Environment Canada - Environnement Canada

Air Quality and Inter-Enviromental Research Branch. Annual Report

Date: 1988/1989

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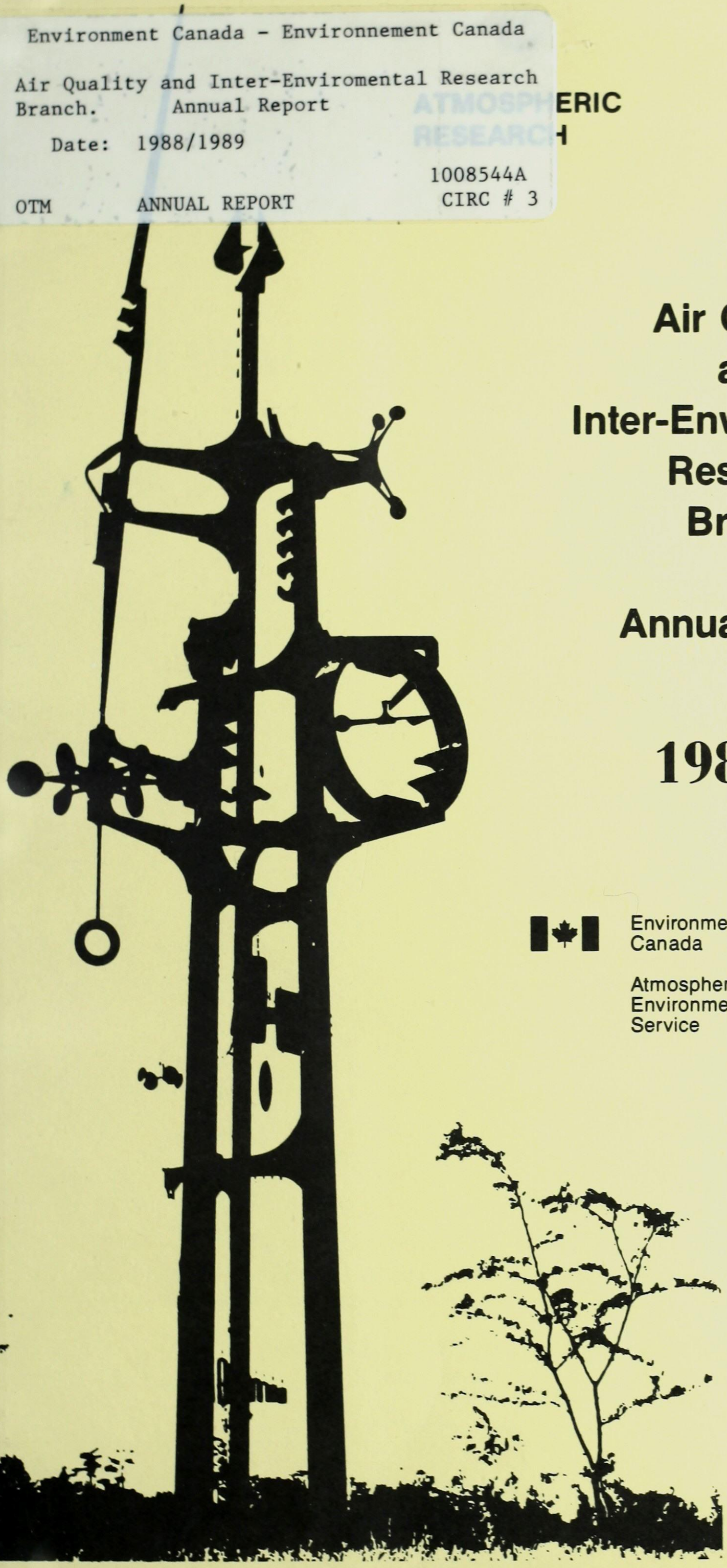

Air Quality and Inter-Environmental Research Branch

Annual Report

1988-89

Environment Canada / Environnement Canada

Atmospheric Environment Service / Service de l'environnement atmosphérique

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AIR QUALITY AND INTER-ENVIRONMENTAL RESEARCH BRANCH

ANNUAL REPORT

1988-89

Compiled by

M.E. Still

June 1989

This is one of a series of management reports produced by the Research Directorate. It is intended for internal use only.

Air Quality and Inter-Environmental Research Branch
Atmospheric Environment Service
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Downsview, Ontario, Canada M3H 5T4

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Foreword

by: James W.S. Young, Director

Air Quality & Inter-Environmental Research Branch (AQRB)

The main goals of this Branch are (1) to provide air quality services for the Government of Canada and (2) to advance the state of knowledge of atmospheric sciences in those areas that the public considers as significant environment problems. To this end, many significant advances were achieved this year.

As a contribution to the Canadian atmospheric science infrastructure, the Centre for Atmospheric Research Experiments (CARE) was opened this year near Egbert, Ontario. This represents a major step toward the First Integrated Research Centre as outlined in the Air Quality Services Strategic Plan. The Branch made a breakthrough in the Toxic Chemicals issue by taking a leadership role for Annex 15 of the Great Lakes Water Quality Agreement (1987) and by establishing a Master Station at Point Petre. The Hudson's Bay Lowland project, funded by NSERC, to study the movement of greenhouse gases is a successful partnership effort involving numerous universities, the National Research Council and various federal departments in the U.S. and Canada. A cooperative project with the U.S. is the evaluation of the Eulerian model. As part of the Eulerian Model Evaluation Field Study (EMEFS), many of the existing Branch projects were modified to support the Summer Intensive study.

During the year, the Branch initiated a new award, the "All Seasons Research Award". This award will be given annually to AES employees in recognition of significant contributions towards achieving the goals of this Branch. Nominations can be forwarded to the Director, AQRB, from anyone within AES anytime during the year. The Air Quality Management Committee will review all nominations received to December 31 and make a final decision before the end of April.

In 1988, awards were received by:

Bill Sukloff for his contribution to improving the efficiency of the Branch operations through his development of the Branch Interactive Budgeting System (BIBS) which is now widely used in AES.

Doug Whelpdale for his advice and guidance to a spectrum of researchers in various fields as well as his well thought out positions to senior management on research and policy issues.

Joe Kovalick for his long standing dedication to supporting and ensuring the success of many air quality research programs.

Don Faulkner for his significant contribution to the provision of air quality services to the governments and to the public of British Columbia over the past 10 years.

Mentioning highlights sometimes misses activities that were significant in assisting the Branch reach its goals. Details of all activities can be found in the following pages. My thanks to all of you for a very successful year.

3. AQRB Program for 1988-1989

3.1 LONG RANGE TRANSPORT OF AIR POLLUTANTS (LRTAP)

3.1.1 Program Management

- K.J. Puckett, M.L. Phillips

J.W.S. Young represented AES on the RMCC/NAPAP [RMCC : Federal/Provincial Research & Monitoring Coordinating Committee; NAPAP : National Acid Precipitation Assessment Program] Eulerian Model Bilateral Steering Committee and K.J. Puckett represented AES on the Project Management Group (PMG) of the US-Canada Eulerian Model Evaluation Field Study (EMEFS). Several meetings were held at which arrangements for the field study were finalized and plans for the model evaluation process itself were formulated. M.L. Phillips continued as the Federal Co-chair of the Atmospheric Sciences Sub-Group of RMCC. This Sub-Group finalized the plans for the LRTAP 1990 Assessment.

3.1.2 Long-Range Transport Modelling - Eulerian and Lagrangian Models

- M.P. Olson, K.K. Oikawa, D. Davies, E. Voldner, J.W. Bottenheim

In the AES Long Range Transport Concentration/Deposition Model, the numerical method used to solve the sulphur/nitrogen conservation equations was changed from the trapezoidal rule to a predictor (Adams-Bashfort)-corrector (trapezoidal) method. The results from the two methods were very similar but the predictor-corrector method is more theoretically sound especially in the chemical feedback terms. The parameterization of the physical/chemical processes was reverted back to the simple processes of the Lagrangian sulphur model to test the sulphur/nitrogen model formulation. The results were quite comparable given the differences in numerical procedures and data handling. The wet scavenging formulation was changed to reflect L. Barrie's work on cloud scavenging processes which uses $p^{-0.4}$ in the scavenging ratio and a seasonal partitioning factor in the sulphur dioxide scavenging process. The sulphur-nitrogen model was used to compute a nitrogen budget and transboundary fluxes for eastern Canada for 1980. Nitrogen parameter investigations and sensitivity tests were done and comparisons of model output were made with observed data.

As part of the joint US/Canada model evaluation, a protocol was developed for the evaluation of ADOM (Acidic Deposition and Oxidants Model) and RADM (Regional Acid Depositional Model). In conjunction with Conservation & Protection and the Provinces, the NAPAP 1985 emission inventory was finalized and an 1988 update to SOx/NOx inventories was produced. Work was initiated on source labelling as an approach to describing source-receptor relationships.

European heavy metals inventories were finalized for the Arctic flux model. Several runs were made to Canadian and European Arctic measurement sites to compare model results with the available measured data. Difficulties were encountered in trying to determine the deposition parameters for the heavy metal aerosol and further model runs were postponed until more measured data were received.

Operational forecast and diagnostic trajectory programs were developed to support the aircraft operation from Muskoka during the Summer Intensive of the Eulerian Model Evaluation Field Study (July/August 1988). The programs are initiated automatically at the Canadian Meteorological Centre in Montreal. After the required trajectories are computed and distributed to AES Headquarters in Downsview, they are available by remote access when required by the field crews.

The Lagrangian model was configured to run on a grid area for the PERD (Panel on Energy Research and Development) study. An inventory was prepared from the same files as were used to create the ADOM inventory. The Lagrangian model was run for the first PERD period (June 8-18, 1983) and daily average sulphur dioxide and sulphate concentrations, and total wet sulphur deposition gridded outputs were prepared. The gridded and contoured outputs showed an episode moving through the area on June 12-15 in very good agreement with the site data.

Lagrangian LRTAP modelling of NO_y is in progress. Some results were presented by M. Olson at a meeting in Cambridge, U.K., in September, 1988. A joint box modelling project is being carried out with Alberta Environment (H. Sandhu) and York University (Gladstone, Niki and Shepson). The Edmonton data were used to refine the model and a report is expected soon.

3.1.3 Canadian Air & Precipitation Monitoring Network (CAPMoN)

- P. Wong

Two existing sites - Montmorency and Chapais - were upgraded, the latter receiving air sampling equipment to operate in conjunction with the precipitation chemistry equipment. Two new sites were established, one at Egbert (sampling commenced in July, 1988) and the other at Snare Rapids (sampling commenced in October, 1988). The existing station at Goose Bay was shifted to a new site several kilometers away. Property was purchased on Saturna Island, B.C., to set up a new site to complete the nation-wide CAPMoN network and sampling will begin in May, 1989.

During the summer, the CAPMoN technical staff, with assistance from Joe Kovalick, John Deary and Bill Jackson, installed new air monitoring systems, ozone analysers and data loggers at air monitoring stations, and Belfort gauges at all sites east of Manitoba in preparation for the network participation in the Eulerian Model Evaluation Field Study (EMEFS). As predicted, the accelerated development of the air system resulted in some teething problems which surfaced only after the systems were installed. The major problem was spurious switching of the filter pack flow system so that filter packs were sampling on incorrect dates. A temporary fix to the problem has been made.

Preparations were completed at Egbert for the installation of samplers from other networks. This site will be the 2nd EMEFS network intercomparison site (Penn State was the first one). The start-up of the Egbert intercomparison study is planned for April, 1989.

3.1.4 Network QA/QC and Data Management

- R.J. Vet

The QA/QC program has continued to maintain the high quality of the CAPMoN precipitation chemistry data. The 1987 CAPMoN precipitation chemistry data summary was quality controlled and published. The 1988 precipitation chemistry data quality control is on schedule and the report is expected to be published in August, 1989.

Quality control of all filter pack data for air chemistry from 1983 to 1987 was completed. Quality control of the June to October, 1988, filter pack data was contracted out so that EMEFS data delivery deadlines can be met. The final step in data management, i.e. blank correcting the filter pack loadings and calculating concentrations, is under development and will be completed in the near future. Development of the new data base management system for the filter pack data was delayed until later this year.

R.J. Vet continued as leader of the Operational Measurements Team (OMT) which answers to the Project Management Group of EMEFS. The laboratory intercomparison study being run for the OMT by National Water Research Institute in Burlington continued on a monthly basis. No serious biases were found between the 5 participating networks' laboratories.

A preliminary analysis of CAPMoN-NADP/NTN [NADP/NTN = United States National Atmospheric Deposition Program/National Trends Network] intercomparison data from Sutton and Penn State (September, 1986, to December, 1987) was presented in a poster paper (co-authored by A. Sirois, R.J. Vet and D. Lamb) at the NADP Technical Meeting in November. The results suggest that CAPMoN and NADP/NTN are quite comparable for sulphate but statistically significantly different for nitrate, ammonium, pH, sample depth and standard gauge depth. On an annual basis, wet deposition of ammonium appears to be approximately 30% higher in CAPMoN than in NADP/NTN and may be related to the loss of ammonium by bacterial uptake in the NADP/NTN weekly sample.

3.1.5 CAPMoN Analytical Chemistry Laboratory

- D. MacTavish, T. Adamson, S. Ahmed

The laboratory participated with satisfactory results in:

(i) the Tenth Intercomparison of Analytical Methods within EMEP (Co-operative Program for Monitoring and Evaluation of the Long Range Transmission of Air Pollutants in Europe), sponsored by the Norwegian Institute for Air Research;

(ii) the EMEFS laboratory intercomparison studies (series E2, E3, E4, E5 and E6); and

(iii) the LRTAP laboratory intercomparison studies (series L18, L19 and L20).

Analyses were completed on all samples for the WATOX-88 (Western Atlantic Ocean Experiment, 1988) project and the Canadian Arctic Air Pollution Studies. As part of the CAPMoN-NADP/NTN network intercomparison study at Sutton and Penn State, all non-zero corrected air chemistry data have been summarized for the period June 15, 1988, to October 15, 1988. The quality controlled 1987 CAPMoN air data have been finalized and are being further analysed.

The first draft of the Laboratory Standard Operating Procedures has been completed. As required under the WHMIS (Workplace Hazardous Material Information System) legislation, 50% of all the chemicals in the laboratory have been classified.

3.1.6 National Atmospheric Chemistry Data Base (NAtChem)

- R.J. Vet, C. Ro, W. Sukloff

In Phase 1 (Core System Development) of the development plan of the data base, the following were completed:

(i) The National Atmospheric Chemistry Data Base Contouring system (NATCON);
(ii) The Network and Site Data Entry system;
(iii) The Site Reporting system;
(iv) Data entry of network and site information data from 3 precipitation chemistry networks (CAPMoN, APIOS & Alberta); and
(v) The updating of the functional specifications.

Other developments included the design of the chemistry sample data base, and the development of an analysis program to estimate area and point emission sources near wet deposition monitoring sites. This was done using 1980 emission inventory data. Work continued on the development of a multi-network data base for north eastern North America. Contractual arrangements were made to complete the input of three more networks into these data bases.

Maps of 1982 to 1986 annual wet deposition in eastern Canada were completed and delivered to the Federal-Provincial Research and Monitoring Co-ordinating Committee (RMCC) Aquatic Effects Subgroup for use as input to an aquatic effects model for eastern Canada. A map of 1986 excess sulphate deposition along the eastern seaboard was produced for inclusion in an atlas of the Bay of Fundy, Gulf of Maine and Georges Bank. Five-year average wet deposition maps for 1982-1986 were prepared for Forestry Canada for use in their forest effects research program.

3.1.7 Analysis of CAPMoN Data

- A. Sirois

The analysis of the CAPMoN air data between 1983 and 1987 has been initiated. An algorithm for the blank correction has been developed. A paper on the effects of missing samples in the calculation of precipitation-weighted mean concentration is in preparation and will be shortly submitted to Atmospheric Environment.

3.1.8 LRTAP Data Analysis Project

- P.W. Summers

Work continued on summarizing sulphur and nitrogen deposition data as input to surface water acidification, to the development of Canadian strategy for NOx controls and to the advancement of the critical loads concept. A major review of empirical relationships between deposition observations and emission sources, and the modelling of North American source-receptor relationships and transboundary fluxes, was prepared for the Swedish Academy of Sciences. The technique of combining observations of heavy deposition and high concentration events with the associated airmass trajectories was further developed and applied to observations at Kejimkujik National Park, Nova Scotia. High ozone and PAN (peroxyacetylnitrate) levels in southern Nova Scotia are clearly linked to the urban and industrial NOx sources in the northeastern United States. The concept of an atmospheric region of influence or airshed (somewhat analogous to a watershed) was expanded beyond the Great Lakes basin and applied to the whole Canada/U.S. border region.

A major new initiative in 1988 was an agreement to assist Health & Welfare Canada with major projects on the health effects of air pollution. The activities included: interpretation of air monitoring data for selection of appropriate health study locations, advice on methodologies to combine air monitoring data with hospital admissions data, and assistance with a pilot acid aerosol monitoring study at the CARE site in Egbert, Ontario.

3.1.9 Atmospheric Chemistry (Surface Measurements)

- K.G. Anlauf, J.W. Bottenheim, H.A. Wiebe, B. Misanchuk, A.J. Gallant, M. Watt, Y.Z. Tang and Y.A. Tham

Most of this year was devoted to preparing for the summer intensive measurement period of the Eulerian Model Evaluation Field Study (EMEFS), taking measurements during the Summer Intensive (July 18-August 31, 1988), and analysing data to meet the March deadline for data submission to the US-Canada data bank.

As part of the field study three hydrogen peroxide analysers, based on the enzymatic fluorimetric principle as described by Kok et al of NCAR, were assembled. Two of these analysers were designed for aircraft operation and the third was for ground-based operation at Egbert, Ontario. For measurement of NO and NO_y, two Monitor Lab nitrogen oxides analysers were modified for increased sensitivity and 2 heated gold converter tubes (according to Fehsenfeld et al) were added to convert atmospheric nitrates to NO ($=NO_y$). Two new TECO Model 43S sulphur dioxide analysers, intended for the aircraft measurement program, were laboratory tested and found to have sensitivities as low as 0.1-0.2 ppb. A contract was let to Concord Scientific to construct an automated dual molydenum oxide denuder system for sampling of atmospheric ammonia during the EMEFS.

The Canadian Air & Precipitation Monitoring Network (CAPMoN) was modified to include ozone analysers. Plans for the CAPMoN ozone data publication and analysis have been finished and implemented on a test set of data. Data for the period July-September, 1988, will be ready for archiving in the common US-Canada data bank by March 31, 1989.

Arrangements were finalized for collaboration with Drs. Niki and Shepson (York University) on the sampling and analysis of aldehydes and other hydrocarbons at Egbert as part of the EMEFS. For the hydrocarbon cannister samples (about 400) all chemical analyses were completed; presently, quality control and analysis of data are in progress. J.W. Bottenheim and A.J. Gallant participated in the EMEFS Summer Intensive and collaborated with York University with measurements of volatile organic compounds, peroxyacetylnitrate, aldehydes and carbon monoxide from an aircraft, and at Egbert and Borden. J.W. Bottenheim continued as Canadian representative on the joint US/Canada Enhanced Network Team, chaired by K. Demerjian. Results from the Egbert measurements were reviewed and discussed in light of concurrent measurements at several U.S. sites.

In additional studies, an internal report on the short term measurement of hydrogen peroxide (H_2O_2) at the CHEF (Chemistry of High Elevation Fog) Sutton Roundtop Mountain site during September 1987 was completed. Observed H_2O_2 concentrations were typical for rural eastern North America: gas phase was 0.1-1 ppb, liquid phase was 0.8 - 40 Molar.

3.1.10 Vertical Profiles of Sulphur Dioxide and Ozone

- R.M. Hoff, R.E. Mickle, F. Froude, J. Arnold and J. Markes

This project is a subproject of the Eulerian Model Evaluation Field Study (EMEFS) designed to obtain profiles of meteorological and chemical parameters at the Centre for Atmospheric Research Experiments (CARE), Egbert, Ontario. These profiles, when formed into time-height cross-sections, can be directly compared to Eulerian Model output for the CARE site in a strictly Eulerian sense.

Three intensive periods were carried out in July and August, 1988. During the first two periods, profiles of meteorology and ozone were obtained using tethered and free flying balloons (Beukersondes) and using the Differential Absorption Lidar (DIAL). During the third period the DIAL was reconfigured for sulphur dioxide profiling. The study gave results for ozone profiling which exceeded the expectations of the researchers. Of 40 ozonesondes which were launched during the project, data quality looks excellent for over 32 flights. Over 70 good quality upper air flights were obtained with the Beukers system. It is clear that the Beukers-ozonesonde link can provide ozone profiles within two hours after release. The interface is currently being submitted for patent. The meteorological tower on the site logged data from July 25 to the end of August. Data are available as 10-minute means and hourly averages.

Data from the tethersonde, Beukers ozonesonde and surface-based measurements of ozone at Egbert and Alliston, Ontario, agreed to within 11% of each other. Analysis of the OME (Ontario Ministry of Environment) network data has shown that surface depletion events at Egbert are not isolated. Decreases in surface ozone happen widely around southern Ontario on a given night and appear to be coupled to the radiative inversion onset which is driven by the synoptic situation at night. Profiles of ozone and meteorology at Egbert and Borden showed that the ozone gradient at each site was different up to 60 metres due to the dissimilarity in ground cover (forest vs open field) but above that height agreed remarkably well. The time dependence of the gradient was surprising in that the ozone depletion at the surface commenced in the early afternoon and continued throughout the night until late morning mixing occurred. It is apparent that the interpretation of surface measurements by photochemical or chemical reaction mechanisms at times other than mid-day will be fraught with problems since the chemical apportionment above 60 metres may be quite different.

DIAL results for ozone agreed reasonably with that obtained with the ozonesonde and aircraft, although the data are noisier than the ozonesondes. The DIAL reconfiguration for sulphur dioxide was a failure as the system noise sensitivity did not allow for the low ppb resolution required to measure ambient sulphur dioxide. Over 200 hours of DIAL profiles data are available as two-minute averages for 15 minutes at the start of each hour. In addition, profiles of aerosol backscattering were made with the Ruby Lidar. Time height contours of Rayleigh ratio were produced on a daily basis (with 4 minute resolution).

3.1.11 Peroxyacetylnitrate/Ozone/Nitrogen Dioxide

- J.W. Bottenheim

Measurements of peroxyacetylnitrate (PAN) and ozone (O_3) continued at Kejimkujik National Park and Alert. PAN and O_3 data from Kejimkujik for 1984-1987 were reported at the symposium "Kejimkujik 1988". A comparison of PAN measurement and calibration techniques was performed at the CARE site in January and March, 1989, with participation from AES, OME, York University and Unisearch.

An LMA/3 nitrogen dioxide analyser has been operated at Kejimkujik since June, 1988, as a test of the instrument for potential incorporation into CAPMoN to measure nitrogen dioxide (NO_2) routinely. Due to instrumental problems with data logging at Kejimkujik, NO_2 data will only be acceptable as of late January, 1989. A passive sampling method for NO_2 is also being evaluated at this site in cooperation with Dr. D. Atkins (EMEP, ISPRA, Italy).

3.1.12 Dry Deposition - Forests

- G. den Hartog, H.H. Neumann, L.F. Guise-Bagley, J. Deary and S. Melnichuk

The primary objective for this period was participation in the Eulerian Model Evaluation Field Study (EMEFS). Measurements included fluxes of heat, water vapour, momentum, and ozone above the canopy at 33 metres and at the midpoint in the canopy near 10 metres, and fluxes of sulphur dioxide, nitrogen dioxide and carbon dioxide at 33 metres. Some 500 hours of flux data were collected representing 600 megabytes of data. Other measurements made were stomatal resistances, temperature and wind profiles and four levels (two above and two within the canopy) of ozone, nitrogen dioxide and carbon dioxide. Leaf wetness was also monitored at 4 levels in the canopy. A preliminary result from this experiment is that the primary sink for the pollutants such as ozone is the very top of the canopy. Typically, the ratio of the flux measured at 33 metres to the flux measured at 10 metres within the canopy is ten to one.

The next major undertaking was the organization of the data collected during the EMEFS, and the preparation of data abstraction and analysis computer programs. A major acquisition was the Corel optical disk drive which allowed essentially immediate access to all of the eddy correlation data on a single 400 megabyte optical disk. Programs were developed to abstract and tabulate the routine monitoring data, the eddy flux data, and to produce spectral plots of the turbulence data.

System development work continued on particulate profile measurements and on the eddy correlation data acquisition system. For the former, this consisted of further program development for display of both archived and real-time data.

Continuous routine monitoring of meteorology and pollutant concentrations of sulphur dioxide (SO_2) and ozone (O_3) continued at Borden. The CAPMoN air filter operation continued until December 27, 1988, at which time the continuous program was terminated. In the future the filters will be run only during intensive field studies.

3.1.13 Boundary Layer Parameters Over a Forest Canopy

- A.K. Lo, G. den Hartog and H.H. Neumann

The Camp Borden wind profile data was used to determine Z_o, d and U_* by employing a modified mass conservation approach. Boundary layer and flux parameters were also calculated based on these estimated values. These preliminary estimates agreed well with direct measured flux parameters. The selection of Camp Borden data is based on the following three categories: wind direction in relation to the fetch; consistency of atmospheric stability conditions; and leaf foliage conditions. Preliminary findings indicate that the results are more dependent on stability conditions and wind directions than on leaf foliage.

3.1.14 Dry Deposition - Complex Terrain

- J. Padro

The computer code of the Concentration Complex Terrain Model has been united with the revised MSFD computer program. Results have been obtained for pollutant fluxes (aerodynamics part of the dry deposition) and concentration perturbation distribution over the hill. They are described in a manuscript prepared for journal publication and co-authored with J.L. Walmsley. The upper boundary values of the model must now be modified to include more realistic values. Preliminary graphs of vertical distributions and cross-sections of concentration and flux perturbations are available. A report has been prepared regarding evaluation of the dry deposition module in ADOM. Model results were verified against observed data (meteorological, and ozone and sulphur dioxide dry deposition) from Camp Borden that was obtained from G. den Hartog and H.H. Neumann.

3.1.15 Western Atlantic Ocean Experiment (WATOX)

- D.M. Whelpdale, S. Melnichuk

The long-term goal of this program is to determine the fate of North American pollutants over the North Atlantic Ocean. Participants include AES, NOAA, BBSR (Bermuda Biological Station for Research), York University, Universities of Delaware and Virginia. During 1988, routine measurements of aerosol and precipitation composition were made on Bermuda and at Adrigole, Ireland, and an intensive summer field program was conducted in the North Atlantic using ship and aircraft platforms.

Results from earlier studies (1985 and 1986) have provided information on atmospheric lifetimes, transformation rates and removal efficiencies of sulphur and nitrogen species, and have shown the extent of antropogenic influence on natural cycles of sulphur and nitrogen in the marine environment. It is now clear that the entire atmosphere of the North Atlantic is perturbed by anthropogenic emissions.

AES involvement in 1988 included the operation of a station on the east end of Bermuda for sampling air from the "clean" eastern Atlantic, and participation in the Coordinated Air-Sea Experiment (CASE-WATOX) from July 15 to September 7. Triple filter pack systems to determine particle constituents, sulphur dioxide and nitric acid were operated at BBSR and aboard the NOAA Research Vessel Mount Mitchell during its cruise Norfolk - Bermuda - Reykjavik - Azores - Barbados. Chemical analysis of the filters is complete. Data interpretation will continue through 1989, but the Bermuda sampling will stop because of funding limitations.

3.2 TOXIC CHEMICALS

3.2.1 Great Lakes Water Quality Agreement (GLWQA) - Annex 15

- R.E. Mickle, T. Allsopp

In May, AES convened a meeting of Canadian and U.S. scientists involved with carrying out activities in support of Annex 15 - "Airborne Toxic Substances" - of the GLWQA. Three informal working groups were established to address components of the planned Integrated Atmospheric Deposition Network (IADN). Their respective responsibility areas were to: (a) identify contaminants to be monitored; (b) design network schedule; and (c) recommend quality assurance/quality control procedures.

In June, a Canada/Ontario Airborne Toxics Committee, co-chaired by AES (J.W.S. Young) and OME (H. Tosine), was established to develop a Canada-Ontario plan for the implementation of Annex 15. The committee formalized the Canadian membership of the Working Groups. The Working Groups responsible for the Annex 15 activities finished their reports on the chemical species to be monitored at the Master Stations, and on the timing of future stations in the Integrated Atmospheric Deposition Network (IADN). By late fall, the COA (Canadian-Ontario Agreement) committee had developed a 5-year management and resourcing strategy for Annex 15 which was forwarded to the Great Lakes Environment Office. In February, 1989, the Canada/U.S. Co-ordinating Committee on Air Toxics was established to develop a strategy for the joint implementation of Annex 15. Formal recognition by the United States of the Working Groups was made so that a Canada/U.S. integrated approach can be developed for a unified network in order to measure spatial and temporal trends of airborne toxics within the Great Lakes Basin.

3.2.2 Master Station at Point Petre, Ontario

- R.M. Hoff

In support of Annex 15, Research and Surveillance and Monitoring Activities for the new Great Lakes Water Quality Agreement (1987), the Master Station at Point Petre commenced operation October 15, 1988. Samples for air concentrations of organochlorines, PAHs (polycyclic aromatic hydrocarbons) and trace metals are being obtained by both AES and the Ontario Ministry of the Environment (OME). Precipitation samples of organics and inorganics are being obtained by AES, OME and the Inland Waters Directorate (IWD). A standard meteorological package is in operation and gives hourly readings. The only remaining component of the Master Station left to be installed are the National Water Research Institute (NWRI) organics precipitation samplers which will be installed in the Spring of 1989.

3.2.3 Toxic Chemicals Laboratory

- R.M. Hoff

The staffing of the two chemist positions for the operations of the Toxic Laboratory is proceeding. These two positions will be responsible for the analysis of air and precipitation samples taken by Environment Canada component of the Point Petre Master Station. The senior chemist position will be responsible for quality assurance and quality control of the laboratory portion of the Annex 15 activities.

Some of the analytical requirements for the Point Petre monitoring will be contracted out and these include sample preparation, total suspended particulate and total organic carbon particulate analyses. In addition, analysis of trace metal samples in precipitation will need to be carried out by other agencies.

3.2.4 Atmospheric Loading

- E.C. Voldner

A plan for assessing atmospheric deposition to the Great Lakes was accepted by the commissioners of the International Joint Commission, incorporated into Annex 15 of the GLWQA, and forms the basis for the GLWQA - Annex 15 Multi-Year Program Plan.

The ENV.3 Toxic Modelling project under the Canada/FRG Agreement was initiated with initial emphasis on mercury. An air/soil exchange module is being developed. Preliminary results indicate the model performs well for half-life in soil under 30 days, but numerical errors are experienced for "long-lived" species.

A cooperative study with Argonne National Laboratory on air/sea exchange processes was delayed. Research focussing on environmental cycling of organochlorines, source emissions and depositions of contaminants to the Great Lakes region resulted in several publications and presentations at international forums.

3.2.5 Atmospheric Loading into the Great Lakes

- A.K. Lo

An in-depth evaluation of how meteorological characteristics relate to the atmospheric loading in the Great Lakes has been carried out. It is concluded that the dissipation rate method could be applied to measurements in the Great Lakes using a buoy. It is also felt that due to the lack of meteorological data during the winter months, the 'Polynya model' (Boundary-Layer Meteorol., 35, 53-71) could be adopted to characterize wind flow parameters over a frozen lake.

3.2.6 Polychlorinated biphenyls (PCBs)

- R.M. Hoff, F. Froude

This project is designed to obtain concentrations of PCBs in air at the CARE (Centre for Atmospheric Research Experiments, Egbert) site throughout the year in order to determine if an annual cycle exists for PCBs and for air mass sources which give rise to higher concentrations. The project is a joint one between AES and Dr. Derek Muir (Freshwater Institute, Winnipeg). Beginning in July 1988, samples were taken on a one-, two- and three-day basis in order to determine the laboratory analytical sensitivity for the PCB isomers of interest. Good detectability was obtained for over 50 congeners of PCBs on even one-day samples. In addition, a suite of pesticides including toxaphene have been detected on the polyurethane foam plugs.

The sampling protocol has been fixed at 600 m^3 over a two-day period and samples will be obtained to the end of the fiscal year. One hundred samples and blanks will form the basis for concentration and to determine physical and chemical factors which drive the air concentrations, such as temperature and wind sector influences. By December, 1988, fifty samples and blanks have been obtained at Egbert and the analysis shows that the PCB concentrations range from 90 $pg.m^{-3}$ to 2.2 $ng.m^{-3}$ with the highest concentrations during summer haze events.

3.2.7 Gas/Particle (GAP) Sampler

- D.A. Lane

The GAP samplers are being modified to make them more rugged and simpler to operate. Ortech has begun the engineering modifications to the designs for the GAP samplers. Evaluation of field measurement results compiled over the past two years have shown that breakthrough of gases may be occurring in the samplers. It is suspected that the denuders may be aging and that it may be necessary to re-coat them at regular intervals. A denuder which has been used 10 times in the field is being tested to assess the extent to which breakthrough is occurring.

Investigation into mass flow meters and controllers indicated that the one manufactured by Tylan Instruments would perform best under the range of environmental conditions under which the GAP samplers will be operated.

3.2.8 Gas Analysis/Chemistry

- D.A. Lane

Data have been entered into the PAH (Polycyclic Aromatic Hydrocarbons) computer database. The parent PAH database (containing data on approximately 120 PAHs) has been extended to include data on more than 300 individual parent PAHs.

A new international and interdisciplinary journal Polycyclic Aromatic Compounds should make its first appearance in May, 1989. Dr. Lane is the Editorial Manager for the journal and also is one of the review editors.

A joint ICPAC-NIST [ICPAC: International Committee on Polycyclic Aromatic Compounds; NIST: National Institute of Standards and Technology, formerly NBS] repository of standard PAC compounds (those which are not commercially available) is being established. Chief initiators of this endeavour include Dr. V. Sniekus (University of Waterloo).

3.2.9 Lichens as Biomonitors

- D.M. Whelpdale

This joint project between AES and the Institute for Environmental Studies (IES) at the University of Toronto involves the collection and chemical analysis of lichens from the upper Great Lakes Basin in order to evaluate their use as biomonitors for trace organic and metal pollutants in atmospheric deposition. Sample collections took place during the snow-free seasons of 1985, 1986 and 1987. Chemical analysis of the samples has been completed, and interpretation of the data continues. A manuscript describing preliminary results of the 1985 study has been prepared for publication, and summary results of the 1986 and 1987 collections were presented in a special symposium on the long-range transport of pesticides at the Toronto ACS conference in June, 1988. This joint project is funded by AES, the Wildlife Toxicology Fund and the Ontario Pesticides Advisory Committee. A final report of the contract work done by IES has been completed.

3.2.10 Resuspension by Breaking Waves

- L.A. Barrie

The experimental measurements collected between Meaford on the south shore of Georgian Bay and Western Island 50 kilometres to the northwest in Georgian Bay under situations of southwesterly flow at high wind speeds indicates that the Bay is not a substantial source of aerosol trace elements to the atmosphere.

3.2.11 Aerial Application of Pesticides

- R.E. Mickle, J. Arnold, and D. Wallace

In June/July, AES co-operated with the National Research Council (NRC) at Kapuskasing to study deposit and drift during the aerial application of ultra-low volume pesticides. Support was provided by the Forest Pest Management Institute through the use of their spray aircraft. Eleven multiple spray runs were flown in conditions varying from early morning stable through to mid-day unstable. Ground and foliar deposit were measured to 400 metres downwind of the spray line while drift past 400 metres and 2 kilometres was measured with the use of balloon-borne rotorods. Tethersonde measurements to 400 metres were used to interpret the meteorological conditions and provide the data base for transport calculations. Preliminary results indicate that for ultra-low volume spraying with the spray aircraft maintaining a constant height, the drift downwind increases with increasing stability.

During the latter part of September, a second joint experiment was undertaken in New Brunswick (Red Rock) to evaluate aircraft type/spray atomizers on target deposit and off target drift for herbicide sprays during operational conditions. The experiment was the joint effort of the Research and Productivity Council, the University of New Brunswick, NRC and AES. For the experiment, comparisons were made between a Bell 206 Jet ranger with boom and nozzle and Turbo thrush with Micronair rotary atomizers. As in the Kapuskasing experiment, the 13 tests were flown in a variety of meteorological conditions in order to determine the best combination of aircraft and spray conditions.

An early morning cross-wind spray has been reworked from the lidar mapping data (New Brunswick, 1987) to produce down-wind dosage of the evaporating spray cloud from which drift and deposit profiles have been calculated. Profile shapes are typical of *in situ* measurements made at Dunphy and Kapuskasing indicating that the lidar may be useful in looking at the spray dynamics and assessing drift and deposit from spray episodes. A proposal is presently being formulated, centred around the lidar mapping system to assess the influence of vortex strength, emission spectra and meteorology on the ultimate drift and deposit.

Results from both experiments will be used as valuable data sets in assessing the accuracy of models in the prediction of off-target deposit and will assist in the setting of appropriate buffer zones for aerial applications.

3.2.12 Pesticide Off-target Drift Model Evaluation

- A.K. Lo, J. Arnold

Implementation of Atias-Weigh's aerial spray model onto the PC Compaq 286 computer has continued in order to reproduce the author's original results. Modifications to Atias-Weigh's original model to include vortex interactions with a forest canopy in a more realistic manner are in the process of being formulated.

3.3 CLIMATE CHANGE

3.3.1 Alert Operations

- S. Iqbal, S. Symington, D. Worthy, N. Trivett

During the annual maintenance of the BAPMoN (WMO Background Air Pollution Monitoring Network) laboratory, a new aerosol monitoring system was installed and a new snow/rain cap with velocity diffuser was fitted on the air intake manifold to enhance air flow. The radon monitoring system from the University of Heidelberg was installed at Alert in January.

The 45-metre tower was declared unsafe to climb by the Department of National Defense and action to have it dismantled has been initiated. Requirement for a replacement tower will be determined later in the year. The replacement of the 50-metre tower was reviewed and a new platform was designed.

3.3.2 Flask Sampling Program

- N. Trivett, S. Iqbal, S. Symington

Calibration of secondary carbon dioxide standards against the Scripps standards proceeded on schedule and working gases were calibrated against the secondary standards before being shipped to, and after they returned from Alert. The site of the proposed regional station for the Hudson's Bay study was inspected for carbon dioxide and methane measurements and a glass sampling stack similar to the one at Alert was designed.

Carbon dioxide flask samples continued to be collected weekly from Sable Island, Cape St. James and Alert. The flask extraction and analysis system was developed but technical problems were encountered in automating the procedure. Manual switching from flasks to calibration cylinders will be implemented until the problem is solved. Further testing of a new control program was written revealed that the analyser was sufficiently non-linear that a three-point calibration was needed. The new flasks (glass with greaseless stopcocks) were received and initial testing indicates that they are quite stable. A new flask program for light hydrocarbons was started in cooperation with the Institute for Chemistry at Julich, West Germany. The sampling protocols for each flask program were reviewed in a summary paper which has been distributed to the cooperating agencies for comment.

3.3.3 Turbidity

- S. Iqbal

A Lotus spreadsheet macro program was written to calculate turbidity and quality control the data from the network.

3.3.4 Carbon Dioxide Data Analysis

- K. Higuchi, N. Trivett

The Alert data analysis procedures were reviewed and the median type of outlier identification was adopted as the preliminary quality control (QC) method for the data. All data will be retained but will be appropriately "flagged". Such QC programs have been written for all the trace gases but not yet for the aerosols. A statistical procedure (combined median and forward stepwise multiple linear regression techniques) has been chosen to analyse carbon dioxide and methane data on a routine basis.

3.3.5 Global Biogeochemical Cycles and Climate Research

- K. Higuchi

Funding was obtained to initiate development of a 2-D climate global carbon cycle interactive process model. This project includes active participation from Prof. Charles Lin (McGill University), Dr. Neil Sargent (AES Canadian Climate Centre), Dr. Douglas Chan (Post Doctoral Fellow, AES) and Dr. Y-H. Chan (Western Ecological Services Ltd.).

The Climate Diagnostic Research Group has initiated a project to investigate the regional characteristics of the "climate jump" in the early 1960's. A paper has been submitted to the Journal of Climate and preliminary results of the study were presented at the 13th Annual Climate Diagnostic Workshop in October, 1988.

3.3.6 Arctic Air Chemistry

- L.A. Barrie

Analysis of weekly aerosol samples for two constituents for the period May 1986 to May 1988 at Alert has been done by neutron activation analysis, inductively coupled plasma emission spectroscopy and ion chromatography. This completes 8 full years of Arctic aerosol chemistry data. At the 2nd Symposium on Baseline Observations of Air Chemistry (Australia, 1988), L. Barrie presented a paper entitled "Chemical Components of Lower Troposphere Aerosols in the High Arctic." In the polluted winter half of the year, four aerosol components were evident: soil, sea spray, a polar sunrise photochemical fraction, and a primary anthropogenic component.

Dr. F. Akeredolo has been working on two projects as part of his post-doctoral studies at AES. A project on black carbon in the Arctic is at the stage of testing 2 continuous samplers for deployment at Alert in winter 1989. Preliminary tests at Egbert have been sucessful. The aim is to learn more about the origin of carbon dioxide and Arctic pollution from the ratios of black carbon to these constituents in the atmosphere. A second project in cooperation with the Norwegian Institute for Air Research involves estimation of the flux of toxic trace metals into the Arctic from mid-latitudes using the LRTAP model of Olson and Oikawa.

3.3.7 Polar Sunrise

- L.A. Barrie, J.W. Bottenheim, J. Kovalick, A.J. Gallant

The Polar Sunrise Experiment was conducted at Alert February 25, 1988, to April 25, 1988, to provide more insight into the phenomenon of lower tropospheric ozone destruction and filterable bromine production after polar sunrise. A paper was published recently in Nature (Barrie et al., 1988, 334, 138-141). The experiment involved 3 universities and 3 government agencies. This experiment is part of a larger effort under the auspices of the Canadian Institute For Atmospheric Chemistry (CIRAC) to study chemical changes in the atmosphere at polar sunrise.

Preliminary results presented by J.W. Bottenheim at the 1988 Fall AGU meeting in San Francisco were as follows:

(i) the confirmation of the O_3-Br anticorrelation;
(ii) the identification of bromoform increase during O_3 decrease;
(iii) probable decrease of NO_2 concurrent with O_3;
(iv) determination of the order of magnitude of formaldehyde; and
(v) a trend in identification of relatively large amounts of alkylnitrates, in phase with PAN observations.

3.3.8 Atmospheric Aerosol Chemistry

- L.A. Barrie

This project forms part of a larger joint study by AES, Ontario Hydro and the Ontario Ministry of the Environment, called Regional Atmospheric Aerosol Chemistry (RAACS). By July 1988, AES established sampling at 4 locations in eastern Canada on a daily basis: ELA-Kenora, Algoma, Egbert and Sutton. Filter samples were divided into five pieces and archived at AES. The analysis of these samples is coordinated by Ontario Hydro. By September 30, 1988, all stations had operated successfully through the Summer Intensive measurement period of the Eulerian Model Evaluation Field Study (EMEFS). Filters of aerosol samples for the period July 18 to September 14, 1988, were sent to Ontario Hydro for analysis by instrumental neutron activation analysis. As an example of the usefulness of such a data base, refer to the following two papers published using a small multi-elemental data set: Barrie, L.A. (J. Geophys. Res., 93), and Hooper, J.F. and L.A. Barrie (Tellus, 40B)

In addition to this activity, an aerosol sampler was readied for use in monitoring toxic inputs into the Great Lakes which is to be established at Point Petre.

3.3.9 Hudson Bay Lowlands

- L.A. Barrie

The plan is to support a major study of movement of greenhouse gases between the Hudson Bay Lowlands and the atmosphere over the next four fiscal years. The program is coordinated out of a secretariat at CIRAC under an NSERC collaborative grant. It will involve numerous universities, AES, Department of Agriculture, National Research Council and US-NASA in a major study in summer 1990.

The AES wetlands program has several components, including establishment of a baseline air chemistry observatory at Abitibi Canyon, north of Timmins, preparation of an ecological/geographical resource document on Eastern Canadian Northern Wetlands (L. Mortsch of CCC, coordinator), formation of a wetlands gas exchange modelling group, and development of a fast response tuneable diode laser instrument for aircraft eddy correlation work (Unisearch Corp.).

3.4 CORE RESEARCH

3.4.1 ERICA (Experiment on Rapidly Intensifying Cyclones over the Atlantic)

- P.A. Taylor (York), J. Deary

Ten surface mesonet stations were installed along the Nova Scotian coast during November as a part of the Canadian component of this U.S.-led experiment. Data collection started December 1st and continued until the end of February, 1989.

3.4.2 Flow Over Complex Terrain

- J.L. Walmsley, W. Gong (Visiting Fellow)

Activities continued in connection with the International Energy Agency (IEA) Annex VIII and Canadian Standards Association (CSA) committees involved with drafting recommended practices and guidelines for the siting of Wind Energy Conversion Systems (WECS). Draft No. 8 of the International Energy Agency (IEA) handbook of techniques for siting of small wind energy conversion systems was completed and distributed to IEA Annex VIII committee members for discussion.

The "Guidelines for Estimating Wind Speeds" have been improved with a calculation of turbulence intensity added. A demonstration was done at the International Centre for Theoretical Physics, Trieste, Italy. A new method of generating gridded topographic heights for contour information has been developed. This has been incorporated in the MS-Micro/2 package of programs for calculating wind speeds in complex terrain. The package is now complete and a user's guide written.

A study comparing formulae for the height of an internal boundary layer (IBL) generated by a step change in surface roughness was completed. The study involved intercomparison of formulae and field data.

A collaborative study on comparison of computer model simulation with data from Blashaval, Scotland is nearing completion. Other participants are P.J. Mason (U.K. Meteorological Office), I. Troen (Riso National Laboratory, Denmark) and D.P. Lalas (Wayne State University, Michigan, and University of Athens, Greece). Work has begun in collaboration with Dr. S.R. Karpick (University of Toronto) on a comparison of results from the MS3DJH and MSFD models with data from Sable Island, Nova Scotia.

Wind flow (mean and turbulence) and surface pressure measurements over a series of 2-D sinusoidal hills installed in the AES wind tunnel have been completed for both smooth (bare foam) and rough (covered with carpet) surfaces. Small but significant lateral variations were observed, which may be related to the stability of flow over waves. However, the exact cause is yet to be uncovered. Data processing and analysis is underway for evaluation of drag on the waves. The second phase of the experiment, probably a repetition of the entire measurement program over hills of half the original height for an unseparated flow situation, will start in the following year.

3.4.3 Gaussian and Heavy Gas Research

- C. Matthias

Heavy gas dispersion experiments for an instantaneous release have been carried out by J. Havens (U. of Arkansas) and by J. McQuaid (Thorney Island). Experiments on the instantaneous release of a dense gas show the gas cloud to be bimodal, i.e., to consist of an inner disk surrounded by a torus. The disk and the torus have properties distinct from one another. The heavy gas model developed at AES has been modified to describe the bimodal property of the cloud. Profiles of surface concentration vs. time comparing experimental and model results are favourable. Concentration profiles in the vertical direction are not as accurate. To the present, the model has been calibrated using only the laboratory data of J. Havens (no wind or ambient turbulence).

A paper was prepared jointly with Concord Scientific Corporation (CSC) for presentation at a workshop on "Air Pollution and Planning". The workshop was held in Lindau, West Germany during December 14-16, 1988. The purpose of the workshop was to bring air pollution modellers, and urban and regional planners together in order that each could understand the other's problems. During the past few years, CSC and AES have worked jointly to develop a heavy gas hazard assessment model named COBRA. CSC has applied the model in studies for several clients. The paper, based upon the information available from these applications, was entitled "A heavy gas model for disaster planning: three case studies". A copy of the paper is available to anyone who is interested.

Following the PCB fire in Montreal, significant dustfall occurred several days later in a part of the city that was previously untouched. A literature search was carried out to gather information on resuspension of dust.

3.4.4 Meteorological Monitoring Network

- S. Daggupaty, J. Arnold, J. Deary, and P.A. Taylor (York)

Data collection and analysis was carried out for the one Primary and eight Secondary mesonet stations around the Pickering Nuclear Generating Station. One site (near Claremont) was abandoned due to repeated vandalism. An agreement was reached with the Ontario Ministries of the Solicitor General and of Environment (OME) to extend data collection until December 31, 1989. Data are being supplied to OME for model comparison studies. We are continuing to test a shielded coil on the R.M. Young anemometer to see if it will eliminate occasional spikes in the wind data. Several stations have had problems with low batteries but overall data recovery remains very good. Hourly averaged data have been supplied to OME and other users. A report on the 1988 data has been prepared and submitted to AECB and OME. Data from the network are also being used in a study to compare surface winds with measurements from the King City Doppler radar.

3.4.5 Exchange at the Air-Sea Interface

- B.R. Kerman, N. Koshyk

Upon completion of the re-engineering of the spar buoy, tests were conducted for seaworthiness and electronic viability, using the diving tank at Seneca College. Subsequently, 2 co-op students (Lucie Bernier and Joan Ryan) were responsible for code development to analyse the fractal properties of a field of breaking waves imaged from an aircraft. In addition, Ms. Bernier helped out with the diving requirements and general field help when the buoy was deployed in Parry Sound in June and July. Ms. Ryan extended her work to the computer simulation of two-dimensional fractal fields to test and calibrate the operational code. A third visit to Parry Sound with a slightly improved acoustic system resulted in useful audio-video records of breaking waves.

After a successful field experiment at Parry Sound, analysis began on the Masscomp to infer the presence of bubbles from acoustic records. Eventually this data will be amalgamated to estimate the 'deposition velocity of air' to water during a breaking wave wind regime. To date, simulations of bubble ringing have established the limits of the signal processing technique of inverse filtering. A contract was arranged with with Dr. B. Johnson of Dalhousie University to examine physical processes and modelling of dispersions, including air and oil.

B. Kerman acted as chairman of an organizing committee meeting at the University of Cambridge in October for the second meeting on natural sound generation at the ocean surface.

3.4.6 Centre for Atmospheric Research Experiments (CARE)

- F. Froude

The Centre for Atmospheric Research Experiments (CARE) and the new Integrated Research Facility (IRF) opened during June 1988. CARE replaces and augments the work previously done at the Station for Atmospheric Experiments that was situated in Woodbridge, Ontario. The CARE facility at Egbert, Ontario, is located about 65 km northwest of the City of Toronto and consists of a 2,100 m^2 laboratory and field components for air quality, climate, solar radiation, and meteorological research. During the summer of 1988, CARE has been host to a major part of the Eulerian Model Evaluation Field Study (EMEFS). This study and the initiation of on-going research has involved scientists from AES cooperating with the Province of Ontario. U.S. agencies, universities and industry.

CARE was officially opened on October 28, 1988. The Branch Director acted as the Master of Ceremonies and introduced the Assistant Deputy Minister of AES, Mr. Howard Ferguson, the local Regional Councillor, Mr. Charlie Pridham, and the local federal Member of Parliament, the Honourable Doug Lewis.

3.5 STRATOSPHERIC STUDIES

3.5.1 Ozone Monitoring

- J.B. Kerr, C.T. McElroy, I.A. Asbridge, W.J. Clark, R.A. Olafson

Ozone monitoring was upgraded to automatic operation with the Brewer instrument as the obsolete Dobson instruments were retired at Edmonton in April, 1988, and at Goose Bay in October, 1988. Intercomparisons between Brewer and Dobson spectrophotometers were completed at Toronto and Edmonton and the results were reported. Analysis of the intercomparison data between the Brewer and Dobson instruments at Goose Bay were initiated. Nine new Brewer instruments were calibrated and delivered to Greece, Finland, Switzerland, USSR and Portugal. Further development of Brewer instrument technology and software continued; this included the development of an operational dual ozone/nitrogen dioxide instrument.

3.5.2 Stratospheric Research

- W.F.J. Evans, H. Fast, C. Midwinter, J.J. Bellefleur, R.H. Hoogerbrug, A. Ullberg, S. Turner

Trend analysis for stratospheric nitric acid, hydrochloric acid, and methane performed on data obtained from balloon flights since 1974 show that the nitric acid concentration is anticorrelated with solar activity and that hydrochloric acid is increasing in the stratosphere in accordance with model predictions.

A balloon campaign was conducted at Vanscoy, Sask., in September, 1988, to continue the monitoring of the ozone layer chemistry, started in 1974, and to develop the capabilities of the mini-radiometer and a chemi-luminescent nitrogen dioxide sonde for Arctic flights with small balloons that can be hand launched.

Another balloon campaign was held at Alert in January and February, 1989 (CANOZE 4) to study the ozone chemistry in the polar vortex by flying 18 miniature scientific balloon payloads, including 5 mini-radiometers, into the stratosphere to measure gases such as nitric acid, chlorofluorocarbons (CFCs) and water vapour. Altitude profiles of polar stratospheric ice cloud crystals were obtained by the University of Wyoming with three NOAA water sondes. The altitude distribution of ozone during the two-month period was monitored by ozone sondes. Ground-based measurements of ozone and nitrogen dioxide were made at Alert and Resolute with two Brewer spectrophotometers using the moon as light source.

3.5.3 Space Shuttle Experiments

- W.F.J. Evans, L. Poulin, C. Midwinter, R.A. Olafson, L.J.B. McArthur

Planning meetings were held to determine phase two of the Sunphotometer Earth Atmosphere Measurement (SPEAM-2) objectives and appropriate instrumentation. An infrared radiometer was proposed for SPEAM-2. A prototype was built and test measurements taken using moonlight and dusk airglow. A safety data package is being prepared. Phase two of the Brewer Earth Atmosphere Measurement (BEAM-2) consists of making the prototype operational. The contract for this part of the project was let to Bristol Aerospace on March 1, 1989.

3.5.4 National Atmospheric Radiation Centre (NARC)

- D.I. Wardle, L.J.B. McArthur, D.V. Barton

Between March 8 and April 23, 1988, global and normal incidence solar radiation measurements were made at Alert, N.W.T. in support of the Polar Sunrise Experiment.

A long-term test, using the radiation facilities on the AES roof, was initiated in the summer of 1988 in order to determine the effects of exposure on pyranometers. Initial results indicate that various pyranometer types age in different manners. Measurements of longwave radiation on the AES roof were obtained to test differences in measurement methods and instruments. The Eppley Pyrgeometer using both a thermistor alone and in a temperature compensation circuit were compared with pyradiometer data.

A new sphere calibration diagnostic program was developed and implemented.

The transfer of the solar radiation measurement program from Woodbridge to the CARE site at Egbert was initiated.

3.5.5 RAGS Observatory

- D.I. Wardle,

The RAGS radiation site at Asquith, Sask., was severely damaged by a tornado in July, 1988. A replacement trailer from the Woodbridge site was installed in September, 1988 and a UVB Brewer ozone spectrophotometer was reinstalled in February, 1989.

3.5.6 Sunphotometer Measurements

- L.J.B. McArthur, G.M. Shah

An AES sunphotometer was used in August and September, 1988, to measure the opacity of smoke plumes from prescribed burns near Timmins, Ont. Five sunphotometers were automated. One automated prototype has been running at the University of Sherbrooke (CARTEL) since August, 1988 without significant problems. Data are now being analysed by CARTEL personnel.

3.6 AIR QUALITY SERVICES

3.6.1 Environmental Emergency Response (EER) Program

- E. Wilson

The developed emergency preparedness and response systems at both the Service and Departmental levels were put to many tests this year with events that required support action beyond the provision of routine weather services, including space debris (satellite) re-entries, the St. Basile le Grand PCB fire and the B.C. oil spill. AES participated in the federal response plan coordinated by Health and Welfare for the COSMOS 1900 re-entry. Briefing reports and post-evaluation recommendations were prepared for a number of emergency events including a Soviet booster rocket re-entry in August, the St. Basile le Grand PCB fire in late August and September, and the Chicoutimi earthquake response in November. An AES 'Policy for Peacetime Emergency Response' has been drafted and reviewed by Service, Regional and Departmental components and approval is expected by the AES Management Committee in late April.

Version 5 of AQPAC (Air Quality Package of Programs), including puff and plume dispersion models, a heavy gas model and a source-strength model, was introduced to the Regional offices. Advances in the CMC hemispheric model included a fully operational system for surface sources and testing of sub-modules for upper atmosphere sources. The Emergency Weather Station (EWS) prototype, designed to collect representative meteorological data during emergencies, was evaluated by regional offices and purchases of six ground systems (one for each Region) are planned for 1989-90. Telecommunications improved with the delivery of an emergency facsimile system to Ottawa, computers and printers for the regions, computers for AES Headquarters and CMC for model graphics, development and response, and an HP9000 system to Training Branch. Emergency training included a national workshop, exercise scenarios, special courses and various drill exercises. The evaluation by Pacific Region of surface wind field models, and a terrain/land-use database, has identified two models that are being compared for regional application in 1990-91. Computer-based training scenarios were completed by Atlantic Region but have not been implemented yet by the other Regions.

Based on a status report put forward to the AES Management Committee in October 1988, there has been an allocation of eight person-years to the Regions, CMC and Headquarters for program implementation. Each Region will introduce an atmospheric chemist to their operations in 1989-90. An emergency team has been proposed for headquarters and a draft Service emergency procedures manual initiated.

To improve communications, emergency contact cards were introduced to the Service in April and updated periodically. National emergency procedures, header codes and formats for transfer of public and technical information within Canada have been developed, tested and problems identified. Proposals were put forward to regional and national offices for appropriate levels of response and provision of AES services, options for regional and national response structures, and site forecast preparation and delivery. Operational applications research continued on the development of forecast boundary layer, heavy gas and complex terrain models.

The Service focal point was maintained for environmental emergency preparedness and program coordination. Advisory committee meetings at the national level included two ACEP (AES Committee on Emergency Preparedness) meetings, three DCEP (Departmental Committee on Emergency Preparedness) meetings and a number of CANATEX (1990 national exercise) meetings.

3.6.2 Air Quality Services

- M.E. Still

The most important activity has been the drafting of the State of the Environment (SOE) Report on Air Quality. This Branch, the AES Climate Centre and the LRTAP Liaison Office submitted drafts to the SOE Branch in Ottawa (December 16, 1988) for the sections on Acid Rain, Arctic Haze, Radionuclides, Stratospheric Ozone and Carbon Dioxide. The SOE Branch wrote the other sections on the Common and Hazardous Air Pollutants. The first draft of the report has been circulated and, following comments received, a further draft will be produced.

A planning workshop was organized by the SOE Branch in November, 1988. The objective was to develop a five-year action plan for SOE Reporting and an overall vision of where SOE Reporting in Canada should be by 1993. A summary of the discussions is available in the Air Quality Services Office. The conclusions of this workshop were that it was required to move forward urgently with the National 1991 SOE Report, to identify new SOE products, to develop indicators for sustainability, to improve SOE Reporting, to develop new ideas for marketing SOE products, and to improve internal communications.

4. WEATHER SERVICES REGIONAL AIR QUALITY REPORT

All the AES Regions are active in air quality whether they are supporting the Headquarters staff in setting up measurement sites or being the AES spokesperson in the Region. Many of the projects that have been described to this point have had support from the Regions. This section highlights the work of the Regions in supplying air quality services for AES. Details may be found in the quarterly report of the Scientific Services Divisions. There are some activities that are common to all Regions: reviewing the national State-of-the-Environment on Air Quality, preparing job descriptions for the position of regional atmospheric chemist, evaluating the Emergency Weather Station, participating in the definition of air quality services and delivering talks on the Greenhouse Effect.

4.1 LONG RANGE TRANSPORT OF AIR POLLUTANTS (LRTAP)

4.1.1 Atlantic Region

- assisted Conservation & Protection (Atlantic Region) in assessing future of Prince Edward Island precipitation chemistry station.

- chaired the annual meeting of the Atlantic Region LRTAP Monitoring and Effects Working Group.

- assisted in organizing the Symposium on Acidification of Waters in Kejimkujik National Park, Nova Scotia, October 24-28, 1988 (Note: Organizing Committee will act as guest editors for a special issue of Water, Air and Soil Pollution that will contain the Symposium papers).

- assisted the Newfoundland Department of Environment and Lands in arranging for a new precipitation chemistry monitoring station on the south coast at Hope Brook.

- assisted Dr. Poje of the Hydrometeorological Institute of Croatia (Yugoslavia) in setting up a precipitation chemistry monitoring network by supplying information on AES networks.

4.1.2 Quebec Region

- continued the preparation of the weekly pH Bulletin for eastern Canada.

- presented on behalf of the Branch a one-day seminar on air quality to the Meteorologists Course in Montreal.

4.1.3 Ontario Region

- analysed data from 4 CAPMoN and APIOS (Ontario Ministry of the Environment network) precipitation monitoring stations of extreme events of deposition and of the associated air trajectories and precipitation patterns.

- investigated, in consultation with the Ontario Ministry of Environment (OME), the feasibility of AES and OME delivering the OME Air Quality Index Forecast with the AES forecast, and the feasibility of developing an index to assess pollution transport.

4.1.4 Central Region

- assisted Manitoba Environment to re-establish a provincial CAPMoN-type network.

4.1.5 Western Region

- installed a CAPMoN station at Snare Rapids, NWT, in conjunction with the Government of NWT who are financing the operations.

4.1.6 Pacific Region

- finalized the purchase of the Saturna Island CAPMoN site.

- analysed synoptic weather patterns for seven sampling periods in support of the Provincial Chemistry of High Elevation Fog Sampling Program.

4.2 TOXIC CHEMICALS

4.2.1 Atlantic Region

- reviewed applications for pesticide spraying permits for environmental concerns for the Atlantic Region Pesticides Advisory Committee (ARPAC).

4.3 CLIMATE CHANGE

4.3.1 Pacific Region

- produced, in conjunction with the Regional Communications Directorate, a two-hour television special on climate change that consisted of a film on the Greenhouse Effect, a panel discussion and a telephone call-in segment.

4.4 ENVIRONMENTAL EMERGENCY RESPONSE PROGRAM (EERP)

4.4.1 Atlantic Region

- managed contract for Phase 1 of Environmental Emergency Response Training Modules (update and expand PC-based scenarios for training in use of AQPAC, for SLICK oil spill model, and for forecast trajectory model).

4.4.2 Quebec Region

- provided meteorological and air quality support during the fire at a PCB warehouse at St-Basile-le-Grand near Montreal.

4.4.3 Ontario Region

- responded to sulphuric acid spill in Fort Erie railyards.

4.4.4 Central Region

- estimated atmospheric stability and dispersion capability regarding release of hydrogen sulphide gas from a secondary lead smelter in Winnipeg and provided to Manitoba Environment.

4.4.5 Pacific Region

- received Seaconsult report on 1st phase of the mesoscale wind modelling contract that reviews needs and models for EER in complex terrains; 2nd phase will test 2 models under various meteorological conditions.

- responded, by using AQPAC, to two toxic chemical releases into the atmosphere, a PCB fire and a ruptured chlorine tank.

4.5 ENVIRONMENTAL ASSESSMENT AND REVIEW PROCESS (EARP)

4.5.1 Atlantic Region

- registered the proposal for a weather radar in New Brunswick with the Regional and Screening Coordinating Committee (Atlantic Region) and consulted with New Brunswick Environment to ascertain whether they have any concerns.

- reviewed several Environmental Impact Assessment documents including the bridge concept for the Northumberland Strait Crossing Project (proposals from developers for 1 tunnel and 6 bridge designs), Part V - Ambient Air Quality for the Trenton #6 power plant, the atmospheric section (meteorological/air quality/acid deposition) of Belledune thermal generating station EIS.

4.5.2 Quebec Region

- represented AES on a committee to evaluate the environmental impacts of the SOLIGAZ project that proposes storing propane/butane in three underground reservoirs.

4.5.3 Ontario Region

- reviewed report for Ontario Hydro's proposed Little Jackfish Generating Station and associated transmission line north of Thunder Bay.

4.5.4 Central Region

- reviewed proposal for an uranium mine near Baker Lake, NWT

4.5.5 Western Region

- commented on proposals by Neptune Mines (gold mine northwest of Yellowknife) and by Urangesellschaft Canada (uranium mine west of Baker Lake).

- reviewed EIAs by Alberta Newsprint Company and for Blood Indian Irrigation Project.

- reviewed EISs on the use of glycol at Calgary and Edmonton International Airports and on the Daishowa Peace River pulp mill.

- reviewed application by Giant Yellowknife Mines to build arsenic trioxide transfer site south of Great Slave Lake.

4.5.6 Pacific Region

- cooperated in screening the documentation for the Saturna Island CAPMoN station and the Lytton weather station.

- provided input to the action plan for environmental management of offshore hydrocarbon exploration in British Columbia.

4.6 STATE-OF-THE-ENVIRONMENT REPORTING

4.6.1 Atlantic Region

- provided input for the planning for a 1990 State-of-the-Environment (SOE) report for the Atlantic Region that is being prepared by the Regional SOE Committee.

- reviewed 1st draft of IWD SOE report on St. Croix River Water Management issues.

4.6.2 Pacific Region

- reviewed proposals for a State-of-the-Environment study in the Lower Fraser River Basin that will be included in 1991 Report as a regional case study.

4.7 PUBLICATIONS/PRESENTATIONS

4.7.1 Journal Publications

Allsopp, T.R. and S.J. Cohen, 1988: "The Potential Impacts of CO_2-induced Climate Change on Ontario", Journal of Climate, July, 1988.

4.7.2 Internal Reports

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4.7.4 Presentations

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6. MAJOR CONTRACTS ($10,000 AND OVER)

Contractor	Contract
Bermuda Biological Station $ 14,000	To collect and analysis aerosol samples.
Chang's Environmental Consultants $ 18,115	To measure atmospheric particles and gases during the Eulerian Model Evaluation Field Study (EMEFS).
Concord Scientific $ 25,300	To load and unload filter packs.
Concord Scientific $ 18,500	To analyse whole air samples for low molecular weight hydrocarbons.
Dalhousie University $ 28,750	To undertake project on dispersion modelling and mechanism.
Inland Waters Directorate $147,000	To analysis CAPMoN precipitation samples.
Institute for Environmental Studies $ 10,190	To undertake biological monitoring for airborne organic & metal contaminants in the upper Great Lakes.
MEP Company $ 49,727	To undertake program design and data development for point source emission sources.
MEP Company $ 39,466	To provide vehicle emission adjustments and data integration for ADOM input.
MEP Company $ 39,307	To develop model for predicting the volatilization of toxic materials from vegetated soils.
MEP Company $ 23,505	To provide technical services for the continuation and maintenance of the Data Management System for model data archiving.
Research & Productivity Council $ 40,000	To examine influence of helicopter operating parameters on herbicide drift in conifer release programs.

Contractor	Contract
Salmon, J.R. $ 20,790	To develop and implement the Emergency Weather Station (EWS).
Salmon, J.R. $ 13,000	To provide services for the Meteorological Monitoring Network, Pickering, Ontario.
Skelton Technical Services $ 57,066	To quality control CAPMoN air and precipitation chemistry data.
Skelton Technical Services $ 31,657	To acquire network & site information for the National Atmospheric Chemistry Database.
Sophos Inc. $ 51,000	To undertake PERD project on supplementary control.
Unisearch Associates Inc. $ 30,000	To develop flux instrument.
Unisearch Associates Inc. $ 25,257	To measure hydrogen peroxide and formaldehyde using tuneable diode laser system.
York University $ 15,700	To deliver a site operator's video for CAPMoN.
York University $ 11,000	To report on the Workshop on "The Role of Canadian Wetlands in Cycling Sulphur, Carbon and Nitrogen between the Atmosphere and Biosphere".

7. PERSONNEL

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