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Introduction

On October 19, 1998, Energy and Environment Ministers signed *The Canada-Wide Acid Rain Strategy for Post-2000* in order to further protect the environment from acid deposition. *The Strategy* contains commitments to address the remaining acid rain problem in eastern Canada. It also calls for a pollution prevention approach for regions such as western and northern Canada where acid deposition, for the most part, is currently below critical loads. Further provisions aim to ensure that Canada's international commitments on acid rain are met, and that the capacity of acid rain science and monitoring programs remains adequate to assess both environmental improvements achieved and the effectiveness of control programs.

The primary long-term goal of *The Strategy* is "to meet the environmental threshold of critical loads for acid deposition across Canada." Achieving that ambitious goal will necessitate additional reductions of sulphur dioxide (SO_2) emissions in eastern Canada and the United States. Reductions of nitrogen oxides (NO_x) will also be required, though the level of reduction to achieve will depend on what further scientific research reveals.

The Strategy also requires that, starting in 1999, federal, provincial and territorial governments report annually to Energy and Environment Ministers on SO_2 and NO_x emissions and forecasts, and on progress in implementing *The Strategy.*

This report fulfills that requirement. It also complements the reporting requirements under the United Nations Economic Commission for Europe (UN ECE) Sulphur and Nitrogen Protocols, the Canada–United States Air Quality Agreement, and the New England Governors–Eastern Canadian Premiers (NEG/ECP) Acid Rain Action Plan.

The NEG/ECP Acid Rain Action Plan recognizes that addressing acid deposition is still a high priority on both sides of the Canada–U.S. border. The objectives and activities of this program share many of the same goals as *The Strategy*, but from a cross-border perspective. The NEG/ECP Action Plan has engaged provincial and state representatives, along with their federal counterparts, to initiate work in many of the areas outlined as key features of *The Strategy*. The work undertaken in this program will serve as a valuable tool in addressing the effects of acid deposition on both sides of the border.

This annual progress report has been prepared by the Acid Rain Work Group, composed of representatives of Alberta, Ontario, Quebec, New Brunswick, Nova Scotia, and the federal government, reporting to the National Air Issues Coordinating Committee–Other Air Issues (NAICC–A). The NAICC–A is a committee of the Canadian Council of Ministers of the Environment, working in cooperation with the Council of Energy Ministers.

The Acid Rain Work Group was established by the NAICC–A to ensure progress in implementing *The Strategy*, to share information among federal, provincial and territorial governments, and to coordinate the work of developing new SO_2 reduction targets and schedules. In addition to the Work Group,

an *ad hoc* scientific Sub-group was established to conduct the review of acid rain science and monitoring in Canada mandated by *The Strategy*.

Progress on specific commitments in *The Strategy*

1. Pursuing emission reductions in the United States

"The federal government, with support from the provinces and territories, will aggressively pursue further SO_2 emission reduction commitments in key areas of the United States and the incorporation of these commitments into the Canada–United States Plan of Action for Addressing Transboundary Air Pollution and/or the Canada–United States Air Quality Agreement."

The United States has cut its SO_2 emissions significantly since 1980. Current reduction commitments under the Canada–U.S. Air Quality Agreement will see U.S. emissions continue to decline to about 40% below 1980 levels by 2010. Nevertheless, further emission reductions in the United States, in addition to continued emission reductions in Canada, will be required if critical loads for acid deposition in Ontario, Quebec and the Atlantic provinces are to be achieved.

Through the NEG/ECP Acid Rain Action Plan, the five eastern Canadian provinces (Quebec, New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland), along with the six New England states (Maine, Vermont, New Hampshire, Connecticut, Rhode Island and Massachusetts), support, in both Canada and the United States, SO_2 emission reductions of at least 50% beyond current commitments by 2010, and NO_x emission reductions of 20 to 30% beyond current commitments by 2007. The NEG/ECP has recommended that each member jurisdiction commit to appropriate reduction targets and control strategies within the above time frames, and that these reductions be consistent with national goals and strategies to protect sensitive ecosystems.

The federal government continues to seek emission reductions under the Canada–U.S. Air Quality Agreement. Although current cooperative efforts under the Agreement are focused on the issues of ground-level ozone and inhalable particles, achieving progress in these areas will result in reductions in the same emissions that also cause acid rain.

Negotiations with the United States to reduce ground-level ozone, the principal component of transboundary smog, were initiated in 1999. The negotiations, which both countries hope to complete in 2000, should result in a ground-level ozone annex under the Air Quality Agreement. The annex is intended to contain commitments by both countries to reduce smog-producing emissions such as NO_x and volatile organic compounds (VOCs) within their borders. This will have ancillary benefits for acid rain, since NO_x contributes to both smog and acidification.

With respect to further SO_2 emission reductions, discussions with the United States are expected to take place over the next two to four years in the context of the transboundary inhalable particles issue (SO_2 transforms in the air into tiny particles of sulphate that can be harmful to human health). The two countries have developed a Joint Work Plan for Transboundary Fine Inhalable Particles, which was approved by the Canadian Minister of the Environment and the U.S. Administrator of the Environmental Protection Agency in June

1998. Implementation of this work plan is proceeding, and is expected to lead to the development of an annex on fine inhalable particles under the Air Quality Agreement. Addressing the particulate matter issue is a high priority in both countries. Reductions in SO_2 to reduce particulate matter will also contribute to reducing acidic deposition. Preliminary analyses of control options in the United States indicate that a further 50% reduction in SO_2 emissions in key parts of the United States would be one of the more cost-effective measures to address the fine particulate problem.

2. Establishing targets and schedules

"Targets and schedules for further SO_2 emission reductions in Ontario, Quebec, New Brunswick and Nova Scotia will be established by each jurisdiction in consultation with stakeholders. Concurrently, the four above provinces will also work cooperatively to develop targets and time-lines for the designated area (SOMA)."

The key finding from preliminary atmospheric modeling of emission reduction scenarios carried out and published in 1997 for eastern North America is that very large SO_2 emission reductions will ultimately be needed on both sides of the Canada–United States border to solve the acid rain problem in eastern Canada. The modeling suggests that a 50% reduction in both countries beyond existing commitments in the Canada–U.S. Air Quality Agreement would protect the Atlantic provinces, but it would leave parts of Ontario and Quebec with sulphate deposition in excess of critical loads. If SO_2 emissions are cut by a full 75% in eastern Canada and the United States, virtually all aquatic ecosystems in eastern Canada would be protected from acid rain.

While these modeling results are preliminary, and it is still uncertain what the ultimate reduction targets will be, there is clearly a need for significant further SO_2 emission reductions. With this in mind, Ontario, Quebec, New Brunswick and Nova Scotia are continuing to hold one-on-one discussions with the major SO_2 emitters in their jurisdictions (e.g., smelters and fossil-fueled power plants) on possible emission reductions and schedules, and the associated costs. In some cases these discussions are focusing solely on acid rain, while in other cases the discussions are broader and include climate change, smog, and particulate matter, since many of the major sources of emissions that cause acid rain also contribute to these problems. In this regard, it should be remembered that Quebec has already committed as a first step to reducing its emissions to 40% below its current SO_2 cap by the year 2002. In addition, provinces are also holding information sessions on emission reductions with environmental and health groups in their respective jurisdictions.

For its part, the federal government is in the process of upgrading its Integrated Assessment Model (IAM), which will serve to further analyze the effects of different combinations of SO_2 reductions in the United States, Ontario, Quebec, New Brunswick and Nova Scotia. The modeling will be one of the tools to help determine the level of emission reductions required from all jurisdictions (American and Canadian) to achieve critical loads throughout eastern Canada. It is expected that the upgraded IAM will be available in late 1999.

The Sulphur Oxide Management Area (SOMA) includes parts of Ontario and Quebec and all of New Brunswick, Nova Scotia and Prince Edward Island. Of the four provinces which are both included in the SOMA and committed to establishing targets and schedules for further SO_2 emission reductions, Quebec, New Brunswick and Nova Scotia are also parties of the Conference of New England Governors and Eastern Canadian Premiers. Under the NEG/ECP Acid Rain Action Plan, these provinces (together with Newfoundland and Prince Edward Island), are committed to support an overall national SO_2 reduction of 50% beyond current commitments, with specific reduction targets in each member jurisdiction to be determined in a manner consistent with national strategies to protect sensitive ecosystems.

The negotiation of targets and timetables for further reductions in each province is expected to be completed before the end of the year 2000**.**

3. Keeping "clean areas clean"

"In areas where acid deposition is below critical loads, governments will take steps to minimize growth in emissions of SO_2 and nitrogen oxides (NO_x), and will seek opportunities for improvements where possible."

In order to achieve *The Strategy*'s long-term objective of meeting critical loads for acid deposition for all of Canada, "clean" areas need to be kept clean. In other words, emissions of SO_2 and NO_x in those areas need to be managed to ensure that deposition levels do not exceed critical loads. Clean areas, i.e., areas that at present are below critical loads, mainly include those areas outside of the SOMA. The *Keep Clean Areas Clean* policy essentially applies to those areas (which, unlike the SOMA, are not subject to a regional cap on emissions). Based on estimated deposition, some areas outside the SOMA may currently receive acid deposition at or close to critical loads.

In 1998, Canadian SO_2 emissions outside the SOMA were less than 1.4 million tonnes, which represents a slight decrease from previous years. However, NO_x emissions outside the SOMA increased slightly in 1998 to about 1.3 million tonnes. Nevertheless, acid deposition in non-SOMA areas, with few exceptions, remains below critical loads. Governments are considering approaches to implement the *Keep Clean Areas Clean* policy in their respective jurisdictions, and will review progress in this regard in future reports.

4. Emissions from new sources

"Consistent with the CCME National Commitment on Pollution Prevention, jurisdictions will ensure, to the extent possible, that new sources of SO_2 and NO_x emissions in all parts of Canada, including government facilities, use processes, practices, materials, products and energy that avoid or minimize creation of these pollutants and, where appropriate, apply similar provisions to existing sources."

This commitment recognizes that pollution prevention is the preferred strategy for protecting the environment, and that it needs to be applied to all new sources in order to prevent new acid rain problems from developing, or, in areas where they already exist, from becoming aggravated. This strategy applies from coast to coast, i.e., to all jurisdictions.

Total Canadian emissions of SO_2 did not change significantly between 1995 and 1998, and emissions of NO_x increased only marginally over that three-year period. Nevertheless, a number of measures are anticipated or have been put in place in various jurisdictions to help minimize potential future growth in emissions of both SO_2 and NO_x. These include:

- pollution prevention outreach and related awareness activities;
- the requirement to use best available technology for new facilities and for expansions or improvements to existing facilities;
- adoption and substitution of natural gas for coal or heavy fuel oil in some jurisdictions.

Further measures could be identified and applied in the future as required.

5. Compliance with international commitments

"The federal government will annually review compliance with international commitments on SO_2 and NO_x emissions."

Canada is meeting its international commitments related to reductions of SO_2 and NO_x emissions, as described in Table 1 below. Furthermore, current emissions and emission forecasts indicate that Canada will continue to meet its international commitments into the foreseeable future.

Table 1: International commitments and compliance on SO_2 and NO_x

Commitment	Compliance in 1998
Canada-U.S. Air Quality Agreement	
• cap SO_2 emissions in seven eastern provinces at 2.3 million tonnes by 1994 until 2000 • cap national SO_2 emissions at 3.2 million tonnes by 2000 onward • reduce NO_x emissions from stationary sources by 100 kilotonnes below the forecast level of 970 kilotonnes, by 2000.	• eastern Canada SO_2 emissions were approximately 1.8 million tonnes, or 20% below the cap • national SO_2 emissions were approximately 2.7 million tonnes, or 16% below the cap • on target to meet the commitment to reduce national stationary-source NO_x emissions by 100 kilotonnes by the year 2000.
1985 UN ECE Sulphur Protocol • permanent national cap of 3.2 million tonnes of SO_2 by 1993.	• national SO_2 emissions were approximately 2.7 million tonnes, or 16% below the cap.
1994 UN ECE Sulphur Protocol • regional cap of 1.75 million tonnes of SO_2 by 2000 in the Sulphur Oxide Management Area (SOMA), plus the permanent national cap.	• SO_2 emissions in the SOMA were 1.3 million tonnes, or 25% below the cap. Furthermore, forecasts of SO_2 emissions up to the year 2005 indicate that emissions will remain well below the national and SOMA caps.
1988 UN ECE NO_x Protocol • stabilize NO_x emissions at 1987 levels by 1994.	• NO_x emissions were down to less than 1987 levels in 1994, as required, and estimates indicate that emissions remained below 1987 levels in 1998.

6. Active science and monitoring role / assess nitrogen acidification

"The federal government will maintain an active role in acid rain science and monitoring in cooperation with provincial and territorial governments, and federal/provincial/territorial governments will cooperate (while respecting the resources and capabilities of different governments) in assessing the role of nitrogen in acidification."

The federal and provincial governments have been active in acid rain science and monitoring over the past couple of decades. The federal government, with the cooperation of provinces, produced acid rain science assessments in 1986, 1990 and 1997. All 10 provinces participated in the 1986 and 1990 reports. The territorial governments were not involved in these efforts because acid rain was not believed to be an environmental problem there.

Assessments in 1986 and in 1990 served as a basis for domestic SO_2 emission controls as well as international negotiations. The most recent scientific assessment, in 1997, documents the improvements seen in the greater Sudbury area, where damage to lakes had been severe. These improvements are the result of very substantial reductions in SO_2 emissions from local smelters as well as from sources outside the region. Reductions in lake acidity in other regions of Ontario, Quebec and Atlantic Canada have been modest and some surface waters are continuing to acidify.

The 1997 assessment also states that the risks posed to forest health and productivity had been underestimated in previous reports and it expresses particular concern about nitrogen deposition. If it continues at present levels, its contribution to acidification will eventually erode the benefits gained from reductions in SO_2 emissions.

Scientific understanding of acid rain has greatly improved during the past 20 years. Scientists now have a more accurate picture of the nature and extent of acidification in Canada, and a better idea of what is needed to help ecosystems recover. The past 20 years have also confirmed the necessity to monitor ecosystem response to changes in emissions and deposition of acidifying substances; there were a few surprises when ecosystems responded somewhat differently than expected. Each instance provides insights into how ecosystems work, and how they are likely to respond in the future.

Networks of air, water, and terrestrial monitoring stations established in the 1970s and 1980s by federal and provincial governments have provided good information for several years on changing concentrations of acid pollutants and their effects on the environment. The science programs were substantially reduced in the 1990s. Some components of the program were abandoned, e.g., the Department of Fisheries and Oceans ceased all acid rain-related activities in 1996. All other components were significantly curtailed. Reducing expenditures in acid rain science was considered to be a reasonable decision in a period when governments were reducing expenditures and when it was generally believed that the problem of acid rain had been solved.

A team of federal and provincial scientists is reviewing existing acid rain science and monitoring, and identifying what needs to be done in order to conduct the next assessment, tentatively in 2004. The results of this review

are reported below in section 7. The review identifies the poor understanding of the role of nitrogen in acidification. It is one of our principal knowledge gaps. Filling this gap will be a priority for future efforts in the science and monitoring program.

7. Assess adequacy of science and monitoring

"With the goal of ensuring the capability to assess both the degree of environmental improvement achieved and the adequacy of the control programs, federal/provincial/territorial governments (each determining its own level of involvement) will review the adequacy of acid rain science and monitoring programs and report, with recommendations, to Energy and Environment Ministers in 1999."

A review of acid rain science and monitoring was carried out in 1999 by the Sub-Group on Science and Monitoring, comprising representatives from Environment Canada, Alberta, Ontario, Quebec, New Brunswick and Nova Scotia. Stakeholders were invited to provide input into the review process at a consultation workshop in Montreal in June. In addition, in-depth discussions among federal and provincial scientific experts were held in several regions of the country. In all, information was gathered from more than 40 experts in acid rain science in Canada, representing federal and provincial governments, industry and universities, and a variety of scientific disciplines, e.g., meteorology, limnology, biology, forestry, soil science. A final report was submitted to the Acid Rain Work Group in October 1999.

The review identifies work that needs to be done in the next few years in the acid rain science and monitoring program. The work is required to monitor changes in lake and river chemistry, to evaluate the response of aquatic biota, to assess changes in forest soil fertility, and to evaluate the risk posed to eastern Canadian forests. Work is also required to assess the role of nitrogen as a nutrient and as an acidifying agent. In order to complete this work, changes are required to all components of the science and monitoring program across Canada.

The review notes that there are regional ecologically sensitive areas affected by acid rain and not properly monitored by the current programs, e.g., surface waters and forests in southern and central New Brunswick, western Quebec, the Parry Sound area of Ontario, sensitive lakes in northern Saskatchewan, and salmon spawning rivers in the southern uplands of Nova Scotia.

Noting the risks posed to forest productivity and health, in particular the potential for acid deposition to reduce or halt forest growth on sensitive soils, the Review Team supports the forest mapping approach described in the Acid Rain Work Plan proposal endorsed by the Conference of New England Governors and Eastern Canadian Premiers in October 1999. The proposed forest mapping project appears to be the only project that, if implemented, would produce maps of critical loads of nitrogen for forest soils in eastern Canada.

The review does not evaluate the scientific programs related to human health. Acidifying emissions contribute to "smog" (fine particulates and ground-level ozone), which has significant human health effects. Other groups, in Canada and elsewhere, are working on this and have made recommendations to address current science gaps in this area. Repeating their recommendations here would be a duplication of effort. Their

recommendations and those of the Review Team are complementary and do not overlap. It must be stressed that a sound air pollution management program should address human health and ecosystem effects.

The Review Team concludes that current science and monitoring programs are not adequate to fulfill the requirements of *The Canada-Wide Acid Rain Strategy for Post-2000*. There are two major problems. The first problem is that existing science programs are not collecting enough data to fully assess atmospheric and ecosystem responses to changes in emissions. The second problem is that there is a lack of human capacity to analyze and assess the data that are currently collected, let alone the data that are not. The human resources currently available to operate monitoring programs, to coordinate programs among jurisdictions, and to evaluate the results of all programs have diminished to the point that there is insufficient capacity to conduct another assessment in or around 2004.

The Review Team is particularly concerned that multi-year time series of surface water chemistry measurements may be broken unless adequate resources are available for the next sampling season, i.e., spring 2000. The Review Team considers it of critical importance that the aquatic program be continued without interruption, and that other components of the existing program not undergo further cuts.

In summary, the review identified significant gaps in the current science and monitoring program, and indicated areas where science and monitoring efforts need to be directed in order to fill those gaps. To address these conclusions and recommendations of the review, federal and provincial governments are undertaking an examination of costs and funding options for a revitalized science and monitoring program. As many of the requirements of the science and monitoring program are of urgent priority, it is intended that this step be concluded in the next six months, to address the needs of the spring 2000 aquatic program. A full report will be provided to Ministers in the year 2000 progress report.

8. Reporting on emissions and forecasts

"*Starting in 1999, federal/provincial/territorial governments will report annually on SO_2 and NO_x emissions and forecasts and progress in implementing* The Strategy *to Energy and Environment Ministers*."

Table 2 shows SO_2 emissions estimates and forecasts up to 2005. Table 3 shows estimated NO_x emissions for 1995 and 1998. It should be noted that the information in these tables is the best available at the time of writing this report. It should also be kept in mind that historical years' inventory data are subject to change as current methodologies improve and are applied to the historical data in order to obtain the best available estimates of multi-year trends.

As can be seen from Table 2, in 1998, total Canadian SO_2 emissions were less than 2.7 million tonnes, or about 16% below the national cap of 3.2 million tonnes. Emissions for the seven easternmost provinces, at 1.8 million tonnes, were 20% below the eastern Canada cap of 2.3 million tonnes. Emissions for the SOMA (1.3 million tonnes) were 25% below the year-2000 SOMA cap of 1.75 million tonnes. Furthermore, forecasts indicate that emissions will remain below all applicable caps well into the future. It should be noted that the forecasts do not take into account

reduction initiatives that may come into effect after 1998, such as Canada-Wide Standards for particulate matter and ozone, new SO_2 targets under *The Canada-Wide Acid Rain Strategy*, and reductions under Phase 3 of the Federal Smog Management Plan and provincial or territorial smog initiatives, all of which should result in significant reductions of SO_2 and/or NO_x.

Table 2: SO_2 emissions and forecasts up to 2005 (kilotonnes)

	1994-99 cap	1990[1] emissions	1995[1] emissions	1998[2] emissions	2000[3] forecast	2005[3] forecast
Yukon	N/A		0	1	1	1
Northwest Territories	N/A	17	16	16	2	6
Nunavut[4]	N/A	N/A	N/A	N/A	-	-
British Columbia	N/A	152	176	188	198	206
Alberta	N/A	567	608	536	537	547
Saskatchewan	N/A	88	131	116	111	106
Manitoba	550[5]	516	365	412	412	412
Ontario	885	1166	633	702	782	885[6]
Quebec	500	391	374	343	347	300[7]
New Brunswick	175	181	116	143	143[8]	143[8]
Nova Scotia	189	178	167	176	170	179[8]
Newfoundland	45[9]	66	65	59	53	45
Prince Edward Island	5	4	3	4	5	6
SOMA[10]	1750	1916	1245	1319	1393	1457
Canada	3200	3326	2653	2696	2761	2836

1. 1990 and 1995 emissions are taken from the 1990 and 1995 Residual Discharge Information System (RDIS) emissions inventory.
2. 1998 values are actual emission values compiled by the provinces and territories.
3. Forecast emissions are interim emissions estimates using 1998 values reported by the provinces and territories and projected with growth factors calculated from total provincial change in emissions found in the National Emissions Inventory and Projections Task Group (NEIPTG) Consensus National Base Case Forecast, 1996.
4. Numbers for Nunavut are not available at this time; forecast years' emissions are included in the NWT totals.
5. Manitoba's cap applied to 1994 only.
6. Reflects the Countdown Acid Rain Cap for Ontario.
7. Corresponds to ministerial commitment to cap at this level.
8. Future emissions in New Brunswick and Nova Scotia are expected to drop below 1998 values after the introduction of natural gas to these provinces, but exact numerical reduction values are not available at this time.
9. Newfoundland's cap applied to 1994 only.
10. The SOMA (Sulphur Oxide Management Area) includes the southern halves of Ontario and Quebec, plus New Brunswick, Nova Scotia and Prince Edward Island.

Jurisdictions have been reporting SO_2 emissions since the beginning of the acid rain program and, as a result, procedures to report the information on an annual basis are well established. However, the annual reporting of emissions for NO_x is new and it will take some time for uniform procedures to be put in place by governments. Table 3 shows NO_x emissions for 1995 and 1998. These numbers are from the 1995 emissions inventory. They are based on a new methodology and include new statistics. The numbers are therefore not comparable to the numbers published for past emissions inventories. This new methodology and comparable statistics will have to be applied to historical emissions inventory information in order to ensure consistency in trend estimates. In particular, the actual level of emissions for the base year 1987 will need to be recalculated to confirm that Canada is meeting its commitment to stabilize NO_x emissions at 1987 levels. Preliminary estimates, however, indicate that current emissions are well within the required level.

Because of these recent changes associated with the NO_x estimates, forecasts have not been included in this report, but will be included in future reports. Early indications, however, are that NO_x emissions will continue to be within the prescribed limit in future years, with recent forecast values for on-road transportation (the largest contributor to total NO_x emissions in Canada) being significantly lower than previous estimates.

Table 3: NO_x emissions for 1995 and 1998 (kilotonnes)

	cap for 1994 & beyond	1995[1] emissions	1998[2] emissions
Yukon	N/A	5	5
Northwest Territories	N/A	9	11
Nunavut	N/A	-	-
British Columbia	N/A	260	266
Alberta	N/A	639	676
Saskatchewan	N/A	169	171
Manitoba	N/A	74	75
Ontario	N/A	538	565
Quebec	N/A	373	367
New Brunswick	N/A	63	72
Nova Scotia	N/A	73	75
Newfoundland	N/A	43	43
Prince Edward Island	N/A	8	6
Canada	1987 level	2253	2332

1. 1995 emissions are taken from the 1995 RDIS emissions inventory.
2. 1998 emissions are a combination of data reported by the provinces and projections from the 1995 inventory.