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Acid Rain: What We Know, What We Did, What We Will Do

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Abstract. This paper reviews the involvement of the Canadian province of Ontario in the acid rain issue. Ontario is a major producer of acid gas emissions and suffers significant environmental consequences because of acid rain. The province's substantial contribution to the scientific understanding of acid rain is summarized with emphasis on the extent and origins of the deposition it receives, the impact on the aquatic environment, and the impact on the terrestrial environment.

This paper discusses the history of the government's success at reducing acid gas emissions through the 1970's when legislators set out to enhance local or "ambient" air quality, the first legislation to require SO_2 reductions from companies *already in compliance with ambient air quality legislation,* and the current *Countdown Acid Rain* program which reduces SO_2 emission limits by 67%. The process used to establish the tough new limits while reasonably anticipating the development of SO_2 control technologies is detailed along with the specific requirements of the major emitters controlled by the regulations.

Projections confirm that while the *Countdown* reductions will bring about significant reductions in deposition, adequate environmental protection in Canada cannot be achieved without some comparable U.S. acid gas abatement effort.

Ontario, Canada is 1.06 million square kilometers in size and at last count, had a population of 9.3 million. It has been estimated that the surface areas of the approximately one quarter of a million lakes makes up 181,153 square kilometers, about 17% of the province's total surface area (Figure 1).

What We Know About Acid Rain

Ontario has been in the forefront of the acid rain issue and acid rain research in North America because we are a major producer of acid rain emissions and suffer significant environmental consequences. Interest in the impacts of acid rain flowed from extensive environmental monitoring work carried out in the greater Sudbury area. Over the past century, mining, smelting, and ancillary lumbering activities in and around Sudbury, resulted in the devastation of the white pine forests of that area. As early as 1960, it was observed that lakes within 15 miles (24 km) of the smelters had elevated sulphate levels and reduced pH. In subsequent years, sampling by university and government scientists revealed that the phenomenon extended much further, to many lakes in the southwest and northeast. At that time, the lake acidification was attributed to the local industrial activities.

In 1973, Ontario's Ministry of the Environment, in cooperation with its Ministry of Natural Resources initiated "The Sudbury Environmental Study" to define the nature and extent of the environmental damage and to develop criteria for better management of atmospheric emissions from the Sudbury mining/smelting industries. As the work proceeded, researchers working on water quality problems within popular summer cottage areas quite distant from Sudbury, noted similar impacts (*i.e.*, high sulphate levels and reduced pH in lakes). After establishing that these results could not be fully attributed to emissions from within Ontario, and in recognition of the new information that pollutants were being carried into the province by long-range transport, the "Acidic Precipitation in Ontario Study" (APIOS) was established in 1979; APIOS has substantially contributed to the world

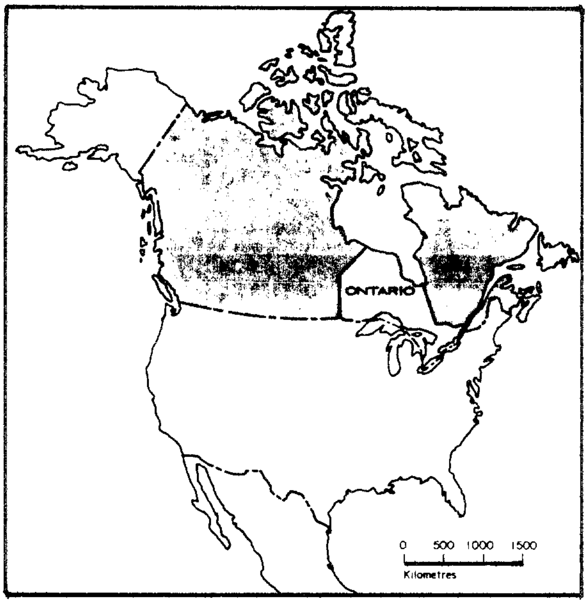

Fig. 1. Illustrates the position and size of Ontario relative to the United States

knowledge of acid rain. The cumulative listing of titles in the most recent APIOS annual report (as of April 1987) confirms 126 scientific reports have been printed directly by the program and 162 related papers have been published in scientific journals by program scientists. This research has enabled Ontario to determine the:

1) extent and origin of acidic deposition across Ontario;
2) impact of acidic deposition on the aquatic environment; and
3) impact of acidic deposition on the terrestrial environment.

Extent and Origins of Deposition in Ontario

Annual wet and dry deposition values for both sulphur oxides and nitrates, using 1981–1984 data are summarized below.

Region	Sulphur Oxide Total Deposition (as kg SO_4/ha/yr)	Wet (%)	Dry (%)	Nitrate Total Deposition (as kg N/ha/yr)	Wet (%)	Dry (%)
Southwestern & West Central	53.8	67.4	32.6	8.61	59.9	40.1
Central	37.9	75.1	24.9	7.61	59.9	40.1
Southeastern	31.5	82.5	17.5	6.59	60.2	39.8
Northeastern	26.3	80.4	19.6	5.16	59.3	40.7
Northwestern	9.1	82.5	17.5	2.01	67.7	32.3

Ontario scientists have determined through the use of computer models and air parcel trajectory analysis that United States sources contribute a major share of the acidic deposition measured in Ontario. For example, air parcel trajectory analysis at Longwoods in the Southwestern Region and Railton in the Southeastern Region show the following apportionment of wet sulphate deposition in kg SO_4/ha/yr, using 1981–1983 data.

	Longwoods	*Railton*
Canadian/Ontario Contribution	5.7%	16.3%
United States	80.6%	57.5%
Unassigned (Both Canadian and U.S.)	5.7%	26.5%

This is not suprising, since southwestern Ontario forms a wedge extending into a heavily industrialized area of the United States. Within two days of air parcel travel time of Longwoods, U.S. sources emit approximately 16 million tonnes of SO_2 per year while the Canadian sources within the same two day range produce less than 10% of that amount. Of course, the deposition measurements include a component due to natural sources which must be added to the emissions numbers to account for the total sulphur within the two-day air parcel travel time of Longwoods.

Other analyses demonstrate that Ontario's Sudbury smelting operations (accounting for about 50% of total annual emissions in Ontario) contribute a relatively small proportion of the total atmospheric deposition of sulpher oxides in the province (less than 14% of wet and approximately 40% for dry).

Impact on the Aquatic Environment

Since its inception, APIOS has directed the bulk of its resources toward the chemical and biological aspects of acidification in the aquatic environment. From the intensive monitoring of calibrated watersheds over five to ten years, through samplings of lake chemistry for many lakes, and through experiments on various aquatic components, Onatrio scientists have enhanced the knowledge of how the acidification mechanisms work and of the extent of damage to the huge surface water resources of the province. A set of calibrated watersheds (20 streams and 8 lakes in Muskoka-Haliburton) has been monitored for periods ranging from 5 to 10 years to measure the long-term effects of acid deposition on the chemistry and biology of these waters.

One of the study lakes, Plastic Lake, has been the focus of intensive monitoring for more than six years. The acidification of this lake (due to the input of strong mineral acids, not naturally occurring organic acids) as evidenced by a four-fold decrease in alkalinity and a decrease of 0.2 pH units occurred despite a reduction in the sulphate deposition (strong acids) over the period of study. Lake acidification caused extensive damage to the aquatic biota. Acidification was accompanied by a decrease in base cation content in the lake but not an increase in strong acid anion (SO_4^{-2}) concentration, indicating that there has been a depletion of available cations in the lake's catchment. Plastic Lake has continued to acidify because of the continuing desorption of sulphate from the catchment despite reduced deposition.

Data collected as part of the calibrated watershed studies have been used to develop and calibrate several models which can be used as both investigative and predictive tools. (As investigative tools, to examine the efficacy of the scientific concepts being modelled. As predictive tools, to predict changes in pH or alkalinity as well as other parameters under different loading scenarios.)

The identification of mercury sources in acid sensitive areas and the relationship between mercury concentrations in water and biota is another component of the calibrated watersheds study. Data currently show that mercury concentrations are low in the spring (less than 5 ng/L) but some reach high levels in the summer or fall (50 ng/L). The concentration in brownwater streams is about ten-fold higher than clear streams.

To provide a better understanding of how Ontario's almost 250,000 lakes are affected by acidic precipitation, and to furnish background data for determining future trends, the Ministries of the Environment and Natural Resources have surveyed more than 6,063 lakes throughout Ontario. The lakes surveyed were selected on the basis of their current importance for recreational use and sport fishing rather than as a study designed to identify the amount of damage acid rain has already caused to Ontario's vast aquatic resource. As the program continues, it is being broadened to permit better quantification of the resource at risk.

Based on laboratory results and field measurements, the lakes are classified into one of five levels. *Level 1 lakes* have zero or negative alkalinity: they have already become acidified. Many fish species will be absent from such lakes, while some may be without fish altogether. Level 1 lakes not naturally high in organic color, such as beaver ponds, are exceptionally clear. Clouds of filamentous algae may accumulate in inshore areas. Clam, snail, and many species of crustaceans are also likely to be absent.

At the other end of the scale are *Level 5 lakes*. They are not sensitive to acid loadings and are capable of withstanding heavy acid loadings during spring run-off without biological damage. Such lakes contain sufficient buffering capacity to neutralize acid rain for an indefinite period of time.

Summary of Ontario Lake Acidification Classifications Completed to Date

Level	Description	Number of Lakes
I	Acidic	244
II	Extreme Sensitivity	934
III	Moderate Sensitivity	2,312
IV	Low Sensitivity	1,031
V	No Sensitivity	1,542
	TOTAL	6,063

All of the lakes, listed alphabetically by county or district, are shown with their classification in a summary document which is published routinely. The booklet is very much in demand by the public as a guide to the status of recreational waters.

Unfortunately, some of our regions with the lowest capacity to resist acid rain (Muskoka, Haliburton, Parry Sound and Algonquin Park) are the areas most heavily used for cottaging and outdoor recreation. These areas (although there are no local significant acid gas emissions) received acidic loadings at levels which cause decreases in alkalinity and pH with the associated changes in water chemistry resulting in decreases in fish populations and impacts on other biological communities.

Summary of Biological Findings

The following summarizes the results from recently reported and ongoing biological work in Ontario. It is presented to provide an indication of the nature and range of acidification impacts within the biological component of the aquatic environment. The findings highlight the complexity of the interrelationships in the natural environment.

I Algae
- A) Odour-Producing Algae
  1. *C. brevitturita* occurs only at pH 5.5–6.5
  2. Blooms produce a lakewide obnoxious odor
  3. pH optimum in culture is 5.5–6.8
  4. Requires selenium
  5. About 10% of lakes affected
- B) Nuisance Algae (Filamentous)
  1. Filamentous algal blooms are very common in low alkalinity lakes
  2. When blooms occur, 66% of cottagers feel it reduces their enjoyment of the lake

II Macrophytes (forms of plant life visible to the naked eye, and a key element of the food chain)
  1. Bryophyte richness is negatively correlated with pH
  2. Charophytes are not found below pH 5.2
  3. Richness is not affected by pH

III Zooplankton
  1. There is a positive correlation between pH and biomass for *Daphnia galeata mendotae* and *Dephnia pulex* in sampled lakes on the Canadian Shield

IV Benthic Invertebrates (bottom dwelling creatures)
- A) Amphipods (tiny shrimp-like creatures)
  1. *Hyalella azeteca* was not found in lakes with alkalinity less than zero
  2. Reproductive failure was observed in Plastic Lake at pH 5.7
  3. For adults the 96-hr LC_{50} was pH 4.4
- B) Crayfish
  1. Juveniles (stage III) of three *Orconectes* spp. failed to survive at pH less than 5.7 in lab toxicity tests and in field transplants
  2. Two species of *Cambarus* were tolerant of low pH
- C) Molluscs
  1. Abundance and richness of snails was below normal in lakes with alkalinities less than 10 μeq/L
  2. Production of *Amnicola limnosa* was half normal levels at 15 to 20 μeq/L alkalinity
  3. Reproductive failure with virtual extinction was observed at 8 μeq/L alkalinity, pH 5.6
  4. Delayed embryonic development occurred at pH 5.5 and developmental arrest at pH 5.0 in laboratory toxicity tests

V Stream Insects
- A) Stream Acidification Experiments
  1. A blackfly (*Prosimuliun hirtipes* complex) and a mayfly (*Leptophlebia cupida*) were tolerant to low pH for four to ten days in transplant experiments
  2. Some species in a high sulphate deposition zone were more tolerant of low pH than the same species in a low deposition zone
  3. Some mayflies (*Baetis*) were not found at sites subject to pH depressions. These species were very sensitive to artificial pH depressions
- B) Long Term Community Changes (50 + years)
  1. At the site subject to the greatest pH depressions, 11 of 13 species of mayflies and stoneflies have disappeared compared to 50 years ago
  2. At a site subject to only slight pH depressions, no species have been lost

VI Amphibians
  1. Adult wood frog (*Rana sylvatica*) density increases with declining pH of ponds, but ponds below pH 5.5 are little used for breeding. Hatching success was reduced at pH 4.14 and Al of 20 μg/L
  2. Densities of bullfrogs, spring peepers, and small green frogs were positively correlated with pH in a survey of 20 ponds

VII Fish
- A) Laboratory Studies
  1. For eggs, the most sensitive phase to hydrogen ion concentration is the first four to six days after fertilization
  2. Fry are most sensitive at the transition from vitelline to gill breathing
  3. Effects of Al are very complex; it can be beneficial, inconsequential, or deleterious, depending on the pH, life stage, and the Al concentration
  4. 100 μg/L Al usually shifts the LC_{50} up 0.2 to 0.3 pH units
- B) Field Studies
  1. The toxicity of stream water varied over spring runoff. Maximum impact occurred at peak flow, lowest pH, highest Al. Zone of impact in the lake was large at peak flow, negligible by late spring

As the above details show, Ontario's research is demonstrating the wide-ranging interrelationships of the effects of acid rain. The whole aquatic community is being affected, not merely a few sportfish or surface water pH.

Impact on the Terrestrial Environment

Research into this aspect of the acidic precipitation problem has yielded findings more slowly than in the aquatic area, because of the complexity of the mediums and organisms and longer time-scale needed to identify changes of soil chemistry, impacts upon tree health, growth and reproduction, and the impacts upon terrestrial wildlife. While exposure experiments on crops yield results during one growing season, a similar level of effort directed toward trees is usually not sufficient to allow investigators to isolate the impact of acid rain from the multitude of other factors directly affecting the tree (e.g. drought, severity of winter, insect infestation, disease, genetics). The emphasis of the first portions of the program was on establishing current soil and vegetation conditions in acid deposition zones throughout the province.

The following summarizes some of the work completed under the APIOS program and provides an indication of the terrestrial acidification impacts.

I Vegetation
- A) Lichen and Bryophyte
  1. Sulphur content of lichens exhibits a south-to-north decrease which follows sulphate deposition pattern
  2. Elemental composition of wet deposition accounts for only part of the variability
- B) Throughfall Chemistry
  1. Deciduous tree canopies buffer incoming acidic precipitation whereas coniferous canopies contribute to throughfall acidity
  2. Sulphate levels in coniferous throughfall are higher than levels in deciduous throughfall, largely due to dry deposition
- C) Mobile Rain Exclusion Canopies (provides field growing conditions but excludes selected pollutants)
  1. For Hodgson soybeans, simulated acid rain (SAR) (pH 3.07 to 4.30) treatments produced no significant yield effects
- D) Greenhouse Experiments
  1. For Hodgson soybean plant biomass was reduced by ozone but not by SAR
  2. For radishes, SAR led to foliar injury and biomass reduction

II Soil
1. Over 400 baseline sites have been sampled
2. Progressive resampling will monitor any changes in soil properties

III Forest Productivity and Decline
- A) Maple Decline
  1. Unexplained decline of sugar maples has been observed in Ontario
  2. For sugar maples, acidic deposition is an additional stress leading to woodlot decline in addition to woodlot management, insects, and disease, and weather
  3. One third of maple syrup producers felt there was a decline in their sugar bushes
- B) Forest Growth
  1. Trees were evaluated in 1962, 1972, 1983, 1984. Over the long-term there was a gradual decrease in growth due to environmental factors
- C) Hardwood Decline
  1. One hundred and ten permanent plots (sugar maple dominated) have been assessed
  2. Of the hardwood species assessed, sugar maple was the third most impacted
  3. Hardwood decline indices increased following temperature isoclines, SO_4 deposition gradient, and soil conditions as one moves northward except for southernmost Ontario
- D) Dendrochronology (study of growth rings in trees)
  1. Regional growth chronologies have been established for sugar maple

IV Wildlife
- A) Cadmium Concentrations in Moose and Deer
  1. In moose, kidney, liver and tissue concentrations are comparable to or higher than in Quebec and consistently higher than in Manitoba, Maine and Scandinavia
  2. In moose, kidneys concentrations were highest in areas with highest acidic deposition
  3. In deer, concentrations were consistently lower than in moose. Highest concentrations were for deer ranging in non-buffered areas

B) Relationship of Soil Buffering Capacity to Cadmium Levels
    1. For white-tailed deer, droppings in non-buffered deer yards had higher cadmium concentrations than in buffered yards

What We Did to Reduce Ontario's Contributions to North American Acid Rain

During the 1970's, the governments of North America were preoccupied with local or "ambient" air quality. During this period, SO_2 emissions in Ontario were cut in half, as provisions under the Ontario *Environmental Protection Act* forced the use of abatement technology on the polluting sources. In the United States, passage of the *Clean Air Act* provided a similar network of rules and regulations aimed at protecting local air quality.

Although protecting local air quality remains important, with ground level concentrations of SO_2 and particulate matter of particular concern with respect to protecting the health of those in the vicinity of the emission, these standards were never designed with any thought to protecting distant natural environments from the slow accumulation of acidic deposition. In fact, the decision in the 1970's to build tall stacks to disperse the pollutants reduced the local air pollution burden by adding to the problem of the long-range transport and deposition of pollutants. Since emissions were not reduced, the stacks merely exported the effects. Hence, legislation and rules designed for the protection of local air quality are neither appropriate nor sufficient to deal with pollution on a regional or continental scale. Ontario was the first jurisdiction in North America to require SO_2 reductions from companies *already in compliance with ambient air quality regulations*. A large non-ferrous smelter and Ontario's public electricity utility were the first recipients of the new type of emission limits in 1980–82.

In Canada, the primary constitutional authority for air pollution control rests with the provinces, not with the federal government. A federal-provincial agreement was negotiated in 1984–1985 with the seven provinces making up the eastern half of the country, providing for a permanent cap of 2.3 million metric tonnes of SO_2 to be achieved by 1994. Each province received a designated share of the reductions, to be applied within its borders. Ontario's portion became known as the *Countdown Acid Rain* program.

Through its *Countdown Acid Rain* program (announced December 1985), Ontario took significant further steps to curb its share of the long-range transport of SO_2. Province-wide legal limits emissions of SO_2 have been cut 67% to 885 thousand metric tonnes (kt) by 1994. This is a 50% reduction from the actual 1980 emissions (1,764 kt), and a 60% cut from the "1980 base case", which was a mixture of legal limits for some sources and actual averaged emissions for other sources. Details of the program are discussed below.

What We Will do to Reduce Ontario's Contribution to Acid Rain

While Ontario's growing economy demands metals, electricity, paper, petroleum products, means of transportation, etc., the Ontario government demonstrated that it was not necessary to accept the increasing levels of acid gas emissions as part of dynamic economic growth. The polluters must accept their responsibility to deal with the by-products of their activities.

Ontario's December 1985 Package of Emission Controls

Canadian and U.S. scientists agreed on 1980 as the "base year", so the SO_2 reductions are measured from this date. Since 1980, all Ontario SO_2 sources have met the regulated limits which had been imposed.

About 80% of Ontario's SO_2 emissions come from only four corporate sources. Consequently, the December 1985 *Countdown Acid Rain* program concentrates on the "big four", although smaller point sources are also being squeezed down by a combination of specific controls, a new general boiler regulation (and shifts in the relative price of fuels).

Regulations for the "big four" were custom-designed, to reduce emissions while still allowing for normal production levels so economic activity will not be inhibited. Consultation with each of the major pollution sources ensured that the government was not demanding the impossible, although in most cases, considerable technological development is still needed. The government made a commitment to vigorously enforce the new regulations, and a package of economic penalties and incentives has been developed to make it more profitable to reduce emission levels than to continue them.

1) *Ontario Hydro*

This public utility, owned by the Province of Ontario, operates three major coal-fired plants in southern Ontario, as well as smaller plants in the northwest, at Thunder Bay and Atikokan. Other fossil-fuel plants are now mothballed, but will probably be brought back on line as demand for power increases. By 1985, electricity was produced about equally from water, coal, and nuclear plants, with coal used as the peaking and reserve fuel. As more nuclear units come on stream between now and 1992, coal use will decline until the mid-1990's. After that, the projected increased demand for electricity is expected to require increasing use of coal as fossil-fuel plants are brought back into use and operate at higher capacity.

Under the *Countdown Acid Rain* program the 1986 SO_2 limit is reduced from 390 kt to 370 kt/year, the 1990 limit is reduced from 260 to 240 kt/year and a new maximum of 175 kt/year is established for 1994 and thereafter. Over the ten-year period 1984 to 1994, SO_2 will be cut from an actual level of 444 kt to a legal limit of 175 kt with regular mandatory reporting to show the steps taken.

The new regulations package does not specify the methods the utility must use to meet the emissions limits, but the tight timetable ensures that proven methods must be in place soon. A requirement for regular progress reports provides assurance that the emission limits will be met on schedule.

2) *INCO*

INCO's Sudbury smelter operations have been the largest point source of SO_2 emissions in North America for many years, although they are exceeded by clusters of coal-fired power stations in several states in the U.S. SO_2 emissions were cut by 59% between 1970 and 1980 in response to increasingly tighter controls based on local air quality. Some of the decreased emissions resulted from lower production levels, but the bulk of the reductions were due to increased containment of the sulphur in the nickel-copper ore.

Effective in 1986, under the *Countdown* program, the total regulated SO_2 limit was cut from 728 kt/year to 685 kt/year. The limit will be further reduced to 265 kt/year, effective in 1994. INCO must provide semi-annual progress reports leading to a final report no later than December 31, 1988, showing the technology and design that will be employed and the cost. In addition, an even tighter objective has been set at 175 kt/year. INCO's December 1988 report must describe in detail the technology and design which could be used to meet this lower objective and the cost. They must also show the feasibility of cutting emissions to 525 kt/year by 1990, and whether further reductions can be made earlier than 1994. Meanwhile the emissions ceiling remains in place as do the Ontario ambient air quality standards.

Ontario's position is that the polluter should pay for necessary emission reductions. But in the current economic situation, with depressed worldwide nickel prices and a reduced cash flow for INCO, assistance may nevertheless be required in order to accelerate the abatement program. The fragile environment cannot wait for improved profits in the smelting industry.

3) *Falconbridge*

Emissions of SO_2 from the Sudbury smelter of Falconbridge Ltd. were reduced by 64% between 1970 and 1980 in response to a series of tighter local air quality controls. In 1978–80, the company modernized its smelting operation by installing new fluid bed roasters, electric furnaces, and an acid plant. Consequently, it has been able to operate well under the existing SO_2 emission limit of 154 kt/year, although part of the reduction has been due to lower production levels resulting from depressed markets. The new *Countdown* regulation requires Falconbridge to reduce its Sudbury SO_2 emission level from 154 kt/year to 100 kt/year by 1994.

The best means of reaching the new SO_2 emission limit appears to be a combination of enhanced pyrrhotite rejection from the ore, an increased degree of roast, and an improved converter slag system. Active research is underway on all three elements of the emission reduction program and some federal funding has been provided for research and development of the new technologies through existing programs. The technical ability of the company to meet the new required emission limit is not in doubt; the lowest-cost method is being sought.

4) *Algoma Steel–Wawa*

The Wawa operation of the Algoma Steel Corporation Limited is an iron sintering plant with no emission abatement equipment. The plant is the mainstay of the town's economy. Ambient air quality has been controlled by limiting production when weather conditions are unfavorable for gas dispersion. A Control Order issued in 1971 and amended in 1973 limits total SO_2 emissions to 285 kt/year. In recent years, the plant has been operating well below capacity and emitted 161 kt of SO_2 in the 1980 base year.

Under the *Countdown* program the new package of abatement measures will require SO_2 reductions beyond those necessary to meet the existing ambient air quality controls. The legal SO_2 emissions limit was reduced to 180 kt/year effective 1986, and further rolled back to 125 kt/year by 1994. The company has already reduced SO_2 emissions through the replacement of a portion of the ore feed with iron oxides produced as byproducts of other industrial processes, such as roll scale from steel plants. This simultaneously addresses a waste disposal problem while reducing SO_2 emissions.

Preliminary research and development work to reduce SO_2 emissions has been completed. This involves a separation of sulphur-bearing rock from the iron ore feed, by means of froth flotation. Reduced levels of production have meant that the company has been able to meet the annual emission limit without installing this equipment. Ambient air quality standards will continue to be met by intermittent production cuts as needed.

What Will we Do?

The anticipated benefits of Ontario's major acid gas emissions reductions are very clear. Deposition of wet sulphate at Dorset, the sensitive Muskoka site of the province's major monitoring and research centre, will be reduced from the 1980 level of 32 kilograms per hectare per year to 27.6 kg/ha/year in 1994. This is a 13.8% reduction. Significant decreases in deposition also occur in many other sensitive areas (*e.g.*, Quebec South site 10.1%, southern Nova Scotia 4.2%, Adirondacks 7.8% and 7.1% in New Hampshire). The scheduled reductions of the other six eastern provinces will further reduce the deposition.

Adequate environmental protection in Canada cannot be achieved without a serious U.S. abatement program which goes beyond reaching compliance with ambient air quality standards. Even if Canadian SO_2 emissions were cut to zero, the target deposition level could not be reached. After 1994, at many of the monitored receptor sites, even with all the Canadian reductions in place, deposition levels will still be well above the target level of 20 kilograms of wet sulphate per hectare per year.

American acid gas reduction programs could take many forms, and it is not Canada's business to suggest what the details should be. But it is clear that the target deposition level of 20 kg/ha/year could be achieved by a serious U.S. abatement program.

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