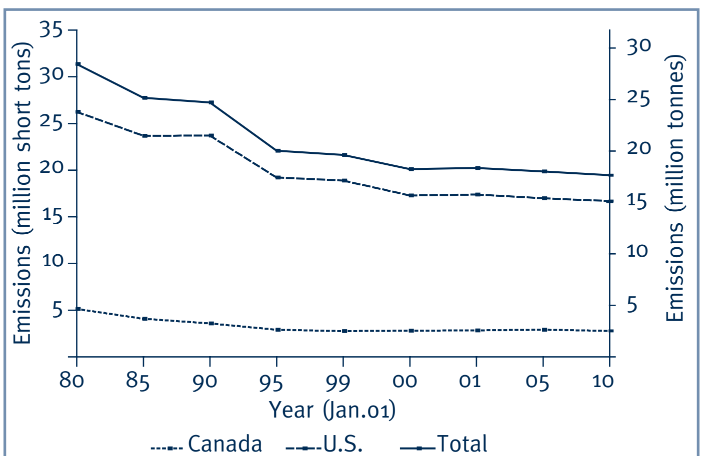
This section outlines emission trends estimates for SO_2, NO_x, and VOCs for both Canada and the United States, reflecting new methodologies for determining total estimates and using new models and results. In addition to the joint emission trends data, the latest available data (1999) on sources of emissions by sector are presented in figures 4, 6, and 7. Canadian emissions data are preliminary.

Sulphur Dioxide

Electric utilities continued to contribute to the majority of total North American SO_2 emissions in 1999. In the United States, well over 90% of these emissions come from coal combustion. Non-ferrous mining and smelting is the main contributor to anthropogenic sources of SO_2 in Canada and along with industrial coal combustion, is a primary source in the United States. Overall, a 38% reduction in SO_2 emissions is projected in Canada and the United States from 1980 to 2010. In the United Sates, these reductions are mainly a result of controls in electric utilities under the Acid Rain program and desulphurization of diesel fuel under Section 214 of the 1990 CAAA. In Canada, they are mainly attributed to reductions from the non-ferrous mining and smelting sector and electric utilities as part of the Canada-Wide Acid Rain Strategy program.



Canada–U.S. SO_2 Emissions by Sector (1999) *Figure 4*



Canada–U.S. SO_2 Emissions, 1980–2010 *Figure 3*

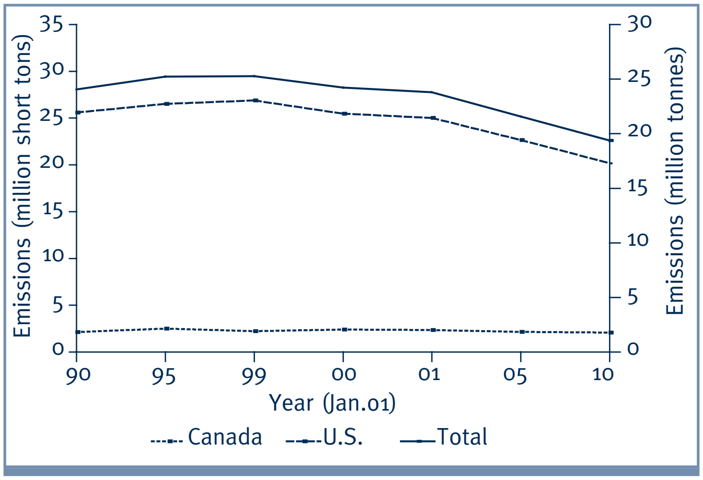
Nitrogen Oxides

The principal anthropogenic source of NO_x emissions remains the combustion of fuels in stationary and mobile sources. Motor vehicles, residential and commercial furnaces, industrial and electric utility boilers and engines, and other equipment contribute to this category.

U.S. reductions in NO_X emissions are attributed to controls in electric utilities under the Acid Rain Program, the estimated controls associated with EPA Regional Transport NO_X SIP Call, the Tier 2 Tailpipe Standard, and Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Rulemaking.

Canadian NO_X emissions as portrayed in figure 5 show a relatively constant level since 1990 and into the future; however, this forecast does not include the substantial NO_X reductions that will result from the implementation of the Ozone Annex, including the stationary source commitments for NO_X emissions and the 10-year vehicle and fuels agenda, which implement the Tier 2 Tailpipe Standards, among other initiatives.

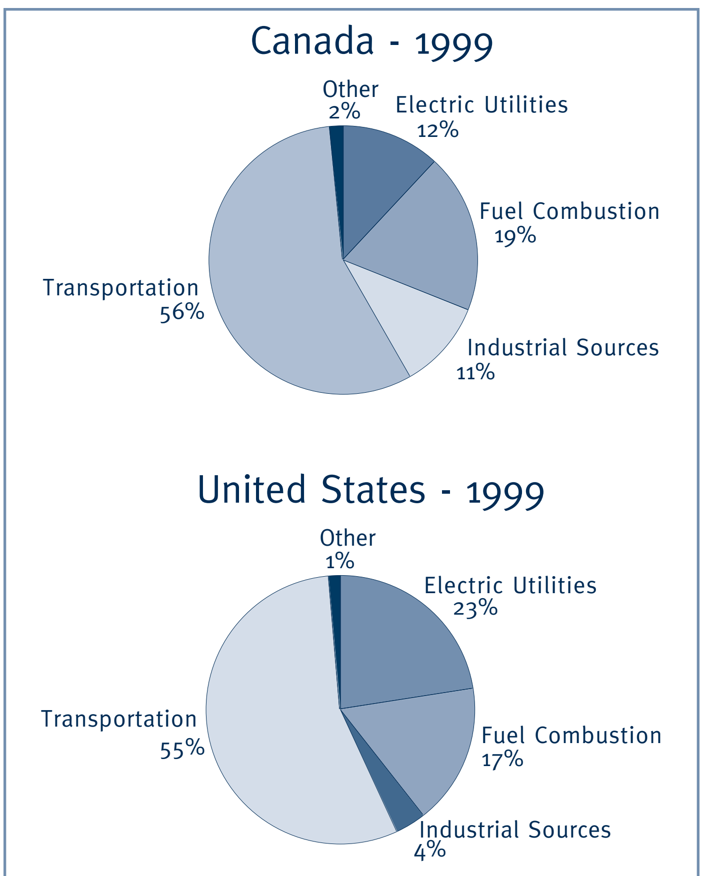
Overall estimated trends for anthropogenic emissions of NO_X in Canada and the United States from 1990 to 2010 are shown in figure 5.



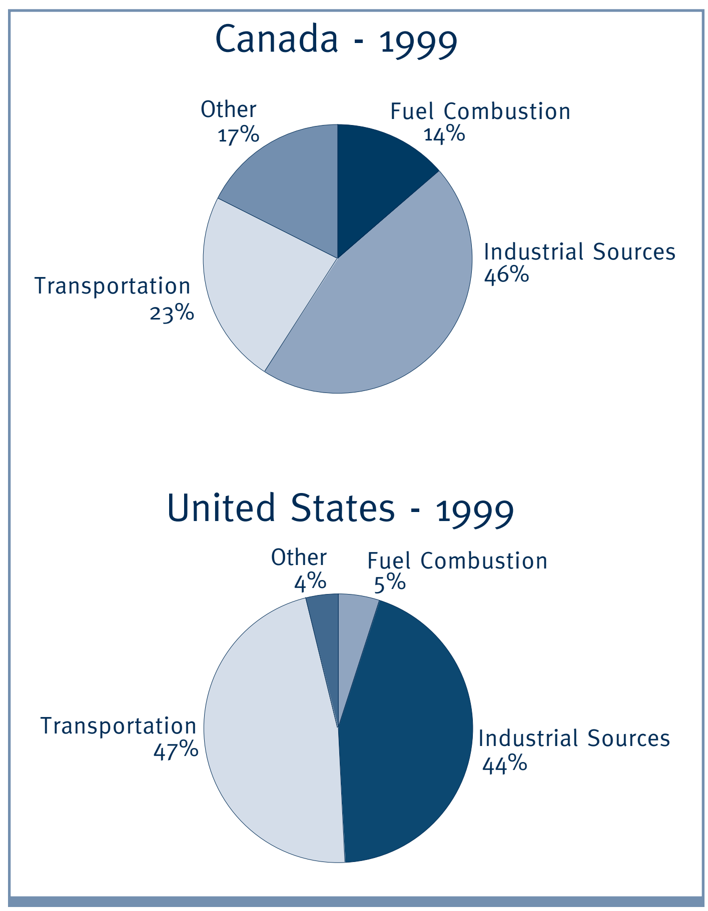
Canada-U.S. NO_X Emissions, 1990–2010 *Figure 5*

Volatile Organic Compounds

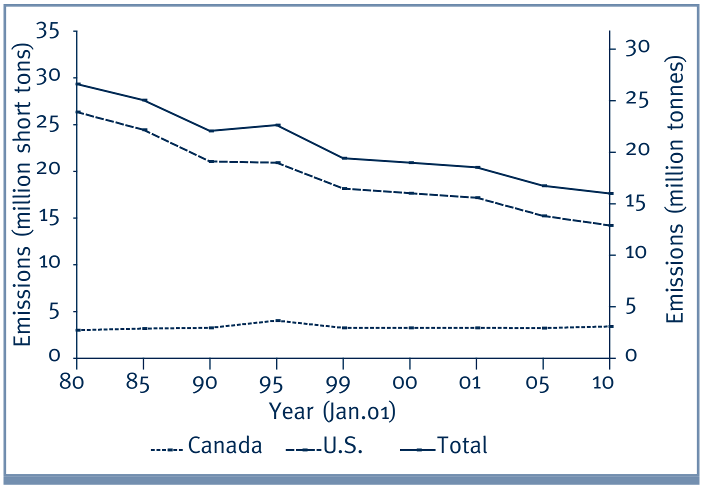
Anthropogenic emissions of VOCs continue to de dominated by on-road vehicles and solvent use source categories (e.g., surface coating, consumer products, and degreasing). In 1999, these two categories contributed to almost 60% of VOC emissions in the United States and 37% in Canada. The primary contributor to VOC emissions in Canada in 1999 was the upstream oil and gas industry. Emissions in Canada and the United States are expected to decline by 40% from 1980 through 2010. U.S. reductions in recent years are a result of the control of VOCs through various maximum achievable control technology (MACT) standards. Overall estimated trends in anthropogenic VOC emissions for Canada and the United States from 1980 to 2010 are shown in figure 8.



Canada-U.S. NO_X Emissions by Sector (1999) *Figure 6*



Canada-U.S. VOC Emissions by Sector (1999) *Figure 7*



Canada-U.S. VOC Emissions, 1980-2010 *Figure 8*

ACID DEPOSITION MONITORING

Airborne pollutants are deposited on the earth's surface by three processes: wet deposition, dry deposition, and deposition by cloud-water and fog. Wet deposition is relatively easy to measure through the analysis of rain and snow.

Wet and dry deposition are monitored in Canada and the United States through well-established networks that measure the chemical composition of air and precipitation. Both countries contribute their monitoring results to an integrated data set from which maps are produced of sulphate and nitrate wet deposition across eastern North America (see figures 9-12).

Canada

Wet deposition in Canada is measured by various federal, provincial and territorial governments. Environment Canada operates the Canadian Air and Precipitation Monitoring Network (CAPMoN) with 21 measurement sites in Canada and 1 in the United States. A map of the CAPMoN measurements sites can be found at the following website: http://www/msc.ec.gc.ca/capmon/Index_e.cfm. Provincial wet deposition monitoring networks are operated by the governments of British Columbia, Alberta, Quebec, New Brunswick, Nova Scotia, Newfoundland and the Northwest Territories.

Dry deposition in Canada is measured at 13 of Environment Canada's CAPMoN sites. No dry deposition measurements are made by the provinces or territories.

CAPMoN sites across Canada are currently being upgraded under the implementation of the Ozone Annex and special funds from the Acid Rain Program. The upgrades include an increase in the number of sites, hardware improvements and an increase in the number of pollutants monitored at selected sites. Also included is the establishment of a new Canada/U.S. Intercomparison site at Frelighsburg, Quebec

United States

The United States has three acid deposition monitoring networks: NADP/NTN; AIRMoN, which is part of NADP; and CASTNet. NADP/NTN has 238 sites monitoring wet deposition, including 15 collocated dry deposition sites, monitored weekly. AIRMoN has 10 sites monitoring wet deposition and 5 sites monitoring dry deposition daily. CASTNet has 79 sites monitoring dry deposition and rural ozone concentrations.

By comparing the wet deposition maps before and after the 1995 Phase 1 emission reductions under the Clean Air Act Amendments, it has been possible to assess the impact of the emission decreases on large-scale wet deposition.

Information and Data Exchange

Environment Canada and EPA are collaborating to improve Canadian and U.S. atmospheric deposition measurements and to enhance the exchange, accessibility, and analysis of data within the two countries. Under a cooperative agreement initiated this year, the two governments are planning to establish a common, cooperative, Canadian—U.S. deposition database, analysis, and Web-based mapping capability that will include data from the NADP, CASTNet, and AIRMoN networks as well as Canadian federal and provincial acid rain monitoring networks.

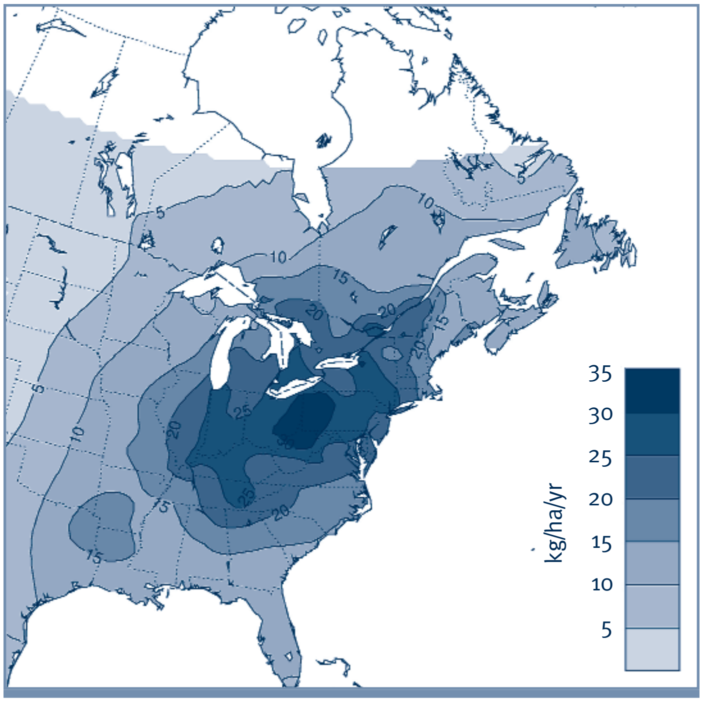
Status and Trends

Five-year average sulphate wet deposition for the years 1996—2000 (figure 11) is considerably reduced from that for the five-year period prior to the Phase 1 reductions (1990—1994). For example, the large area that received 25 to 30 kg/ha/yr (kilogram per hectare per year) of sulphate in 1990—94 almost disappeared in 1996—2000. The marked shrinkage of wet deposition strongly suggests that the Phase 1 SO_2 emission reductions were successful in reducing the sulphate wet deposition over a large section of eastern North America.

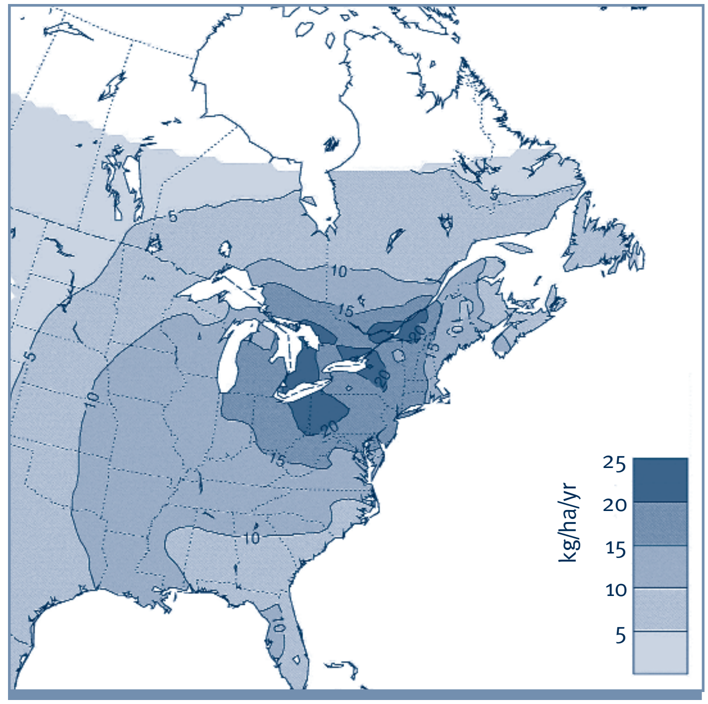
For nitrate wet deposition, the spatial patterns shown in figures 10 and 12 are approximately the same before and after the Phase 1 emission reductions. This suggests that the minimal reductions in NO_x emissions after Phase 1 resulted in minimal changes to nitrate wet deposition over eastern North America.

The data used for this assessment came from national and provincial networks in Canada and from national networks in the United States. Five-year average wet deposition maps were produced in order to minimize meteorological variability that seriously affects annual wet deposition patterns. The 1996—2000 maps are less certain in the provinces of Ontario and Quebec because of the lack of provincial data in 1999 and 2000.

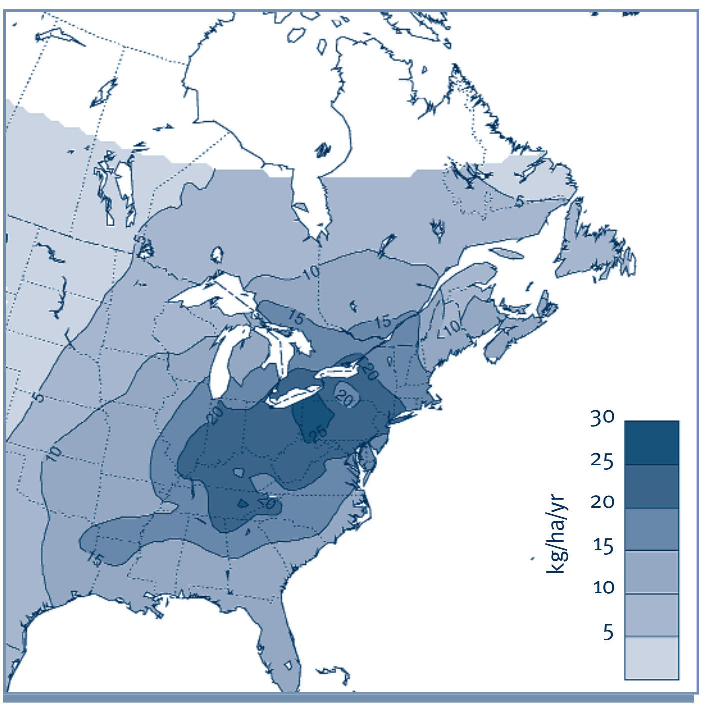
Wet Sulphate and Nitrate Deposition in 1990-1994 and 1996-2000



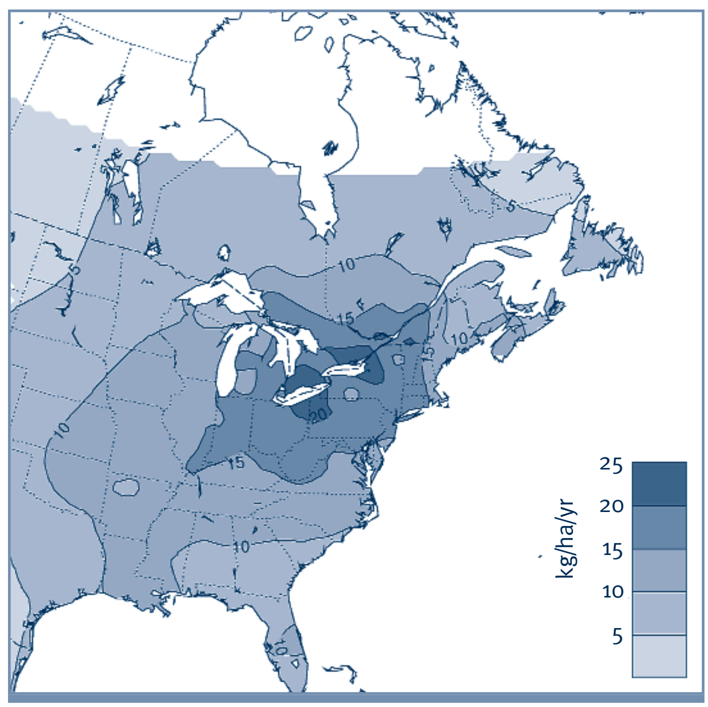
1990–1994 Wet Sulphate Deposition *Figure 9*



1990–1994 Wet Nitrate Deposition *Figure 10*



1996–2000 Wet Sulphate Deposition *Figure 11*



1996–2000 Wet Nitrate Deposition *Figure 12*

Analyses of National Atmospheric Deposition Program/National Trends Network (NADP/NTN) data continued to show dramatic reductions in sulphate deposition over the past decade. Data for 1998–2000 showed up to 30% reductions over a large area of the eastern United States compared with 1989–1991 data. The greatest reductions were in the northeastern United States, where many sensitive ecosystems are located.

NADP/NTN data for nitrate deposition showed variable decreases in nitrate deposition in the Northeast and increases in the Upper Midwest and Rockies for the 1998–2000 period compared with the 1989–1991 period. Nitrate deposition was 10% to 20% less in New York and West Virginia; in Maine, 10% less. Nitrate deposition percentages in low deposition areas in the western United States increased by 20% to 50%.

A trend analysis for the 1990 to 1999 period at 34 eastern U.S. Clean Air Status and Trends Network (CASTNet) sites showed significant declines in SO_2 and sulphate concentrations in ambient air. The average SO_2 reduction was 32%; for sulphate the reduction was 24%. Patterns were similar to those reported in the last Progress Report.

In the early 1990s, ambient SO_2 concentrations in the rural eastern United States were highest in western Pennsylvania and along the Ohio Valley in the vicinity of Chicago and Gary, Indiana. Large SO_2 air quality improvements can be seen by comparing the 1990 to 1992 period with the 1999 period. The largest decrease in concentrations is noted in the vicinity of Chicago and throughout states bordering the Ohio Valley (Illinois, Ohio, Pennsylvania, Kentucky, and West Virginia). The highest SO_2 concentrations in the rural parts of the eastern United States are concentrated in southwestern Pennsylvania.

As reported in the last Progress Report, CASTNet data for ambient concentrations of nitrogen containing compounds from 1990 to1999 from sites in the rural eastern United States did not change appreciably. The highest concentrations were found in Ohio, Indiana, and Illinois.

GROUND-LEVEL OZONE MONITORING AND MAPPING

Ground-level ozone continues to be a pervasive pollution problem throughout many areas of the United States and southern Canada. Ozone, formed by the reaction of VOCs and NO_x in the presence of heat and sunlight is not emitted directly into the air but rather is readily formed in the atmosphere by photochemical reactions under summer sunlight.

Ozone Monitoring

Both governments have extensive ground-level ozone monitoring programs.

Canada

Ambient monitoring of ground-level ozone and precursors is conducted throughout Canada under the National Air Pollution Surveillance (NAPS) network, a joint program of the federal and provincial governments. As of December 31, 2000, 164 ozone monitoring sites were reporting data to NAPS.

Data records for ozone, NO_2, NO, and NO_x date back to the early 1980s, and special VOC measurements have been collected since 1989 at more than 40 sites across Canada. Most monitoring of ground-level ozone and precursors is focused in the country's densely urbanized regions. In addition, Environment Canada operates CAPMoN which samples at regionally representative, nonurban locations across Canada.

United States

The national ambient air quality monitoring program—the State and Local Air Monitoring Stations (SLAMS) network—is implemented by state and local air pollution control agencies. The SLAMS network consists of three major categories of monitoring stations: (1) those that are SLAMS only; (2) National Air Monitoring Stations (NAMS); and (3) Photochemical Assessment Monitoring Stations (PAMS). PAMS measure a variety of criteria and noncriteria pollutants, specifically ozone precursors. EPA operates CASTNet, which provides ozone levels in rural areas as well as dry acidic deposition levels and trends.

Currently, there are 646 SLAMS and 189 NAMS sites for ozone which are used for SIP support, state/local data, national policy support, national trends development, measurement of maximum concentrations and population exposures, EPA regional office oversight, and EPA headquarters oversight. Additionally, the state, local, tribal, and other nongovernmental agencies operate approximately 332 special purpose monitors (SPM) for ozone. These are generally used for special studies and state/local oversight. The SPM are also used for regulatory purposes, including designations. There is little distinction among the state, local, or tribal sites that are SLAMS, NAMS, or SPM for ozone–all types are used as described above.

The PAMS networks measure ozone precursors as required by the 1990 Clean Air Act Amendments (CAAA) to monitor the most severe ozone nonattainment areas. The PAMS requirements were designed to provide information on the roles of ozone precursors, pollutant transport, and local meteorology in the photochemical process and to assist in information gathering for proposed ozone control strategies. In 2000, approximately 83 PAMS were in operation in five regions of the United States–the Northeast, the Great Lakes area, Atlanta, Texas (primarily Houston), and California.

Ozone Mapping

Joint Efforts

AIRNOW

In 2001, Canadian and American jurisdictions (primarily provinces and states) expanded EPA's AIRNOW, real-time air quality program, to include data and develop maps from six Canadian provinces. The real-time ozone air quality maps include the provinces of New Brunswick, Newfoundland, Nova Scotia, Ontario, Prince Edward Island, and Quebec and the northeastern United States. The maps were generated using the ozone standard for Canada and the Air Quality Index (AQI) for the United States. Work is underway to expand the Canadian ozone mapping effort to include data from British Columbia in conjunction with Washington State in the summer of 2002.

For the United States, the project completes existing smog advisory programs and the smog forecasting program. Forty states are participating in the AIRNOW program.

Air Quality Index

Over the past year, Canada has been engaged in a multi-stakeholder review of the air quality index (AQI) system in use in the country. The primary objective has been to ensure that the index becomes more reflective of the health risk of air pollution and a better means of providing people with information they can use to protect their health. Issues considered include the relationship between pollutants and combined exposures; the distinction between air pollution management targets and relative risks; monitoring capabilities and limitations; national consistency versus regional flexibility; associated health messages; and the marketing challenges. A report containing recommendations will be available this fall. Decisions about real-time reporting of ambient air quality remain at the provincial or local level, so the next step will be to develop a mechanism that brings together decision makers and stakeholders for the ongoing coordination and implementation of changes to the AQI.

EPA's AQI continues to provide data on health risks associated with increased pollutant concentrations, pollutant-specific health and cautionary statements on effective risk reduction behaviour, an AQI update for use by the media, an ozone subindex in terms of 8-hr average concentrations, and a subindex for PM ($PM_{2.5}$). (For AQI on the Internet, see www.epa.gov/airnow/publications.html.)

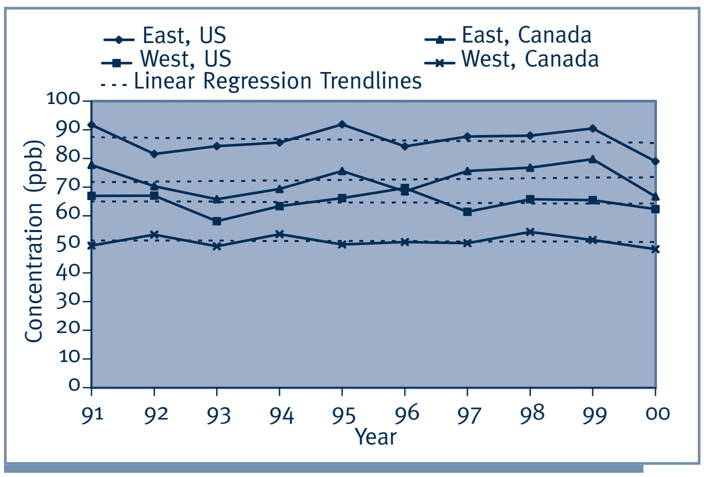
Air Quality Reporting Data

As part of the new Ozone Annex to the Air Quality Agreement (see section II, p. 8 and appendix B), Canada and the United States agreed to report on air quality data beginning in 2002. Data include ambient ozone concentrations in the form of applicable standards 10-year trends in ambient ozone concentrations, ambient VOC concentrations, 10-year ambient VOC concentrations, ambient NO_X concentrations, and 10-year trends in ambient NO_X.

Data were collected for all sites within 500 km of the Canada-U.S. border, and all available data were used to create the contour maps presented below. However, only sites meeting certain data completeness requirements were used in the statistical trends analysis. For ozone, these criteria required that each annual fourth highest daily maximum 8-hr concentration be based on 75% or more of all possible daily values during the EPA designated ozone monitoring season and that eight or more annual values in the 10-year period analyzed (1991-2000) are valid.

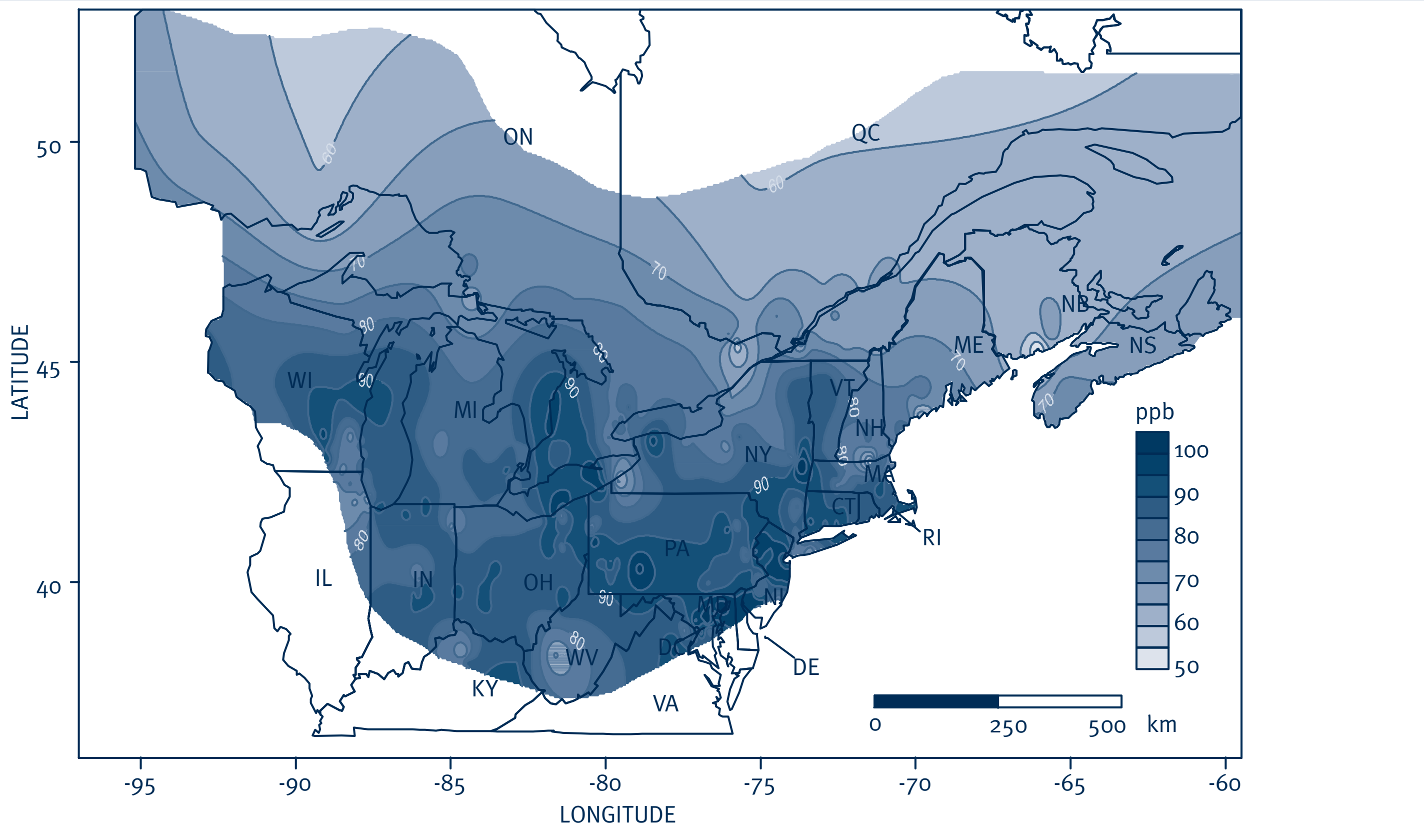
Trend sites for NO_X have eight or more valid annual averages where a valid average is based on 50% or more of all possible hourly averages. Hydrocarbon monitoring stations were included as trend sites if there were three or more annual averages reported. The completeness criteria were relaxed for hydrocarbons because these data are far more limited than is the case for NO_X and ozone. Additionally, only urban monitoring sites in Canada were included in trend calculations to provide trends that are roughly comparable to the urban-oriented U.S. monitoring network.

These data are presented in figures 13-17 and in Appendix C (figures 21-23). Figure 14 shows the annual fourth highest daily maximum 8-hour ozone averaged over the period 1998-2000. The highest values are generally near major urban areas in the eastern region of the U. S.. Ozone concentrations are based on monitoring data from ozone sites located within approximately 500 km of the U.S./Canadian border depicted in Appendix C (five Canadian sites subject to significant NO scavenging or at high altitude excluded). Figure 15 shows the annual fourth highest daily maximum 8-hour ozone averages over the period 1998-2000. The lowest values are generally found in southern Manitoba and southern British Columbia near Vancouver. Ozone concentrations



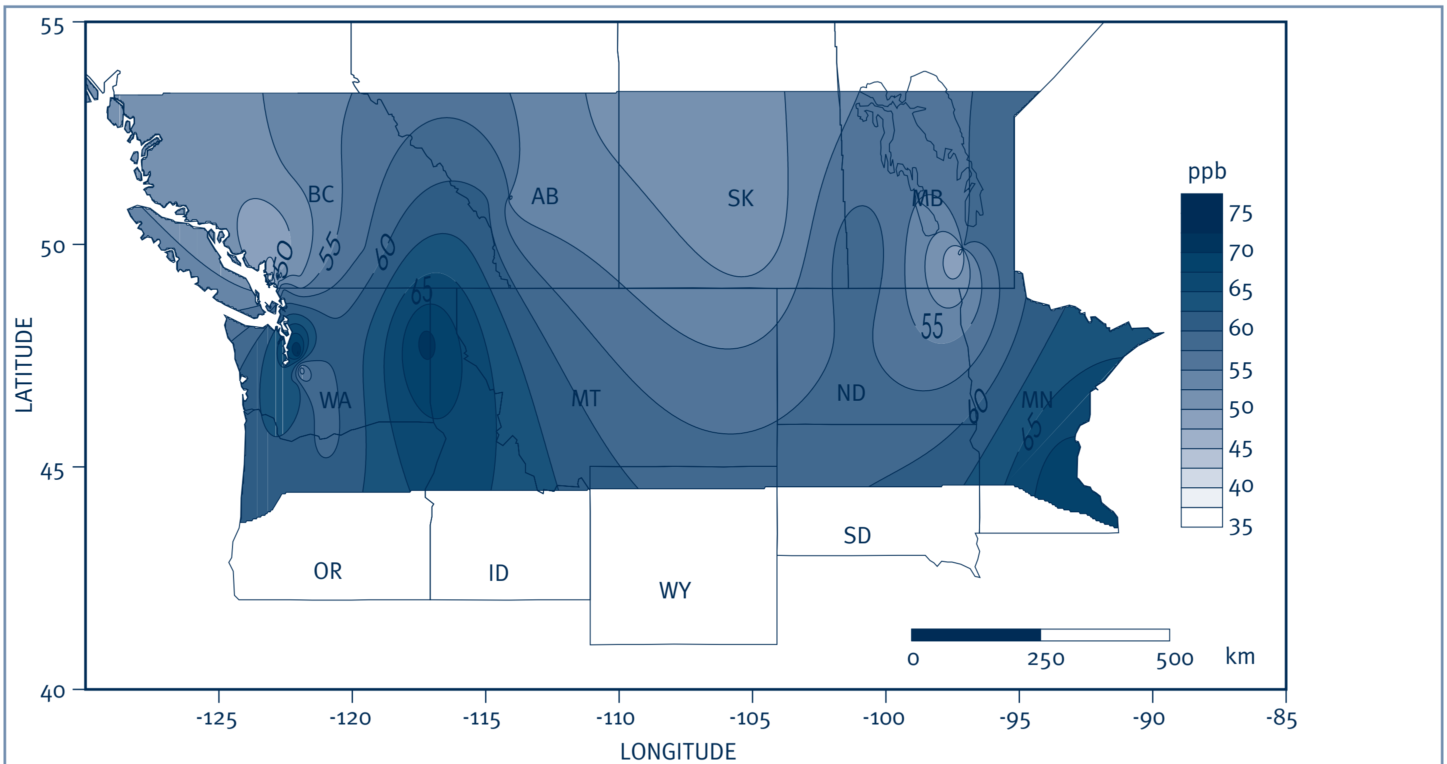
Composite Trends: Annual Fourth Highest Daily Maximum 8-Hour Ozone Concentration *Figure 13*

This graph shows the composite trend in the annual fourth highest daily maximum 8-hour ozone during the period 1991-2000. These 8-hour ozone concentrations are on average showing little change or slight decreases in some areas during this period.



Ozone Concentrations in the Eastern Regions of the U.S. and Canada (Average Annual Fourth Highest Daily Maximum 8-Hour Ozone, 1998-2000)

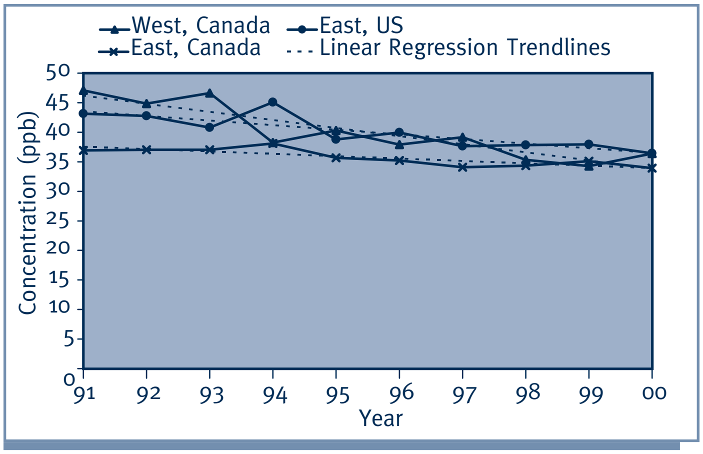
Figure 14



Ozone Concentrations in the Western Regions of the U.S. and Canada (Average Annual Fourth Highest Daily Maximum 8-Hour Ozone, 1998-2000)

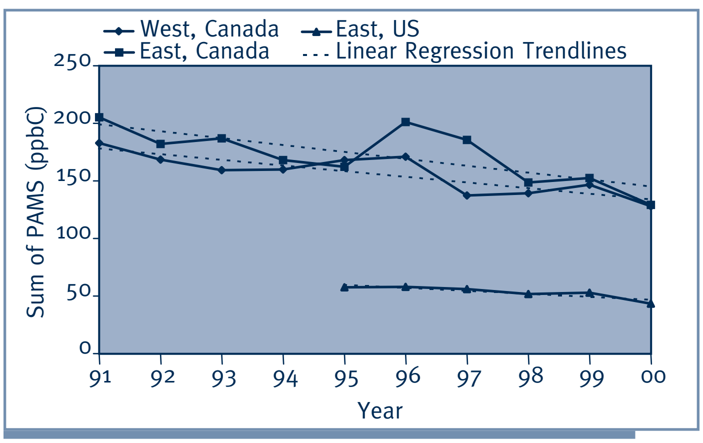
Figure 15

are based on monitoring data from ozone sites located within approximately 500 km of the U.S./Canadian border depicted in Appendix C (five Canadian sites subject to significant NO scavenging or at high altitude excluded).



Composite Trends: Annual Average Hourly NO_x Concentration
Figure 16

This graph shows the composite trend in annual average 1-hour NO_x concentrations for the period 1991-2000. Note there are no trend sites monitoring NO_x concentrations in the western U.S. within 500 km of the U.S./Canadian border. These NO_x concentrations are on average showing a downward trend during this period in all areas.



Composite Trends: Annual Average 1-Hour Hydrocarbon Concentration
Figure 17

This graph shows the composite trend in annual average 1-hour hydrocarbon concentrations for the period 1991-2000. Note there are no trend sites monitoring hydrocarbon concentrations in the western U.S. within 500 km of the U.S./Canadian border. These hydrocarbon concentrations are on average showing a downward trend during this period in all areas. The relative differences between the US and Canadian hydrocarbon concentrations shown on the graph are currently being investigated.

PARTICULATE MATTER MONITORING, DATA ANALYSIS, MODELLING AND MAPPING

Transboundary PM Analysis and PM Workplan

As an outgrowth of the Joint Plan of Action to address transboundary PM issues (see page 14), the governments of Canada and the United States are executing and evaluating regional air quality models with parallel ambient data analysis to characterize transboundary contributions of PM and precursors in border regions by the end of 2003. The report will be the focus of decision making on whether to develop a PM annex to the Air Quality Agreement.

As part of this undertaking, the governments have developed a PM workplan resulting from discussions at a second joint PM workshop held in the United States in November 2001. The first workshop was held in Canada in 1999. Key elements of the PM workplan are outlined below.

Canada and the United States plan to jointly analyze high $PM_{2.5}$ episodes in North America. The largest component of $PM_{2.5}$ in the summer is sulphate; nitrate can be a significant component of $PM_{2.5}$ in the winter. Organic carbon is a large component of $PM_{2.5}$ in all seasons.

A joint 1995/1996 Canada-U.S. emissions inventory for 36 km grids is being developed and processed for the Regional Modelling System for Aerosols and Deposition (REMSAD) and the Community Multiscale Air Quality model (CMAQ) with a target completion date of August 2002. Projected Canada—U.S. emission inventories to future years are targeted for completion by fall 2002. An approach for resolving confidentiality issues associated with Canadian data was identified and is being used in the development of these inventories. Considerable work is already underway in both countries using the air quality transport model AURAMS (A Unified Regional Air Quality Modelling System) in Canada and the CMAQ model in both the United States and Canada to investigate the impact of emission changes on PM and ozone air quality. Over the next six months to a year, the models will move through their evaluation phases and begin to be applied against emission reduction scenarios investigating the potential for transboundary impacts.

Joint Canada-U.S. modelling will take place for the full year of 1996 (MM5 meteorology) with REMSAD at 36 km horizontal grid resolution run as a base case with the 1995/1996 emissions inventory. The REMSAD modelling domain is being expanded northward and eastward to cover most of Canada. Episodes for July 1995 with MM5 meteorology will be run with the CMAQ and AURAMS models. Projection years (e.g., 2010, 2020) will also be run with the models. The joint 1995/1996 base case modelling is scheduled to be completed before the third U.S.—Canada workshop. The workshop, which will be held in Toronto, Canada in fall 2002, will focus on assessing progress and refining measures to complete the transboundary impact assessment.

The Canadian National Atmospheric Chemistry (NAtChem) Database And Analysis System, NAPS, CASTNET, IMPROVE, and Aerometric Information Retrieval System (AIRS) air quality databases also are being used to illustrate transboundary transport by combining the PM data with meteorological data and trajectories. Over the next year, specific ambient data analysis tasks will be identified and carried out.

This undertaking will be one of the first major policy applications of the PM regional air quality models. The combined approach of using regional air quality models and ambient data analysis is essential for PM. Using the weight of evidence derived from both approaches will result in the best policy guidance based on current scientific understanding.

PM Monitoring Comparison

Several different monitoring methods are used within the Canadian and U.S. networks. They operate on various sampling schedules, from continuous hourly measurements to 24-hour average measurements taken once every six days.

Monitoring agencies in the United States and Canada are operating both filter-based and continuous fine PM samplers. In the United States, a robust network of Federal Reference Method (FRM) samplers is augmented by a smaller number of continuous monitors. Most U.S. monitoring agencies use the Tapered Element Oscillating Microbalance (TEOM) as their continuous monitor; a smaller number of agencies use other technologies. However, many of the TEOMs operated are using different method approaches with respect to operating temperature and use of a particle separation device. In Canada, most city and provincial monitoring agencies operate the dichotomous sampler at a limited number of sites to obtain filter measurements collocated with the TEOM continuous monitor for a real-time PM signal.

A larger number of Canadian sites operate the TEOM without a collocated filter-based measurement. Canadian monitoring agencies are also operating the TEOMs in varying ways with respect to temperature and particle separation device. Since each country primarily relies on different methods for filter-based measurements and differences within a method with respect to the TEOM, an understanding of the comparability of these methods is required for data to be appropriately analyzed across the two countries. To provide an understanding of methods employed in each country, monitoring representatives from Canada and the United States have been cooperating by sharing information on methods used.

Monitoring contacts at the Federal, State, and regional levels from the United States have participated with Canadians in workshops designed to work toward better data comparability within each country and between the countries. Additionally, EPA is working with monitoring agencies in the United States and Canada to test mapping of data from continuous PM monitors.

Through the work of NEG/ECP there are collocated TEOMs and FRMs in Nova Scotia, New Brunswick, Quebec, and Prince Edward Island.

PM Monitoring

Canada

In Canada, the $PM_{2.5}$ and PM_{10} monitoring initiated in the mid-1980s is continuing to be updated to meet current scientific and policy needs. In 2002, the regional CAPMoN network is planning to add up to five $PM_{2.5}$ and PM_{10} gravimetric monitors, in addition to all the gaseous precursors (SO_2, NO_x, VOCs, and NH_3) at two of the five sites. Currently, in the primarily urban NAPS network the federal and provincial governments are operating 106 gravimetric PM_{10} monitors and 50 TEOM PM_{10} monitors. Similarly, there are 102 $PM_{2.5}$ TEOM sites and 21 gravimetric monitors. $PM_{2.5}$ chemical monitors being set up at five sites in the NAPS network this year will identify particle sulphate, nitrate, ammonium, organic carbon, black carbon, and soil contributions to total $PM_{2.5}$ mass.

United States

In the United States, deployment of new monitoring networks for $PM_{2.5}$ is supplying $PM_{2.5}$ compliance monitoring data and Air Quality Index data for reporting to the public. Specific monitoring network data include:

- Approximately 1,100 Federal Reference Method $PM_{2.5}$ sites, which were installed throughout 1999 and into 2000. Data from this compliance portion of the network are available publicly. Work has begun to identify design values for upcoming designation decisions.
- Approximately 267 continuous ambient monitors, which are particularly needed for public data reporting and mapping work that is being planned currently. EPA is focusing on getting near real-time data reporting through the AIRNOW system in the 36 metropolitan areas that are carried by various media sources, including *USA Today*.
- A network of sites that provide chemically speciated PM data, including 54 urban trends sites operated by state and local agencies, 213 supplemental sites important for SIP development and also operated by state and local agencies, 28 rural sites operated by state and local agencies that use the regional haze program's IMPROVE protocols, and 110 sites operated by Federal land managers in Class 1 areas for the IMPROVE program. Also within the state and local agencies' urban networks, EPA expects to have up to 15 chemical speciation sites that use continuous speciation technologies for nitrates, sulphates, and carbon. EPA is investigating these continuous methods at five state and local agency locations prior to releasing states to purchase equipment for all sites. Tribal agencies are also providing additional fine PM data through the use of

both filter-based Federal reference methods and the IMPROVE protocols.

- Eight supersites with useful data in 2001, specifically from monitoring sites located in New York, Pittsburgh, Baltimore, St. Louis, Atlanta, Fresno, Los Angeles, and Houston. The supersites were developed as platforms for research and measurement methods by various universities in these eight areas. The measurement equipment and analysis techniques used at each supersite were often experimental or more advanced than those typically used in the routine PM networks. Data and information from each supersite are being analyzed both by the individual universities and through a data analysis program designed to evaluate data centrally from all eight supersites.
- CASTNet data

Figure 19 shows the annual average $PM_{2.5}$ concentrations for the period 1999-2000 measured by these networks.

Sulphate and Nitrate Concentrations in the Eastern United States and Canada

Particle sulphate concentrations in eastern North America are highest in the central portion of the eastern United States in an area encompassing southeastern Ohio, southwestern Pennsylvania, Kentucky, Virginia, West Virginia, Tennessee, northern Georgia, and northwestern Alabama (see figure 18). Almost all states south of the Great Lakes (except Florida) show moderately high concentrations. Southwestern Ontario has the highest concentrations in eastern Canada.

In contrast, particle nitrate concentrations are highest in the northwest part of the eastern United States in an area that includes Illinois, Indiana, Ohio, and southwestern Ontario. The lowest concentrations occur in the southern Appalachian area, New England, and northern and Atlantic Canada.

PM Modelling

Canada

At the Meteorological Service of Canada (MSC), work is underway on a “unified” regional air quality modelling system to address multiple-pollutant, multiple-issue applications, including PM, ozone, acid rain, and air toxics—AURAMS . The four foundation components for this new modelling system are the Environment Canada CEPS (Canadian Emission Processing System), MC2 (Mesoscale Compressible Community Multiscale Meteorological Model), CHRONOS (Canadian Hemispheric and Regional Ozone and NO_x System), Eulerian regional photochemical model, and a sectional size distributed aerosol module. The latest version (March 2002) of AURAMS will be evaluated with available data. Current model development and evaluation uses data sets from the 1990 emission inventory and various studies. Visibility modelling in Canada is planned via application of the CMAQ methodology based upon anomalous diffraction theory within the AURAMS framework post 2001. Also at MSC, CHRONOS, a tropospheric ozone model whose domain now includes all of Canada and most of the United States, is being enhanced to include methodologies from AURAMS for PM processes and ultimately to feed public air quality advisory programs.

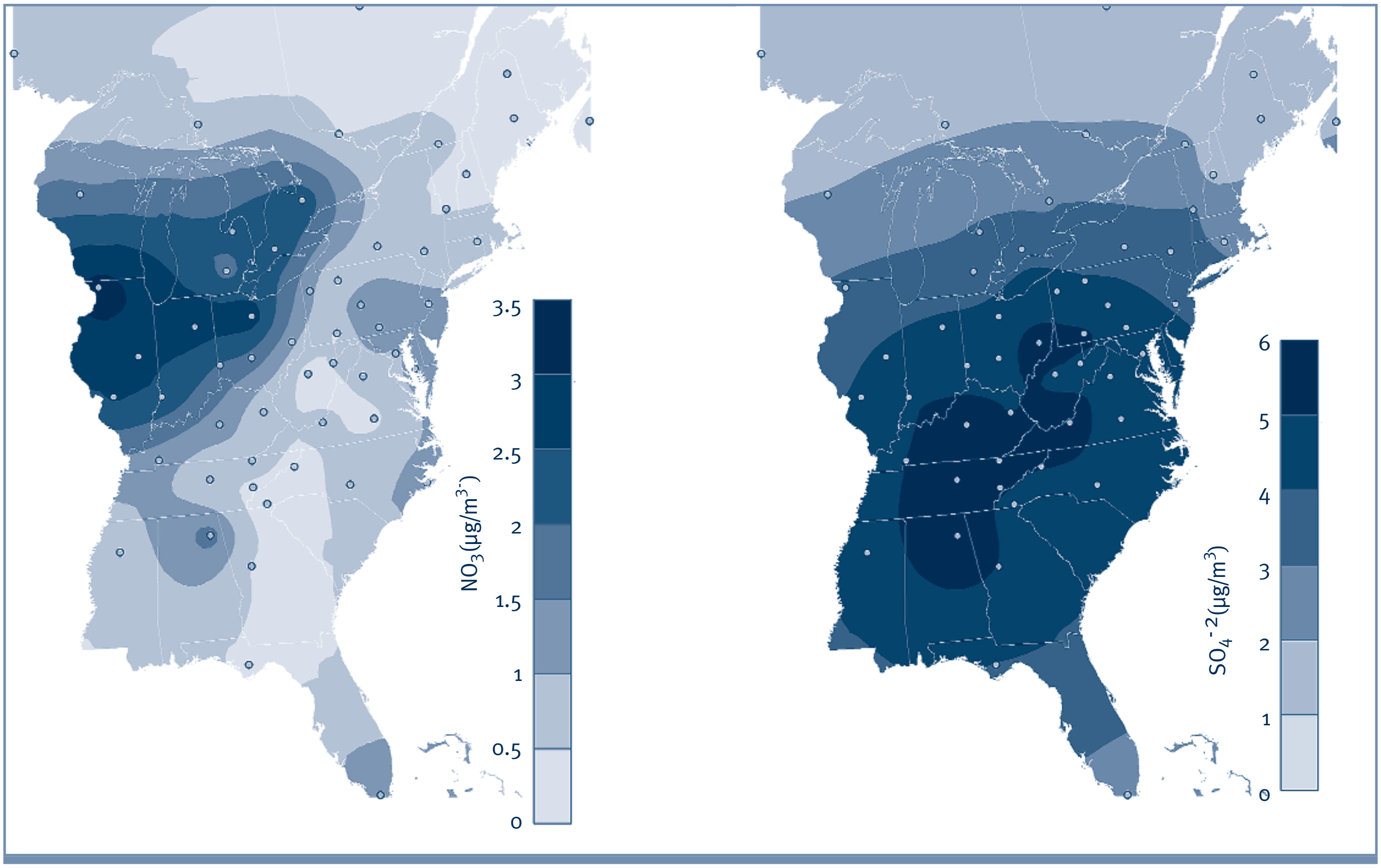
Environment Canada and Indiana University have been applying a Lagrangian aerosol model, ACDEP (Atmospheric Chemistry and Deposition model), to simulate aerosol levels in the Lower Fraser Valley airshed in southwestern British Columbia and northwestern Washington State. Model-predicted inorganic aerosol fields have been evaluated against 1993 event-specific field data (the Pacific 1993 field campaign). The model has been extended to describe the formation of secondary organic aerosols and has been renamed the Inorganic and Secondary Organic PARTicle model (ISOPART). Also for this region, MC2/UAM-VPM (Urban Airshed Model V Particulate Matter) is under development by Environment Canada and other government and industrial partners. In cooperation with the University of Washington and Environment Canada, CMAQ is being applied over the Pacific Northwest on a 12 km grid.

The Ontario Ministry of the Environment, the University of Waterloo, and Environment Canada are working with the Models-3/CMAQ platform. The model domain extended from 300 km west of Chicago to Quebec City, with Tennessee as the southernmost state. At the National Research Council of Canada, the Models-3/CMAQ modelling system has been modified, evaluated, and applied to the Lower Fraser Valley (LFV), which includes southwest British Columbia and northwest Washington State. To generate better boundary conditions for the LFV study, model runs have also been conducted for a larger area extending southward into the State of Oregon. The modifications to the Models-3/CMAQ system include the development and integration of a new secondary organic aerosol modelling component, development of a new CMAQ postprocessor for converting CMAQ model PM results into size-resolved PM concentrations, and adjustment to the CMAQ parameters for primary PM speciation.

United States

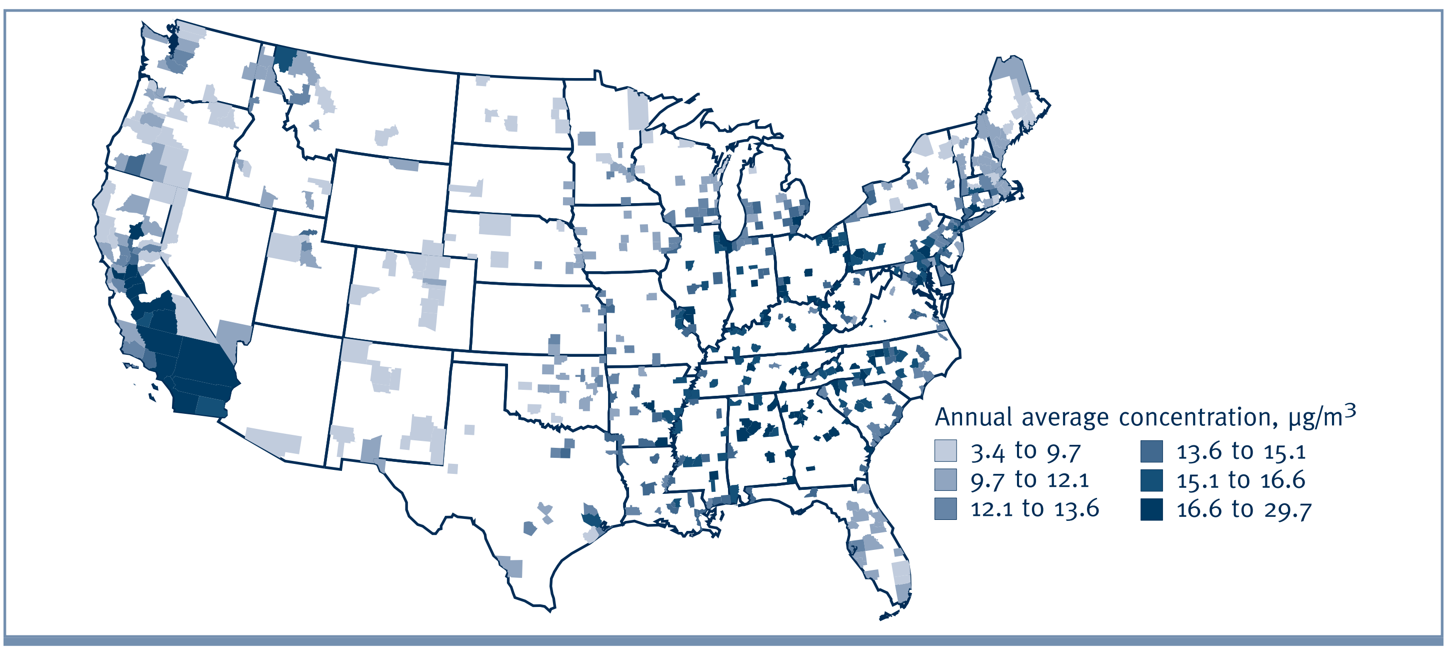
The United States is proceeding with development, testing, application, and evaluation of REMSAD and CMAQ. REMSAD has been revised to include updates recommended by a scientific peer review panel. EPA is planning to use Version 7 of REMSAD. The latest version of CMAQ was issued in June 2002. Both models have been applied for the continental United States, southern Canada, and northern Mexico for every hour of a full year using 1996 MM5 meteorology generated at 36 km horizontal grid square resolution. REMSAD has also been applied using 1998 Rapid Update Cycle (RUC) meteorology. The emission inventory for the United States is the 1996 National Emissions Inventory (NEI).

The United States has been using Canadian data for REMSAD applications. Canadian emissions for the REMSAD applications have been 1990 point, area, and mobile sources. The Canadian emissions for the CMAQ applications have been 1995 area and



1999–2000 Average Concentrations of Particle-Sulphate and Particle-Nitrate Concentrations *Figure 18*

The estimated pattern of two-year (1999-2000) average concentrations of particle-sulfate (left) and particle-nitrate (right) concentrations in ambient air at non-urban sites (in µg/m3). Data provided by the U.S. Clean Air Status and Trends Network (CASTNet) and the Canadian Air and Precipitation Monitoring Network (CAPMoN). Dots represent monitoring sites.



Annual Average U.S. $PM_{2.5}$ Concentrations, 1999–2000 *Figure 19* mobile sources. The latest 1995 Canadian point, area, and mobile emissions will be incorporated into future applications of both models. REMSAD has been run for future years (2010, 2020, and 2030) to evaluate the effects of regulatory initiatives, including the heavy-duty engine rule (see p. 4) and President Bush's proposed Clear Skies Initiative (see p. 20). The REMSAD modelling domain is currently being expanded northward and eastward to include most of Canada. REMSAD 1996 base case modelling using the latest Canadian emissions and the expanded modelling domain are scheduled for completion by October 2002.

PM Mapping

Joint Efforts

In 2001, initial work was completed to begin the transfer, as with ozone (see p. 28), of real-time $PM_{2.5}$ data from six Canadian provinces and several northeastern states to begin exploring the concept of mapping $PM_{2.5}$. The plan is to test the real-time delivery of the data and explore the feasibility of mapping this parameter.

Effects of Air Pollution

In Annex 2, the Parties also specifically agreed "to cooperate and exchange information" concerning the monitoring of ecosystem effects such as those evident in aquatic ecosystems, visibility, and forests and concerning effects of atmospheric pollution in general on human health and ecosystems, including research on health effects of acid aerosols and research on the long-term effects of low concentrations of air pollutants on ecosystems, "possibly in a critical loads framework." This section focuses on Canadian and U.S. progress in meeting this commitment.

HEALTH EFFECTS

Joint Efforts

In addition to the American Cancer Society cohort study, Canadian, American, and European researchers are collaborating on a joint analysis of the relationship between air pollution and mortality, with support from the Health Effects Institute and the European Union.[11]

Canada

Research on the health effects of air pollution involves scientists from federal and provincial governments as well as university-based researchers. Health Canada maintains an in-house program of research in toxicology, epidemiology, and biostatistics, and also funds outside collaborators on a contractual basis. Until March 2002, Health Canada and Environment Canada also provided grants to external researchers through the Toxic Substances Research Initiative, one theme of which was the health effects of air pollution.[12]

Recent research in toxicology includes evidence linking exposure to particulate matter with the release of endothelin, which plays an important role in the pathophysiology of circulatory disease[13] Controlled clinical studies of exposure to particulate matter and ozone have also identified modest effects on chemical mediators of thrombosis or blood clotting[14] Related work in clinical studies produced evidence linking exposure to particulate matter with vascular reactivity or reversible constriction of blood vessels.[15]

[11] K. Katsouyanni. 2002. J. Samet, and A. Cohen, *Air Pollution and health. A European and North American Approach,* Abstract presented at the Health Effects Institute Annual Conference, Seattle, Washington, April 28--30, 2002.

[12] M. Jerrett et al. 2001. *TSRI Environmental Justice and Health Research,* Summaries of the Toxic Substances Research Initiative Projects(Ottawa: Health Canada and Environment Canada, 2002), 100.

[13] R. Vincent et al. 2001. "Inhalation toxicology of urban ambient particulate matter: Acute cardiovascular effects in rats," *Res Rep Health Eff Inst.* 104 Oct.:5--54

[14] F. Silverman et al., 2002. *Cardiorespiratory effects of controlled human exposures to particulate matter and ozone,* Summaries of the Toxic Substances Research Initiative Projects (Ottawa: Health Canada and Environment Canada), 105.

[15] R.D. Brook, et al. 2002. "Inhalation of fine particulate air pollution and ozone causes acute arterial vasoconstriction in healthy adults" *Circulation* 105(13): 1534--36.

A study of air pollution exposure and heart rate variability has also been completed and analysis is underway.[16]

In epidemiology and biostatistics research, a team of investigators including Health Canada researchers and scientists from Canadian and American universities recently reported results from extended follow-up of the American Cancer Society cohort study.[17] This significantly strengthened the evidence base linking long-term exposure to air pollution with cardiopulmonary mortality and provided persuasive evidence of a link with lung cancer. Canadian investigators have also reported evidence identifying circulatory conditions, including diabetes and congestive heart failure as factors that potentially increase the probability of adverse effects of air pollution.[18] With respect to time-series studies, Health Canada scientists recently completed a meta-analysis of the more than 100 studies linking short-term air pollution exposure with mortality.[19] A study in Hamilton, Ontario, also found that areas characterized by lower socioeconomic status experienced more pronounced adverse effects from air pollution exposure[20].

United States

EPA continues to carry out a major PM research program that seeks to answer the following key questions about health effects:

- What characteristics of PM (e.g., size, chemical composition) cause harm?
- What are the physiologic mechanisms by which PM causes health problems?
- What is the role of PM, alone and in combination with other pollutants, in producing health problems?
- What groups of people (e.g., asthmatics, children, elderly) are most sensitive to PM and what are the critical levels of exposure for these groups?

This research program is consistent with the recommendations of the National Research Council's Committee on Research Priorities for Airborne Particulate Matter. Some of the research being conducted to answer the key questions is summarized below.

To better understand the health problems related to PM, EPA conducted a series of epidemiologic studies looking at the relationship between exposure to PM and physiologic responses in sensitive populations such as the elderly, children, and asthmatics. Several important findings emerged: the relationship between $PM_{2.5}$ and heart rate was consistent with findings from earlier studies; heart rate variability decreased at higher concentrations of $PM_{2.5}$; and respiratory function decreased with increasing $PM_{2.5}$ concentration. Decreased heart rate variability has been identified as a risk factor for death from cardiovascular disease.

To further characterize the effects of PM on humans, EPA scientists conducted clinical studies in which volunteers in a controlled exposure chamber were exposed to concentrated particles collected from outdoor air.[21] Healthy young adult participants (18-35 years old) experienced no symptoms of illness, no reduction in lung function, and no change in heart rate variability after a total exposure of two hours, during which they exercised. However, when elderly participants (65-80 years old) were subjected to the same conditions, they immediately experienced decreased heart rate variability which persisted for many hours after exposure stopped. These findings are consistent with the studies conducted at retirement homes and suggest that PM exposure influences nervous system control of heart rate in older people.[22]

EPA has a strong program in animal toxicology studies investigating PM and other air pollutant.[23] The program encompasses studies of PM constituents, molecular mechanisms, and pathophysiologic outcomes in healthy and susceptible animal models. Recent findings include studies where rodents were exposed to PM and other pollutants collected from outdoor air.[24] Exposure to PM was associated with reduced heart rate and an increased incidence

16 R. Dales, . 2002. *"The adverse cardiac effects of air pollution"*, Summaries of the Toxic Substances Research Initiative Projects (Ottawa: Health Canada and Environment Canada), 95.

17 C.A. Pope III et al. 2002. "Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution," *JAMA* 287(9):1132--41.

18 M.S. Goldberget al. 2001. "Identification of persons with cardio respiratory conditions who are at risk of dying from the acute effects of ambient air particles," *Environ Health Perspect.* Aug.109, Supp 4:487--94; M.S. Goldberg et al. 1986. "The association between daily mortality and ambient air particle pollution in Montreal, Quebec. 2. Cause-specific mortality," *Environ Res.* May 86(1):26--36.

19 D.M. Stieb, S. Judek, and R.T. Burnet,. "Meta-analysis of time series studies of air pollution and mortality: Effects of gases and particles and the influence of cause of death, age and season," *J Air Waste Manage Assoc.* 52:470--484.

20 Toxic Substances Research Initiative. National Conference Programme, March 5-8, 2001. Crowne Plaza Hotel, Ottawa, pp. 18-19.

21 A. Ghio, C. Kim, and R. Devlin, 2000. "Concentrated ambient air particles induce mild pulmonary inflammation in healthy human volunteers," *Am J Respir Crit Care Med.* Sep;162(3 Pt 1):981--8.

22 J. Creason et al., 2001. "Particulate matter and heart rate variability among elderly retirees: the Baltimore 1998 PM study," *J Expo Anal Environ Epidemiol.* Mar-Apr;11(2):116--22. PMID: 11409004.

23 D.L. Costa and K.L. Dreher. 1997. "Bioavailable transition metals in particulate matter mediate cardiopulmonary injury in healthy and compromised animal models," in K.E. Driscoll and G. Oberdörster, eds., Proceedings of the sixth international meeting on the toxicology of natural and man-made fibrous and non-fibrous particles, September 1996, Lake Placid, NY, *Environ. Health Perspect. Suppl.* 105(5):1053--1060.

24 R. Silbajoris, A.J. Ghio,J.M. Samet, R.Jaskot, K.I. Draher, L.E. Brighton, "In vivo and in vitrocorrelation of pulmonary MAP kinase activation following metallic exposure." Inhal *Toxicol.* 2000 Jun;12(6)-453-68. W.P. Watkinson, M. . Campen, and D.L. Costa, 1998. "Cardiac arrhythmia induction after exposure to residual fly ash particles in a rodent model of pulmonary hypertension," *Toxicol.* Sci 41:209-216.

of abnormal heart rhythms and death, especially among rodents with compromised heart or respiratory function.[25] EPA is exploring potential mechanisms responsible for these effects.

In a particularly interesting study, a labour strike that closed a steel mill in the Utah Valley for a year provided opportunities to evaluate the toxicity of ambient air particles. Previous epidemiologic studies found a reduction in hospital admissions for respiratory conditions when the mill was closed compared with when it was operating. EPA scientists, in collaboration with academic researchers, obtained particulate matter (PM_{10}) samples from a Utah Valley air monitoring station for the year before (year 1), the year during (year 2), and the year after (year 3) the steel mill closure. Year 2 dust had lowest concentrations of soluble iron, copper, and zinc and generated the lowest number of oxidants (reactive compounds believed to be a major cause of lung particulate matter) from each of the three years. Dust from years 1 and 3 caused significant lung injury and inflammation, whereas dust from year 2 caused minimal injury. This study, and additional laboratory research, suggests a potential mechanism for the health effects reported in the Utah Valley. EPA investigators demonstrated that cultured human lung cells exposed to particulate matter from years 1 and 3 produced significantly higher levels of inflammatory mediators than cells exposed to particulate matter from year 2. Researchers are currently using this in vitro system to investigate whether transition metals in Utah Valley particulate matter cause the inflammation.[26]

In addition to in-house research, EPA has established five PM Research Centers to investigate the heath effects of PM (see http://www.epa.gov/ttn/amtic/pmcenter.html). University scientists are working with EPA to characterize the relationship between ambient PM levels and actual personal exposure, identify the toxic components of PM and their associated biological effects, investigate the amount and distribution of PM deposited in the respiratory tract, and identify groups of people that are particularly susceptible to the adverse effects of PM. Findings from the first two years of research include the following:

- Inhalation of PM at concentrations only slightly above peak ambient levels can cause airway inflammation which can lead to other physiological responses, such as thickening of the blood.
- Controlled exposure studies in humans and animals have shown associations between ultrafine particles and changes in heart rate, heart rate variability, abnormal heart rhythms, and other heart and blood characteristics.
- Asthmatics may be particularly sensitive to ultrafine particles because these particles tend to be deposited in central airways of the respiratory system.
- In a study of healthy senior citizens, outdoor $PM_{2.5}$ concentrations were significantly correlated with an individual's personal exposure to $PM_{2.5}$.
- An epidemiologic study found significant associations between mortality and exposure to PM from traffic and coal-combustion sources but not between mortality and exposure to PM from oil combustion or soil.

EPA is also conducting research related to health effects of pollutants such as air toxics and ozone. (For more information on PM research, see the international inventory of PM research activities at www.pmra.org)

AQUATIC EFFECTS RESEARCH AND MONITORING

Water Chemistry Trend Analyses

A study of the 1989–1999 water chemistry trends observed at sites included in the International Cooperative Programme on Assessment and Monitoring of Acidification of Rivers and Lakes[27] confirmed the results of previous analyses that used data up until 1995.[28] The new study showed that in midwestern North America (northwestern Ontario, Michigan, Wisconsin, and Minnesota) and in eastern North America (central Ontario, Quebec, Atlantic Canada, and New York)

[25] U.P. Kodavanti et al. 2000a."Variable pulmonary responses from exposure to concentrated ambient air particles in a rat model of bronchitis," Toxicol. Sci. 54:441--451; U P. Kodavanti et al. 2000b. "The spontaneously hypertensive rat as a model of human cardiovascular disease: Evidence of exacerbated cardiopulmonary injury and oxidative stress from inhaled emission particulate matter," *Toxicol. Appl. Pharmacol.* 164:250--263.

[26] A. J. Ghio and R.B. Devlin. 2001. "Inflammatory lung injury after bronchial instillation of air pollution particles," *Am. J. Respir. Crit. Care Med.* 164:704-708;M.W. Frampton et al. 1999. "Effects of aqueous extracts of PM_{10} filters from the Utah Valley on human Airway epithelial cells," *Am. J. Physiol.* 277:L960-L967; J.A. Dye, et. al. 2001. "Acute pulmonary toxicity of particulate matter fiber extracts in rats: coherence with epidemiological 52 studies in Utah Valley residents." *Environ. Health Perspect.* 109(supp. 3), 395-403.53.

[27] G,L. Skjelkvale, J.L. Stoddard. Amd T. Anderson. 2001. "Trends in surface water acidification in Europe and North America (1989-1998)," *Water Air and Soil Pollution* 130:787-792.

[28] J.L. Stoddardl et al. 1999. *Nature* 401:575-578

declining sulphate and base cation (calcium + magnesium + sodium + potassium) concentrations were the predominant trends, i.e., they occurred in more than 50% of the monitored sites. These trends were both spatially widespread in occurrence and highly statistically significant. The fact that base cation declines appear to be a primary ionic compensation for sulphate declines is at least part of the reason why increases in pH and/or alkalinity (considered by many the "real" measure of acidification recovery) were not so predominant (see following paragraph). Nitrate concentrations also remain mostly unchanged in both regions, but concentrations of dissolved organic carbon (DOC) are increasing in some lakes. Increasing DOC may be important since, like increasing base cations, it can offset the pH and/or alkalinity improvements expected to accompany declining sulphate. On the other hand, increasing DOC may have the beneficial effect of reducing aluminum toxicity. Acidic waters typically have elevated concentrations of inorganic forms of aluminum that are toxic to aquatic biota. In the presence of DOC, inorganic aluminum combines with organic molecules, which renders it much less harmful.

Analyses of recent water chemistry trends observed in long-term monitoring networks from some eastern Canadian provinces confirm the foregoing generalities; however, they also show that differences exist both between provinces and between lake types. Declining sulphate was the predominant trend in long-term monitoring networks from Newfoundland and Nova Scotia,[29] Quebec,[30] and Ontario[31] but declining base cation concentrations was the most important compensatory response for only the latter two. Another Ontario network with a sample population composed of small lakes in wetland landscapes gave an entirely different result:[32] For this network, "no significant change" was the dominant sulphate response, probably reflecting mobilization (oxidation) and export of sulphur from wetland soils during periods of drought.[33] The effect of this climatic stressor is to counteract the chemical signal expected from declining sulphate deposition. Increasing lake pH or alkalinity was observed in 10%, 14%, 49%, 15%, and 41% of the lakes from Newfoundland, Nova Scotia, Quebec, Ontario (with wetland lakes), and Ontario (without wetland lakes), respectively. Continued monitoring is required to understand the complex chemical responses that are occurring in the face of multiple and sometimes competing ecosystem stressors.

FOREST EFFECTS

Several factors affect forest health: biotic, climatic, soil-related as well as management intervention. Eastern forests are routinely

exposed to acid deposition (as sulphur and nitrogen), as well as to ground-level ozone, in levels that are known to cause damage to sensitive components of ecosystems.

Joint Efforts

The NEG/ECP Forest Mapping Project

As reported on page 18, the Acid Rain Action plan, endorsed by the Conference of New England Governors and Eastern Canadian premiers (NEG/ECP), includes a component called The Forest Mapping Project. The project recognizes that in the presence of triggering stresses acid precipitation reduces soil fertility in some forests and is the underlying cause of decline of forest health and dieback. The goal of The Forest Mapping Project is to determine sustainable levels of acid deposition for forest soils in northeastern United States and eastern Canada using a calculation and mapping system inspired by a model developed and implemented in Europe for estimating 'critical loads' and their 'exceedances'.

The project receives funding and in-kind resources from a number of organizations and involves scientists from both countries.

In 1991, a Protocol for Assessing and Mapping Forest Sensitivity to Atmospheric Sulphur and Nitrogen Deposition was developed and published. The protocol lays out the methodology for estimating the 'sustainable' acid deposition rate, i.e., the rate that maintains or enhances the current level of soil base saturation such that soil reserves of plant nutrients can be maintained under given forest management practices and/or natural disturbance regimes for the foreseeable future (i.e., several forest rotations). The assessment of sustainable deposition is based on the long-term equilibrium

[29] T.A. Clair et al., 2002 ''Changes in freshwater acidification trends in Canada's Atlantic provinces: 1983-1997,'' *Water, Air Soil Pollution* 135:335--354.

[30] A. Kemp, 1999. "Trends in lake water quality in southern Quebec following reductions in sulphur emissions," *Environment Canada–Quebec Region, St. Lawrence Centre, Scientific and Technical Report ST-212E,* 126 p.

[31] W. Keller et al., 2001. "Sulphate in Sudbury, Ontario, Canada, lakes: Recent trends and statistics," *Water, Air Soil Pollution* 130:793-798;

[32] D.K. McNicol et al., 1996. "Recent temporal patterns in the chemistry of small, acid-sensitive lakes in central Ontario, Canada," *Water, Air Soil Pollution* 105:343--351.

[33] D.S. Jeffries et al., 2002. ''Temporal trends in water chemistry in the Turkey Lakes Watershed, Ontario, Canada, 1982-1999.,'' *Water Air Soil Pollution: Focus* 2:5--22

between the provision and removal of nutrients (calcium, magnesium, potassium, and nitrogen) from forest ecosystems. The protocol takes the following into account: atmospheric deposition, mineral nutrients freed from weathering of soil minerals, nutrients removed from a site through forest harvesting, and nutrients leached out of the soils by acidic deposition.

During phase 1 of the project, maps of sustainable deposition and actual exceedances were prepared for Vermont and Newfoundland. Preliminary results were presented and discussed with some foresters in both jurisdictions, and as a result, additional data and further improvements were incorporated in the calculations. During the next three years, maps will be produced for all of the New England states and eastern provinces.

Documenting Effects of Ozone on Forests

The North American Forestry Commission (NAFC; Mexico, United States, Canada) has developed a proposal outlining research and field activity to carry out an integrated assessment of the effects of air pollution on forest ecosystems of North America. Monitoring protocols are being developed as a first step toward implementation of the proposal. Examples of pollutants of concern to forest health that can be sampled with passive samplers are O_3, SO_2, NH_3, NO_2, and HNO_3.

NAFC is also producing a pamphlet, aimed at a general audience, looking at impacts of ground-level ozone on sensitive forest ecosystems in North America. This pamphlet will concentrate on four sensitive forest ecosystems: one in Canada, two in the United States, and one in Mexico. The tentative date of publication is early 2003.

Canada

The Forest Indicators of Global Change (FIGC) project completed its third year of activity since the establishment of plots in 1998. The project comprises 26 eastern Canadian, forested, permanent sample plots arranged across four zones of acidic deposition critical load exceedence and four of ozone critical level exceedence. The 1,800 km transect features a 2-7˚C variation of mean annual temperature and a 700-1,500 millimetre (mm) variation of mean annual precipitation. The most westerly plot is located at Turkey Lakes in northern Ontario and the most easterly near the Bay of Fundy, New Brunswick.

Sugar maple is contiguous as a dominant species across the gradient; white pine dominates as the coniferous species in Ontario; and red spruce is the predominant species in Quebec/New Brunswick. Sugar maple and red spruce have been the most prominent northeastern species suffering decline since the 1960s. The gradient includes CFS Acid Rain National Early Warning System (ARNEWS), Canada—U.S. North American Maple Project (NAMP), and new plots selected to fill geographical gaps. Nested within the whole are two sub-gradient studies focusing on high-elevation cloud/fog impacts and the 1998 ice storm. ARNEWS plots have been intensively monitored for up to 15 years, while NAMP plots have been monitored for more than10 years. With respect to the 11 Ontario plots, 0% to 83.3% of trees per plot were classed in 2001 as moderately damaged and 0% to 35.5% classed as healthy.

Outputs planned for in the FIGC include new indicators for early detection of changes in forest health as a result of global change, enhanced global change risk assessment, and linkage of indicator responses with monitoring trends.

United States

The USDA Forest Service initiated the Forest Health Monitoring (FHM) program in 1991 as a multi-agency, cooperative effort to determine the status, changes, and trends of health indicators in all forest ecosystems in the United States. The FHM program comprises four interrelated components:

- Detection Monitoring – field plot and aerial survey activities for national and regional monitoring
- Evaluation Monitoring – intensified monitoring or analysis in problem areas
- Intensive Site Ecosystem Monitoring – monitoring to understand processes and improve predictive capabilities
- Research on Monitoring Techniques – research to improve monitoring

The FHM program uses the Santiago Declaration and accompanying Criteria and Indicators as a framework for forest sustainability assessment and reporting.[34] Periodic assessments and reports are issued by the FHM program evaluating the status and changes of forest health indicators and stressors such as land use and forest fragmentation, air pollution, drought, storms, insects and pathogens, alteration of fire cycles, and invasive species.[35] The forest health indicators are analyzed in another report by ecoregion section.[36] More information on the FHM program is available on the FHM national Web site at http://www.na.fs.fed.us/spfo/fhm/index.htm. In 1999, the ground plot activities of FHM's Detection Monitoring component were integrated with the Forest Inventory and Analysis (FIA) program to maximize the strengths of both programs. More information about the enhanced FIA program can be found on the FIA national Web site at http://www.fia.fs.fed.us.

34 USDA Forest Service, 2001. "2000 RPA assessment of forest and range lands. FS-687" (Washington, D.C.: U.S. Department of Agriculture), 78 p. (http://svinet2.fs.fed.us/pl/rpa/rpaasses.pdf)

35 B.L. Conkling, J.W. Coulston, and M.J. Ambrose, eds., 2002. *FHM national technical report 1991-1999* (Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. To be published as a General Technical Report.)

36 R.G. Bailey, 1995."Description of the ecoregions of the United States," 2nd ed., *Misc. Publ.* 1391 (Washington, DC: U.S. Department of Agriculture),108 p.

Current Forest Conditions

The FHM program produces annual summaries of forest health indicators, including species diversity, bioindicator species (lichens and plants sensitive to ozone), changes in trees (crown condition, damage, and mortality), soil physical and chemical characteristics, and above- and below-ground carbon pools. The program tracks several tree health variables that relate to amount and fullness of foliage and the vigour of the apical growing points of the crown. Two of these variables are the mortality of the terminal twigs in the sun-exposed portions of tree crowns (dieback) and the transparency of the foliage of the whole tree crown to sunlight (i.e., sparseness of the crown foliage). Hardwood transparency has been increasing in portions of the United States over the period of FHM data collection (1991—1999), particularly in the Upper Midwest and portions of northern Idaho and eastern Washington. Hardwood dieback was highest in northeastern Maine and moderately high in New England. Softwood transparency was found to be increasing in the Appalachian Mountain area as well as in portions of Minnesota and Wisconsin. Softwood dieback was increasing in north-central Wyoming, eastern Maine, and lower New England in the Hudson Valley.

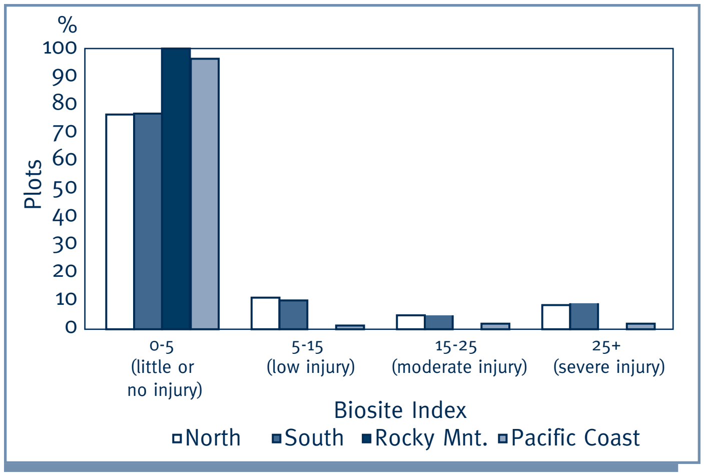
Tree mortality was analyzed by comparing the volume of mortality to the volume of growth for specific sections of ecoregions. Areas of highest mortality relative to growth were Central Till Plains and Beech-Maple in Illinois, Shawnee Hills in Indiana, and northern California Coast Ranges.

Air pollution

The FHM program has analyzed average exposure and trends in exposure of forests to air pollution for wet deposition of nitrate (NO_3^-) and sulphate (SO_4^{2-}) and ozone (SUM60)[37] from 1994 to 2000. A biomonitoring approach based on ozone-sensitive plants and lichens is also used to assess air pollution effects on forest environments. More than 900 biomonitoring sites in 33 states were evaluated in 2000. Data and field documentation are available online at http://www.na.fs.fed.us/spfo/fhm/ozonetrng/biozone.htm.

Average wet sulphate deposition rates were highest in the north and south forest regions from 1994 to 2000, with approximately half of the forest areas exposed to more than 23 kg/ha/yr. Significant decreasing trends in wet sulphate deposition rates were detected in north and south regions. The rates in Pacific Coast and Rocky Mountain forests were about one-sixth of the deposition rates for the North and South.

Wet nitrate deposition was highest in the North, with approximately half of the forest exposed to more than 18 kg/ha/yr. The only region with a significant decreasing trend in nitrate deposition was the South. Relatively low wet nitrate deposition rates occurred in the Pacific Coast and Rocky Mountain regions, with 50% of the forests receiving less than 6 kg/ha/yr.



Frequency Distribution of Average Percent Forest Subjected to Levels of Ozone Injury *Figure 20*

Growing season ozone concentrations were generally highest in the South, with 90% of the forests exposed to SUM60 ozone concentrations of more than 25 ppm-hours. High ozone exposure also occurred in forested areas in California. A plot level index calculated for ozone biomonitoring plots was based on amount and severity rating for each plant and the number of species evaluated at each site. Index values between 0 and 4.9 indicated little or no foliar injury; values between 5 and 24.9 indicated low to moderate injury ; and values greater than 25 indicated severe foliar injury. Little or no ozone injury to plants was recorded on most biomonitoring plots. In the North and South, approximately 77% of the plots had little or no injury from ambient levels of ozone. Only a small portion of plots had severe foliar injury. These were clustered in the airsheds surrounding the more industrialized portions of Illinois, Indiana, and Ohio, and all along the eastern corridor from Georgia, north through Virginia and up into southern New England had severe foliar injury. Severe foliar injury was also recorded on approximately 1% of the plots in the Pacific Coast region.

The relative exposure of forest types to air pollution was analyzed via cluster analysis of six air pollution indicators (ozone biosite index, average SUM60, average NO_3^-, NO_3^- change, average SO_4^{2-}, and SO_4^{2-} change). Higher relative air pollution exposure scores indicate higher exposure to air pollution. Forest types in the eastern United States had higher relative air pollution exposure scores than western forest types (figure 20). The oak-hickory forest type, which covers much of north and south forest regions, had the highest relative air pollution exposure score. Other eastern forest types with high relative air pollution exposure scores were oak-gum-cypress, loblolly-shortleaf pine, and oak-pine. Western forest types with the highest relative air pollution exposure score were the western hardwoods, pinyon-juniper, and chaparral types.

[37] The sum of all average hourly concentrations greater than 60 parts per billion (ppb).

EFFECTS ON MATERIALS

Joint Efforts

The U.S. National Center for the Preservation of Technology and Training (NCPTT) and the Canadian Conservation Institute are continuing studies begun in 2000 on using lasers for conservation of cultural materials and on the potential benefits of laser technology, in general.

United States

The effects of sulphur dioxide and other pollutants on cultural resources such as monuments, buildings, and sculpture are being studied by NCPTT, an office of the U.S. National Park Service. NCPTT operates an Environmental and Materials Research Program that focuses on determining the effects of air pollution on cultural resources and on developing treatments to mitigate those effects. The research focuses on air pollution interactions with limestone, marble, and bronze materials. Recently published work includes the effects of stone surface morphology on pollution deposition; studies on pollution-caused soiling to limestone buildings; a review of acid deposition and stone deterioration; and the interaction of pollutants and microorganisms on stone decay. NCPTT funds research on new treatments to prevent deterioration caused by air pollution, including development and testing of organic coatings for the protection of outdoor bronze. Finally, NCPTT funds the development of particle-modified material to consolidate deteriorating stone caused by pollution damage.

NCPTT operates a one-of-a-kind environmental exposure facility, including an environmental exposure chamber constructed in 1987 by the National Oceanic and Atmospheric Administration and the U.S. Geological Survey in conjunction with the National Park Service. The chamber is used to test the uptake of pollution onto materials.

One recent NCPTT laboratory study focused on effects of stone surface morphology and stone porosity on SO_2 deposition.[38] The study focused on four high-calcium limestones: Salem, Cordova Cream, Cottonwood Top Ledge, and Monks Park.

The results of this work show that porosity emerged as the dominant factor influencing dry deposition of SO_2 onto limestone. A secondary factor influencing deposition was surface roughness. Findings showed that the valleys on a stone surface enhanced deposition while the protruding "peaks" limited deposition.

NCPTT-funded research with Carnegie Mellon University concluded in 2001 with the culmination of 10 years of study of the effects of air pollution on tall limestone buildings.[39] This project encompassed a series of graduate and undergraduate projects designed to document the soiling patterns and characterize the conditions that led to the soiling of the Cathedral of Learning in Pittsburgh, Pennsylvania. The overall goals of this project were to better understand why and how soiling occurs and to develop models that link soiling to pollution types and concentrations. Results show that soiling at the Cathedral occurred somewhat uniformly over the building surface and that the building became soiled relatively quickly (within a few years) after construction. The main pollutants responsible are sulphur oxides, elemental carbon, and fly ash, all from coal combustion. Since pollutant levels have decreased since construction from the 1920s to the 1930s, the soiling patterns now seen are the result of rain eroding the soiled surfaces of the building. Computational fluid dynamics modelling results are consistent with soiling patterns observed on the building. Furthermore, measurements of rain fluxes to the building walls are in reasonable agreement with the fluid dynamics modelling.

In other studies, a review of the field of scientific literature on stone deterioration due to "acid rain" was conducted.[40] The reviewed articles indicate that dry deposition, mainly influenced by short-range transport of pollutants from local sources, is the main source of damage. A secondary source is wet deposition that is responsible for long-range transport of pollutants. However, in areas where buildings and monuments remain wet for long periods of time, and in rural areas, wet deposition can be a major source of damage. If pollution is very low, this phenomenon becomes indistinguishable from the "normal" weathering of stone by "clean" rain.

Other NCPTT-funded research studies concluded in 2000 on interactions between air pollutants and microorganisms on the deterioration of stone.[41] This three-year project resulted in

[38] Elizabeth A. Bede, 2000. "Characterization of surface morphology of carbonate stone and its effect on surface uptake of SO_2," InVasco Vassina, ed, *9th International Congress on Deterioration and Conservation of Stone* v1 (Amsterdam, Netherlands: Elsevier Science),303--11.

[39] Cliff Davidson et al., 2002. "Soiling patterns on a tall limestone building: Changes over 60 years," *Environmental Science and Technology* 34(4): 560-565; V. Etyemezian et al.2000. "Impingement of rain drops on a tall building," *Atmospheric Environment* 34:2499-12; W. Tang et al., in press. "Wind-driven rain on a tall limestone building: Washoff of soiling caused by pollutant deposition" in *Proceedings, International Symposium on Atmospheric Deposition and Impacts on Ecosystems* (Antwerp, Belgium: University of Antwerp Press).

[40] A. Elena Charola, 2001. "Acid deposition on stone," US/ICOMOS Scientific Journal III (1) :19--58. M. Zinn et al., "Deterioration of historic limestone materials by biofilms in a polluted environment," In *Proc. Annual Meeting Amer. Soc. Microbiology Q,* 156.

[41] M.Zinn, et.al. 2000 Deterioration of historic limestone materials by biofilms in a polluted envirionment. *Proc. Eastern Analytical Symposium*, 62. R. Mitchell, T. Perry, and M. Bruekker, 2000. "Interaction of air pollutants with microbial biofilms on historic limestone," *Proc. Eastern Analytical Symposium*, 62; R. Mitchell and J-D. Gu, 2000. "Changes in biofilm microflora of limestone caused by atmospheric Pollutants," *International Biodegradation* 46:299--303;C. McNamara, T. Perry, and R. Mitchell, 2002. "Biodeterioration of concrete and stone," *Corrosion*, in press; Mary F. Striegel, Ralph Mitchell, and Margaret Bruekker, in press 2001. "Biodeterioration of coatings on bronze sculpture," *Metals*, UNESCO ICOM-CC.

the development of a new analytic technique called micro-computer-assisted-tomography (mCT), which investigates the processes involved in microbial interactions with these pollutants on limestone. The data showed that stone treated with products of acid rain increased in volume and gypsum crusts were formed. When researchers exposed this stone to other microbial acids, they detected no loss in volume or voids within the stone and concluded that the minerals formed by the interaction of sulphates with the limestone provided protection from the action of microbial acids. Therefore, while pollutants do affect the microbial ecology found on limestone, the microorganisms do not enhance the chemical deterioration of limestone.

In other studies, a team of researchers at North Dakota State University is developing new coating systems for the protection of outdoor bronze from air pollution.[42] Pollutants such as SO_2, NO_x, CO_2, and chlorides affect various materials including bronze and lead to greater atmospheric corrosion. The team focuses on exploration of new coating technologies that would be appropriate for outdoor bronze sculpture.

Another NCPTT-funded project is developing new treatments to strengthen degraded stone.[43] Calcareous stone, such as limestone and marble, is susceptible to attack by sulphur dioxide in air pollution, a chemical interaction that leads to the formation of calcium sulphate, also known as gypsum. Since calcium sulphate is relatively water soluble, rain can dissolve and remove material, including the cementitious materials that bind the grains of stone together. The result is a weak, sugaring stone. Ethyl silicate-based consolidants are used to restore strength to degraded stones; however, one of the limitations of strength development using these products is cracking during drying. The research team is using particle modified consolidants (PMC), which consist of a silicate matrix plus colloidal oxide particles, to consolidate degraded stone. The presence of particles physically limits the silicate network from shrinking under capillary pressures and thereby reduces the loss of strength during drying. In addition, the network maintains a higher permeability because the dried consolidants remain porous.

[42] G. Bierwagen, T. Shedlosky, and L. Ellingson, in press "Electrochemical studies of the protection of bronzes from corrosion by organic coatings," *Metals 2001*, UNESCO ICOM-CC.

[43] Eleni Aggelakopoulou et al., in press. "Rheology optimization of particle modified consolidants," Materials Issues in *Art and Archeology* VI, Materials Research Society; Matthew R. Escalante, John Valenza, and George W. Scherer, 2000. "Compatible consolidants from particle-modified gels, "in Vasco Vassina, ed, *9th International Congress on Deterioration and Conservation of Stone* 2, ed. Vasco Vassina, Vol 2 : (Amsterdam, Netherlands: Elsevier Science) 459–65.

SECTION V

Conclusion

Continued success is being achieved both in Canada and in the United States in reducing emissions of SO_2 and NO_x, the major contributors of acid rain. Acid rain was the original focus of cooperative transboundary efforts under the 1991 Canada—U.S. Air Quality Agreement, and both countries continue to be on target for meeting reduction requirements for these pollutants.

Since the 1997 signing of the commitment to develop a Joint Plan of Action for Addressing Transboundary Air Pollution, both governments have expanded their commitments to address transboundary flows of air pollution to include ground-level ozone and PM.

The signing of the Ozone Annex to the Canada—U.S. Air Quality Agreement in December 2000 represents an achievement that will address transboundary flows of ground-level ozone and precursor pollutants in eastern Canada and the eastern United States. Both countries are on track to meet their emission reduction obligations in addition to their joint analysis and reporting commitments.

Cooperation between the two countries on transboundary smog issues is rich and complex. Joint efforts are underway from the East, where the Ozone Annex is currently focused, to the West, where the Georgia Basin-Puget Sound airshed discussions are underway. Other cooperative efforts are evaluating the scope and nature of the transboundary PM issue, tracking air quality and industrial emissions, and exploring emissions trading.

Second Five-year Review and Assessment of the Canada—United States Air Quality Agreement

INTRODUCTION

Article X, Review and Assessment of the Canada—United States Air Quality Agreement is intended to ensure that the Parties periodically review and assess the Agreement to determine whether it is working well and is "a practical and effective instrument to address shared concerns regarding transboundary air pollution." This second review will address the issues raised in 1996 when the first review was undertaken, outline where progress has been made, and indicate where challenges continue to exist.

ISSUES RAISED IN THE 1996 REVIEW

1. Article III: General Air Quality Objectives – The Parties agreed in 1996 that the control of transboundary air pollution has not occurred to the extent necessary to fully protect the environment, particularly in highly sensitive areas.

There are three components to this issue. First is the lack of an evolving environmental objective in the acid rain annexes of the Air Quality Agreement against which to measure progress. In Canada, the goal of the acidification program is to prevent damage and assess recovery to the sensitive ecosystems by achieving the critical loads for sulphate in aquatic ecosystems. While the United States does not use sulphate or acidification critical loads to guide its acid rain program but uses emission reductions and a cap to achieve its goals, sulphate deposition levels are closely followed and compared to ecosystem damage to assess recovery. The Parties agree that tracking progress made by emission reductions toward a goal of reducing and, when possible, preventing damage to the environment is important and should be a routine part of the work undertaken under the Air Quality Agreement.

The second part of this issue is the recognition that nitrogen emissions are an important part of the acidification issue, in addition to being a smog precursor. The development of nitrogen critical loads would be an important and useful tool through which to guide assessments of how much greater NO_x emission reductions should be to address both acidification and smog. This is particularly important since the scientific research in the past decade has shown clearly a strong link between sulphate and nitrate deposition. To prevent acidification damage, the extent of the reduction necessary from nitrogen oxide emissions may be greater than originally thought. The Parties agree that the role of nitrogen oxide emissions in both acidification and smog issues is important and that revised ecological goals for acidification, such as nitrogen critical loads, should be developed as soon as possible to guide assessments of transboundary issues.

The third component of the issue is the recognition that more reductions of emissions of sulphur dioxide and nitrogen dioxide are required to prevent damage to areas in Canada and the United States that are moderately and highly sensitive to acidification. The Parties agree that further reductions of emissions of the pollutants that cause acidification should be an important goal for future bilateral cooperation on transboundary air pollution under the Agreement, including in any future negotiations of an annex to address transboundary particulate matter. Joint efforts to analyze the impacts of current commitments to reduce sulphur dioxide and nitrogen oxide pollutants should be conducted to answer the question of how further emission reductions would impact the environment from acidification.

2. Article III: General Air Quality Objectives – The Parties recognized in 1996 that the Agreement and its annexes focused on acid rain and did not address other types of transboundary air pollutants, such as ground-level ozone or air toxics and particles.

The first Five-Year Review recognized the value of expanding the Agreement to address other issues of concern. Concrete steps were taken to respond to this issue on the occasion of the meeting between the Canadian prime minister and U.S. president in April 1997 when the Canadian minister of the Environment and the U.S. administrator of the Environmental Protection Agency signed a commitment to develop a Joint Plan of Action to address transboundary air pollution. The Joint Plan of Action set in motion cooperative analyses and work plans on transboundary ozone and fine inhalable particles. The development of the joint transboundary ozone report, its conclusion that a bilateral negotiation to address ground-level ozone would benefit air quality and health in both Canada and the United States, and the subsequent Canada—U.S. negotiation of the Ozone Annex in 2000 fulfill the first part of the 1997 Joint Plan of Action. The second part to address particulate matter (PM) in air in an effort to reduce transboundary particle levels is underway with a joint report of the transboundary PM issue being developed by scientists in both countries. The Parties agree to review the conclusions regarding the transboundary PM issue and to make a decision regarding a recommendation to governments in 2004 when the Ozone Annex is revisited, as the terms of the Annex provide.

With respect to addressing air toxics under the Air Quality Agreement, the Air Quality Committee decided in 1996 at its annual meeting that overlap and duplication among various existing bilateral mechanisms dealing with air pollution should be avoided. Transboundary air toxics are being addressed by Canada and the United States jointly through bilateral, trilateral, and multilateral agreements and arrangements. The Parties agree that they will keep abreast of and share information on developments on toxic pollutants of concern with a view toward discussions within the context of the Air Quality Agreement in the future if such discussions would be effective and not duplicative.

3. Article IV: Specific Air Quality Objectives: Annex 1 – The United States expressed concerns in 1996 regarding Canada's compliance with the prevention of significant air quality deterioration and the protection of visibility commitment in the Air Quality Agreement.

Canada's commitment in the Air Quality Agreement is to develop and implement for the Canadian sources that could cause significant transboundary air pollution the means to prevent significant air quality deterioration and to protect visibility in a way that is as effective as the U.S. programs for Prevention of Significant Deterioration (PSD) and protection of visibility in parks and wilderness areas. There are two key elements in the U.S. programs that are important with respect to transboundary air quality issues. First is the principle in the PSD and visibility programs that air quality should be protected not only where air quality standards are exceeded but also where air quality standards are already met. Second is the principle that both new industrial sources and the modifications made to existing sources should be built as cleanly as possible to prevent pollution.

Canadian governments, in June 2000, agreed to Canada-wide Standards (CWS) for ozone and particle air quality, including the principles to "keep clean areas clean" and to "continuously improve" air quality. As Canadian jurisdictions develop their plans and programs to meet the ozone and PM Canada-wide Standards by 2010, they will build in the measures to protect against deterioration of air quality. In addition, through the programs being developed to achieve the PM Canada-wide Standard, visibility will be improved across the country, including in areas where there is transboundary flow.

The Parties now agree that Canada's implementation of the Canada-wide Standard for PM and Ozone will likely address further air quality deterioration and may have benefits for visibility protection. However, the United States continues to be concerned that prevention of air quality deterioration and the protection of visibility are required programs in the United States while Canada does not have comparable requirements.

4. Article V: Assessment, Notification, and Mitigation – The Parties concluded in 1996 that they had concerns with the functioning of assessment and mitigation under the Agreement.

Although Canada and the United States have differences in laws and regulations on assessment and mitigation, the Parties have been successful in setting this different interpretation to the side and working together to address issues where there is a transboundary pollution concern. In 1998, at the annual Air Quality Committee meeting, *Guidelines for Implementing the Consultation Process under Article XI of the United States–Canada Air Quality Agreement* were approved. The guidelines provide for informal consultation between the Parties and are an effective process for implementing the consultation commitment laid out in Article XI of the Agreement. The immediate concerns leading to the development of the guidelines were a desire to discuss concerns expressed by U.S. residents regarding possible transboundary air pollution in the Sault Ste. Marie, Ontario, area in relation to the Algoma steel plant and in the Estevan area in Saskatchewan in relation to the Boundary Dam Power Station. Following the guidance in the guidelines, important working level cooperation and relationships have been developed that are not only addressing the original concerns expressed but also helping to address future issues that may arise under the information consultation provision of the Air Quality Agreement.

In addition to the informal bilateral intergovernmental consultations that are continuing successfully with respect to the Algoma steel plant and the Boundary Dam Power Station, a third informal consultation on the Conners Creek Power Plant in Detroit, Michigan, has been successfully concluded. In this case, Canadian residents expressed concerns about possible transboundary pollution resulting from the startup of a coal-fired power plant. The requirement for the power plant to refuel with natural gas was considered a positive conclusion by Canadians concerned about the plant's operations.

The Parties agree to continue to meet the consultation commitment under the Agreement using as guidance the informal guidelines established in 1998.

5. Article VI: Scientific and Technical Activities and Economic Research – The Parties concluded in 1996 that additional research and monitoring activities would be helpful in addressing transboundary air pollution issues.

Annex 2, which covers scientific and technical activities and economic research, falls under this article. The three issues that the science focuses on are acid rain, ground-level ozone, and particulate matter.

Acid deposition is seen as a success story as sulphate levels fall in most of the sensitive areas. In view of this, ongoing scientific work focuses on the role of nitrogen, the monitoring of acid deposition, and of lake and river chemistry. Some work is also being done to assess whether sulphate and nitrogen deposition loads will be reduced sufficiently to protect sensitive ecosystems after emission control programs are implemented in both countries. Until recently, most of the work has been carried out in parallel rather than in a truly cooperative mode. Efforts are now underway to enhance cooperation.

Since the 1996 review, the focus of the science program has shifted to ground- level ozone with emphasis almost entirely on health effects. In contrast to the acid rain issue, the science of ground-level ozone and particulate matter is focusing almost entirely on health effects. Both the United States and Canada have pioneered epidemiological studies based on large data bases that have shown an association between mortality/morbidity and air pollution levels with no apparent threshold. In addition to the health work, some forest effects ozone research is underway.

The Ozone Annex to the Air Quality Agreement and the amendments to the Annex II to address ozone science builds upon existing bilateral reporting under the Agreement and provides for each country a commitment to complete monitoring and assessment activities to track progress toward the achievement of each country's ozone air quality standards, to track facility-specific emission levels, to evaluate transboundary flow, and to monitor health and air quality along the border within 500 km.

The Ozone Annex committed Canada and the United States to explore market mechanisms and, in particular, emissions trading. Emissions cap and trade programs for NO_X and SO_2 emissions in the United States have proven to be an efficient and cost-effective method of achieving emission reductions to address acidification and ground-level ozone air quality concerns. There have been bilateral discussions of emissions trading, including a workshop in April 2001, when details were shared on U.S. trading programs. The Parties are developing a joint project designed to analyze and explore required infrastructure for a cross-border NO_X emissions cap and trade and to evaluate the impact of emissions trading on public health and the environment.

There is joint scientific work underway to understand the transboundary nature of particulate matter in order to frame the issue for the Air Quality Committee in a report to be issued by the end of 2003 that will be the focus of decision-making on whether to develop a PM annex to the Air Quality Agreement.

6. Article VII: Exchange of Information – The Parties agreed in 1996 that, when resources allowed, exchange of information ought to be expanded.

Exchange of information between the Parties has been enhanced through the new commitments under the Ozone Annex. The Ozone Annex requires, for the first time in 2002 and thereafter, specific ozone, ambient nitrogen oxide (NO_X), ambient volatile organic compound (VOC) concentration, and trend data will be reported in the biennial Canada—U.S. Progress Report for all relevant sites within 500 km of the border between Canada and the United States. To prepare the reports, common protocols and reporting formats are being defined.

Furthermore, the Ozone Annex requires by the 2004 biennial Canada—U.S. Progress Report and, thereafter, both Canada and the United States to begin reporting annual and ozone season and five-year trend data on nitrogen oxide and volatile organic compound emissions for the key source sectors in the transboundary ozone region or Pollutant Emission Management Area (PEMA) defined in the Annex. In addition, the Parties have broadened their coordination and exchange of data relating to acid deposition measurements.

In 2001, Canada and the United States established a cooperative agreement to characterize and improve U.S.—Canadian atmospheric deposition measurements and to enhance the exchange, accessibility, and analysis of data within the two countries. Under a cooperative agreement initiated this year, the two governments are planning to establish a common, cooperative, Canadian—U.S. deposition data-base, analysis, and Web-based mapping capability that will include data from the NADP, CASTNet, and AIRMoN networks as well as Canadian federal and provincial acid rain monitoring networks.

7. Article VIII: The Air Quality Committee – In 1996, the Parties agreed that detailed progress reports every five years and short interim progress reports would be sufficient.

In response to the Five-Year review comment, the Air Quality Committee decided that the progress reports should be shortened and attempts should be made to make them more "accessible" to the lay public. The 1998 and 2000 reports were shorter and less detailed to respond to the committee's direction. Despite their smaller size, however, they are technical in nature. At the same time, the academic community has found the lengthy 1996 progress report useful as course material. The Parties agree that while a biennial compliance report is technical in nature, such a report could be accompanied by a much shorter summary that can highlight the successes of the bilateral cooperation under the agreement.

8. Article IX: Responsibilities of the International Joint Commission (IJC) – The Parties' views on the role and responsibilities for the IJC differed in 1996.

At the 1999 annual meeting of the Air Quality Committee, the role and responsibilities of the International Joint Commission were discussed. The impetus for the discussion was a letter from the IJC in which a proposal was made that the role of the IJC be expanded. The Air Quality Committee agreed that the IJC should continue in its current role of soliciting and synthesizing public comments on the progress reports.

9. Article X: Review and Assessment – The Parties concluded in 1996 that involvement of a third party could assist in the review process.

After some consideration, the Parties do not see strong value in involving a third party in the review and assessment of the Agreement at this time. The Ozone Annex negotiation demonstrates the ability of the Agreement to function and adapt to transboundary pollution issues of concern to the Parties.

10. Articles XI: Consultations; XII: Referrals; and XIII: Settlement of Disputes – The Parties questioned in 1996 whether matters could be successfully resolved through a formal consultation process.

The Parties are satisfied that development and use of the informal Guidelines for Implementing the Consultation Process under Article XI of the United States—Canada Air Quality Agreement provide an appropriate opportunity for addressing and potentially resolving concerns regarding transboundary pollution.

NEW TRANSBOUNDARY AIR ISSUES

The Parties are each developing domestic programs through which to implement their PM air quality standards for particles. Subcommittee 2 is currently developing a description of the transboundary PM issue for the Air Quality Committee. This characterization will provide information to the Air Quality Committee from Subcommittee 1 on the benefits of developing bilateral management options to address the contribution of transboundary flows to the achievement of the air quality standards in the two countries. If the Air Quality Committee agrees that a bilateral approach to the transboundary PM issue is warranted, the committee may recommend to both governments that a PM annex be negotiated under the Air Quality Agreement.

The Georgia Basin-Puget Sound region in British Columbia and Washington State is currently undertaking to describe its transboundary air pollution issue sufficiently to enable an assessment of the value of a bilateral management approach in the area. Under the Ozone Annex, the opportunity to add a new region or Pollutant Emission Management Area exists. In 2004, when the Ozone Annex is revisited, the consensus achieved through the current discussion will be brought to the table for review and assessment.

Protection of visibility continues to be a requirement in the United States, while it is not considered an issue of concern in Canada. However, the Parties now agree that Canada's implementation of the Canada-wide Standard for PM and Ozone will likely address further air quality deterioration and may have benefits for visibility protection.

However, the United States continues to be concerned that prevention of the deterioration of air quality and the protection of visibility are required programs in the United States while Canada does not have comparable requirements.

The Air Quality Committee may be interested in mercury-related analyses as it relates to emissions from power plant generation and multipollutant efforts in both countries to address emissions from this sector.

CONCLUSION

Over the last five years, Canada and the United States continued to successfully fulfill the obligations set forth in the Air Quality Agreement. Implementation of each country's acid rain control program continues to be a particularly notable achievement of the Agreement. However, both countries recognize that control of transboundary pollution still has not occurred to the extent necessary to fully protect the environment, particularly in highly sensitive areas. To address this shortcoming, the Parties agree that 1) progress in tracking emissions reductions must be continued, and the United States continues to be particularly interested in making facility-specific emissions data publicly accessible; 2) revised ecological goals must be developed, particularly to assess the role of nitrogen oxide emissions in transboundary pollution issues; and 3) further reductions of the pollutants causing acidification should be a goal for future bilateral cooperation on transboundary pollution under the Agreement.

The first Five-Year Review recognized the value of expanding the Agreement to cover other issues of concern. Since the last review, the Parties successfully negotiated an Ozone Annex setting summertime nitrogen oxide emission reduction targets, or "caps," to address transboundary ozone pollution in the eastern border regions of each country. Efforts to address particulate matter to reduce transboundary PM transport are underway, and a joint scientific report on transboundary PM issues is being developed. The Parties agree to review the conclusions regarding transboundary PM issues and to make a decision regarding a recommendation to governments in 2004 when the Ozone Annex is revisited as the terms of the Annex provide.

In the first Five-Year Review, the Parties expressed disagreement over two main obligations, and both are areas in which progress has been made over the intervening five years. First, the Parties disagreed in 1996 over the prevention of air quality deterioration and the protection of visibility. The Parties now agree that Canada's implementation of the Canada-wide Standard for PM and Ozone will likely address further air quality deterioration and may have benefits for the protection of visibility. However, the United States continues to be concerned that prevention of air quality deterioration and protection of visibility are required programs in the United States while Canada does not have comparable requirements. Second, the Parties disagreed in 1996 regarding certain aspects of assessment and mitigation. The Parties continue to interpret differently the commitment on assessment and mitigation as a result of differences in laws and regulations. However, they have successfully set aside this difference and worked together to address transboundary pollution concerns. One result of this progress has been the approval of informal *Guidelines for Implementing the Consultation Process under Article XI of the United States—Canada Air Quality Agreement,* facilitating a practical and effective process for implementing the consultation commitment laid out in Article XI of the Agreement.

United States–Canada Air Quality Committee

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Assistant Deputy Minister
Environmental Protection Service
Environment Canada

Members:

Randy Angle
Air Issues and Monitoring
Alberta Environmental Protection

Lynn Bailey
Water, Air and Climate Change Branch
Ministry of Water, Land and Air Protection
British Columbia

John Banigan
Environmental Affairs Group
Industry Canada

Raynald Brulotte
Service de la Qualité de l'Atmosphère
Ministère de l'Environnement

David Egar
Air Pollution Prevention Directorate
Environmental Protection Service
Environment Canada

Marc-Denis Everell
Meteorological Services Canada
Environment Canada

Peter Fawcett
U.S. Transboundary Division
Foreign Affairs and International Trade

Robert Langdon
Environment and Natural Areas Management
Nova Scotia Department of Environment and Labour

John Lowe
Energy Policy Branch
Natural Resources Canada

Mark Raizenne
Healthy Environment and Consumer Safety Branch
Health Canada

Tony Rockingham
Air Policy and Climate Change Branch
Ontario Ministry of Environment

UNITED STATES

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Department of State

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Environmental Protection Agency

Bruce Polkowsky
Air Resources Division
National Park Service

Brian McLean
Director
Office of Atmospheric Programs
Environmental Protection Agency

Stephen Rothblatt
Air and Radiation
Environmental Protection Agency, Region 5

David Shaw
Assistant Director
Division of Air Resources
New York State Department of Environmental Conservation

Ed Watts
Office of Policy and International Affairs
Department of Energy

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Transboundary Air Issues Branch
Environmental Protection Service
Environment Canada

Brian McLean
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Office of Atmospheric Programs
Environmental Protection Agency

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Policy and Corporate Affairs
Meteorological Services
Environment Canada

Laurel Schultz
Office of Science Policy
Office of Research and Development
Environmental Protection Agency

Air Quality Agreement – Ozone Annex

Protocol between the Government of Canada and the Government of the United States of America Amending the "Agreement between the Government of Canada and the Government of the United States of America on Air Quality"

The Government of Canada and the Government of the United States of America, hereinafter referred to as "the Parties",

Recalling the Agreement between the Government of Canada and the Government of the United States of America on Air Quality done at Ottawa March 13, 1991, hereinafter referred to as "the Agreement,"

Recognizing that cooperative and coordinated action through the Agreement provides an effective means of addressing transboundary air pollution;

Intending to reduce the transboundary flow of tropospheric ozone and precursor emissions (NO_x and VOC), thereby helping both countries attain their respective air quality goals;

Recognizing that tropospheric ozone and its precursors (NO_x and VOC) originating in Canada and the United States are transported across their international border, thereby affecting the ability of downwind areas in each country to attain their air quality goals;

Concerned about the serious adverse effects to human health and the environment from these pollutants;

Recognizing the need to take new scientific evidence into account; and

Acknowledging the importance of public awareness, information, education and involvement;

Have agreed as follows:

Article I

A new Annex 3, titled "Specific Objectives Concerning Ground-Level Ozone Precursors" and attached as an appendix to this Protocol, shall be added to the Agreement.

Article II

Paragraph 2 of Article IV of the Agreement shall be deleted and replaced with the following:

"2. Each Party's specific objectives for emissions limitations or reductions are set forth in annexes to this Agreement as follows:

(a) Specific objectives for sulphur dioxide and nitrogen oxides, which will reduce transboundary flows of these acidic deposition precursors, are set forth in Annex 1.

(b) Specific objectives for volatile organic compounds and nitrogen oxides, which will reduce transboundary flows of tropospheric ozone and these precursors, thereby helping both countries attain their respective air quality goals over time, are set forth in Annex 3.

Specific objectives for such other air pollutants as the Parties agree to address should take into account, as appropriate, the activities undertaken pursuant to Article VI."

Article III

1. Article VII of the Agreement shall be amended by adding a new paragraph 2 as follows:

   "2. The Parties agree to provide, subject to their respective laws and regulations, public access to the databases containing the emissions and monitoring data reported or shared under this Agreement."

2. Paragraph 2 of Article VII of the Agreement shall be renumbered paragraph 3.

Article IV

Paragraph 3 of Annex 2 of the Agreement shall be amended as follows:

1. Subparagraph (e) shall be deleted and replaced with the following:

   "(e) their analysis of and experience with market-based mechanisms, including emissions trading. Specifically, through the Air Quality Committee established under Article VII of the Agreement, the Parties shall exchange information, within 12 months of entry into force of the Protocol amending this Agreement and as may be agreed upon thereafter, about the structure, components, public information and disclosure requirements (including verification), environmental impacts, and administration of their respective NO_x and SO_2 emissions trading programs including emissions monitoring, reporting and tracking of transfers of authority to emit;"

2. Subparagraph (f) shall be amended by deleting the period and replacing it with "; and".

3. A new subparagraph (g) shall be added as follows:

   "(g) public engagement and outreach activities."

Article V

Annex 2 of the Agreement shall be amended by adding a new paragraph 5 as follows:

“5. The Parties further agree, subject to their respective laws and regulations, to consult and share respective information on data, tools and methodologies and develop joint analyses on ground-level ozone and precursors, including:

(a) research and applications that contribute to tracking of human health and environmental responses to controls;

(b) facility-specific emissions data, quantification methods, and related information required for modeling and regulatory policy development, assumptions and models used to estimate emissions from other sources, and air quality data for all relevant monitors;

(c) evaluation of transboundary transport, using methods such as, *inter alia*, monitoring and meteorological data analyses, and modeling;

(d) evaluation of adequacy of monitoring networks;

(e) review of new technologies; and

(f) analysis of options for reductions from significant emitting source categories such as transportation, manufacturing and electricity where there may be opportunities to achieve further cost-effective emission reductions through various means, for example, energy efficiency, renewable energy, cleaner fuels, and alternative technologies and approaches."

Article VI

Pursuant to Article XVI of the Agreement, this Protocol shall enter into force upon signature by the Parties.

IN WITNESS WHEREOF the undersigned, being duly authorized by their respective Governments, have signed this Protocol.

DONE this ____________ day of ____________, 2000, in duplicate in the English and French languages, each version being equally authentic.

FOR THE GOVERNMENT OF CANADA

FOR THE GOVERNMENT OF THE UNITED STATES OF AMERICA

APPENDIX TO THE PROTOCOL

Annex 3

Specific Objectives Concerning Ground-Level Ozone Precursors

Part I -- Purpose

The objective of the annex is to control and reduce, in accordance with the provisions herein, the anthropogenic emissions of nitrogen oxides (NO_X) and volatile organic compounds (VOC) that are precursors to the formation of ground-level ozone and that contribute to transboundary air pollution, thereby helping both countries attain their respective air quality goals over time to protect human health and the environment. The Parties' goal is that in the long term and in a stepwise approach, taking into account advances in scientific knowledge, atmospheric concentrations not exceed:

A. **For Canada,** the Canada Wide Standard (CWS) for Ozone; and

B. **For the United States,** the National Ambient Air Quality Standards for Ozone.

Part II -- Pollutant Emission Management Area

Each Party hereby designates a Pollution Emission Management Area (PEMA), to which obligations in this Annex shall apply in accordance with the provisions herein.

A. **For Canada,** the area of 301,330km_ that covers all of the Canadian territory south of about the 48th parallel beginning east of Lake Superior to the Ottawa River, and south of the corridor that extends from the Outaouais Region east to Quebec City, as definitively designated on the map at Appendix 1 to this Annex.

B. **For the United States,** the area comprising the states of Connecticut, Delaware, Illinois, Indiana, Kentucky, Maine, Maryland, Massachusetts, Michigan, New Hampshire, New York, New Jersey, Ohio, Pennsylvania, Rhode Island, Vermont, West Virginia, and Wisconsin, and the District of Columbia, as indicated on the illustrative map at Appendix 2 to this Annex.

Part III -- Specific Obligations

A. **For Canada:**

1. With respect to mobile sources of NO_X and VOC emissions, Canada shall control and reduce its emissions of NO_X and VOC in accordance with the following obligations:

   (a) Continue the application of the following emission control measures:

   (i) Emission standards for new light-duty vehicles, light-duty trucks, heavy-duty vehicles, heavy-duty engines and motorcycles: *Motor Vehicle Safety Act* (and successor legislation), Schedule V of the Motor Vehicle Safety Regulations: Vehicle Emissions (Standard 1100), SOR/97-376, (28 July, 1997).

(ii) The Recreational Marine Engine Memorandum of Understanding between Environment Canada and manufacturers of spark-ignited marine engines to supply the Canadian market with engines designed to comply with U.S. federal spark-ignited marine engine emissions standards starting with the 2001 model year. This is an interim measure that will be overtaken and replaced by the regulation referred to in subparagraph (b)(iv) below.

(iii) The Handheld Spark-Ignition Engine Memorandum of Understanding between Environment Canada and manufacturers of handheld spark-ignited utility engines to supply engines to the Canadian market that are designed to comply with U.S. federal emissions standards for spark-ignited handheld utility engines starting January 1, 2000. This is an interim measure that will be overtaken and replaced by the regulation referred to in subparagraph (b)(iv) below.

(iv) The Nonhandheld Nonroad Engine Memorandum of Understanding between Environment Canada and manufacturers of Class I and II non-handheld spark-ignited utility engines to supply engines to the Canadian market that are designed to comply with U.S. federal emissions standards for new class I and class II nonhandheld nonroad spark-ignition engines starting January 1, 2001. This is an interim measure that will be overtaken and replaced by the regulation referred to in subparagraph (b)(iv) below.

(v) The Non-Road Diesel Memorandum of Understanding between Environment Canada and manufacturers of compression ignition (C.I.) non-road engines to supply engines designed to comply with U.S. federal emissions standards to the Canadian market starting with the 2000 model year. This is an interim measure that will be overtaken and replaced by the regulation referred to in subparagraph (b)(iv) below.

(vi) *Canadian Environmental Protection Act*, Diesel Fuel Regulations, SOR/97-110 (4 February, 1997).

(vii) *Canadian Environmental Protection Act*, Benzene in Gasoline Regulations, SOR/97-493 (6 November, 1997).

(viii) *Canadian Environmental Protection Act*, Sulphur in Gasoline Regulations, SOR/99-236 (4 June, 1999).

(ix) *Canadian Environmental Protection Act*, Gasoline and Gasoline Blend Dispensing Flow Rate Regulations, SOR/2000-43 (1 February, 2000).

(b) Develop and implement the following new emission control measures:

(i) Proceed with consultations with the objective of developing and implementing a Memorandum of Understanding between Environment Canada and manufacturers and importers of on-road vehicles to ensure that low-emission vehicles will be marketed and sold in Canada in the 2001-2003 model years, in alignment with the voluntary U.S. National Low Emission Vehicle (NLEV) program.

(ii) Emission regulations under the *Canadian Environmental Protection Act 1999* for new on-road vehicles and engines to align with future U.S. national standards beginning with the 2004 model year, including the U.S. Tier 2 program for new light-duty vehicles, light-duty trucks and medium-duty passenger vehicles and Phase 1 and Phase 2 programs for new heavy-duty vehicles and engines. The final standards and effective dates are subject to the procedures and outcome of the regulatory development process.

(iii) A regulation under the *Canadian Environmental Protection Act 1999* to reduce the allowable level of sulphur in on-road diesel fuel to align with future U.S. standards. The final standards and effective dates are subject to the procedures and outcome of the regulatory development process.

(iv) Emission regulations under the *Canadian Environmental Protection Act 1999* for new non-road engines aligned with the U.S. federal emissions program. The final scope of the standards and effective dates are subject to the procedures and outcome of the regulatory development process.

2. With respect to stationary sources of NO_x emissions, Canada shall control and reduce its emissions in accordance with the following obligations:

(a) By 2007, cap the annual total emissions of NO_x (as NO_2) from fossil fuel-fired power plants with a capacity greater than 25 megawatts within the PEMA at 39 kilotonnes for the Ontario portion of the PEMA and 5 kilotonnes for the Quebec portion of the PEMA.

(b) Proposed national Guideline under s.54 of the *Canadian Environmental Protection Act, 1999*, respecting Renewable Low-Impact Electricity.

3. With respect to sources of emissions of VOC, Canada shall control and reduce its emissions in accordance with the following obligations:

(a) *Canadian Environmental Protection Act 1999*, Proposed national Regulation on Tetrachloroethylene and other toxic substances used in dry cleaning.

(b) *Canadian Environmental Protection Act 1999*, Proposed national Regulation on degreasing from commercial and industrial degreasing facilities.

(c) Limit values for controlling emissions of VOC from new stationary sources in the following stationary source categories will be determined on the basis of available information on control technology and levels, including limit values applied in other countries, and the following documents:

(i) Canadian Council of Ministers of Environment (CCME). Environmental Guideline for the Control of Volatile Organic Compounds Process Emissions from

New Organic Chemical Operations. September 1993. PN1108;

(ii) CCME. Environmental Code of Practice for the Measurement and Control of Fugitive VOC Emissions from Equipment Leaks. October 1993. PN1106;

(iii) CCME. A Program to Reduce Volatile Organic Compound Emissions by 40 Percent from Adhesives and Sealants. March 1994. PN1116;

(iv) CCME. A Plan to Reduce Volatile Organic Compound Emissions by 20 Percent from Consumer Surface Coatings. March 1994. PN1114;

(v) CCME. Environmental Guidelines for Controlling Emissions of Volatile Organic Compounds from Aboveground Storage Tanks. June 1995. PN1180;

(vi) CCME. New Source Performance Standards and Guidelines for the Reduction of Volatile Organic Compound Emissions from Canadian Automotive Original Equipment Manufacturer (OEM) Coating Facilities. August 1995. PN1234;

(vii) CCME. Environmental Guideline for the Reduction of Volatile Organic Compound Emissions from the Plastics Processing Industry. July 1997. PN1276; and

(viii) CCME. National Standards for the Volatile Organic Compound Content of Canadian Commercial/Industrial Surface Coating Products - Automotive Refinishing. August 1997. PN1288.

4. In order to attain the CWS for Ozone in the PEMA by 2010, Canada shall undertake by 2005, and implement between 2005 and 2010, measures based on a comprehensive, national multi-pollutant emission reduction approach as agreed by Canadian Ministers of Environment, consistent with the overall program for achieving the CWS for Ozone, for the following sectors: pulp and paper, lumber and allied wood products, electric power, iron and steel, base metal smelting and concrete batch mix and asphalt mix plants. These measures shall address, inter alia, NO_X emissions from new, modified and existing industrial and commercial boilers. In addition, measures shall be developed to reduce VOC emissions from solvents, paints and consumer products using a mix of instruments such as eco-labelling criteria and public education programs pertaining to VOC in consumer products, environmental performance standards for key products (e.g. surface coating of wood products, automotive parts, metal products) and for other significant solvent sources.

5. In addition, in the Quebec portion of the PEMA, the following shall be implemented:

(a) Proposed amendments to *Le Réglement sur la qualité de l'atmosphère du Québec* ("Québec's Regulation respecting the Quality of the Atmosphere") to reduce NO_X emissions from new and modified industrial and commercial boilers.

(b) Proposed amendments to *Le Réglement sur la qualité de l'atmosphère du Québec* ("Québec's Regulation respecting the Quality of the Atmosphere") to reduce VOC emissions from surface coatings, commercial printing, dry cleaning and aboveground storage tanks.

(c) Implementation of the Agreement on Environmental Management between the Government of Québec and petroleum refineries and major petrochemical plants to control and reduce VOC emission from their operations.

(d) Implementation of the existing *Réglement sur les produits pétroliers du Québec* ("Québec's Regulation on Petroleum Products") concerning gasoline volatility.

(e) Proposed amendments to *Le Réglement sur les produits pétroliers du Québec* ("Québec's Regulation on Petroleum Products") to reduce VOC emissions from gasoline distribution networks.

6. In addition, in the Ontario portion of the PEMA, the following shall be implemented:

(a) The Ontario Drive Clean program (*Ontario Environmental Protection Act* Regulation 361/98) as amended by Ontario Regulation 401/98, as amended by Ontario Regulation 86/99 and as amended by Ontario Regulation 438/99.

(b) Regulation (*Ontario Environmental Protection Act* Regulation 455/94) of Stage I vapour recovery.

(c) Regulation (*Ontario Environmental Protection Act* Regulation 271/91 as amended by *Ontario Environmental Protection Act* Regulation 45/97) of volatility of gasoline at 9 psi during the summer months in southern Ontario and 10.5 psi in northern Ontario.

(d) Regulation (*Ontario Environmental Protection Act* Regulation 323/94) requiring environmental training for dry cleaners.

(e) Implementation of the CCME guideline for new and modified combustion turbines.

(f) Implementation of the CCME guideline for new commercial/industrial boilers and heaters.

(g) Regulation (*Ontario Environmental Protection Act* Regulation 227/00) to be applied to the electricity sector requiring annual monitoring and reporting of 28 pollutants of concern with a commitment to extend the monitoring and reporting requirement to other industry sectors.

B. For the United States:

1. Specific NO_X Reduction Commitments
   (a) The United States shall require States that are located in the PEMA and that are subject to EPA's NO_X regulation (referred to as the "NO_X SIP Call") to implement that regulation in accordance with 40 Code of Federal Regulations (CFR) sections 51.121 and 51.122 including any modifications as a result of any court decision. The NO_X SIP Call requires States to ensure that seasonal NO_X emissions do not exceed specified levels ("budgets").
   (b) The United States shall implement a motor vehicle control program in the PEMA that meets the requirements of 40 CFR Part 80, Subpart D (reformulated gasoline), 40 CFR Part 86 (control of emissions from new and in-use highway vehicles and engines); and 40 CFR Part 80, section 80.29 (controls and prohibitions on diesel fuel quality).
   (c) The United States shall implement standards for non-road engines in the PEMA as provided for in 40 CFR Part 87 (aircraft), Part 89 (compression-ignition engines), Part 90 (spark-ignition engines), Part 92 (locomotives), and Part 94 (marine engines).

2. Specific VOC Reduction Commitments
   (a) The United States shall implement controls in the PEMA that reduce VOC emissions as required by 40 CFR Part 59, Subpart B (automobile repair coatings), Subpart C (consumer and commercial products), and Subpart D (architectural coatings).
   (b) The United States shall implement controls on hazardous air pollutants in the PEMA that also reduce VOC emissions as required by 40 CFR Part 63. This includes the following Subparts:

   Subpart M (dry cleaning);
   Subparts F, G, H, and I (Hazardous Organic NESHAP);
   Subpart GG (aerospace industry);
   Subpart N (chromium electroplating);
   Subpart L (coke ovens: charging, top side and door leads);
   Subpart O (commercial sterilizers);
   Subpart T (degreasing organic cleaners);
   Subpart R (gasoline distribution (Stage 1));
   Subpart Q (industrial cooling towers);
   Subpart EE (magnetic tape);
   Subpart Y (marine vessel loading operations);
   Subpart DD (off-site waste and recovery operations);
   Subpart CC (petroleum refineries);
   Subpart U (polymers and resins I);
   Subpart W (polymers and resins II);
   Subpart JJJ (polymers and resins III);
   Subpart KK (printing/publishing);
   Subpart X (secondary lead smelters);
   Subpart II (shipbuilding and ship repair);
   Subpart JJ (wood furniture);
   Subpart XXX (ferralloys production);
   Subpart III (flexible polyurethane foam production);
   Subpart YY (generic MACT);
   Subpart DDD (mineral wool production);
   Subpart HH (oil and natural gas transmission and production);
   Subpart MMM (pesticide active ingredient production);
   Subpart GGG (pharmaceuticals production);
   Subpart AA/BB (phosphoric acid/phosphate fertilizers);
   Subpart PPP (polyether polyols productions);
   Subpart OOO (polymers and resins III: amino/phenol resins);
   Subpart LLL (portland cement manufacturing);
   Subpart LL (primary aluminum production);
   Subpart TTT (primary lead smelting);
   Subpart VVV (publicly owned treatment works);
   Subpart S (pulp and paper (Non-combust) MACT I);
   Subpart S (pulp and paper cluster rule MACT III);
   Subpart RRR (secondary aluminum);
   Subpart CCC (steel pickling);
   Subpart F (tetrahydrobenzaldehyde manufacture); and
   Subpart NNN (wool fiberglass manufacturing).
   (c) The United States shall implement controls in the PEMA on motor vehicles and non-road engines as described above in Part III.B (1) above.

3. New Source Standards

   The United States shall require major new VOC and NO_X sources in the PEMA to meet New Source Performance Standards as required by 40 CFR Part 60. This includes the following Subparts:

   Subpart D (fossil fuel fired steam generators);
   Subpart Da (electric utility steam generating units);
   Subpart Db (industrial/commercial/institutional steam generating units);
   Subpart Dc (small industrial-commercial-institutional steam generating units);
   Subpart E (incinerators);
   Subpart Ea (municipal waste combustors);
   Subpart Eb (large municipal waste combustors);
   Subpart Ec (hospital/medical/infectious waste incinerators);
   Subpart G (nitric acid);
   Subpart K (storage vessels for petroleum liquids);
   Subpart Ka (storage vessels for petroleum liquids);
   Subpart Kb (volatile organic liquid storage vessels);
   Subpart EE (surface coating of metal furniture);
   Subpart GG (stationary gas turbines);
   Subpart MM (automobile or light-duty truck assembly plants);
   Subpart QQ (graphic arts industry: publication rotogravure printing);
   Subpart RR (pressure sensitive tape and label surface coating operations);
   Subpart SS (industrial surface coating of large appliances);
   Subpart TT (metal coil surface coatings);
   Subpart VV (synthetic organic chemical manufacturing industry (SOCMI));

Subpart WW (municipal solid waste landfill);
Subpart XX (bulk gasoline terminals);
Subpart BBB (passenger and light duty truck tire manufacturing);
Subpart DDD (polymer manufacturing industry);
Subpart FFF (rotogravure printing of flexible vinyl or urethane products);
Subpart GGG (petroleum refinery leaking equipment);
Subpart HHH (synthetic fiber production facilities);
Subpart JJJ (petroleum dry cleaners);
Subpart KKK (onshore natural gas processing plant leaking equipment);
Subpart NNN (SOCMI distillation operations);
Subpart QQQ (individual drain systems;
Subpart RRR (SOCMI reactor processes);
Subpart SSS (magnetic tape manufacturing);
Subpart TTT (surface coating of plastic parts for business machines);
Subpart VVV (polymeric coating of supporting substrates); and
Subpart WWW (municipal solid waste landfills).

C. For both Parties:

Taking into account the purpose of this Annex, the Parties agree that the regulations, guidelines and caps referenced in all of the commitments in Part III above are subject to modification from time to time as a result of domestic legal processes that may take place.

Part IV -- Anticipated Additional Control Measures and Indicative Reductions

In addition to the obligations set forth in Part III above, each Party currently implements or anticipates implementing additional measures that are expected to contribute to overall reductions of NO_X and VOC emissions. For illustrative purposes only, additional control measures currently in place and anticipated additional control measures are set forth below, as are predicted overall emission reduction rates.

A. For Canada:

1. National Reductions

   In order to achieve, by 2010, the CWS for Ozone (65 ppb 8-hour average 4th highest averaged over 3 years), Canada intends to develop and implement further reductions of emissions of NO_X and VOC.

2. Area-Specific Reductions

   In Ontario, a 45% reduction of NO_X and VOC emissions from 1990 levels is expected to be required to meet the CWS for Ozone, assuming comparable reductions in the U.S. PEMA. In the Ontario portion of the PEMA, measures to reduce VOC emissions from small to medium sized solvent users will be developed. In the Québec portion of the PEMA, measures to reduce NO_X and VOC emissions from existing light and heavy-duty vehicles will be considered.

3. Quantitative Estimates

   The emission reduction obligations identified in Part III.A above are estimated to reduce annual NO_X emissions in the PEMA from 1990 levels by 39% by 2007 and 44% by 2010 and annual VOC emissions in the PEMA from 1990 levels by 18% in 2007 and 20% in 2010. Once all the measures identified in Part III.A are implemented, in conjunction with the anticipated national and area-specific reductions identified above, it is expected that emissions reductions will be greater than currently estimated.

B. For the United States:

1. National Reductions

   The United States has developed or intends to develop and implement standards to further reduce emissions of NO_X and VOC, including:

   (a) Tier 2 vehicle and fuel sulphur standards
   (b) Tier 3 standards for nonroad compression ignition engines
   (c) Heavy-duty engine standards
   (d) Recreational vehicle standards

2. Area-Specific Reductions

   The United States has implemented and intends to continue to implement NO_X and VOC control measures in specific areas as required by applicable provisions of the Clean Air Act. The area specific measures include: NO_X and VOC reasonably available control technology, marine vessel loading, treatment storage and disposal facilities, municipal solid waste landfills, onboard refuelling, residential wood combustion, vehicle inspection/maintenance, and reformulated gasoline. In addition to these measures, under Clean Air Act mandates, U.S. states have already adopted or will be required to adopt additional measures for particular areas in the PEMA in order to meet the applicable National Ambient Air Quality Standards for Ozone.

3. Quantitative Estimates

   The emission reduction obligations identified in Part III.B above, in conjunction with the anticipated national and area-specific reductions identified above, are estimated to reduce annual NO_X emissions in the PEMA from 1990 levels by 27% by 2007 and 36% by 2010[1] and annual VOC emissions in the PEMA from 1990 levels by 35% in 2007 and 38% in 2010.[1] Further, the emission reduction obligations identified in Part III.B above in conjunction with the anticipated national and area-specific reductions identified above, are estimated to reduce ozone season NO_X emissions in the PEMA from 1990 levels by 35% by

[1] The assumptions used in calculating the indicative reductions are detailed in "Procedures for Developing Base Year and Future Year Mass Modeling Inventories for the Tier 2 Final Rulemaking" (EPA420-R-99-034, September 1999).

2007 and 43% by 2010 and ozone season VOC emissions in the PEMA from 1990 levels by 39% in 2007 and 36% in 2010.

C. For Both Parties:

Each Party shall update its quantitative estimates referred to above, by 2004 and from time to time thereafter, and shall make such estimates available to the other Party and to the public.

Part V --Reporting

A. Beginning in 2004, as part of the biennial progress reports under Article VIII.2 of the Agreement, the Parties agree to provide information on all anthropogenic NO_X and all anthropogenic and biogenic VOC emissions within the PEMA specified in Part II above. This information shall be from a year not more than two years prior to the year of the report and shall include:

1. Annual and ozone season (May 1 to September 30) estimates for VOC emissions categorized into the following sectors:
   (a) Industrial Sources
   (b) Non-Industrial Fuel Combustion
   (c) Electric Power Generation
   (d) Onroad Transportation
   (e) Nonroad Transportation
   (f) Solvent Utilization
   (g) Other Anthropogenic Sources
   (h) Biogenic sources (VOC emissions from vegetation and NO_X emissions from soil).
2. Annual and ozone season (May 1 to September 30) estimates for NO_X emissions categorized into the following sectors:
   (a) Industrial Sources
   (b) Non-Industrial Fuel Combustion
   (c) Electric Power Generation
   (d) Onroad Transportation
   (e) Nonroad Transportation
   (f) Other Anthropogenic Sources.
3. NO_X and VOC 5-year emissions trends for the sectors listed above as well as total emissions.

B. For the purpose of these reports, the Parties shall develop a common definition of what source categories are covered in each sector and a common format and level of aggregation and disaggregation of data for reporting emissions.

C. Beginning in 2002, as part of the biennial progress reports, the Parties agree to provide the following ambient air quality information:

1. Ambient ozone concentrations, reported in the form of the applicable standards
2. 10-year trends in ambient ozone concentrations
3. Ambient VOC concentrations
4. 10-year trends in ambient VOC concentrations
5. Ambient NO_X concentrations
6. 10-year trends in ambient NO_X.

D. The ambient air quality information listed above shall be reported for all relevant monitors located within 500 km of the border between Canada and the lower 48 states of the United States.

E. For the purpose of these reports, the Parties shall develop common protocols and reporting formats, including identification of relevant monitors, for reporting air quality and trends information.

F. Beginning in 2004, as part of the biennial progress reports, the Parties agree to provide information on implementation of the controls agreed to under this Annex.

Part VI -- Revisiting

A. The Parties agree to assess in 2004 progress in implementing the obligations in the Annex with a view to negotiating further reductions.

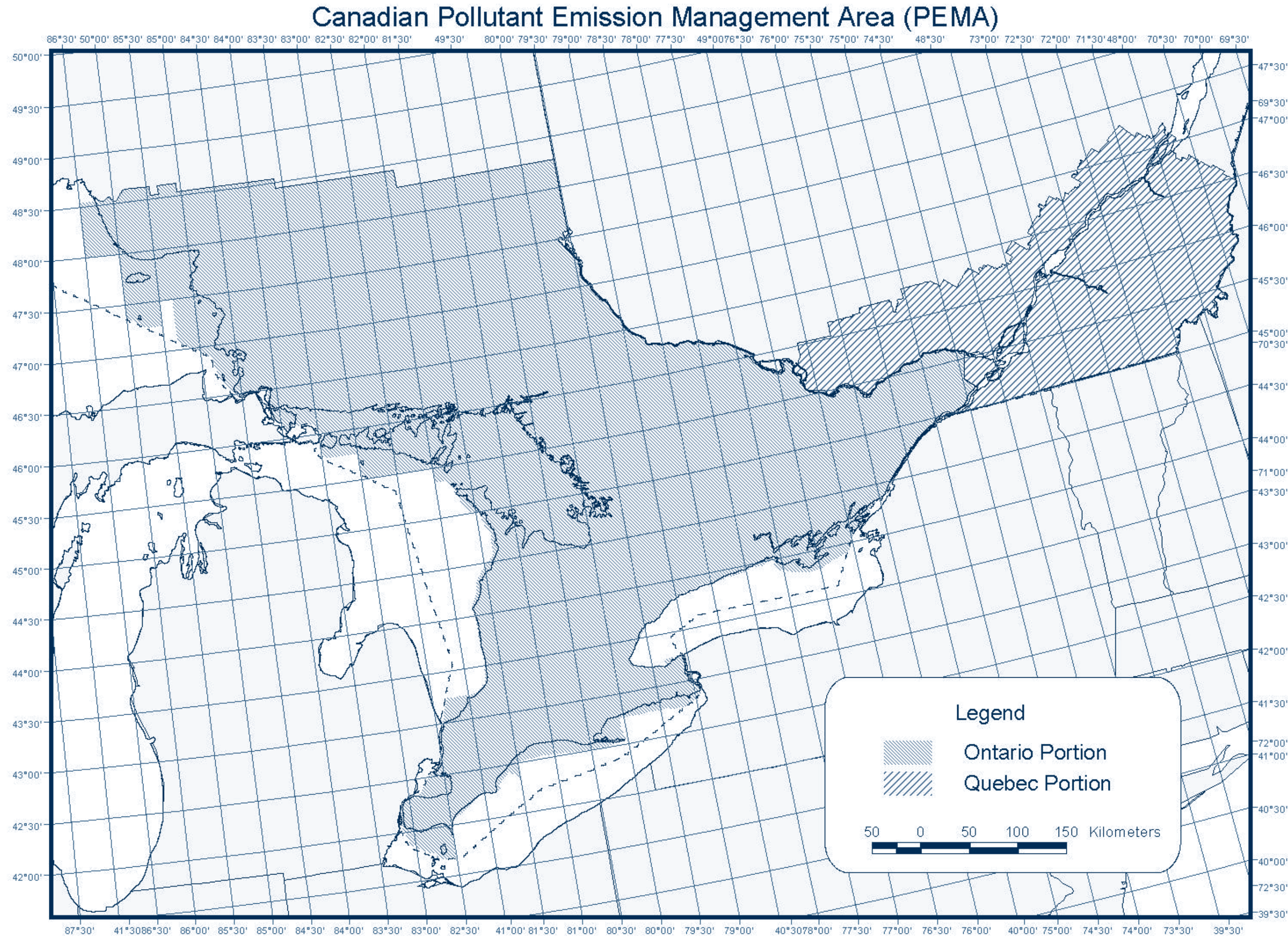
B. The Parties agree to discuss, at the request of either Party, the possibility of amending this Annex to designate additional emission management areas and/or to revise the emissions commitments currently specified.

C. As part of the comprehensive review under Article X of the Agreement, the Parties shall also review the adequacy of the obligations in this Annex for achieving the objectives of this Annex.

Part VII -- More Stringent Measures

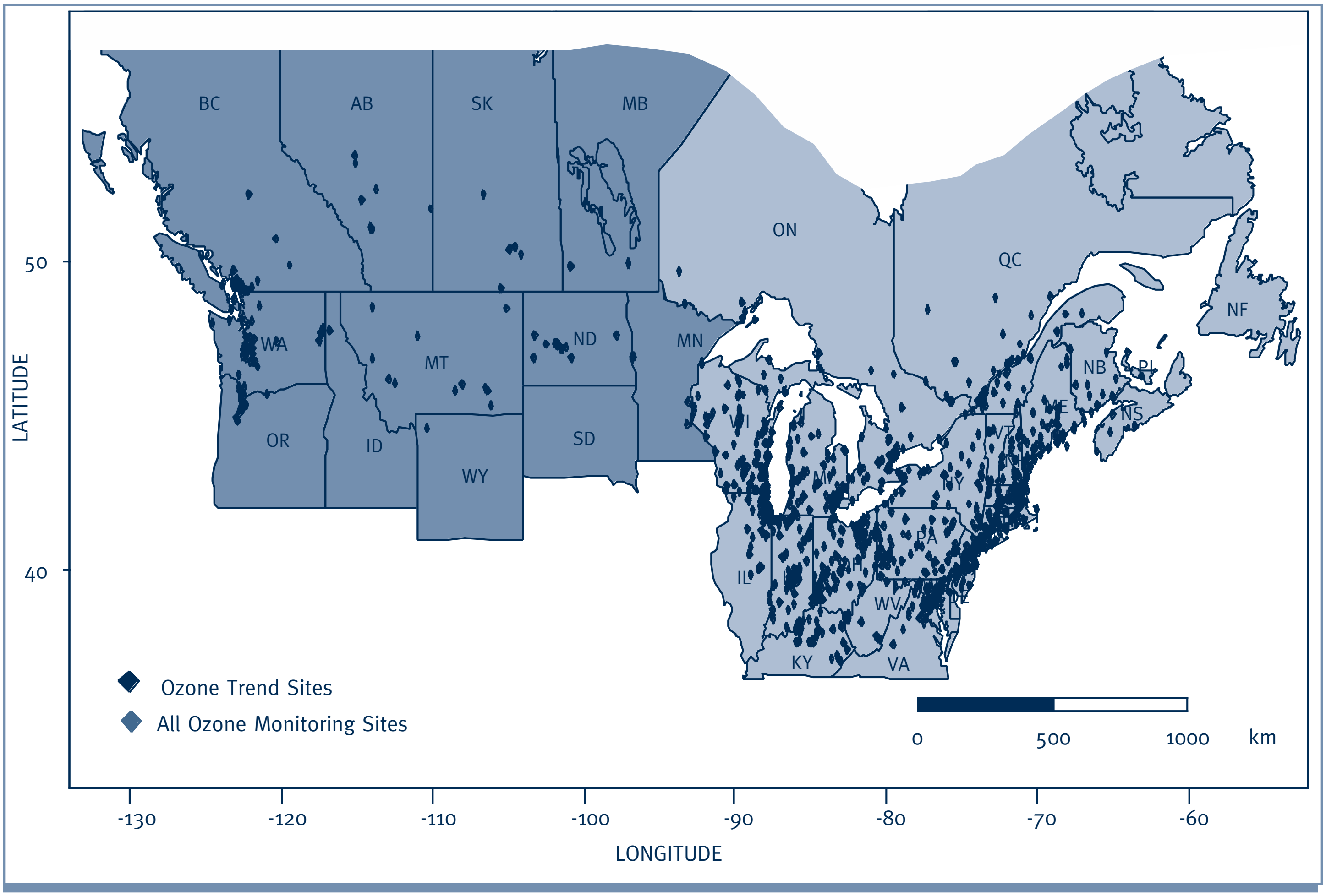
Either Party may take more stringent measures to control and reduce NO_X and VOC emissions than those specified in this Annex.

APPENDIX 1 TO THE OZONE ANNEX

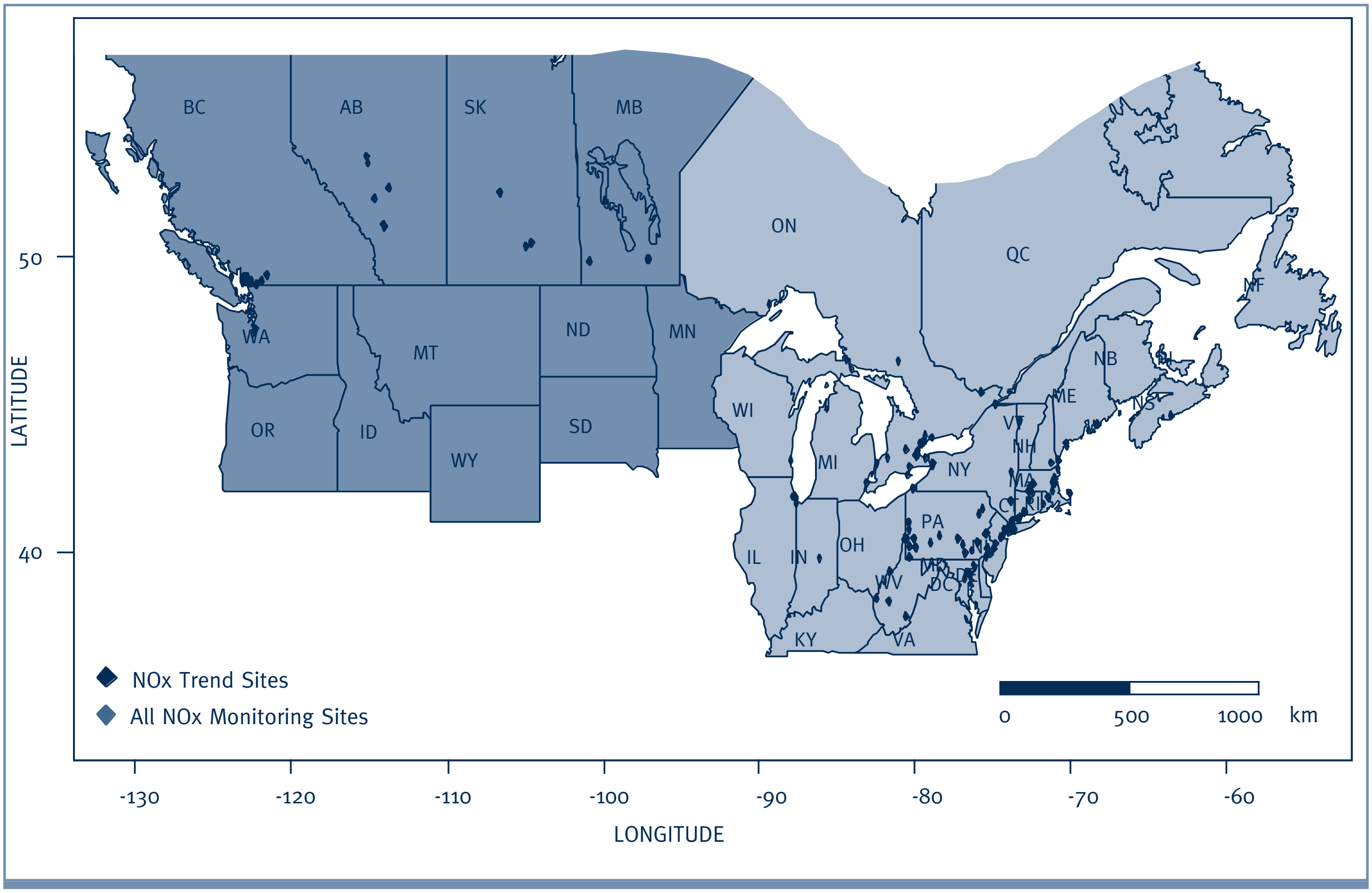


APPENDIX 2 TO THE OZONE ANNEX

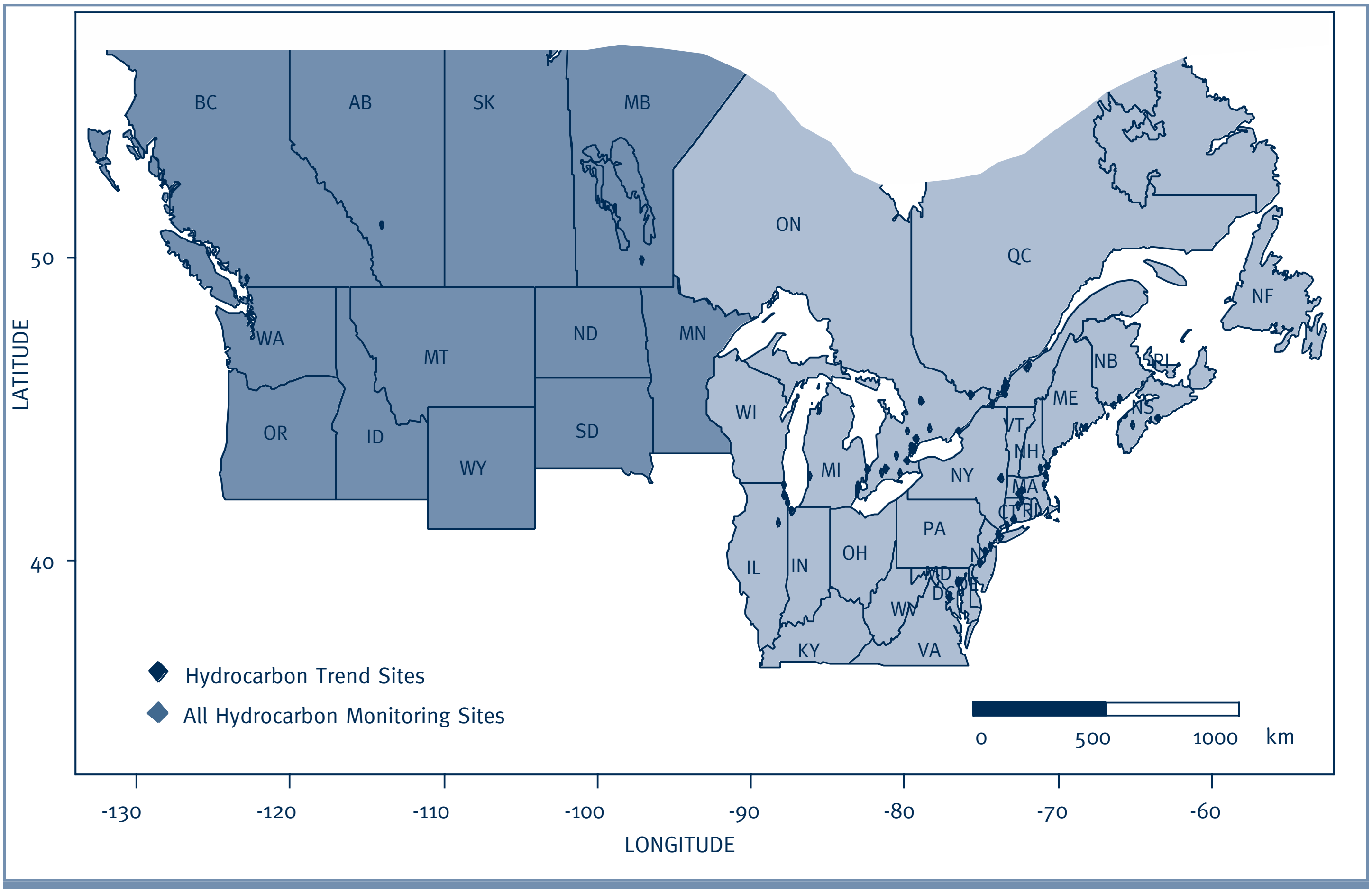
Trend Site Monitoring Locations



Trend Sites for Annual Fourth Highest Daily Maximum 8-Hour Ozone Concentration *Figure 21*



Trend Sites for Annual Average Hourly NOx Concentration *Figure 22*



Trend Sites for Annual Average Hourly Hydrocarbon Concentration *Figure 23*