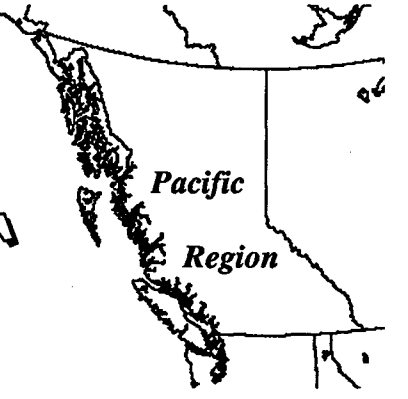
SCIENTIFIC SERVICES DIVISION

REPORT



AN ANNOTATED BIBLIOGRAPHY OF LITERATURE RELATED TO ACID DEPOSITION IN WESTERN CANADA

Prepared by:
Scientific Services Division
Atmospheric Environment Service
Pacific Region

For:
Western and Northern Canada
LRTAP Technical Committee

December, 1987
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AN ANNOTATED BIBLIOGRAPHY OF LITERATURE RELATED TO ACID DEPOSITION IN WESTERN CANADA

Prepared by:
DESIREE BRADLEY LIBRARY AND TECHNICAL SERVICES

For:
ENVIRONMENT CANADA
ATMOSPHERIC ENVIRONMENT SERVICE
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PREFACE

This report was prepared by Desiree Bradley Library and Technical Services under contract to Scientific Services Division, Pacific Region, Atmospheric Environment Service (AES). Funds for the work were provided by the Air Quality Research Branch of AES. It is a contribution to the work of the Western and Northern Canada LRTAP (Long Range Transport of Air Pollutants) Technical Committee. Additional copies should be requested from:

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INTRODUCTION

This bibliography attempts to list all the reports and papers on acidic depositions in the Western Provinces, Yukon and the Northwest Territories, excluding the Arctic Islands.

The bibliography is divided into seven sections: General, Natural and Anthropogenic Emissions, Atmospheric Physical and Chemical Processes, Aquatic Processes and Effects, Terrestial Processes and Effects, Health Effects, and Controls and Legislation. Except when one has not yet been obtained, an abstract is included with the listing of each report. At the end of the bibliography, the reports are listed alphabetically by author. This list includes the number of the page in the bibliography where the report and abstract are located.

The project was the idea of Donald Faulkner, of the Atmospheric Environment Service, Pacific Region. Many of the reports in this bibliography were obtained through his contacting Federal and Provincial government departments. The bibliography was prepared by Desiree Bradley Library and Technical Services.

TABLE OF CONTENTS

INTRODUCTION

GENERAL

Addison, P.A., 1980. **Ecological bench-marking and biomonitoring for detection of airborne pollutant effects on vegetation and soils.** Project LS 3.4. Report prepared for Alberta Oil Sands Environmental Research Program.

Abstract: Biomonitoring plots established in 1976 and 1977 were revisited in 1979. No measurable change was detected in the vascular plant community of the lower stratum, the lichen community of black spruce branches, or the soil and plant element contents. Despite higher tissue pollutant levels close to existing industrial developments, there was very limited evidence of biological damage. However, certain techniques showed promise for long-term biomonitoring for pollution effects.

Addison, P.A., and J. Baker, 1979. **Interim report on ecological benchmarking for detection of air-borne pollutant effects on vegetation and soils, 1975 to 1978.** Report prepared for Alberta Oil Sands Environmental Research Program Project VE 3.4..

Abstract: A set of 11 sites was established to provide baseline information on vegetation and soils for use in long-term biomonitoring of air pollution impact. The sites were described with respect to their vascular and cryptogamic species list, soil characteristics and type, and cover and frequency of lower strata species. No air pollutant impacts were detected.

Addison, P.A., K.A. Kennedy, and D.G. Maynard, 1984. **Effects of sour gas processing on a forest ecosystem in west-central Alberta.** Canadian Forestry Service, Northern Forest Research Centre, Information Report NOR-X-265.

Abstract: This report discusses a study of the effects of sulphur deposition and sulphur dioxide emissions on the vegetation and soils in an area containing two natural gas processing plants. Most sites affected by sulphur dust showed no changes in soil chemistry and understorey vegetation. Growth and reproduction of Pinus contorta showed no significant change.

Air Pollution Control Association, 1985. **Impact of air toxics on the quality of life.** Proceedings of the 1985 Joint Annual Meeting, Canadian Prairie and Northern Section and Pacific Northwest International Section, November 13-15, 1985, Calgary, Alberta, Canada.

Abstract: The proceedings are divided into the following sections: Epidemiology and Risk Analysis, Indoor Air Quality, Air Quality Monitoring, Acid Gases, Waste Management and Wood Burning, Emergency Response, and Stack Monitoring and Air Quality and Deposition Modelling, and Government Affairs.

Alberta Government/Industry Acid Deposition Research Program, 1984. **First annual report: January 1, 1983 to March 31, 1984.**

Abstract: The Acid Deposition Research Program was established to determine if public concern in Alberta regarding emissions is justified and to identify solutions. Research conducted will focus on oxides of sulphur and oxides of nitrogen. This annual report summarizes recommendations of the Acid Deposition Research Program Human Health Workshop. The summary of the Acid Deposition Research Program Biophysical Workshop discussions includes a description of the Biophysical Research Plan.

Alberta Government/Industry Acid Deposition Research Program, 1985. **Second annual report: April 1,1984 to March 31, 1985.**

Abstract: This report of Acid Deposition Research Program activities describes a contract awarded by the Acid Deposition Research Program for the investigation of health concerns regarding sour gas emissions, and lists contracts awarded under the Biophysical Research Plan to investigate possible future environmental damage caused by acid-forming gases.

Baldwin, J.H., ed., 1985. **Acid rain in the Pacific Northwest: proceedings of the Acid Rain Symposium, Annual Conference of the Northwest Association for Environmental Studies.** University of Victoria, Victoria, British Columbia.

Abstract: Papers were given on the chemistry of precipitation in British Columbia and the State of Washington, and on the environmental risks of acid rain to this area. Current surface water chemistry and the risks of acidification to aquatic life were dominant topics. Most Washington papers discussed western Washington and the Cascade Mountains.

Bernard, D ., 1981. **Brief presented to the House of Commons Committee on Acid Rain.**

Abstract: Analyses of precipitation collected in the University of British Columbia Research Forest in Haney (approximately 60 km east of Vancouver) and from areas closer to Vancouver show acid rain is falling on the Greater Vancouver area. To prevent future damage to forests and fisheries, an environmental strategy is recommended.

British Columbia. Ministry of Environment, Waste Management Branch, 1985. **British Columbia acid rain program: a brief overview.** 13 pp.

Abstract: This booklet provides an overview of the activities of a programme initiated by the Ministry of Environment to determine the nature and environmental impact of acidic deposition in British Columbia.

Erickson, P.K., comp., 1986. **Annotated bibliography on long-range transport of air pollutants.** Environmental Protection Service, Western and Northern Region, Scientific Programs Branch, Edmonton.

Abstract: This annotated bibliography contains abstracts of 174 articles, relevant to the long-range transport of air pollutants and acid deposition, that are on file with Edmonton office of the Environmental Protection Service, Western and Northern Region.

Faulkner, D.A., ed., 1983. **Pacific and Yukon Region Workshop on Acid Depositions, January 20, 1983.** Atmospheric Environment Service, Pacific Region, Scientific Services Division Report No. PAES 83-1.

Abstract: To coordinate the work of agencies involved in West Coast and Yukon acid rain-related research and monitoring on the West Coast, Environment Canada and the British Columbia Ministry of Environment sponsored a joint workshop. Topics included acidity of precipitation, acid-forming emissions, and mapping environmental sensitivity to acidic deposition. This report contains the editor's summaries or author's abstracts of presentations made.

Hammer, U.T., 1980. **Acid rain: the potential for Saskatchewan.** Prepared for the Saskatchewan Environmental Advisory Council, Regina.

Abstract: This report outlines the history of acid rain in Europe and eastern North America. Western Canadian sources of sulphur and nitrogen oxides emissions are determined, and the future effects on Saskatchewan aquatic and terrestrial ecosystems of acid deposition resulting from synthetic crude oil developments are estimated.

Hammer, U.T., 1980. **Acid rain in Saskatchewan: now and tomorrow.** Musk-Ox 27:75-77.

Abstract: This paper discusses the effect of acid precipitation on the Saskatchewan lakes, forests, soils, mammals, and poultry. Synthetic oil production from tar sands is already a source of acidic deposition, and all of Saskatchewan is a potential fallout area for acids from synthetic crude oil developments in the Fort McMurray and Cold Lake-Lloydminster regions.

Hardy Associates (1978) Ltd., 1979. **Impacts of sulphur-gas emissions on vegetation and soils in the Cold Lake area.**

Abstract: The report assesses future ground level concentrations of sulphur dioxide from the proposed bitumen upgrading and steam generating plants near Cold Lake, Alberta. To evaluate the effects of the proposed plants, the report reviews the long-term effects on soil and vegetation of sulphur dioxide from existing Alberta petroleum industry plants . Methods for monitoring the emission levels and environmental impact are proposed.

Hocking, D., and D. Reiter, eds., 1973. **Proceedings of a workshop on sulphur gas research in Alberta.** Jointly sponsored by Alberta Environment Research Secretariat and Environment Canada Northern Forest Research Centre. Canadian Forestry Service, Northern Forest Research Centre Information Report NOR-X-72.

Abstract: The primary sources of sulphur dioxide are sour gas natural gas processing plants. Even before the tar sands plants in northeastern Alberta become operational resulting in more sulphur dioxide emissions, this air pollutant is already a problem in Alberta.

Hogan, G.D., and D.L. Wotton, 1984. **Pollutant distribution and effects in forests adjacent to smelters.** Journal of Environmental Quality 13(3): 333-382.

Abstract: This paper discusses the effects on a boreal forest system of 50 years of exposure to smelter effluents. Levels of metals in the soil were positively correlated with distance from the smelter. Soil pH and distance from the smelter were not related. High sulphur levels were found in the foliage of black spruce close to the smelter, but not in jack pine foliage.

Krouse, H.R., and J.W. Case, 1983. **Sulphur isotope abundances in the environment and their relation to long term sour gas flaring, near Valleyview, Alberta: final report.** Alberta Research Management Division RMD Report 83/18.

Abstract: Samples, consisting of stack gas, ambient air, rain, surface waters, soil, vegetation, crop seeds and fertilizers from the Valleyview area of Alberta, were analysed for their sulphur concentration and isotopic abundance. Substantial quantities of sulphur from sour gas flaring operations were found. The report recommends increased sampling of sulphur compounds and monitoring of effects on soils and vegetation of the sour gas processing plant.

Legge, A.H., E.M. van Z. Bakker, Jr., E. Peake, and D.C. Lindsay, 1980. **The oxides of nitrogen and their interactions in the environment: a review.** A final report submitted to the Research Secretariat, Alberta Environment. 169pp.

Abstract: This is a discussion of the impacts on soils, vegetation, and human health of emissions of nitrogen oxides with reference to Alberta. Major sources are thermal power plants and the Calgary and Edmonton urban areas. The Athabasca oil sands will become a more important emissions source.

MacDonald, W.R., and H.S. Sandhu, eds., 1975. **Proceedings of Alberta sulphur gas research workshop II.** Held at Environmental Sciences Centre, Kananaskis, Alberta, January 16-17, 1975. Jointly sponsored by Alberta Environment Research Secretariat and University of Calgary Environmental Sciences Centre. 174pp.

Abstract: These are the proceedings of a workshop held to discuss the effects of emissions from the Alberta petroleum industry.

Marmorek, D.R., D . Bernard, and M.L. Jones, C.S. Davis, N.W. Reid, A.R. Fridkin, and R. Caton, 1986. **Target loadings for acidic deposition in western Canada: a synthesis of available information.** Prepared by ESSA Environmental and Social Systems Analysts Ltd. and Concord Scientific Corporation. Final report to the Western Target Loading Planning Group and the National Research Council Associate Committee on Scientific Criteria for Environmental Quality.

Abstract: This report reviews information on the risks and effects of acidic deposition to ecosystems of western Canada and the Northwest Territories. The effects on agriculture, forests, aquatic systems, and wetlands are discussed. The report suggests a course of action to determine the level,or levels, of acidic deposition that will endanger the environment.

Maynard, D.G., P.A. Addison, and K.A. Kennedy, 1983. **Impact of elemental sulfur dust deposition on soils and vegetation of Pinus-contrata stands in west central Alberta, Canada.** Aquilo, Ser. Botanica 19(2):314-325.

Abstract: Compared with control sites, two sites close (200 m) to sulphur dust sources showed higher total and water soluble sulphur contents in the soil, lower soil pH levels, and loss of Mg and Mn from the LFH horizon. There was a reduction in cover and composition of the plant community.

Maynard, D.G., P.A. Addison, and K.A. Kennedy, 1983. **Elemental sulphur dust deposition on soil and vegetation of lodgepole pine sands in west-central Alberta.** In Resources and Dynamics of the Boreal Zone, edited by R.W. Wein et al, Association of Canadian Universities for Northern Studies, Ottawa. Pp. 458-464.

Abstract: The influence of the addition of elemental sulphur dust on forest vegetation and soils in west-central Alberta was studied. Compared with the two sites further away, the two within 200 m of the sulphur dust sources had higher soil sulphur contents and lower soil pH levels. Sulphur deposition resulted in an almost complete elimination of the mosses and a reduction in the herb cover.

Northwest Association for Environmental Studies, 1984. **Across the border: transboundary environmental issues in the Pacific Northwest: the third annual conference of the Northwest Association for Environmental Studies, November 1-3, 1984, Victoria, B.C.** Program with abstracts.

Abstract: This conference program contains abstracts of papers on pollution problems of British Columbia and the United States Pacific Northwest. Included in this conference was an acid rain symposium.

Roth, P., C. Blanchard, J. Harte, H. Michaels, and M. El-Ashry, 1985. **The American West's acid rain test.** World Resources Institute Research Report No. 1.

Abstract: This report on acidic deposition, and on emissions of sulphur dioxide and oxides of nitrogen, in the western United States mentions the pH levels of precipitation in the Vancouver area and the Fraser Valley.

Sanderson, K., 1984. **Acid-forming emissions: transportation and effects.** Environmental Council of Alberta Staff Report ECA-ST/1.

Abstract: This report reviews the relationship between the hydrologic cycle and air pollution. It discusses the effects and transport of acid emissions. Alberta's position concerning atmospheric transport of pollutants is considered, as well as the jurisdictional aspects.

Sandhu, H.S., and R.G. Wilson, 1987. **Management strategy for acidic deposition in western and northern Canada.** Submitted to Environmental Management.

Abstract: This is a overview of government research and monitoring programmes, and of joint government strategy for management of acidic deposition west of Ontario.

Sandhu, H.S., and L. Blower, 1986. **Acid-forming emissions in Alberta, Canada.** Environmental Management 10(5):689-696.

Abstract: This paper examines the transport, deposition, and effects of sulphur dioxide and nitrogen oxides emissions in Alberta. Because of the dry, cold, continental climate of Alberta, dry sulphate or sulphur deposition is equally or more important than wet deposition. The development of atmospheric target loadings for Alberta environmental conditions is recommended for the protection of sensitive aquatic ecosystems from future acid rain damage.

Sandhu, H.S., J.R. Clements, and B.L. Magill, 1982. **Acid forming emissions in Alberta and their ecological effects: Proceedings of the March 9 to 12, 1982, Edmonton symposium/workshop proceedings.** Alberta Environment, Research Management Division.

Abstract: These are the proceedings of a 1982 symposium cosponsored by Alberta Department of the Environment, the Canadian Petroleum Association, and the Oil Sands Environmental Study Group. The atmospheric transport and chemistry of Alberta petroleum industry sulphur dioxide emissions, the chemistry of the plumes, impacts of these emissions on the environment, and the effects on human health were discussed.

Sandhu, H.S., A.H. Legge, J.I. Pringle, and S. Vance, eds., 1987. **Acid forming emissions in Alberta and their ecological effects: Proceedings of the Second Symposium/Workshop, 1986 May 12-15, Calgary, Alberta.** Prepared by Alberta Environment, Research Management Division and University of Calgary, Kananaskis Centre for Environmental Research. 478 pp.

Abstract: The symposium was sponsored by Alberta Environment, Research Management Division, the Canadian Petroleum Association, the Alberta Energy Resources Conservation Board and the University of Calgary Kananaskis Centre for Environmental Research. The proceedings contain papers on the extent of acid emissions in Alberta, the environmental and human health risks of these emissions, as well as papers on acidic deposition.

Sandhu, H.S., and M. Nyborg, eds., 1978. **Proceedings of the Alberta sulphur gas research workshop III: technical summary and list of participants.** Held at the University of Alberta, Edmonton, November 17-18, 1977. Jointly sponsored by Alberta Environment Research Secretariat and Alberta Institute of Pedology. 20pp.

Abstract: This is a summary of the proceedings of a workshop on sulphur dioxide emissions in Alberta.

Sandhu, H.S., and M. Nyborg, eds., 1978. **Proceedings of the Alberta sulphur gas research workshop III.** Held at the University of Alberta, Edmonton, November 17-18, 1977. Jointly sponsored by Alberta Environment Research Secretariat and Alberta Institute of Pedology. 335pp.

Abstract: A workshop was held to discuss the effects of industrial sulphur dioxide emissions resulting from Alberta's petroleum industry. Topics included atmospheric dispersion and chemistry, and the effects of these emissions on soils, vegetation and human health.

Shewchuk, S.R., 1986. **Rain, snow and lake water chemistry on and near the Precambrian Shield of western Canada.** Water, Air, and Soil Pollution 30(1-2):115-123.

Abstract: This paper discusses the results of regional surveys of rain, snow and lake water chemistry in several locations in western Canada that are considered sensitive to acidic deposition and are within several hundred kilometers of major point source emitters of sulphur dioxide.

Shewchuk, S.R., 1983. **An acid deposition perspective for the Northwest Territories.** Science Advisory Board of the Northwest Territories Contract Report No. 8.

Abstract: This report reviews acidic deposition in the Northwest Territories and atmospheric flows in the region. The sensitivity of terrestrial and aquatic ecosystems of the Northwest Territories to acidic deposition is discussed.

Shewchuk, S.R., Z.M. Abouguendia, F.M. Atton, and J. Dublin, 1981. **Transport of acid forming emissions and potential effects of deposition in northeastern Alberta and northern Saskatchewan: a problem analysis.** Saskatchewan Research Council Technical Report No. 122.

Abstract: This report discusses the transport and deposition of emissions in northeastern Alberta and northern Saskatchewan. It assesses the sensitivity of soils, vegetation, and aquatic systems in the study area to future acidic deposition.

Summers, P.W., 1980. **Note on the potential for acid rain in western Canada.** Atmospheric Environment Service Report AQRB-80-015-ARQD. Unpublished manuscript.

Abstract: This report gives an overview of the potential for acid rain in western Canada, and compares the differences between western and eastern Canada in emissions, meteorology, and ecosystem sensitivity.

Taylor, G.J., 1981. **Acid precipitation: a possible consequence of developing the Athabasca Oil Sands.** University of Calgary, Faculty of Environmental Design M.E.Des. Thesis.

Abstract: Not available.

Walmsley, M.E., 1985. **Acid rain research and monitoring studies in British Columbia, Yukon and the U.S. Pacific Northwest: a review of on-going and planned studies.** Prepared by Pedology Consultants for Canadian Forestry Service, Victoria. B.C.

Abstract: This report lists acid rain-related research studies being conducted by agencies in British Columbia, Washington, and Oregon. It contains information on research methods and objectives, problems encountered, and achievements. The research includes studies of acid rain effects on forests, soils, water quality, and air quality.

Wotton, D.L., and G.D. Hogan, 1981. **The effects of atmospheric emissions from the Thompson mining and smelting industry in forest vegetation and soils.** Submission to the Clean Environment Commission of the Province of Manitoba, October 1981.

Abstract: The effects of sulphur dioxide and heavy metal emissions were studied in the vicinity of Thompson, Manitoba. Metal levels were found to be preventing the regeneration of stands by seedlings at sites closer than 5 km to the smelter. Sulphur emissions do not appear to have caused soil acidification. The pH values of precipitation could not be related to distance of study sites from the smelter.

NATURAL AND ANTHROPOGENIC EMISSIONS

Bennett, R.C., 1981. **Summary of emissions, air quality and meteorology for the Peace region.** British Columbia Ministry of Environment, Assessment and Planning Division Working Paper 1981-01-01.

Abstract: This is a summary of relevant existing information to allow a preliminary assessment of anthropogenic emissions on precipitation chemistry in the Peace region. Emissions of sulphur dioxide were found to be all related to the oil and gas industry, with the bulk coming from natural gas processing plants at Fort Nelson, Taylor and Hasler Flats.

Cirrus Consultants and Technology Resource, Inc., 1987. **Greater Vancouver Regional District area source emission inventory. Volume I. Summary of results.** Prepared for Greater Vancouver Regional District Project 535.

Abstract: Not available

Colley, D.G., R.W. Poon, M.J. Zelensky, and L. Zanzotto, 1983. **Alberta oxides of nitrogen emissions forecast: 1980 to 2000.** Prepared by Western Research Division of Bow Valley Resource Services Ltd. Alberta Environment Research Management Division Report RMD 83/26.

Abstract: Two growth scenarios for Alberta, one assuming high economic growth and the other lower growth, were used in the preparation of a forecast of emissions of oxides of nitrogen. The report estimates emissions levels attainable through use of the best practicable and the best available technologies. In both of the growth scenarios, transportation sources are the most significant sources of oxides of nitrogen emissions. The natural gas industry is the second most significant source.

Gizyn, W.I., 1980. **The chemistry and impact of the bituminous shale fires at the Smoking Hills, N.W.T.**

Abstract: Bituminous shale deposits in the sea cliffs on the eastern side of the Cape Bathurst peninsula are undergoing spontaneous combustion. The resulting emissions, in the form of smoke plumes, consist of sulphur dioxide, acid aerosols, particulates and water vapour. There are sufficient similarities between these shale fires and anthropogenic combustion processes to make this study useful in predicting the consequences of long-term acid deposition to an arctic environment.

Greater Vancouver Regional District, Pollution Control, 1987. **1985 Lower Mainland emission inventory: point sources. Volume I.** Prepared for British Columbia Ministry of Environment and Parks, Victoria, British Columbia.
Abstract: Not available

Jackson, A.L., and A.W. Schultz, 1987. **Summary of emission inventory of atmospheric sulphur dioxide, nitrogen dioxide, particulate and lead pollutants within the Province of Manitoba for 1983-1985.** Manitoba Environmental Control Services, Environmental Management Division. Unpublished report.
Abstract: This report estimates emissions of sulphur dioxide, nitrogen dioxide, particulates and lead in the Province of Manitoba for the years 1983-1985. This inventory includes major industrial sources, power generating stations, and industrial point sources. Emission calculations were based on stack sampling surveys. When specific data were unavailable, emission estimates were made using currently accepted methods.

Keshvani, K.A., 1984. **Source testing code for the measurement of emissions of sulphuric acid mist and sulphur dioxide from stationary sources.** Rev. B.C. Ministry of Environment, Air Quality Engineering Unit MOE Manual 6.
Abstract: This code presents six standard test methods for measurement of emissions of sulphuric acid mist (including sulphur trioxide) and sulphur dioxide simultaneously or sulphur dioxide alone from stationary sources. These methods are to be used to obtain data required under the Waste Management Act of the Province of British Columbia.

Kolomeichuk, R.J., 1977. **Determination of gaseous emissions from Polar Gas activities and facilities.** Prepared by Dames and Moore for Polar Gas Limited, Toronto, Ontario.
Abstract: This report predicts concentrations of nitrogen oxides, carbon monoxide, sulphur dioxide, and hydrocarbons emitted by stationary and mobile equipment to be operated by Polar Gas. It compares the predicted ambient concentrations of air contaminants with concentrations given in federal and provincial objectives, criteria and standards. The report also analyses the probability of the formation of ice fog at cold temperatures.

Kotturi, M.S., 1980. **The corrosion rates of metals exposed to pulp-mill and smelter emissions.** British Columbia Ministry of Environment, Environmental Studies Branch, Victoria, British Columbia.

Abstract: Small aircraft parked in the vicinity of a pulp-mill and a smelter near Castlegar, B.C. have showed some body corrosion. Metals, including aircraft-body specimens, were tested for corrosion in both smelter and pulp-mill emissions. The corrosion rates of the nonferrous metals were found to be correlated with the sulphur dioxide concentrations at the industrial sites.

Krouse, H.R., and J.W. Case, 1982. **Sulphur isotope tracing of acid forming emissions into the environment of Alberta.** For presentation to Symposium Acid Forming Emissions in Alberta and their Ecological Effects, Edmonton, Alberta, March 10-12, 1982.

Abstract: Sulphur emissions from sour gas processing plants in Alberta have a higher proportion of Sulphur-34 than the surrounding environment has. The proportion of this isotope in trees, lichens, the soil, and the atmosphere is used to trace sulphur compounds from sour gas emissions and to show the influx of sulphur from the emissions into the environment.

Howard, G.L., and G . Underwood, 1985. **Saskatchewan air emission inventory of sulphur dioxide and nitrogen oxides - 1983.** Saskatchewan Environment, Air Pollution Control Branch, Regina, Saskatchewan.

Abstract: This inventory provides information on Saskatchewan sulphur dioxide and nitrogen oxide emissions. Increases in these emissions were due to increased power generation and increased fuel consumption.

Leung, T.B., and W.D. Bockhart, 1983. **Sulphur dioxide emission inventory of British Columbia for 1982.** B.C. Ministry of Environment MOE Working Report 3.

Abstract: This report summarizes 1982 sulphur dioxide emissions records for all regions of British Columbia as part of the Ministry of Environment acid precipitation monitoring programme. Emissions levels for the province are analysed by region and by industry.

McKinnon, Allen & Associates Ltd., 1976. **Effects of Shell Waterton Gas Plant on soils, waters and rainfall.** Prepared for Alberta Environment, Edmonton.
Abstract: The purpose of this report is to provide the results of the long-term monitoring of airborne emission effects on an agricultural community in the vicinity of major source of SO_2. The report analyses data collected prior to implementation of Shell's tail-gas cleanup (S.C.O.T.) process.

Peters, R.R., and H.S. Sandhu, 1980. **Nitrogen oxides emissions for Alberta: 1976 to 1979.** Alberta Environment, Research Management Division Report RMD-80/3.
Abstract: This inventory reports estimated nitrogen oxides emissions from major Alberta sources. Existing monitoring is insufficient for computing precise values of nitrogen oxides emissions. Estimates based on stack surveys and extrapolations are not precise.

Reeve, K.E., 1984. **Source testing for sulfur dioxide gas and sulfuric acid mist emissions from Border Chemical Company Limited, Day Street and Gunn Road, Winnipeg, Manitoba.** Manitoba Environmental Control Services, Environmental Management Division, Winnipeg.
Abstract: In July 1984 a series of isokinetic source emission tests were conducted on the absorption tower stack at Border Chemical Company Limited.

Reeve, K.E., 1983. **Source emission testing for sulfur dioxide and sulfuric acid mist at Canada Metal Co. Ltd., Winnipeg, Manitoba, 1982.** Manitoba Environmental Control Services, Environmental Management Division, 1983.
Abstract: In June 1982 a series of sub-isokinetic source emission tests were conducted on the reverberatory furnace baghouse exhaust stack of the Canada Metal Co. Ltd., Winnipeg.

Sandhu, H.S., 1979. **Industrial sulphur emissions for Alberta: 1974-1978.** Alberta Environment, Research Secretariat.
Abstract: The Alberta Environment Research Secretariat compiled information on sulphur emissions for the Province of Alberta. This report contains tables listing the sulphur emissions from industries operating in Alberta for the period 1974-1978.

Shelfentook, W., 1978. **An inventory system for atmospheric emissions in the AOSERP study area.** Prepared by SNC Tottrup Services Ltd. for Alberta Oil Sands Environmental Research Program Project ME 2.2.

Abstract: This report describes the inventory system developed to provide a comprehensive data base for AOSERP study area emissions considered to be of environmental concern. After the entry of data from an evaluation of man-related activities and natural processes into a computerized data retrieval system, an evaluation of the data showed organic emissions to be largely of natural origin, as are substantial quantities of ammonia and oxides of nitrogen. Industrial development was the main cause of the other emissions.

The Environmental Applications Group Limited, Pilorusso Research Associates Inc., and Kent Engineering Limited, 1987. **Lower Mainland mobile source emission inc. Volume I: Emission summary.** Prepared for Greater Vancouver Regional District.

Abstract: Not available

Woo, D., comp., 1986. **Western Canada sulphur dioxide and nitrogen oxides atmospheric emission inventory methods manual.** 1986 edition. Prepared for the Western Canada Air Emission Inventory Working Group.

Abstract: This a compilation of standard procedures in preparing atmospheric emission inventories for sulphur dioxide and nitrogen oxides. Methods of calculating emissions are described. The use of these methods in area source and point source methodologies is discussed.

ATMOSPHERIC PHYSICAL AND CHEMICAL PROCESSES

Agnew, T., J.D. Reid, and D. Faulkner, 1982. **An AES modelling study of medium-range transport of Hat Creek Power Plant emissions and their impacts.** Report: AQRB-82-001-M. Atmospheric Environment Service, Air Quality and Inter-Environmental Research Branch, Downsview, Ontario. Unpublished manuscript.

Abstract: This report evaluates the probable acidification of the initial snowmelt runoff resulting from emissions of oxides of sulphur and nitrogen from the proposed B.C. Hydro Hat Creek Power Plant. According to the numerical model used in this evaluation, the dry deposition of SO2 is found to be the dominant contributor to snowpack acidification.

Angle, R ., 1979. **Air quality modelling and user needs.** Prepared by Alberta Environment, Air Quality Control Branch for Alberta Oil Sands Environmental Research Program Project AS 4.5.

Abstract: Atmospheric dispersion models can be used either for fundamental research or for practical decision making. The desired characteristics of user-oriented atmospheric dispersion models are simplicity, clarity, reliability, appropriateness, and practicality. For the successful application of models to decision-making, there must be close cooperation between modellers and users.

Barrie. L.A., 1986. **Background pollution in the arctic air mass and its relevance to North American acid rain studies.** Water, Air and Soil Pollution 30(3-4):765-777.

Abstract: This paper discusses the transport of airborne pollutants from Eurasian mid-latitudinal sources to North America. During winter, poor pollutant removal and a strong transport pathway result in higher levels of acidic anthropogenic gases and aerosols in the arctic air mass and increased acidity of snow in western Canada.

Barrie, L.A., and J. Kovalick, 1980. **A wintertime investigation of the deposition of pollutants around an isolated power plant in northern Alberta.** Prepared for Alberta Oil Sands Environmental Research Program Project AS 3.2. AOSERP Report 90.

Abstract: Snow was collected from sites within 100 km of the Great Canadian Oil Sands extraction plant. Relationships between snowpack chemistry, site location, and chemical composition of power plant emissions are discussed.

Barrie, L.A., and D.M. Whelpdale, 1977. **Wintertime sulphur deposition measurements in the Athabasca Oil Sands area.** In Proceedings of Alberta Sulphur Gas Research Workshop III, Edmonton, Alberta, November 17-18, 1977, edited by H.S. Sandhu and M. Nyborg. Pp. 318-111.

Abstract: Snow cores taken at sites around an oil sands extraction plant near Fort McMurray were analysed for soluble sulphur, pH, and conductivity. This paper estimates the sulphur deposition rates at varying distances from the plant.

Bertram, H.L., N.C. Das, and Y.K. Lau, 1986. **Precipitation chemistry measurement in Alberta.** Water, Air and Soil Pollution 30(1-2):231-237.

Abstract: Precipitation samples collected and analysed monthly from six Alberta Environment stations were analysed for the major ions, pH and acidity. The data were tabulated and analysed for spatial distribution, seasonal variation, temporal trends, ionic character and wet sulphate deposition.

Bottenheim, J.W., and O . Strausz, 1981. **Development of a chemically reactive plume model for application in the AOSERP study area.** Prepared for Alberta Oil Sands Research Program Project AS 3.5.4.

Abstract: A chemically reactive plume model was developed, describing the homogeneous gas phase chemistry of a power plant plume, containing sulphur dioxide and nitrogen oxides, dispersing in a Gaussian fashion in ambient air containing reactive hydrocarbons. The model was applied to field observations from a summer 1977 study in the AOSERP area and to the data collected in 1977 by a Battelle research team concerning the dispersal of a power plant plume over Lake Michigan.

Bottenheim, J.W., and O . Strausz, 1978. **Computer modelling of polluted atmospheres and the conversion of atmospheric sulfur dioxide to sulphuric acid. Final report.** Alberta Environment Research Secretariat Report 1978/5.

Abstract: The homogeneous gas chemistry of sulphur dioxide is reviewed, and it is concluded that the homogeneous oxidation of sulphur dioxide is a viable route of atmospheric oxidation. Reports of preliminary modelling studies of SO2 polluted atmospheres show that sulphur-containing aerosols might be formed several hours after emission. During the first few hours after emission from the stack of a plume containing large amounts of sulphur dioxide and oxides of nitrogen, the decrease in sulphur dioxide concentration in the plume is almost entirely due to plume dispersion.

Bottenheim, J.W., and O . Strausz, 1977. **Review of pollutant transformation processes relevant to the Alberta oil sands area.** Prepared for Alberta Oil Sands Environmental Research Program Project ME 3.5.1.

Abstract: This report describes chemical transformation processes in polluted atmospheres, with particular reference to the northeastern Alberta oil sands area. Clean air chemistry, oxidant chemistry, SO_2 chemistry, and aerosol chemistry are discussed. Having identified atmospheric chemical processes for which data are lacking, the report outlines research projects that would lead to better understanding and prediction of the chemistry of polluted air, with emphasis on potential atmospheric problems in the Alberta oil sands extraction plants.

British Columbia Ministry of Environment. **Annual acid precipitation monthly reports, 1984, 1985, 1986.**

Abstract: These reports summarize the acidity of the precipitation being monitored at stations of the Provincial Network for precipitation sampling. The most acidic rainfall was recorded in the coastal areas.

Canadian Meteorological and Oceanographic Society, 1981. **Proceedings, Air Pollution Sessions, Fifteenth Annual Congress, 27-29 May 1981, Saskatoon, Saskatchewan.** Alberta Environment, Edmonton.

Abstract: At this meeting of the special interest group on air pollution meteorology, papers were given on air pollution modelling and assessment, on acidification in western Canada, and on Alberta Oil Sands environmental studies

Cheng, L., E. Peake, D. Rogers, and A. Davis, 1986. **Oxidation of nitric oxide controlled by turbulent mixing in plumes from oil sands extraction plants.** Atmospheric Environment 20(9):1697-1703.

Abstract: This paper presents results of airborne measurements of conversion rates of NO to NO_2. The measurements were taken in oil sands extraction plant plumes in Fort McMurray, Alberta.

Cheng, L., E. Peake, and A. Davis, 1987. **The rate of SO_2 to sulphate particle formation in an air parcel from an oil sands extraction plant plume.** Journal of the Air Pollut. Control Assoc. 37(2):163-167.

Abstract: This paper reports on the results of a field programme to determine the transformation of sulphur dioxide to particulate sulphate in the emissions from oil sands extractions plants near Fort McMurray. The measurements were made under cold winter conditions in March and December 1983 and under warm summer conditions in June 1984.

Davison, D.S., and K.L. Grandia, 1979. **Plume dispersion measurements from an oil sands extraction plant, June 1977.** Project ME 2.3.2. Prepared by Intera Environmental Consultants Ltd. for Alberta Oil Sands Environmental Research Program.

Abstract: During the June 1977 plume survey field programme, airborne measurements were made in the area of the Great Canadian Oil Sands plant. Data from four flights were selected for detailed analysis of plume geometry and turbulence characteristics. The turbulence data, except for the flight of 19 June, was in good agreement with the statistical theory for lateral dispersion. The vertical plume spread was not predicted well by the statistical theory.

Davison, D.S., and R.B. Lantz, 1980. **Review of requirements for air quality simulation models.** Project AS 4.2.4. Prepared by INTERA Environmental Consultants Ltd. for Alberta Oil Sands Environmental Research Program.

Abstract: To update a previous survey, potential users of air quality models were interviewed regarding their needs. The simulation of the physical processes determining the wind flow and dispersion from an industrial source, the requirements for implementation and use, and the importance of physical processes for user needs, were considered in selecting air quality models for use in the AOSERP region. A number of air quality model types were recommended. Model characteristics, as well as accuracy limits of numerical simulations, were discussed with users. Stages of a programme for implementing an air quality model were outlined.

Davison, D.S., and E.D. Leavitt, 1979. **Analysis of AOSERP plume sigma data.** Prepared by Intera Environmental Consultants Ltd. for Alberta Oil Sands Environmental Research Program Project ME 3.8.3.

Abstract: This report synthesizes the available plume dispersion data from the AOSERP study area in order to derive a useful procedure for predicting the plume sigma values. Procedures were recommended for plume sigma specification, and schemes recommended for lateral dispersion and vertical dispersion. The effects of wind direction shear were reviewed, and the major areas of uncertainty of concern for sigma specification were identified.

Davison, D.S., E.D. Leavitt, R.R. McKenna, R.C. Rudolph, and M.J.E. Davies, 1981. **Airshed management system for the Alberta Oil Sands. Volume I. A Gaussian frequency distribution model.** Prepared by INTERA Environmental Consultants Ltd. and Western Research and Development for Alberta Environment Research Management Division.

Abstract: A climatological air quality dispersion model, incorporating a time series approach, was developed. The three components of the model are the time series of file of meteorological variables, the programme (GLCGEN) used to generate ground level concentrations, and the frequency analysis programme (FRQDTN). The model assumes a Gaussian plume framework.

Davison, D.S., M.C. Hansen, R.C. Rudolph, and M.J.E. Davies, 1981. **Airshed management system for the Alberta oil sands. Volume II. Meteorological data.** Prepared by INTERA Environmental Consultants Ltd. and Western Research and Development for Alberta Environment, Research Management Division.

Abstract: A climatological air quality dispersion model was developed. The three components are the time series file of meteorological variables, the programme (GLCGEN) used to generate ground level concentrations, and the frequency analysis programme (FRQDTN) which defines analyses for a particular run.

Davison, D.S., M.J.E. Davies, R.C. Rudolph, and M.C. Hansen, 1981. **Airshed management system for the Alberta Oil Sands. Volume III. Verification and sensitivity studies.** Prepared by INTERA Environmental Consultants Ltd. and Western Research and Development for Alberta Environment Research Management Division.

Abstract: A climatological air quality dispersion model, incorporating a time series approach and assuming a Gaussian plume, was developed. This report discusses the verification and sensitivity studies that were conducted.

Davison, D.S., C.J. Fortens, and K.L. Grandia, 1976. **Plume dispersion measurements from an oil sands extraction plant, March 1976.** Project ME 2.3.1. Prepared by INTERA Environmental Consultants Ltd. for Alberta Oil Sands Environmental Research Program.

Abstract: During March 1976 a plume survey field programme was conducted to determine the diffusion coefficients and turbulence parameters associated with the Great Canadian Oil Sands plant effluent plume. Five cases were selected for detailed analysis of plume geometry, mass flux calculations, and turbulence characteristics.

Denison, P.J., T.A. McMahon, and J.R. Kramer, 1979. **Literature review on pollution deposition processes.** Prepared for Alberta Oil Sands Environmental Research Program and Syncrude Canada Ltd. Project ME 3.6

Abstract: Literature related to deposition of gases and particulates by dry deposition and precipitation scavenging is reviewed. A programme was designed to provide data for calibrating the models recommended appropriate to the Alberta Oil Sands Environmental Research Program study area.

Dufour, C.M.L, B. Chapman, J.A. Lore, and M. Nosal, 1985. **Acid deposition near a sour gas plant in southwestern Alberta.** Water, Air and Soil Pollution 24(4):361-373.

Abstract: During summer of 1971, 1973 and 1982 atmospheric fallout in the vicinity of a sour gas plant was collected on an event basis with bulk precipitation collectors. The samples, collected at nine sites within 20 km of the plant, were analysed for acidity and sulphate deposition.

Fanaki, F., 1978. **Meteorology and air quality winter field study in the AOSERP study area, March 1976.** Prepared by Atmospheric Environment Service, Downsview, Ontario for Alberta Oil Sands Environmental Research Program Project ME 1.5.1.

Abstract: Intensive field studies were carried out in the Alberta Oil Sands Environmental Research Program study area to examine the fine structure of the atmosphere and dispersion under winter conditions. The study identified atmospheric features of the area, and river valley effects, that during winter affected atmospheric circulation and pollutant deposition.

Faulkner, D.A., 1987. **The effect of a major emitter on the rain chemistry of southwestern British Columbia - a preliminary analysis. Part I.** Atmospheric Environment Service, Pacific Region, Scientific Services Division Report PAES 87-1. Unpublished Manuscript.

Abstract: The ASARCO copper smelter in Tacoma, Washington was a major emitter of sulphur dioxide and atmospheric arsenic prior to its closing in March 1985. Precipitation chemistry data collected from a network parallel to the US/Canada border in southwestern British Columbia were analysed to determine if the smelter closure had resulted in a change in rain chemistry. Arsenic concentrations were found to be significantly lower than before the smelter closure, but it was not clear that the decreased sulphate and nitrate concentrations could be attributed to the closing of the ASARCO smelter.

Faulkner, D.A., 1987. **The effect of a major emitter on the rain chemistry of southwestern British Columbia - a preliminary analysis. Part II - Data listings.** Atmospheric Environment Service, Pacific Region, Scientific Services Division Report PAES 87-2. Unpublished Manuscript.

Abstract: The ASARCO copper smelter in Tacoma, Washington was a major emitter of sulphur dioxide and atmospheric arsenic prior to its closing in March 1985. Precipitation chemistry data collected from a network parallel to the US/Canada border in southwestern British Columbia were analysed to determine if the smelter closure had resulted in a change in rain chemistry. This report contains the data listings used in this study

Faulkner, D.A., 1987. **The effect of a major emitter on the rain chemistry of southwestern British Columbia a second look.** In Proceedings: Annual Meeting Pacific Northwest International Section Air Pollution Control Association, November 8-10, 1987, edited by M.G. Ruby. Air Pollution Control Association, Pacific Northwest International Section, Seattle, Washington.

Abstract: The ASARCO copper smelter in Tacoma, Washington was a major emitter of sulphur dioxide and atmospheric arsenic prior to its closing in March 1985. This investigation into the effects of the smelter's closing uses data from chemical analyses of event samples collected during the period October 1984 to January 1986 from a precipitation network parallel to the US/Canada border in southwestern British Columbia. Data from chemical analyses of precipitation samples collected daily from Vancouver Airport were used also. Statistical analyses of the data showed significant reductions of sulphate levels at mainland sites near the Strait of Georgia, for arsenic concentrations at all locations near the Strait of Georgia, no change in arsenic concentrations for western Vancouver Island stations, and significant decreases in vanadium concentrations at all sites.

Faulkner, D.A., 1984. **Trajectory analysis for British Columbia.** Atmospheric Environment Service, Pacific Region, Scientific Services Division Report PAES 84-1. Unpublished Manuscript.

Abstract: This report presents analyses of numerically calculated back trajectories for four British Columbia locations. Mean tracks of air parcels arriving at locations in southern B.C. are over Puget Sound and southwestern B.C., source areas of pre-cursor sulphate and nitrate pollutants. The report suggests a technique for forecasting probability of precipitation by using forecast trajectories.

Faulkner, D.A., n.d. **Precipitation ion concentrations in the vicinity of Vancouver, Canada.** Draft.

Abstract: The precipitation pH data presented in this report show a gradient of pH from the Vancouver city core to the Fraser Valley. The lowest pH is found in the Burrard Inlet area and the industrialized area. The precipitation pH increases southward from the city core and in the Fraser Valley, as the distance from Vancouver increases.

Holdsworth, G., and E. Peake, 1985. **Acid content of snow from a mid-troposphere sampling site on Mount Logan, Yukon Territory, Canada.** Annals of Glaciology 7:153-160.

Abstract: From analyses of an ice core from the icefield plateau of Mount Logan, there was no long-term change in the background precipitation acidity level. The peaks in the acid-ion levels in the ice core section corresponding to approximately 1880 to the present are provisionally identified with several documented volcanic events.

Iribane, J.V., and S.R. Shewchuk, 1985. **On the origin of strong acidity in the snow pack of northern Saskatchewan.** Saskatchewan Research Council Technical Report No. 186.

Abstract: Snow cores collected from the Haultain Lake and Wollaston Lake areas were analysed for organic ions. Inorganic anion deficits were found in most samples. This probably was due to the presence of organic ions which are, in part, related to acids.

Klemm, R.F., 1977. **Sulfur in precipitation: contribution to an Alberta sulfur inventory.** Submitted to Alberta Environment by the Alberta Research Council. 126pp.

Abstract: This report describes investigations concerned with a sulfur inventory of central Alberta. Measurements were made of sulfur in rain, snow, hail, and dustfall. The development of a small-scale device for the generation of ppb levels of SO_2 is described. This device was used in laboratory simulation of SO_2 uptake by soil, tree bark, and forest litter.

Klemm, R.F., 1975. **Sulfur related environmental studies at Alberta Research: a status report.** In Proceedings of the Alberta Sulphur Gas Research Workshop II, Environmental Sciences Centre, Kananaskis, Alberta, January 16-17, 1975, edited by W.R. MacDonald and H.S. Sandhu. Pp. 94-105.

Abstract: At the Alberta Research Council the study of sulphur in precipitation began in 1966 as the Alberta gas processing industry was going through a period of rapid expansion. The measurement of sulphate in precipitation was begun and continued until 1970. In 1973 a three-year grant from Alberta Environment resulted in further monitoring of sulphur compounds in precipitation. This paper outlines the status of projects begun since December 1st, 1973.

Kociuba, P.J., 1983. **Lodgepole trajectories: December 5-7, 1982.** Atmospheric Environment Service, Western Region, Scientific Services Division Report 83-2.

Abstract: A report was prepared for Alberta Environment to support their assessment of H_2S measurements. The AES Trajectory Model was run, the trajectories being initiated from Lodgepole.

Kociuba, P.J., 1974. **Estimate of sulphate deposition in precipitation for Alberta.** Atmospheric Environment Service, Western Region, Scientific Services Report 84-2.

Abstract: This report assesses estimates of sulphate 1982 data with that of previous years. Preliminary results of long range transport models are used to estimate dry deposition.

Kociuba, P.J., D.A. Faulkner, and R.F. Hopkinson, 1984. **Sulphur deposition modelling in western Canada.** Atmospheric Environment Service, Western Region, Scientific Services Division Report 84-1.

Abstract: The Atmospheric Environment Service long range transport model was used in locations in western Canada to assess the ability of the model to estimate sulphate deposition from industrial sources in western North America. The results from the model were compared with measured values.

Kotturi, M.S., 1984. **Chemical composition of individual storms as a function of air parcel trajectories.** for the prediction of acid rain characteristics. In The Biosphere, Problems and Solutions: Proceedings of the Miami Symposium on the Biosphere, edited by T.N. Veziroglu. Elsevier Sci. Publ., Amsterdam.

Abstract: This paper reports on the results of an investigation of the effects of local industrial emissions on precipitation chemistry in northwestern British Columbia. The impact of sulphur dioxide and hydrogen fluoride emissions on pH was assessed by collecting and analysing event precipitation samples. The data showed that acidity and fluoride concentration in rain were higher in the summer. Storm trajectories were compared with observed ionic loading to assess pollution received by rainwater from local individual industrial sources, and also from distant sources.

Kotturi, M.S., 1985. **Snow chemistry in south central British Columbia.** British Columbia Ministry of Environment, Air Management Branch, Victoria.

Abstract: This report summarizes snowpack chemistry data from sixteen sampling sites in south central British Columbia. Samples were collected during four winters, beginning with the winter of 1980/81, and analysed for pH, acidity, sulphate, nitrate, and other impurities.

Kotturi, M.S., and R . Richards, 1985. **Snowpack chemistry in south central British Columbia.** Paper presented at the Western Snow Conference, Fifty-third annual meeting, Boulder, Colorado, April 16-18, 1985.

Abstract: During the four winters from 1981 to 1984, snowpack chemistry data were collected in the Middle Fraser, and North and South Thompson basins. This paper reports on the pH values found in the snowpack meltwater. During deposition and between snow storms, dry atmospheric fallout as well as local sources of contamination add to the impurities found in and on the snowpack.

Kotturi, M.S., 1985. **Assessment of 1985 precipitation chemistry data collected in the Georgia Strait area.** British Columbia Ministry of Environment and Parks, Waste Management Branch, Environmental Services Section, Victoria.

Abstract: This report assesses 1985 precipitation chemistry data collected in the Georgia Strait area. The study included an assessment of chemical composition of precipitation before and after the shutdown of the Tacoma smelter. Multivariate statistical techniques were applied to the 1985 data to identify sources influencing area rainwater chemistry and also to classify data based on within site and between site variations in precipitation chemistry.

Kotturi, M.S., 1982. **Emissions, report on air quality and precipitation in the Prince Rupert-Terrace-Kitimat area.** British Columbia Ministry of Environment, Waste Management Branch, Air Quality Engineering Unit, Victoria.

Abstract: This report summarizes emissions at Port Edward and Kitimat, and describes air quality in the Terrace, Kitimat and Port Edward areas. It presents precipitation data for Prince Rupert and Terrace. For Kitimat it presents data on both wind and precipitation. The investigation of rain acidity fills in the data gaps identified earlier in Terrace CANSAP data.

Lam, E., 1984. **A survey of I.W.D. chemical analyses.** Atmospheric Environment Service, Scientific Services Division, Vancouver, British Columbia. Unpublished report.

Abstract: This report is a review of analytical procedures used by the Water Quality Laboratory of the Inland Waters Directorate in determining trace elements and ions in precipitation samples collected from a network of monitoring stations established by the Scientific Services Division of the Atmospheric Environment Service. This network was established to examine the extent of acid rain pollution in the Lower Mainland.

Lau, Y.K., 1982. **Precipitation chemistry: I. Precipitation acidity measurements, II. Specific conductance and ion concentrations.** Alberta Environment, Pollution Control Division, Air Quality Control Branch, Edmonton.

Abstract: This report discusses chemical aspects of acidity measurements of precipitation samples. The methods studied for measurement of precipitation acidity are pH measurement, titration and cation-anion balance. The possibility of using specific conductance-ion concentration correlation as a quality assurance index of chemical analyses of precipitation samples is investigated.

Leahey, D.M., and M.B. Schroeder, 1986. Predictions of maximum ground-level H2S concentrations resulting from two sour gas well blowouts. J. Air. Pollut. Control Assoc. 36(10):1147-1149.

Abstract: Sulphur emissions associated with the Lodgepole blowout were 1400 tonnes per day, and 2 tonnes per day in the case of the Claresholm incident. Special air quality monitoring was conducted with respect to hydrogen sulphide to assess the impacts of these blowouts. Maximum ground level hydrogen sulphide concentrations were compared to levels predicted through using a Gaussian model.

Leahey, D.M., M.J.E. Davies, and H.A. Bambrough, 1983. **Values of NO2:NO(chi) observed in the exhaust plume from a turbine driven compressor installation.** Atmospheric Environment 17(5):991-997.

Abstract: Ratios of nitrogen dioxide to total oxides of nitrogen were obtained for the exhaust plume of a large southern Alberta turbine driven compressor installation. The median values were not sensitive to downwind travel time, the presence of clouds or stack emission parameters. The ratios were found to be comparable to those observed in power plant plumes.

Leahey, D.M., and A.L. Jamieson, 1977. **Development of three statistical long range transport of air pollutant models.** Prepared by Bow Valley Research, Western Research Division for Atmospheric Environment Service, Western Region.

Abstract: This report presents source, meteorological, and scavenging parameters required by the three statistical long range transport of air pollutants models that are to be used to assess acid deposition in western Canada.

Lester, P.F., E.C. Rhodes, and A.H. Legge, 1986. **Sulphur gas emissions on the boreal forest: the West Whitecourt case study. IV. Air quality and the meteorological environment.** Water, Air and Soil Pollution 27(1-2):85-108.

Abstract: In support of the West Whitecourt case study in Alberta measurements of temperature, moisture, wind, and sulphur dioxide concentrations were carried out in and around an isolated stand of mature logdepole x jack pine. Special attention was given to the transport of sulphur dioxide gas. Air impinging on the stand tended to flow around the edges of the stand, over the canopy, and into the trunk space.

McBean, G.A., and S. Nikleva, 1986. **Composition of snow in Pacific coastal mountains.** Atmospheric Environment 20(3):1161-1164.

Abstract: Snow was collected from the mountains of Vancouver Island and southwestern British Columbia. Chemical analysis showed lower pH levels with increased sulphate and nitrate concentrations in snow collected near Vancouver and Georgia Strait, when compared with snow collected from other areas. Nitrate and ammonium appeared to be associated in the form of ammonium nitrate.

McLaren, R.R., 1985. **Lower Mainland and South Coast precipitation chemistry data.** Atmospheric Environment Service, Pacific Region, Scientific Services Division Report No. PAES 85-2. Unpublished manuscript.

Abstract: This report presents the precipitation chemistry data from the Lower Mainland Sampling network for the period January 1982 to December 1982, as well as data from the South Coast B.C. Sampling network for the period December 1982 to June 1984. The South Coast B.C. Sampling network includes sites in the Lower Mainland and southern Vancouver Island. The data includes the results of chemical analyses of rain and snow for pH, sulphur compounds, and nitrates.

McLaren, R.R., 1982. **Sampling of snowpacks for chemical analysis in southwestern British Columbia.** Atmospheric Environment Service, Pacific Region, Scientific Services Division Report No. PAES 82-3.

Abstract: This report presents the data from a programme of snow sampling carried out during March 1982. The samples, taken at varying distances and elevations downwind from Vancouver, were analysed for pH and sulphates as well as for other indicators of pollution.

McLaren, R.R., 1982. **Lower Mainland precipitation chemistry data.** Atmospheric Environment Service, Pacific Region, Scientific Services Division Report No. PAES 82-4. Unpublished manuscript.

Abstract: This report presents the precipitation chemistry data collected from January to April, 1981, by the Lower Mainland Sampling Program. The data includes the results of chemical analyses of rain and snow for pH, sulphur compounds, and nitrates.

McLaren, R.R., 1982. **An event rain sampler for precipitation chemistry.** Atmospheric Environment Service, Pacific Region, Scientific Services Division Report No. PAES 82-5. Unpublished manuscript.
Abstract: This report describes a simple and inexpensive sampler developed by staff of the Atmospheric Environment Service, Pacific Region for monitoring the chemical composition of precipitation.

Murray, W.A., 1981. **The 1981 snowpack survey in the AOSERP study area.** Prepared for Research Management Division, Alberta Environment.
Abstract: Snow samples were collected in the Athabasca Oil Sands region of northeastern Alberta. The results of chemical analyses of the snow cores showed an increase, when compared in levels found in a 1978 study, of the amounts of sulphate and nitrate deposited in the snow within 25 km of the oil sands plants. The was a marked decrease in deposition of insoluble particulates.

Nikleva, S., 1983. **Acid rain on the west coast of British Columbia.** Submitted to Parliamentary Sub-Committee on Acid Rain, Vancouver, B.C., October 28, 1983 by Department of Environment, Atmospheric Environment Service, Pacific Region.
Abstract: Data from measurements taken at British Columbia CANSAP (Canadian Network for Sampling Precipitation) stations along the west coast show precipitation pH values to be near 5.0., the most acidic values reported outside of eastern Canada. The ALCAN smelter at Kitimat contributed to the lowering of precipitation pH at Terrace, and emissions from the Port Alice pulpmill lowered Port Hardy precipitation pH. The southern Strait of Georgia and the Vancouver area are receiving acidic rain. The lowest values are for the city centre and the Burrard Inlet industrial area. Local sources and transboundary emissions are contributing factors.

Nikleva, S., 1982. **Progress report to Western LRTAP Committee on AES Pacific Region Program.** Atmospheric Environment Service, Pacific Region, Scientific Services Division Report No. PAES 82-6. Unpublished manuscript.

Abstract: Samples of precipitation from the Port Hardy area of Vancouver Island and from the British Columbia Lower Mainland were analysed. Sulphate ion concentration levels in Port Hardy precipitation samples were found to be significantly higher when the Port Alice pulp mill was in operation. The pH of Fraser Valley precipitation was found to be much higher than the pH in the Vancouver city centre and the Burrard Inlet industrialized area. The report proposes the expansion of the Lower Mainland monitoring network to investigate possible transboundary effects in the Georgia Strait area of pollution from Washington State.

Olson, R., B. Thomson, H. Bertram, and R. Peters, 1982. **Athabasca Oil Sands precipitation chemistry studies: 1976-79 and 1981.** AOSERP Report No. 129. Alberta Research Management Division, Edmonton.

Abstract: A study of the wet deposition of atmospheric pollutants in northeastern Alberta was begin in 1976 by Alberta Environment and the Atmospheric Environment Service to determine changes in pollutant deposition and to provide a data base on the precipitation chemistry of the area. In 1980 scientists from the Research Management Division, Alberta Environment reviewed the procedures and techniques being used in other precipitation studies. During 1981 Alberta Environment introduced changes that would minimize the possibility of non-representative samples and ensure that the data would be comparable to that from other precipitation chemistry studies.

Olson, R., B. Magill, B. Thomson, and H. Bertram, 1982. **Alberta Oil Sands precipitation chemistry study.** For presentation at Symposium on Acidic Deposition: a Western Perspective, Bellingham, Washington, 24-26 June 1982.

Abstract: This paper describes a study of the chemistry of rain and snow samples collected in the Oil Sands area of northeastern Alberta. The samples were analysed for heavy metals and major ions, such as sulphates and nitrates.

Padro, J., 1979. **Review of dispersion models and possible applications in the AOSERP study area.** Project ME 4.2.1. Prepared by Atmospheric Environment Service for Alberta Oil Sands Environmental Research Program.

Abstract: A literature survey was conducted of existing air quality models that had possible applications in the air quality programme of the AOSERP study area. Also, private companies and government agencies with available models, and individuals working in the field were contacted. No existing model was found that could meet the requirements of all users. Models capable of dealing with complex terrain problems were recommended for applications in Alberta Oil Sands air quality problems.

Peters, R.R., H.S. Sandhu, and W.D. Hume, 1981. **An analysis of precipitation chemistry in the oil sands area of northern Alberta.** In Proceedings of the Air Pollution Session, Canadian Meteorological and Oceanographic Society, 15th Annual Congress, 27-29 May 1981, Saskatoon, Saskatchewan. Pp. 147-157.

Abstract: For the period 1976 to 1979, rain samples were collected on an event basis during the months of May to October. Preliminary analysis of the data showed a seasonal cycle of chemical constituents in rainfall. Sample collection procedures, limitations of the chemical techniques, and reliability of the data without a quality assurance programme were discussed.

Phillips, S.F., D.L. Wotton, and D.B. McEachern, 1986. **Snow chemistry in the Flin Flon area of Manitoba, 1981-1984.** Water, Air and Soil Pollution 30(1-2):253-261.

Abstract: This paper discusses the results of analysing samples of the March snowpack to determine patterns of smelter emissions, and of monitoring the snowpack for air pollutant dispersion. The pH of snow decreased with distance from the smelter and was positively correlated with heavy metals, but was not correlated with sulphate deposition.

Rae, T.M., 1985. **Manitoba network for precipitation collection - summary - 1983.** Manitoba Department of Environment and Workplace Safety and Health, Air Standards and Studies Section Report No. 85-09.

Abstract: The Manitoba Network for Precipitation Collection programme has monitored the quality of precipitation since 1980. This report presents data from Island Lake and Norway House for 1983. The mean pH values and sulphate deposition rates for both areas are given.

Rooney, D.R., L.H. Lam, and E. Alp, 1986. **Implementation of statistical long range transport of air pollution models.** Prepared by Concord Scientific Corporation for Atmospheric Environment Service, Western Region.

Abstract: This report describes the implementation of three statistical long range transport of air pollution (LRTAP) models. The models, whose implementation was commissioned by the Atmospheric Environment Service, Western Region, were the Regional Climatological Deposition Model, the Ontario Ministry of the Environment Model, and Fisher's Statistical Model.

Rudolph, R.C., and D.S. Davison, 1985. **Estimates of roughness length from minisonde profiles in the Athabasca Oil Sands area.** Prepared by INTERA Technologies Ltd. for Alberta Environment, Research Management Division. (Alberta Environment Research Management Division RMD Report L-87)

Abstract: Minisonde data collected in the Athabasca Oil Sands area from 1975 to 1979 were analysed to determine regional values of roughness length. Mean values of roughness length calculated with allowance for diabatic and displacement height effects from about 8 m downwind of the Syncrude plant site to about 1 m in the Athabasca River valley.

Sagert, P.G., M.G. Ruby, B. Fane, and J.L. Fraser, 1986. **Background concentrations of sulphate in precipitation along the B.C. Coast.** Prepared by Cirrus Consultants for Atmospheric Environment Service. Atmospheric Environment Service, Pacific Region, Scientific Services Division Report PAES-86-1. Unpublished manuscript.

Abstract: In this report, "background" sulphate was defined as the concentration in rainfall obtained at nearby remote sites, upwind of urbanized areas, with the further requirement that data with evidence of possible anthropogenic contamination be excluded. Data from long-term precipitation sites along the coasts of British Columbia, Washington and Oregon were evaluated in order to estimate a "background" sulphate level in rainfall. The results suggest a background excess sulphate concentration in rainfall along the B.C. coast that occurs most frequently in the range of 6 to 10 microequivalents per litre.

Shewchuk, S.R., 1986. **The rain chemistry of Saskatchewan.** For presentation to the 20th Annual CMOS Congress, June 4-6, 1986.

Abstract: Two networks, one in northern and the other in southern areas of Saskatchewan, have been set up to study the rain chemistry of the province. Differences in pH of precipitation between the northern and southern areas were observed.

Shewchuk, S.R., 1985. **An air mass back trajectory and precipitation chemistry analysis within northern Saskatchewan.** Saskatchewan Research Council Technical Report No. 173.

Abstract: This report analyses and interprets the data from the rain chemistry network that Saskatchewan Environment had in place during 1982 and 1983. Northern Saskatchewan rain quality is affected by trajectories from southern areas of the province. Most of the rainfall samples were acidic. The area is highly sensitive to increases in acidic deposition.

Shewchuk, S.R., 1985. **A study of atmospheric deposition onto the snowpack in northern Saskatchewan.** Annals of Glaciology 7:191-195.

Abstract: Twenty-six small lakes in northern Saskatchewan were used as sites in a snowpack chemistry study. Sulphate deposition was found to be lower in the Precambrian Shield area, when compared with the area south of the treeline. Most of the snow on the Precambrian Shield areas was found to be acidic. The study included a survey of metal deposition onto northern Saskatchewan snow.

Shewchuk, S.R., 1984. **A snowpack and water quality survey of several small lakes in the southwest Precambrian Shield area of the Northwest Territories: an acid deposition approach.** Saskatchewan Research Council Technical Report No. 171.

Abstract: A survey of snow chemistry and lake water chemistry was carried out in the southwest Precambrian Shield area during March 1984 in order to study acid deposition in the area. The snowpack was not found to be affected by metals deposition from Arctic haze aerosols, but it was considered possible that some of the sulphur could have been deposited by Arctic haze. The Precambrian Shield lakes, except for fringe of Shield lakes, were found to be sensitive to acid deposition.

Shewchuk, S.R., 1982. **A precipitation study by event collection from Reindeer Lake, Saskatchewan.** Saskatchewan Research Council Technical Report No. 135.

Abstract: Event collection of precipitation was carried out during the summer of 1981 near Southend, Saskatchewan on Reindeer Lake. The rain was analysed for major ions of sulphate and nitrate. In addition, sample pH values were determined. The highest rainwater acidity levels were associated with forest fire smoke in the area.

Shewchuk, S.R., 1982. **A snowpack chemistry study of small lakes in northern Saskatchewan.** Saskatchewan Research Council Technical Report No. 137.

Abstract: Snow surveys were conducted on a number of small lakes in northern Saskatchewan to assess the chemical quality of the snowpack, study rates of acidic deposition, and assemble a data base on snowpack chemistry.

Shewchuk, S.R., 1981. **The extent of acidic deposition in a regional context of Western Canada.** Paper presented at the Air Pollution Session, Fifteenth Annual Congress of the Canadian Meteorological and Oceanographic Society, May 27-29, 1981, University of Saskatchewan, Saskatoon.

Abstract: As most of the research baseline work within the project area has been conducted for the Alberta Oil Sands Environmental Research Program, the research effort has been restricted to a specific portion of the Athabasca River valley. To compare Western Canadian acidic deposition with that of that of other Canadian regions, Environment Canada CANSAP (Canadian Network for Sampling and Analysis of Precipitation) sulphate and nitrate data were analysed. Snowpack analysis is discussed as a method of monitoring pollutant deposition, with particular reference to sulphates and to snow pH.

Shewchuk, S.R., 1979. **A background report of potential sulphur stresses in west central Saskatchewan.** Saskatchewan Research Council Report No. P79-6.

Abstract: Studies were conducted of levels of atmospheric sulphur and sulphate in the precipitation in the La Loche area of west central Saskatchewan. Values were at, or near, background levels. In most cases of high gaseous sulphur levels, it was shown by an analysis of the trajectories that the air mass had passed near the tar sands region of Alberta.

Strosher, M.M., 1981. **Background air quality in the AOSERP study area: March 1977 to March 1980.** Project AS 2.1.1. Prepared by Alberta Environment Pollution Control Division for Alberta Environment Research Management Division.

Abstract: This report summarizes data from ambient monitoring stations. It contains frequency distribution analyses of one-half hour SO_2 concentrations, in graphs and tables. Also included is information on average and peak readings for nitrogen oxides, ozone and carbon monoxide, as well as on metals in suspended particulate analysis. The report makes recommendations how this information can best be used in future air quality assessments.

Strosher, M.M., 1978. Ambient air quality in the AOSERP study area, 1977. Prepared by Alberta Department of the Environment, Pollution Control Division for Alberta Oil Sands Environmental Research Program Project ME 2.1.

Abstract: The ambient air quality monitoring network in the AOSERP study is described with reference to site location, measurement techniques, instrumentation, and data sources. The report contains initial evaluations of ground level air concentrations of sulphur dioxide, as well as levels of ozone and nitrogen dioxide at a background station. Initial evaluations of the data show levels of total suspended particulates to be very low except in the Fort McMurray area.

Strosher, M.M., and R.R. Peters, 1980. Meteorological factors affecting ambient SO2 concentrations near an oil sands extraction plant. Prepared by Alberta Environment, Pollution Control Division for Alberta Oil Sands Environmental Research Program Project AS 2.1.

Abstract: Observed SO2 ground level concentrations are related to meteorological processes. Analysis of ambient monitoring measurements from a continuous air quality monitoring network in the Alberta Oil Sands Research Program shows that SO2 concentrations are caused by arctic air mass inversions. Alberta Environment's dispersion programme is used to compare observed and calculated ground level SO2 concentrations.

Summers, P.W., 1987. Scavenging of SO2 by convective storms.

Abstract: In the summer of 1968 fifteen hours of SO2 observations were made during flights of a meteorological research aircraft over central Alberta, using a continuous SO2 analyzer. Precipitation samples were collected simultaneously by ground mobile units. Sulphur budgets of three storms indicate high rainout efficiency.

Summers, P.W., 1986. **The role of acidic and basic substances in wet and dry deposition in western Canada.** In Acid Forming Emissions in Alberta and Their Ecological Effects: Proceedings of the 2nd Symposium/Workshop, 12-15 May 1986, Calgary, Alberta. Edited by H.S. Sandhu, A.H. Legge, J.I. Pringle, and S. Vance. Alberta Environment Research Management Division, 1987. Pp. 85-116.

Abstract: This overview of atmospheric deposition in the Prairie Provinces discusses the relative importance of wet and dry deposition, the background deposition levels, and the relationship between sulphate concentrations and pH. The station at Cree Lake, Saskatchewan, the only one with long-term measurements of air concentrations, is the source of atmospheric deposition data in the paper. Results from previous investigations are used for an overview of acid deposition throughout the Prairie Provinces.

Summers, P.W., and B. Hitchon, 1973. **Source and budget of sulfate in precipitation from central Alberta, Canada.** Journal of the Air Pollution Control Association 23(3):194-199.

Abstract: The results of analysing rain, hail, and snow samples collected in central Alberta point to most of the sulphate being of local industrial origin. A local atmospheric sulphur budget is derived by comparing the sulphate deposition around one isolated gas plant with the known SO_2 emission rate. The budget shows summertime convective storms to be more efficient than snowfall in removing SO_2 from the atmosphere.

Thomson, R.B., 1986. **Atmospheric Environment Service Long Range Transport of Air Pollutant activities in the Territories.** Water Sci. Technol., 18:109-115.

Abstract: This paper reviews acid deposition and modelling in the Northwest Territories and Yukon Territory. Trajectory models are discussed that indicate a pattern of northeastward transportation of pollutants from Alberta to southern sections of the Northwest Territories.

Thomson, R.B., 1986. **The effect of arctic haze on northern climate.** Atmospheric Environment Service, Western Region, Scientific Services Division Report 86-2. Unpublished manuscript.

Abstract: This paper reviews current knowledge on Arctic Haze research and discusses potential impacts of arctic haze on northern climates. There is evidence that anthropogenic aerosols and associated greenhouse gases are modifying the surface-troposphere radiation budget. Also, elemental carbon deposition to snow and increasing atmospheric CO2 levels modify this radiation budget.

Thomson, R.B., 1985. **Sulphur deposition in western Canada during 1982.** Atmospheric Environment Service, Western Region, Scientific Services Division Report 85-1. Unpublished manuscript.

Abstract: For the calculation of anthropogenic additions to air pollution in British Columbia, Alberta and the Territories, networks were established to sample precipitation chemistry. This report discusses the quality and quantity of the precipitation data, as well as estimating the amount of sulphur deposited in 1982 at the sampling sites.

Thomson, R.B., 1985. **Atmospheric Environment Service long range transport of air pollutant activities in the Territories.** Atmospheric Environment Service, Western Region, Scientific Series Report 85-2. Unpublished manuscript.

Abstract: This report reviews acid deposition and modelling in the Northwest and Yukon Territories. Trajectory calculations using numerical models show a pattern of northeastward transport of pollutants into southern sections of the Northwest Territories.

Thomson, R.B., 1984. **Northwest Territories precipitation chemistry network.** Atmospheric Environment Service, Western Region, Scientific Services Division Report 84-4. Unpublished manuscript.

Abstract: This report discusses technical details related to sampling procedures, site selection, and sample gathering for the collection of precipitation for chemical analysis.

Thomson, R.B., R . Angle, and S. Sakiyama, 1987. **Selecting air quality - acid deposition models for mesoscale application.** Journal of Air Pollution Control Association 37(3):260-265.

Abstract: This paper discusses the characteristics considered important for a model that would be used in studies of air quality and acid deposition in western Canada.

Thomson, R.B., D.A. Faulkner, and R.F. Hopkinson, 1985. **Sulphur deposition modelling in western Canada (1982 study).** Atmospheric Environment Service, Western Region, Scientific Services Division Report 85-3. Unpublished manuscript.

Abstract: The Atmospheric Environment Service Long Range Transport (AES-LRT) model was run using 1982 meteorological data and 1980 emission values. The results are compared with those of a previous study in which this model was run using 1978 meteorological data and combined emission inventories for 1976 and 1978.

van Verdingen, R.O., M.A. Shakur, and H.R. Krouse, 1982. **Isotope geochemistry of dissolved, precipitated, airborne, and fallout sulfur species associated with springs near Paige Mountain, Norman Range, N.W.T.** Canadian Journal of Earth Sciences 19(7):1385-1407.

Abstract: Isotope geochemistry, used to analyse sulphur compounds associated with the springs near Paige Mountain, identified gypsum beds in a rock formation as the sulphate source. Isotope analysis showed that more than half the oxygen reacting with airborne hydrogen sulphide, to form sulphuric acid fallout, is derived from water.

Vet, R.J., N.W. Reid, and J.E. Hunt, 1983. **Assessment of the potential incremental acid deposition in the Greater Vancouver area from the Burrard Thermal Generating Plant.** Prepared by Concord Scientific Corporation for B.C. Hydro and Power Authority.

Abstract: This report presents the results of an assessment of potential acidic deposition in the Vancouver area from the operation of the Burrard Thermal Generating Plant, a natural gas fired generating plant east of Vancouver. The assessment is based on an examination of the emission rate of nitrogen oxides from the Burrard Thermal Generating Plant relative to total emissions of pollutants in the Greater Vancouver Regional District, incorporating relevant meteorological and climatological data.

Walmsley, J.L., and D.L. Bagg, 1977. **Calculations of annual averaged sulphur dioxide concentrations at ground level in the AOSERP study area.** Project ME 4.1. Prepared for Alberta Oil Sands Environmental Research Program.

Abstract: The Climatological Dispersion Model and the input data required for calculation of annual averaged values of sulphur dioxide concentrations at ground level are described. The most important meteorological input to the model is the long-term joint frequency distribution of winds in the vicinity of emissions sources. Statistics of wind correlation between Fort McMurray and Mildred Lake, Alberta are used. Levels of sulphur loading due to dry deposition are estimated.

Western Mesoscale Modelling Task Group, 1985. **A review of mesoscale modelling for application to western Canada.** Prepared for Western Canada LRTAP Technical Committee, December 1985.

Abstract: This report describes the review strategy and screening criteria used to choose Eulerian and Lagrangian models for application over western Canada. The Acid Deposition and Oxidants Model (ADOM) was one of those reviewed. None of the models recommended was considered satisfactory for studies of seasonal or annual loadings for western Canada.

Western Mesoscale Modelling Task Group, 1985. **Requirements for mesoscale acid deposition modelling and monitoring in western Canada: Victoria, British Columbia, January 31, 1985 - February 1, 1985.** LRTAP Workshop No. 4. Sponsored by the Western LRTAP Technical Committee and the Federal LRTAP Liaison Office. Atmospheric Environment Service, LRTAP Liaison Office, Downsview, Ontario.

Abstract: This workshop was held to review the relative contribution of local and distance sources to acid deposition in Western Canada, to review available long range and mesoscale acid deposition models, and to develop an action plan for selecting, testing and using acid deposition models in emissions management.

AQUATIC PROCESSES AND EFFECTS

Brown, D.J., 1985. **Water quality data report: LRTAP parameters, Manitoba lakes, water quality computer data base.** Manitoba Environment and Workplace Safety and Health, Water Standards and Studies Departmental Technical Report, Winnipeg.

Abstract: Manitoba maintained a surface water quality monitoring programme up to March 1984, and stored the data in a computer file. The parameters of greatest interest to LRTAP (conductivity, pH, total alkalinity and calcium) are presented in Appendix I.

Brown, D.J., 1985. **Water quality data report: LRTAP parameters, Manitoba rivers and streams, water quality computer data base.** Manitoba Environment and Workplace Safety and Health, Water Standards and Studies Departmental Technical Report, Winnipeg.

Abstract: Manitoba maintained a surface water quality monitoring programme up to March 1984, and stored the data in a computer file. Table 1 is comprised of a list of river and stream stations with data relevant to Long Range Transport of Air Pollutants (LRTAP) and acid deposition. The parameters of greatest interest to LRTAP (conductivity, pH, total alkalinity and calcium) are presented in Appendix I.

Clark, M.J.R., and M. Bonham, 1982. **Potential sensitivity of the British Columbia aquatic environment to acid rain.** British Columbia Ministry of Environment, Victoria.

Abstract: Total alkalinity data for streams and lakes throughout British Columbia were reviewed. A majority of streams and lakes sampled appeared to be adequately buffered, but every region of the province had some waters with not enough buffering capacity for protection against acid rain. The Lower Mainland and Vancouver have many sites with low buffering capacity, while the Omineca-Peace area has few. No data had been gathered for large areas of the province, particularly the West Coast and north of Latitude 56.

Dalley, N.E., 1986. **High frequency monitoring of a coastal stream.** In Statistical aspects of Water Quality Monitoring, edited by A.H. El-Shaarawi and R. Kwiatkowski, Elsevier Sci. Publ. Co., New York. Pp. 433-442.

Abstract: This paper discusses high frequency monitoring of Kanaka Creek, a tributary of the lower Fraser River, for pH, dissolved oxygen, and other water quality indicators. A computer programme was written for presentation and preliminary analysis of the high-frequency environmental data. Because pH levels and other variables change rapidly in streams with highly variable flows, the study concludes that high-frequency monitoring is the preferred approach to water quality assessment of such streams.

Department of Fisheries and Oceans, Freshwater Institute, 1986. **Bibliography of acid rain-related research for western Canada.** Department of Fisheries and Oceans, Winnipeg, Manitoba.

Abstract: This is a bibliography of papers resulting from acid rain related research conducted out of the Freshwater Institute.

Department of Fisheries and Oceans, Freshwater Institute, 1986. **Acid rain - related publications of the Fish Habitat Research Section, Freshwater Institute, Winnipeg.** Department of Fisheries and Oceans, Winnipeg, Manitoba.

Abstract: This lists publications on acid rain related research conducted out of the Freshwater Institute.

Feller, M.C., 1987. **The influence of acid precipitation on stream chemistry in a small forested basin in southwestern British Columbia.** In Forest Hydrology and Watershed Management: proceedings of the Vancouver Symposium, August 1987, edited by R.J. Swanson, P.Y. Bernier, and P.D. Woodward. IASH Publication No. 167.

Abstract: Precipitation and streamwater chemistry have been assessed since 1970 in a small forested drainage basin located in southwestern British Columbia. Soils are being acidified, resulting in the release of basic cations. However, acid precipitation has not significantly altered streamwater chemistry.

Havas, M., and T.C. Hutchinson, 1982. **Aquatic invertebrates from the Smoking Hills, N.W.T.: effect of pH and metals on mortality.** Canadian Journal of Fisheries and Aquatic Sciences 39(6):890-903.

Abstract: This paper reports the results of experiments on planktonic crustaceans and insect larvae from acidic and alkaline tundra ponds near the Smoking Hills, N.W.T. The experiments were conducted to determine the tolerance of these invertebrates to low pH and high levels of potentially toxic elements, including aluminum, The chemistry of the acidic ponds is influenced by emissions from nearby lignite burns. The absence of crustaceans from the acidic ponds may be due to their sensitivity to pH.

Hesslein, R.H., 1979. **Lake acidification potential in the Alberta Oil Sands Environmental Research Program study area.** Prepared by Environment Canada, Freshwater Institute for Alberta Oil Sands Research Program Project HY 2.2.

Abstract: Twenty lakes in the AOSERP study area were surveyed in 1976 to determine their susceptibility to pH change from increased acid emissions. Models using the survey information were used to predict levels of pH in the lakes under various acid loading rates. Most of the lakes have high alkalinities. The only lakes considered to be at possible risk would not be seriously affected unless average rain pH levels were below 4.0. Such a low average is considered unlikely to occur.

Jernelov, A., B. Nagell, and A. Svenson, 1981. **Adaptation to an acid environment in Chironomus riparius (Diptera, Chironomidae) from Smoking Hills, NWT, Canada.** Holarctic Ecology 4(2):116-119.

Abstract: The Smoking Hills have burned for centuries, causing long-term acidification of ponds in the vicinity. This paper discusses comparisons made between Canadian Chironomous riparius larvae and those of larvae of the same species from Sweden, as well as with those of other Swedish Chironomous larvae. The hemoglobin content of the Canadian larvae was found to be double that of the same species from Sweden.

Kristensen, J., 1981. **Investigations of goldeye and other fish species in the Wood Buffalo National Park Section of the Peace-Athabasca Delta, 1977.** Prepared by LGL Limited for Department of Fisheries and Oceans. Canadian Manuscript Report Fisheries and Aquatic Sciences 1560.

Abstract: This report studies migrations of goldeye in the Peace-Athabasca Delta, as well as the age and growth of the goldeye population. Reproductive potential is estimated to be low. The information in the report will be useful, when compared to studies undertaken after the tar sands plants have been in operation, in assessing the effects of these plants on Pe ace-Athabasca goldeye populations.

Kristensen, J., 1979. **Walleye studies in the Peace-Athabasca Delta, 1978.** Report prepared for Fisheries Subcommittee, Peace-Athabasca Delta Monitoring Committee.

Abstract: This report assesses walleye spawning areas and compares the importance to commercial fisheries of walleye spawning in Richardson Lake with walleye spawning elsewhere.

Lechner, L.J., and G.L. Howard, 1987. **Sensitivity of Saskatchewan surface waters to acidic inputs.** Saskatchewan Environment, Air Pollution Control Branch Regina.

Abstract: This overview of the sensitivity of Saskatchewan lakes to acidic deposition shows that lakes in the Precambrian Shield area are moderately to highly sensitive. Lakes in the rest of the province are well buffered against the effects of acid rain.

Liaw, W.K., 1981. **Sensitivity to acid of fishing waters in northern Saskatchewan.** Saskatchewan Department of Parks and Renewable Resources, Fisheries Branch Technical Report 81-1.

Abstract: This report assesses the vulnerability of northern Saskatchewan fishing lakes to acidification caused by acid rain.

Liaw, W.K., and F.M. Atton, 1981. **Acid rain on northern lakes: background studies in Saskatchewan.** Musk-Ox 28:26-42.

Abstract: This report examines water quality data for over 600 Saskatchewan water bodies and provides background information required to identify lakes in Saskatchewan sensitive to acid rain. It suggests there is a need to monitor the lakes lying downwind from the Fort McMurray and Cold Lake oil sands developments.

McFarlane, G.A., W.G. Franzin, and A.Lutz, 1979. **Chemical analyses of Flin Flon area lake waters and precipitation: 1973 to 1977.** Can. Fish. Mar. Serv. MS Rep. 1486.

Abstract: Samples of water from lakes in the vicinity of a base metal smelter at Flin Flon, Manitoba were analysed for pH, conductivity, chloride, sulphate, potassium, magnesium, calcium, zinc, copper, cadmium, manganese, and iron. Precipitation and lake surface snow were analysed as well.

Motluk, D., 1982. **Acid rain: a product of our industrial age.** Manitoba Department of Natural Resources Fish. Bull. 21(2):4-9.

Abstract: This paper gives an overview of the effects of acid rain on aquatic life. The Prairies are the area of Canada least sensitive to acid precipitation, and the Precambrian Shield the most sensitive. In 1980 stations were set up to monitor sulphur dioxide levels drifting from smelters at Thompson and Flin Flon. Sampling of Manitoba Precambrian Shield rivers and lakes is underway.

Newcombe, C.P., 1987. **Acid deposition in aquatic ecosystems: setting limits empirically.** Environmental Management 9(4):277-288.

Abstract: The problem of acid deposition and its harmful effects on aquatic ecosystems has created the need for knowledge on which legislative controls can be based. Current legislation requires evidence of cause and effect between industrial emissions and pollution, but science is unable to provide this information over the short term. Therefore, controversy has arisen about whether existing information warrants control measures at this time. This article proposes the use of an empirical model. This model, integrating all the major variables and many of the minor ones, constructs a three-dimensionally curved surface capable of representing the status of any waterbody subjected to acid deposition. When suitably calibrated, the model can be used to depict limits to the rate of acid deposition required for any level of environmental protection.

Servizi, J.A., R.W. Gordon, S.C. Samis, L.C. Pella, M.A. Sullivan, and M.D. Nassichuk, 1985. **Survey of selected stream streams for sensitivity to acidification from the proposed Hat Creek coal development.** Can. Tech. Rep. Fish. Aquat. Sci. 1389.

Abstract: Thirty two Pacific salmon streams downwind of the proposed B.C. Hydro coal-fired electric power generating plant in south central British Columbia were sampled for pH, alkalinity and metals. Buffer capacities were calculated for 14 streams with low alkalinities. The depressed pH and alkalinity of two rivers during snowmelt coincided with the spring freshet.

Sheath, R.G., M.Havas, J.A. Hellebust, and T.C. Hutchinson, 1982. **Effects of long-term natural acidification on the algal communities of tundra ponds at the Smoking Hills, N.W.T., Canada.** Canadian Journal of Botany 60(1):58-72.

Abstract: The epipelic and planktonic algal communities from four tundra ponds were examined over a three-year period. These ponds have high metal concentrations and very low pH values, due to long-term fumigation by sulphur dioxide and sulphuric acid from nearby lignite burns. These communities were compared with the flora of the control ponds, situated further from the lignite burns and having alkaline waters (pH 8).

Shewchuk, S.R., 1983. **A snowpack and surface water chemistry survey of small lakes in northern Saskatchewan.** Saskatchewan Research Council Publication No. E-906-14-B-83. Prepared for Saskatchewan Environment, Air Pollution Control Branch.

Abstract: Examples are given of the use of snowpack chemistry analysis to assess natural and anthropogenic acidic deposition. This report examines last year's data to determine if it deviates from the statistical long term average, compares acidic deposition on snow on lake and land surfaces, and investigates the reason for low pH values in snow samples. Ice cores were taken from several lakes and water samples were extracted for analysis. Almost all the lakes were in the Canadian Shield. As anthropogenic sulphur and nitrogen oxides were found to be entering the Saskatchewan Precambrian Shield, the establishment of a long-term snow survey network was recommended.

Shewchuk, S.R., 1983. **A winter time chemistry study of the snow pack and surface waters of small lakes in northern Saskatchewan.** Saskatchewan Research Council Publication No. E-906-14-B-83.
Abstract: Northern Saskatchewan snow pack and lake water samples were analysed. Data on levels of pH and sulphates were obtained.

Shewchuk, S.R., 1982. **A snowpack and surface water chemistry survey of small lakes in northern Saskatchewan.** Saskatchewan Research Council Technical Report No. 137.
Abstract: This report investigates reasons for low pH, compares acidic deposition on lake surfaces with deposition on land surfaces, examines the previous year's data to see if it is typical on a long-term average, and interprets the data to determine the origin of constituents deposited.

Sullivan, M.A., and S.C. Samis, In prep. **Assessment of the acidification potential of Lower Mainland and Vancouver Island streams.** Can. Tech. Rep. Fish. Aquat. Sci. 0000
Abstract: Surface water samples from thirty-six streams on the Lower Mainland of British Columbia and Vancouver Island were analysed for pH, alkalinity, conductivity, colour, sulphate, nitrate, chloride and metals. Henriksen's acidification index was determined for all streams in the study.

Sullivan, M.A., S.C. Samis, J.A. Servizi, and R.W. Gordon, 1985. **Survey of selected British Columbia and Yukon salmon streams for sensitivity to acidification from precipitation.** Can. Tech. Rep. Fish. Aquat. Sci. 1388.
Abstract: Surface water samples were collected from 174 Pacific salmon streams on the British Columbia North Coast, Sunshine Coast, Lower Mainland, the Queen Charlotte Islands, and Vancouver Island. The Yukon samples were collected from streams near Whitehorse. The samples were analysed for pH, alkalinity and metals as were the snow samples collected from 26 of the watershed drained by these streams. A number of streams in all the British Columbia sampling areas were found to be of low alkalinity. Buffer capacities were calculated

for a large portion of the low alkalinity streams.

Swain, L.G., 1985. **Chemical sensitivity of lakes in British Columbia to acidic inputs.** B.C. Ministry of Environment, Water Management Branch, Water Quality Studies, Victoria. Unpublished report.
Abstract: This report summarizes lake chemistry data and estimates sensitivity to acidic inputs of about 700 British Columbia. The lakes were sampled in the period 1977-1985. Lake sensitivity to acidic inputs was determined from measurements of the alkalinity and/or calcium present. The report provides the locations of lakes having pH values below 6.0 and included a generalized map of lake sensitivity.

Swain, L.G., 1985. **How air pollution affects aquatic systems.** Paper presented to Environmental Studies Seminar, University of Victoria, Victoria, B.C., November 20, 1985.
Abstract: Acid precipitation is the air pollution problem with the potential to affect the largest number of aquatic systems. This paper discusses basic concepts such as the pH scale, buffering within an aquatic system to neutralize acids, and the potential effects of acid precipitation on organisms in lakes. It gives an overview of the sensitivity of British Columbia lakes and of long-term studies being undertaken to determine if British Columbia lakes are being affected by acid rain.

Swain, L.G., 1982. **Mapping lake sensitivity to acid rain: the British Columbia experience.** Unpublished paper presented to the North American Lake Management Society Conference, Vancouver, British Columbia.
Abstract: In 1981 the Aquatic Studies Branch of the British Columbia Ministry of Environment began a programme to map lakes within the Province according to their sensitivity to acid rain. Data collected between 1977 and 1981 on pH, alkalinity, calcium, magnesium, and aluminum were used to prepared preliminary sensitivity maps. The Aquatic Studies Branch is collecting more data, and is planning to use morphometric parameters to predict lake sensitivity. From the previous survey, data gaps existed for coastal British Columbia and North from 56N latitude.

Warrington, P.D., 1986. The pH tolerance of the aquatic plants of British Columbia. Part 1. Literature survey of the pH limits of aquatic plants of the world. British Columbia Ministry of Environment and Parks, Water Management Branch, Victoria. Unpublished report.
Abstract: Not available.

Warrington, P.D., 1986. **The pH tolerance of the aquatic plants of British Columbia. Part 2. Analysis of existing British Columbia environmental data.** British Columbia Ministry of Environment and Parks, Water Management Branch, Victoria. Unpublished report.
Abstract: Not available.

Welch, H.E., and J.A. Legault, 1986. **Precipitation chemistry and chemical limnology of fertilized and natural lakes at Saqvaqjuac, N.W.T.** Can. J. Fish. Aquat. Sci. 43(6):1104-1134.
Abstract: Precipitation at Saqvaqjuac on the northwest coast of Hudson Bay was found to have high concentrations of sea salts and to be moderately acidic. Studies of chemical limnology of area lakes were carried out.

Western Canada Long Range Transport of Atmospheric Pollutants, Technical Committee, 1982. **Evaluation of the status of surface water sensitivity mapping for acidic deposition in western Canada.** Prepared by Coordinating Committee on Surface Waters. (Saskatchewan Research Council Publication No. C-805-11-E82).
Abstract: This report is a survey of available water quality data from surveys of lakes in British Columbia, Alberta, Saskatchewan, and Manitoba. Appendices contain sampling data from surveys of lakes in the four western provinces for water quality parameters such as pH and alkalinity. Maps of the provinces, showing sampling sites, are included.

Whitfield, P.H., 1986. **Spectral analysis of long-term water quality records.** In Statistical aspects of Water Quality Monitoring, edited by A.H. El-Shaarawi and R. Kwiatkowski, Elsevier Sci. Publ. Co., New York. Pp. 388-403.
Abstract: The Capilano, Seymour, and Coquitlam Rivers are the source of the Greater Vancouver Regional District water supply. Records of water quality measurement of these rivers were reduced to weekly averages and examined in the frequency domain, using spectral analysis. According to this analysis of longterm water quality records, pH has shown a decrease over the past 25 years on a linear basis.

Whitfield, P.H., and N.E. Dalley, 1987. **Rainfall driven pH depressions in a British Columbia coastal stream.** Paper presented at Symposium on Monitoring, Modeling, and Mediating Water Quality.

Abstract: Instream pH values from Kanaka Creek, a tributary of the lower Fraser River, were measured at 15 minute intervals. The relationship between rainfall events and stream pH was examined. It was observed that the stream pH became markedly depressed during rainfall events. The extent of this decrease appears to be greater during heavy rainstorms, but it is strongly modified by the volume of water present in the stream at the onset of the rainfall event. Depressions of pH greater than 1.0 were commonly observed.

TERRESTRIAL PROCESSES AND EFFECTS

Baker, J., 1980. **Differences in the composition of soils under open and canopy conditions at two sites close-in to the Great Canadian Oil Sands Operation, Fort McMurray, Alberta.** Prepared for Alberta Oil Sands Environmental Research Program. Project LS 3.4.1. AOSERP Report 97.

Abstract: Soils sampled at two sites south of the Great Canadian Oil Sands plant were found to differ statistically with respect to nutrients and pH. Despite higher sulphur concentrations in soils and jack pine foliage under the canopy at Site 1, there is no conclusive evidence that the oil sands operation has altered the soil nutrient regime.

Baker, J., D. Hocking, and M. Nyborg, 1977. **Acidity of open and intercepted precipitation in forests and effects on forest soils in Alberta.** Water, Air and Soil Pollution 7(4):449-460.

Abstract: This paper reports that high concentrations of sulphur dioxide emitted from industrial plants appear to be causing acidification of the grossfall, throughfall and stemflow of rain. The result is increasing soil acidity.

Bewley, R.J.F., and D. Parkinson, 1986. **Monitoring the impact of acid deposition on the soil microbiota, using glucose and vanillin decomposition.** Water, Air and Soil Pollution 27(1-2):57-68.

Abstract: Soil samples were collected from three sites in a boreal forest in the vicinity of a sour gas plant emitting sulphur dioxide. Their rates of vanillin and glucose decomposition was observed. Fewer bacteria were isolated from Site 1 (2.8 km from the plant) than from Site 2 and Site 3, 6.0 km and 9.6 km from the plant. A greater proportion of the soil bacteria from Site 1 were spore formers and bisulphite-tolerant isolates, compared with those from the other sites.

Bewley, R.J.F., and D. Parkinson, 1985. **Bacterial and fungal activity in sulphur dioxide polluted soils.** Canadian Journal of Microbiology 31(1):13-15.

Abstract: This paper reports on the result of using a selective inhibitor technique to determine the relative contributions of bacteria and fungi, to the total microbial respiration in pine forest soils at sites at varying distances from a sour gas plant.

Bewley, R.J.F., and D. Parkinson, 1984. **Effects of sulphur dioxide pollution on forest soil microorganisms.** Canadian Journal of Microbiology 30(2):179-185.

Abstract: This paper reports on the results of a study comparing forest soil microflora at sites 2.8 km, 6 km, and 9.6 km downwind of a sour gas plant emitting sulphur dioxide. At the site closest the plant, there was a significant reduction in total numbers of bacteria. There was no such difference in the numbers of fungi. However, compared with those at the two sites closest to the sour gas plant, a smaller proportion of fungi at the furthest site were tolerant of sulphite or bisulphite.

Crampton, C.B., 1984. **Concentric zonation of gleyed soils under individual tree canopies in southwestern British Columbia, Canada.** Geoderma 32(4):329-334.

Abstract: A study of concentric zoning of soils under the stems of western hemlock and western red cedar in the British Columbia coastal rainforest showed that the most acid soil profiles occur near each stem. Circular belts of gleyed soils appear to be associated with a flow of very acid water from precipitation down the stem and much greater flow of less acid water from the periphery of the canopy.

Crampton, C.B., 1983. **Variations of pH with annual precipitation in loamy forest soils.** Canadian Journal of Soil Science 63(2):401-403.

Abstract: Measurements, made between 1974 and 1981, of pH in well-drained loamy soils, showed that subsoil acidification increased after two consecutive drier-than-average years. The acidity of the subsoil in imperfectly drained soils was relatively stable, regardless of the changing precipitation patterns.

Friesen, P., 1985. **CAPAMP algorithm documentation: soil sensitivity to acidification (LAVAN1, LAVAN2, and Chilliwack-Agassiz Project Areas.** British Columbia Ministry of Environment and Parks, Surveys and Mapping Branch, Victoria.

Abstract: The British Columbia Ministry of Environment and Parks is using a computerized mapping system, referred to as CAPAMP (Computer Assisted Planning and Assessment Mapping Program). This report describes an algorithm developed to be used with this system to derive computerized ratings of soil sensitivity to acidification, based on previously collected soil survey information. Output products are a listing of sensitivity ratings of soils within a selected map area, and a map portraying these sensitivity ratings. The report describes three sensitivity rating schemes developed for the Fraser Valley.

Holowaychuk, N., and J.D. Lindsay, 1982. **Distribution and relative sensitivity to acidification of soils: Sand River area, Alberta.** Prepared by Alberta Research Council, Soils Department for Alberta Environment Research Management Division and Canadian Petroleum Association. Alberta Research Management Division Report RMD 82/13.

Abstract: Soils in the Sand River area of east central Alberta were classified into categories of sensitivity. Cold Lake, Lac la Biche and Grande Centre are located in the area. A detailed soil survey of the Sand River area had been completed recently, and there is a potential for petroleum extraction in the region. The objectives of the project were to explore the feasibility of using soil survey data to develop criteria for classifying soils into categories of sensitivity to acidification and to develop procedures to use soil survey maps to show the areal distribution of soils classified according to their category of sensitivity.

Holowaychuk, N., G. Padbury, and B. Schreiner, 1981. **Sensitivity of soils to acidic deposition in a selected region of western Canada.** Paper presented at the Canadian Meteorological and Oceanographic Society, 15th Annual Congress, May 27-29, 1981, Saskatoon, Saskatchewan.

Abstract: This paper evaluates the relative sensitivity to acidic deposition of the soils of northern Saskatchewan and northeastern Alberta. Three categories of soil sensitivity were established. Most of the soils in the most sensitive category are classified in the podzolic and brunisolic orders and occur in the Canadian Shield. Large tracts of relatively sensitive organic soils occur in northern Alberta.

Lore, J.A., 1984. **Observations of pH in field soils near a sour gas plant in Alberta.** Water, Air, and Soil Pollution 21(1-4):403-410.

Abstract: Soil pH was observed in natural soil profiles near a sour gas plant in southern Alberta. Samples were collected during the spring and fall from 1973 to 1981. No soil acidification was observed.

Nyborg, M., R.W. Parker, S. Takyi, and P. Yeung, 1985. **Deposition of sulphur and its influence on soils in the AOSERP study area.** AOSERP Report L-96. Prepared for Research Management Division, Alberta.

Abstract: Field investigations were carried out to determine the amounts of sulphur deposited in rain, in rain washing off trees, and by direct absorption of SO2 by soil. It was found that soils absorbed SO2 directly from air and that this absorption resulted in increased top layer acidity. In field experiments ground limestone counteracted the effects of applied sulphuric acid on the soil acidity levels.

Nyborg, M, J. Crepin, D. Hocking, and J. Baker, 1977. **Effect of sulphur dioxide on precipitation an on the sulphur content and acidity of soils in Alberta, Canada.** Water, Air and Soil Pollution 7(4):439-448.

Abstract: Rain and snow in Alberta are seldom acid, but rain intercepted by forest trees exposed to sulphur dioxide emissions becomes acid and has a sulphur content 3 to 4 times higher than unpolluted rain. Soils absorb large amounts of sulphur from emissions. Particulates deposit 3 to 4 times as much sulphur as is deposited by rainfall.

Overrein, L.N., 1978. **Acid precipitation - impacts on the natural environment.** Paper presented at the Alberta Sulphur Gas Research Workshop III, Edmonton, November 17-18, 1977.

Abstract: Anthropogenic emissions of sulphur and nitrogen oxides have been observed to result in increases of acidity in precipitation. Scandinavia and eastern North America are examples of areas where, due to long range transport of air pollutants, precipitation is acidic. Effects on terrestrial ecosystems are often subtle, when compared to those on aquatic systems. Desulphurization of fuels and stack gases appear to be the only short-term solution. International cooperation is necessary for a solution to this problem.

Quesnel, H.J., J.H. Wiens, and H. Chuah. In prep. **Acid buffering in British Columbia soils - a buffer parameter and predictive relationships.** British Columbia Ministry of Environment and Parks, and British Columbia Ministry of Agriculture and Fisheries, Victoria.

Abstract: This report describes investigations of the acid buffering characteristics of soils in British Columbia. In a laboratory investigation, 236 soil samples from 14 soil survey areas of British Columbia were equilibrated with sulphuric acid. Titration curves were drawn, and several measures of buffering capacity derived. After these measures were statistically analysed, predictive measures were derived for different areas of the province and for different groupings of soils.

Shewchuk, S.R., 1982. **An acid deposition perspective for northeastern Alberta and Northern Saskatchewan.** Water, Air and Soil Pollution 18:413-419.

Abstract: In the bedrock geology there is a zone of calcareous material running through the study area. Lakes to the north of this zone are in the Precambrian Shield and are highly sensitive to acid deposition. Those to the south are relatively insensitive. Deposition of sulphur and nitrogen compounds in study area is low but may increase in the future due to emissions growth.

Wiens, J.H., P.F. Epp, H.A. Luttmerding, and V. Hignett, 1987. **Soil and geology sensitivity to acidification in British Columbia.** British Columbia Ministry of Environment and Parks, Waste Management Branch and Surveys and Resource Mapping Branch, Victoria.

Abstract: This report accompanies three maps being prepared for British Columbia: "Soil and Geology Characteristics Significant to Acidic Input Sensitivity", "Potential of Soil and Geology to Reduce Acidity of Atmospheric Deposition", and "Soil Sensitivity to Acidic Inputs". The report reviews the rating criteria and evaluation methods, as well as the sources of inventory information, used in preparing these maps.

Wiens, J.H., G.A. Padbury, R.J. Fessenden, D.L. Wotton, J.P. Senyk, E. Paquin, and N. Holowaychuk, 1987. **Sensitivity of Western and Northern Canadian soils and geology to acidic inputs.** Prepared by the Western Canada Committee on Soil and Geology Sensitivity Mapping for the Western Canada LRTAP Technical Committee.

Abstract: This report accompanies two maps, "Potential of Soils and Geology to Reduce Acidity of Atmospheric Deposition" and "Soil Sensitivity to Acidic Inputs", being prepared for Western and Northern Canada. The report explains the meaning of "sensitivity" with reference to these maps, and reviews the rating criteria that were used in preparing the source maps. Important aspects of mapping methodologies used in each of the provinces and territories are discussed.

Wiens, J.H., 1983. **Soils and geology sensitivity mapping in western Canada.** British Columbia Ministry of Environment and Parks, Victoria.

Abstract: This report outlines issues discussed and decisions taken at a meeting of the Task Force on Soil and Geology Sensitivity Mapping. It discusses sensitivity rating criteria, including sensitivity class limits and the assessment procedures to be used. The report is the basic guiding document for methods to be used in the cooperative project between the Western Provinces and the Territories to map soil and geology sensitivity to acidic inputs.

Wiens, J.H., 1982. **Soils and geology sensitivity mapping in western Canada - issues and guidelines.** British Columbia Ministry of Environment and Parks, Victoria.

Abstract: This preliminary report reviews issues discussed prior to the beginning of soil and geology and sensitivity mapping in Western Canada. After discussing concerns regarding the use of proposed ecodistrict mapping as a basis for preparation of sensitivity maps, the report outlines critical issues on which agreement will need to be reached for a coordinated programme of sensitivity mapping.

Wotton, D.L., and P.W. Haluschak, 1986. **Mapping of soils and bedrock sensitivity to acidic deposition in Manitoba.** Manitoba Department of the Environment, Workplace Safety and Health, Terrestrial Standards and Studies Report 86-1.

Abstract: The Manitoba Department of Environment and Workplace Safety and Health and the Canada-Manitoba Soil Survey cooperatively developed two maps to reflect soil and geological sensitivity to acidic deposition. Areas of high sensitivity were located on the east side of Lake Winnipeg and in the northwest corner of Manitoba.

Yeung, P.Y.P., 1980. **Soil acidification by emitted sulphur in the Athabasca Oil Sands area.** University of Alberta, M.Sc. thesis.

Abstract: The amount of emitted sulphur absorbed by a lichen-covered soil was measured during field experiments in the AOSERP study area. Sulphur in rainfall was found to be relatively low, compared to sulphur absorbed directly by the soil. Soil acidification by the application of sulphuric acid and elemental sulphur were also studied, as well as the use of liming to correct soil acidity.

EFFECTS ON VEGETATION

Abouguendia, Z.M., 1982. **Relative sensitivity of Saskatchewan forest vegetation to acidic precipitation.** Saskatchewan Research Council Publication No. C-805-23-F-82.

Abstract: Not available.

Abouguendia, Z.M., L.A. Baschak, and R.C. Godwin, 1986. **Effects of simulated acidic precipitation on Saskatchewan crop and forest species: results of the 1985/86 experiments.** Saskatchewan Research Council Technical Report No. 191.

Abstract: Not available.

Abouguendia, Z., and L.A. Baschak, 1987. **Response of two western Canadian conifers to simulated acidic precipitation.** Water, Air, and Soil Pollution 33(1-2):15-22.

Abstract: Ready-to-plant nursery stock of jack pine (Pinus banksiana Lamb.) and white spruce (Picea glauca (Moench) Voss) were subjected to simulated acid rains of varying pH to determine the threshold for damage. Growth and chlorophyll content of jack pine were not affected. White spruce showed no statistically significant effects, except for reduction of chlorophyll b

Abouguendia, Z.M., and R.C. Godwin, 1982. **Potential effects of acidic deposition on plants and plant communities with special reference to northern Saskatchewan.** Saskatchewan Research Council Publication No. C-805-44-A-82.

Abstract: Not available.

Abouguendia, Z.M., and P.C. Godwin, 1981. **The effects of acidic precipitation on plants with special reference to northern Saskatchewan and north eastern Alberta.** Saskatchewan Research Council Report No. C-805-28-E-80.

Abstract: Not available.

Abouguendia, Z.M., and R.C. Godwin, 1981. **Potential effects of acidic deposition on plants and plant communities with special reference to northern Saskatchewan.** Paper presented at Canadian Meteorological and Oceanographic Society, 15th Annual Congress, 27-29 May 1981, Saskatoon, Saskatchewan.

Abstract: This paper reviews the literature pertaining to the effects of acidic deposition on plants. It attempts to assess the potential ecological effects on northern Saskatchewan of projected increases in air pollutant emissions and acidic deposition. A tentative relative sensitivity analysis of the natural terrestrial and wetland ecosystems is presented.

Adams, C.M., N.G. Dengler, and T.C. Hutchinson, 1984. **Acid rain effects on foliar histology of Artemisia tilesii.** Canadian Journal of Botany 62(3):463-474.

Abstract: This paper describes the effects of simulated acid rain on foliar histology of an arctic herb, Artemisia tilesii, which is tolerant to the naturally occurring atmospheric acidity of the Smoking Hills area.

Addison, P.A., 1980. **Baseline condition of the jack pine biomonitoring plots in the Athabasca Oil Sands area, 1976-1977.** Project LS 3.4.2. Report prepared for Alberta Oil Sands Environmental Research Program.

Abstract: A set of 13 jack pine biomonitoring sites was established to order impingement and impact of emissions from oil sands extraction operations. No measurable air pollutant effect on either vascular or lichen communities was observed, despite increased tissue pollutant concentrations having been documented from sites with 10 km of the Great Canadian Oil Sands plant.

Addison, P.A., S.S. Malhotra, and A.A. Khan, 1984. **Effect of sulfur dioxide on woody boreal forest species grown on native soils and tailings.** Journal of Environmental Quality 13(3):333-336.

Abstract: This paper reports on a study of the influence of sulphur dioxide emissions on net carbon dioxide assimilation rate of trees and development of visible symptoms of injury. In fumigation experiments, deciduous species were found to be more affected by sulphur dioxide than were conifers. Conifers grown on an oil sands tailings dike had lower rates of carbon dioxide assimilation than did other conifers.

Addison, P.A., and K.J. Puckett, 1980. **Deposition of atmospheric pollutants as measured by lichen element content in the Athabasca oil sands area.** Canadian Journal of Botany 58(22):2323-2334.

Abstract: This paper reports on the results of determining the aluminum, potassium, sulphur, titanium, and vanadium contents of lichens in sites in the Athabasca oil sands area. The accumulation of these elements by lichens was related to both gaseous and particulate emissions from industrial sources and to a localized windblown dust component. Deposition of atmospheric emissions around an oil-extraction plant, as measured by lichen thallus concentration closely followed distribution patterns measured by physical and chemical methods.

Addison, P.A., S.J. L'Hirondelle, D.G. Maynard, S.S. Malhotra, and A.A. Khan, 1986. **Effects of oil sands processing emissions on the boreal forest.** Canadian Forestry Service, Northern Forest Research Centre Information Report NOR-X-284.

Abstract: A research programme was carried out to determine the effects of emissions from oil sands processing on the boreal forest of the Athabasca Oil Sands area. Significant uptake by vegetation and soils of industrial emissions was generally restricted to within 10 km of the major source. Lichens and mosses were the most affected. The results suggest that the low level and infrequency of pollutant episodes, coupled with the assimilative capacity of the soil and the resiliency of vascular plants, have prevented damage to trees.

Amundson, R.G., R.B. Walker, and A.H. Legge, 1986. **Sulphur gas emissions in the boreal forest: the West Whitecourt Case Study. VII. Pine tree physiology.** Water, Air and Soil Pollution 29(2):129-147.

Abstract: Net photosynthesis, leaf resistance, and transpiration of a naturally occurring hybrid (lodgepole pine x jack pine) were measured as part of a study investigating the chronic exposure of a forest ecosystem to emissions from a gas plant in west central Alberta. The objectives of this portion of the study were to determine if exposure to sulphur gas emissions (and also ambient SO_2 concentrations) were affecting the rate of net photosynthesis.

Baschak,L., and Z.M. Abouguendia, 1982. **Response of Saskatchewan boreal plant species to acidic deposition: results of preliminary experiments.** Saskatchewan Research Council Technical Report No. 125.

Abstract: Not available.

Case, J.W., 1984. **Lichen biomonitoring networks in Alberta.** Environmental Monitoring and Assessment 4(3):303-313.

Abstract: The paper discusses the use of lichens for monitoring air pollution. Because lichens and bryophytes make up a significant portion of the forest vegetation in Alberta, lichen biomonitoring is an important technique for monitoring the effects of air pollution and acid rain. Bioaccumulation studies can be used to estimate actual rates of deposition and to check the accuracy of pollutant dispersion models.

Feller, M.C., 1986. **Analysis and interpretation of stream and precipitation chemistry for the ARNEWS plot at the U.B.C. Research Forest. Final report.** Submitted to Canadian Forestry Service, Pacific Forestry Centre, Victoria, B.C.

Abstract: This report discusses stream and precipitation chemistry data relevant to the ARNEWS (Acid Rain National Early Warning System) plot near Haney, approximately 40 km east of Vancouver. This plot lies on the boundary of a small forested watershed which has been studied since 1971. A proposal for future research into acid rain effects on coastal B.C. forests is presented.

Fox, C.A., 1986. **Tree-ring variation in western larch (Larix occidentalis) exposed to sulfur dioxide emissions.** Canadian Journal of Forest Research 16(2):283-292.

Abstract: Cores were collected from trees in three control stands, and from five stands known to have been polluted by sulphur dioxide emissions from the lead-zinc smelter at Trail, British Columbia. Tree-ring analyses of radial growth were made for years before and after the installation of two tall stacks (1925), for drought and nondrought years, and for the years before smelting began. The study suggests that the effects of sulphur dioxide emissions on tree growth in polluted areas persisted after the introduction of pollution controls.

Fox, C.A., 1980. **The impact of air pollution on western larch as detected by tree-ring analysis.** Arizona State University Ph.D. thesis.

Abstract: The growth response of western larch to sulphur dioxide was studied in the Columbia River Valley near the lead-zinc smelter at Trail, British Columbia. Increasing sulphur emissions in the early 1900's, reaching a maximum in 1930, resulted in decreased annual tree growth. After 1930, following the introduction of pollution abatement measures, sulphur emissions decreased dramatically. However, growth recovery in the western larch was not immediate. This study at sites at varying distances from the smelter shows the applicability of tree-ring analysis to examining the long-term effects of air pollution on trees and to examining the interrelationships between air pollution, climate, and annual tree growth.

Kennedy, K.A., P.A. Addison, and D.G. Maynard, 1985. **Effect of particulate elemental sulphur on moss.** Environmental Pollution 39,Ser A (Ecol. Biol.) (1):71-77.

Abstract: In a study of the influence of particulate elemental sulphur on the moss component of lodgepole pine in west-central Alberta, mosses closest to the emissions source were found to be eliminated. The percentage of moss alive and the total sulphur content of the forest litter are proposed as indicators of the impact and extent of elemental sulphur contamination of lodgepole pine forests in the foothills of Alberta.

Kotturi, M.S., et al, 1985. **Pine Valley Lichen Study: preliminary report.** British Columbia Ministry of Environment, Waste Management Branch, Environmental Services Section. Unpublished report.

Abstract: In May 1980 twenty lichen monitoring stations were established to study the impact on lichens of sulphur dioxide emissions from the Pine River Gas Plant near Chetwynd, B.C. Lichen specimens were photographed in 1980, and in 1983 specimens from nine sites were rephotographed. A preliminary assessment showed no correlation between lichen growth rate and ambient sulphur dioxide levels. The report recommends relocation of some sites and refinement of photographic techniques.

Krouse, H.R., A.H. Legge, and H.M. Brown, 1984. Sulphur gas emissions in the boreal forest: the West Whitecourt case study. V. Stable sulphur isotopes. Water, Air, and Soil Pollution 22(3):321-347.

Abstract: As part of a study of sulphur gas emissions from the West Whitecourt Gas Plant, this paper discusses the use of sulphur isotope ratios to assess the fate of sulphur gas emissions and the movement of sulphur compounds in the four main compartments of the forest ecosystem - air, vegetation, soil, and water. The stable sulphur isotope compositions of lodgepole x jack pine needles at sampling locations around the gas plant were consistent with wind summaries for the area. Stable sulphur isotopes were found to be practical environmental tracer of industrial sulphur in the forest ecosystem of Alberta.

Legge, A.H., et al, 1978. Sulphur gas emissions in the boreal forest: the West Whitecourt Case Study. II. Final report. Submitted to the Whitecourt Environmental Study Group (WESC).

Abstract: This study was undertaken to determine the consequences to the forest ecosystem of chronic exposure to low concentrations of sulphur gas emissions originating from the West Whitecourt Gas Plant. Foliage of lodgepole x jackpine trees was used for physiological and biochemical experiments.

Malhotra, S.S., 1979. Interim report on physiology and mechanisms of air-borne pollutant injury to vegetation, 1975 to 1978. Prepared for Alberta Oil Sands Environmental Research Program Project VE 3.3.

Abstract: Biochemical studies conducted under controlled conditions to measure response of plants to low concentrations of S02. Although there was no visually apparent damage to the foliage, the plants showed biochemical responses that could adversely affect the growth and yield of vegetation. An attempt was made to detect pre-visual SO2 injury to jack pine and white spruce in the immediate vicinity of the Great Canadian Oil Sands operation. No appreciable differences in biochemical or physiological functions were found.

Malhotra, S.S., and P.A. Addison, 1980. **Interim report on symptomology and threshold levels of air pollutant injury to vegetation, 1975 to 1978.** Report prepared for Alberta Oil Sands Environmental Research Program Project VE 3.1..

Abstract: Six boreal forest plant species were fumigated in an environmental growth chamber for up to 40 days at 0.34 ppm SO_2. All species showed a gradual decline in CO_2 gas exchange. Paper birch was the species the most sensitive to SO_2 injury followed by green alder, jack pine, Labrador tea, and white and black spruce.

Malhotra, S.S., and R.A. Blauel, 1980. **Diagnosis of air pollutant and natural stress symptoms on forest vegetation in western Canada.** Environment Canada, Canadian Forestry Service, Northern Forest Research Centre, Information Report NOR-X-228.

Abstract: Industrial operations in Alberta, Saskatchewan, Manitoba, and the Northwest Territories release airborne emissions that can injure forest vegetation. This report describes symptoms of industrial pollutant effects and of natural stresses that may appear similar. Both deciduous and coniferous species are discussed.

Malhotra, S.S., and A.A. Khan, 1979. **Interim report on physiology and mechanisms of airborne pollutant injury to vegetation, 1978-1979.** Prepared for Alberta Oil Sands Environmental Research Program.

Project LS 3.3. AOSERP Open File Report O.F.2.

Abstract: Controlled exposure studies showed that activities of important enzymes altered significantly after fumigation of plants with SO_2. It was observed also vanadium and nickel were toxic to cellular processes. Laboratory methods were used to detect air pollutant injury to vegetation in the oil sands area.

Malhotra, S.S., A. Addison, and A.A. Khan, 1980. **Symptomatology and threshold levels of air pollutant injury to vegetation, 1979-80.** Prepared by Canadian Forestry Service, Northern Forest Research Centre for Alberta Oil Sands Environmental Research Program Project LS 3.1.

Abstract: Coniferous and deciduous species that had been growing on the Suncor tailings sand dike for five to seven years were fumigated with SO2 under controlled environmental conditions. When the results were compared with those from similarly fumigating the same coniferous species grown on native soils, the coniferous species grown on the tailings dike were found to be much more sensitive to SO2 injury. Due to a pollution chamber breakdown, the deciduous species were not ranked.

Nosal, M., 1983. **Atmosphere-biosphere interface: probability analysis and an experimental design for studies of air pollutant-induced plant response.** Alberta Environment Research Management Division Report RMD 83/25.

Abstract: This report assesses the state of knowledge about the numerical definition of air pollutant dose as it related to vegetation response. The first part of the report is a literature survey of recent publications, including reports of the National Crop Loss Assessment Network. A numerical probabilistic model is then developed and its statistical goodness-of-fit to Minnesota air pollutant exposure-soybean response data is analysed. The findings are applied to an experimental design for integrating air quality data to vegetation response and predictions in Alberta.

Palmer, K.A., 1986. **The establishment of cryptogamic biomonitoring supblots to supplement Canadian Forest Service ARNEWS plots.** Submitted by Larkspur Biological Consultants to Canadian Forest Service, Pacific Forestry Centre, Victoria, B.C.

Abstract: Thirty four permanent supblots were established in five of the Canadian Forest Service ARNEWS (Acid Rain National Early Warning System) plots. The plots were located on Saltspring Island, in the Shawinigan Lake and Coquitlam Lake areas, and in the U.B.C. Research Forest at Haney. Six permanent subplots were established on Saltspring Island and the Shawinigan Lake area. Ash analyses of samples from the Saltspring and Coquitlam plots revealed higher than background levels of sulphur, lead and aluminum. It is recommended that the lower elevation ARNEWS Coquitlam Lake plot be evaluated for suitability in the ARNEWS plot system and that precipitation chemistry in the Saltspring Island plot be monitored.

van Barneveld, J.W., 1983. **Crop sensitivity to soil acidification.** British Columbia Ministry of Environment and Parks, Waste Management Branch, Victoria. Unpublished manuscript.

Abstract: This report on soil acidification, discusses the type of crop, the initial acidity of the soil, the ability of the soil to neutralize acidifying inputs, the rate at which acidifying inputs are applied to the soil. The report also discusses fertilizing, soil management, as the well as the counteracting of acidification by the use of liming.

van Barneveld, J.W., and R.D. Marsh, 1986. **Port Alice SO2 impacts: vegetation.** British Columbia Ministry of Environment and Parks, Waste Management Branch Technical Report 25.

Abstract: This report describes damage to plants caused by sulphur dioxide emissions from the Port Alice pulpmill. The damage includes chlorosis, necrosis, defoliation and die-back. In some cases, the emissions have caused death of plants. In areas of moderate to high sulphur dioxide concentrations, some evergreen species were less abundant than expected. In areas of severe impact, there were no lichens. Sulphur concentration in foliage is a function of sulphur dioxide concentrations in the air and of the duration of exposure. Foliage exposed to the main airflows had higher sulphur concentrations than did foliage within the forest canopy. Drought, disease, and insect infestations were not causes of these plant injuries.

Wong, R.K.W., and M. English, 1984. **Crop damage and sulfur emission trends in central Alberta.** Alberta Research Council Atmospheric Sciences Report 84-1.

Abstract: This report explores historical trends in hail crop damage and the amount of sulphur emitted from sour gas plants processing plants in central Alberta. There appears to be a statistical relationship between crop damage and sulphur emissions. Because of climatic variations, these observations may be due to coincidence.

Wood, C.S., and G.A. Van Sickle, 1987. **Forest insect and disease conditions: British Columbia and Yukon, 1986.** Canadian Forestry Service, Pacific Forestry Centre Information Report BC-X-287.

Abstract: This report on forest pest conditions contains a brief discussion of the establishment of forest plots to be monitored for damage from acid rain. Symptoms directly attributable to acid rain have not been seen. Damage observed has usually been attributable to previous or current pest conditions.

Wood, C.S., and G.A. Van Sickle, 1986. **Forest insect and disease conditions: British Columbia and Yukon, 1985.** Canadian Forestry Service, Pacific Forestry Centre Information Report BC-X-277.

Abstract: This report on forest pest conditions contains a brief discussion of the establishment of forest plots for the obtaining of baseline knowledge and the detection and monitoring of changes that are caused by acid rain.

HEALTH EFFECTS

Hazra, A.K., R. Prokopuk, and M.J. Hardin, 1977. **Chemical characteristics of snow in the Yellowknife area, N.W.T., 1975.** Environment Canada, Environmental Protection Service, Northwest Region Surveillance Report EPS-5-NW-77-7.

Abstract: During the winter of 1975 the Environmental Protection Service investigated the distribution and concentration of contaminants in snow in the Yellowknife area. The results showed that snow in the Yellowknife are does not conform to specifications for pH, arsenic, lead, iron and manganese under the Canadian Drinking Water Standards, 1968. The report therefore recommends that the public in the area be informed of the potential hazard and be dissuaded from using melted snow as a source of potable water.

Meranger, J.C., and D.R. Gladwell, 1986. **Application of a conceptual model to assessing the impact of acid rain on drinking water quality.** Water Quality Bulletin 11(1):26-33,60.

Abstract: This study examines the effects of acid precipitation on surface and subsurface freshwater chemistry and the quality of domestic water in order to develop an index to allow prediction of drinking water quality in acid-sensitive areas. Shelburne, Nova Scotia and Sioux Lookout, Ontario were the two acid-sensitive areas chosen for the study. La Ronge, Saskatchewan was the control area.

Meranger, J.C., D.R. Gladwell, and R.E. Lett, 1986. **Application of a conceptual model to assess the impact of acid precipitation on drinking water quality. II. - Studies of chemical thermodynamic equilibria in water.** Water Quality Bulletin 11(3):152-159,173. Abstract: A theoretical conceptual model developed to study the degree of acid rain impact on drinking water sources in acid-sensitive areas of Canada is used to generate saturation index values for over 100 minerals. The model was derived from data obtained through analysis of water samples collected at two acid-sensitive areas, Shelburne, Nova Scotia and Sioux Lookout, Ontario, and one control area, La Ronge, Saskatchewan.

Razienne, M., R. Burnett, B. Stern, and J.C. Meranger, 1986. **Transported air pollutants and respiratory health in two Canadian communities.** Paper presented at Third International Conference on Environmental Lung Disease, Montreal, Quebec, Canada, October 15-18, 1986. Abstract in Chest 91(2)1987: 314.

Abstract: A study was conducted to examine the possible examination between transported air pollution, commonly known as "acid rain", and the respiratory health of children chronically exposed to these pollutants. Two communities, Tillsonburg, Ontario and Portage La Prairie, Manitoba were selected. Tillsonburg residents represented the exposed population. Portage La Prairie was the control community. Results of the study show that respiratory health and function of children living in areas impacted by acid rain may be adversely affected by the air pollutants.

Spitzer, W.O., 1986. **Southwest Alberta Medical Diagnostic Review Project: methods and results. Summary.** Report of the McGill Inter-University Research Group

Abstract: Investigators conducted a clinical epidemiological field study of an area that was exposed to sour gas emissions. It was not found that the health of the population was being affected by the emissions. The greater frequency of reported symptoms by study area residents, when compared to reports by control area residents, appears to be caused by greater concerns of the study area residents about their health.

CONTROLS AND LEGISLATION

British Columbia Hydro and Power Authority, 1977. **A brief on coal-fired power plants submitted to the Pollution Control Branch for presentation at the Public Inquiry to Review Pollution Control Objectives for the Mining, Mine-Milling and Smelting Industries of British Columbia, commencing at Victoria, British Columbia, 10 January, 1978.**

Abstract: Available technology for control of particulates and sulphur dioxide emissions from coal-fired power plants is reviewed. Considering environmental and economic factors, the brief proposes changes to specific objectives and guidelines for contaminants in emissions from large scale coal-fired power plants.

Edwards, C., 1987. **Current acid gas emission control options for western Canada - a review.** Report prepared for Western Canada LRTAP Technical Committee.

Abstract: This report reviews proven control technologies applicable to major Western Canadian emission sources of sulphur dioxide and nitrogen oxides. Industries are grouped under the gas to be controlled, and the control technologies are summarized briefly.

Hart, A.G., R.G. Humphreys, A.L. McMullen, and B.U. Patel, 1983. **A review of the technology available for the control of atmospheric emissions from oil sands plants.** Prepared by Dynawest Projects Ltd. for Alberta Environment. Alberta Environment Research Management Division Rept. RMD 83/19.

Abstract: This report provides an overview of technology available for the control of sulphur and nitrogen oxide emissions from oil sands plants. Processes are described. Capital and annual operating costs are discussed.

RTM Engineering Limited, 1985. **Characterization and control of odourous emissions from oil and natural gas fields.** Prepared for Environment Canada, British Columbia Ministry of Energy, Mines and Petroleum Resources, and British Columbia Ministry of Environment.

Abstract: Concentrations of hydrogen sulphide, sulphur dioxide, and hydrocarbons in the ambient air were monitored at 19 petroleum industry facilities in the Fort St. John area. After a review of the process technology being used at these facilities and a literature of emission control technologies, recommendations were made regarding monitoring and control of odourous emissions.

Scott, A., 1984. **Acid rain, the I.J.C., certificates and the principles of international negotiation.** University of British Columbia Programme in Natural Resource Economics Resources Paper No. 98.

Abstract: This paper discusses the limitations of the International Joint Commission in dealing with acid rain, the latest crisis in Canadian-American environmental relations. An international pollution-certificates proposal is shown to have promise as providing an agenda under which the "principles" issue of territoriality versus neighbourliness can be negotiated with respect to the acid rain problem.

Summers, P.W., 1985. **Regional background atmospheric sulphate levels in Canada: preliminary estimates and implications for control strategies.** Prepared for the Federal Provincial Advisory Committee on Air Quality.

Abstract: It is now believed that geographic and climatic factors, as well as distance from upwind air pollution sources, result in the precipitation of each region having its own background pH level. As part of the discussion of precipitation pH levels, differences in regional atmospheric chemistry within Canada are described. The significance of regional background pH levels in precipitation for the development of control strategies is discussed.

ALPHABETICAL INDEX OF AUTHORS

Alberta Government/Industry Acid Deposition Research Program, 1984. **First annual report: January 1, 1983 to March 31, 1984.** 2

Alberta Government/Industry Acid Deposition Research Program, 1985. **Second annual report: April 1,1984 to March 31, 1985.** 2

Amundson, R.G., R.B. Walker, and A.H. Legge, 1986. **Sulphur gas emissions in the boreal forest: the West Whitecourt Case Study. VII. Pine tree physiology.** Water, Air and Soil Pollution 29(2):129-147. 62

Angle, R.P., 1979. **Air quality modelling and user needs.** Prepared by Alberta Environment, Air Quality Control Branch for Alberta Oil Sands Environmental Research Program Project AS 4.5. 17

Baker, J., 1980. **Differences in the composition of soils under open and canopy conditions at two sites close-in to the Great Canadian Oil Sands Operation, Fort McMurray, Alberta.** Prepared for Alberta Oil Sands Environmental Research Program. Project LS 3.4.1. AOSERP Report 97. 53

Baker, J., D. Hocking, and M. Nyborg, 1977. **Acidity of open and intercepted precipitation in forests and effects on forest soils in Alberta.** Water, Air and Soil Pollution 7(4):449-460. 53

Baldwin, J.H., ed., 1985. **Acid rain in the Pacific Northwest: proceedings of the Acid Rain Symposium, Annual Conference of the Northwest Association for Environmental Studies.** University of Victoria, Victoria, British Columbia. 3

Barrie. L.A., 1986. **Background pollution in the arctic air mass and its relevance to North American acid rain studies.** Water, Air and Soil Pollution 30(3-4):765-777. 17

Barrie, L.A., and J. Kovalick, 1980. **A wintertime investigation of the deposition of pollutants around an isolated power plant in northern Alberta.** Prepared for Alberta Oil Sands Environmental Research Program Project AS 3.2. AOSERP Report 90. 17

Barrie, L.A., and D.M. Whelpdale, 1977. **Wintertime sulphur deposition measurements in the Athabasca Oil Sands area.** In Proceedings of Alberta Sulphur Gas Research Workshop III, Edmonton, Alberta, November 17-18, 1977. 18

Baschak,L., and Z.M. Abouguendia, 1982. **Response of Saskatchewan boreal plant species to acidic deposition: results of preliminary experiments.** Saskatchewan Research Council Technical Report No. 125. 63

Bennett, R.C., 1981. **Summary of emissions, air quality and meteorology for the Peace region.** British Columbia Ministry of Environment, Assessment and Planning Division Working Paper 1981-01-01. 12

Bernard, D.P., 1981. **Brief presented to the House of Commons Committee on Acid Rain.** 3

Bertram, H.L., N.C. Das, and Y.K. Lau, 1986. **Precipitation chemistry measurement in Alberta.** Water, Air and Soil Pollution 30(1-2):231-237. 18

Bewley, R.J.F., and D. Parkinson, 1986. **Monitoring the impact of acid deposition on the soil microbiota, using glucose and vanillin decomposition.** Water, Air and Soil Pollution 27(1-2):57-68. 53

Bewley, R.J.F., and D. Parkinson, 1985. **Bacterial and fungal activity in sulphur dioxide polluted soils.** Canadian Journal of Microbiology 31(1):13-15. 53

Bewley, R.J.F., and D. Parkinson, 1984. **Effects of sulphur dioxide pollution on forest soil microorganisms.** Canadian Journal of Microbiology 30(2):179-185. 54

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Abstract: This report on forest pest conditions contains a brief discussion of the establishment of forest plots for the obtaining of baseline knowledge and the detection and monitoring of changes that are caused by acid rain.