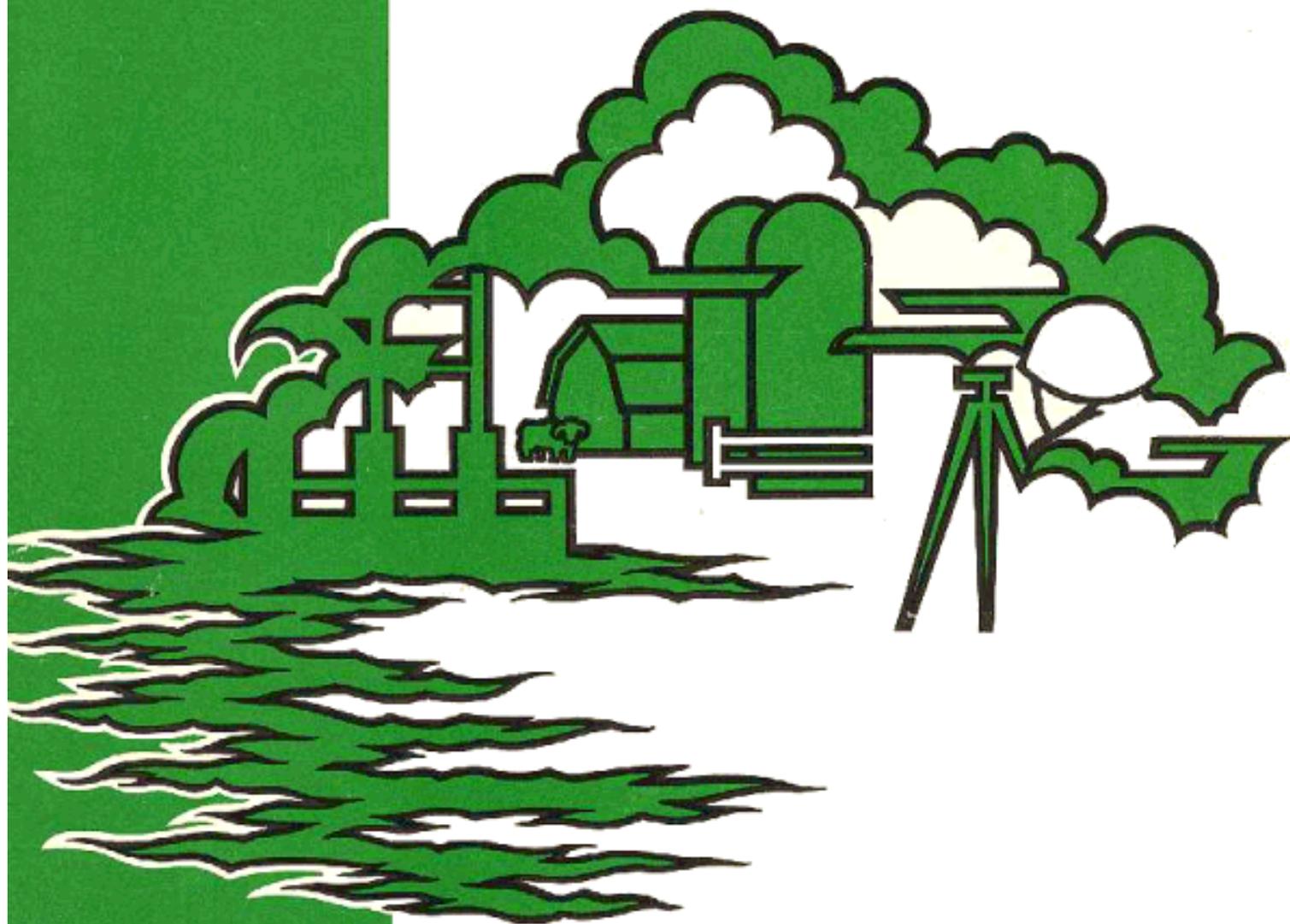


**INTERNATIONAL REFERENCE GROUP  
ON GREAT LAKES POLLUTION  
FROM LAND USE ACTIVITIES**



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**INTERNATIONAL  
JOINT  
COMMISSION**

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**ANNOTATED BIBLIOGRAPHY OF  
PLUARG REPORTS**

**INTERNATIONAL REFERENCE GROUP ON GREAT LAKES POLLUTION  
FROM LAND USE ACTIVITIES (PLUARG)**

**ANNOTATED BIBLIOGRAPHY OF PLUARG REPORTS**

**INTERNATIONAL JOINT COMMISSION  
GREAT LAKES REGIONAL OFFICE**

**1979**



## PREFACE

Studies concerning the water quality in Lakes Erie and Ontario were completed and submitted to the International Joint Commission in 1969. These studies demonstrated that diffuse land drainage sources of pollutants were not only significant, but also highly variable. They were, therefore, difficult to measure. Subsequent improvements in wastewater treatment for point sources of pollution magnified the relative importance of the land drainage sources of many pollutants, necessitating a clearer definition of the impact of land use activities, practices and programs on water quality in the Great Lakes. Therefore, the governments of Canada and the United States, on signing the 1972 Great Lakes Water Quality Agreement, requested the International Joint Commission to investigate pollution of the Great Lakes system from agriculture, silviculture and other land use activities. Specifically, the Commission was requested to report on the following questions:

- (1) Are the boundary waters of the Great Lakes System being polluted by land drainage (including ground and surface runoff and sediments) from agriculture, forestry, urban and industrial land development, recreational and park land development, utility and transportation systems and natural sources?
- (2) If the answer to the foregoing question is in the affirmative, to what extent, by what causes, and in what localities is the pollution taking place?
- (3) If the Commission should find that pollution of the character just referred to is taking place, what remedial measures would, in its judgment, be most practicable and what would be the probable cost thereof?

The Commission was further requested to consider the adequacy of existing programs and control measures, and the need for improvements relating to:

- (a) inputs of nutrients, pest control products, sediments, and other pollutants from the sources referred to above;
- (b) land use;
- (c) land fills, land dumping, and deep well disposal practices;
- (d) confined livestock feeding operations and other animal husbandry operations and
- (e) pollution from other agricultural, forestry and land use sources.

In carrying out its study the Commission was also asked to identify deficiencies in technology and recommend actions for their correction.

In November 1972 the Commission appointed an International Reference Group on Great Lakes Pollution from Land Use Activities (PLUARG), composed of nine Canadian and nine United States representatives, to conduct the study under the Great Lakes Water Quality Board.

Detailed plans for the study were developed early in 1973 and assignments were made to both Canadian and American agencies and qualified individuals to commence studies on specific tasks and programs within the PLUARG study. The detailed plans were subsequently updated in 1976.

The Study Plan emphasized four main tasks:

- Task A To assess problems, management programs and research and to attempt to set priorities in relation to the best information now available on the effects of land use activities on water quality in boundary waters of the Great Lakes.
- Task B To inventory land use and land use practices, with emphasis on certain trends and projections to 1980 and, if possible, to 2020.
- Task C To study intensively a small number of representative watersheds, selected to permit some extrapolation of data to the entire Great Lakes Basin and to relate contamination of water quality, which may be found at river mouths on the Great Lakes, to specific land uses and practices.
- Task D To diagnose the degree of impairment of water quality in the Great Lakes, including an assessment of concentrations of contaminants in sediments, fish and other aquatic resources.

The Study involved five years of intensive surveys, data analysis, interpretation and reporting. A final report entitled "Environmental Management Strategy for the Great Lakes System" was presented to the Commission in July 1978.

This annotated bibliography describes all the PLUARG Technical Reports as well as the major unpublished reports, background documentation, and detailed data compilations prepared as part of the Reference Group's study. The reports are listed according to Task A, B, C or D as set up under the detailed study plan.

PLUARG report numbers are all prefaced by ZZ IJC 769/PLUARG followed by the year of the publication and the page number of the item in the bibliography. The PLUARG numbers are located at the bottom right-hand corner of the pages.

The Library at the Regional Office has copies of all the documents listed in the bibliography and most may be borrowed on interlibrary loan. All the published reports will eventually be available on microfiche and a limited number of paper copies are still available from the IJC Great Lakes Regional Office, 100 Ouellette Avenue, 8th Floor, Windsor, Ontario N9A 6T3 Canada.

A selection of thirty out-of-print documents is available on microfiche or printed on request at the National Technical Information Service (NTIS), Document Sales, U.S. Department of Commerce, Springfield, Virginia 22161. NTIS accession numbers are printed at the bottom left-hand corner of relevant pages.

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# **PLUARG FINAL REPORT**



- # International Reference Group on Great Lakes Pollution from Land Use Activities. **Environmental Management Strategy for the Great Lakes System. Final Report to the International Joint Commission.** Windsor, Ontario, July 1978, 115 pp.

### Summary

The Canada-United States Agreement on Great Lakes Water Quality signed at Ottawa, April 15, 1972, by the President of the United States and the Prime Minister of Canada, requested the International Joint Commission to conduct a study of pollution of the boundary waters of the Great Lakes System from agricultural, forestry and other land use activities. As a result, an intensive inquiry was conducted by the International Reference Group on Great Lakes Pollution from Land Use Activities (PLUARG), established by the International Joint Commission.

Effective strategies at the international, national and local levels must be developed to cope with pollution from land use activities, since it transcends jurisdictional and political boundaries. Flexible management systems and control measures capable of incremental adjustments in response to a changing environment will be required. As well, questions of equity must be taken into account and a formula arrived at for the reasonable allocation of responsibility between governments, institutions and individuals. Above all, it is essential to recognize that the management of nonpoint sources will require a dramatic departure from the traditional approach followed for the control of point sources.



## **PLUARG MODELLING REPORTS**



# Johnson, Murray G. et al. **Management Information Base and Overview Modelling.** Submitted to the International Reference Group on Great Lakes Pollution from Land Use Activities of the International Joint Commission. Windsor, Ontario, August 1978, 90 pp.

Heidtke, Thomas M., William C. Sonzogni and Timothy J. Monteith. **Management Information Base and Overview Modeling: Update of Projected Pollutant Loadings to the Great Lakes.** Submitted to the International Reference Group on Great Lakes Pollution from Land Use Activities. April 1979, 38 pp.

### Summary

The data management base developed for overview modelling and the modelling process itself have contributed to PLUARG's goal of determining the relative importance of all pollutant sources and in developing plans for pollution abatement from land sources. Overview modelling provides a means of comparing present and future trends in pollutant inputs to the lakes, as well as a methodology for measuring the effectiveness of alternative remedial programs applied to urban nonpoint, rural nonpoint and municipal point sources.

In the update pollutant projections have been generated for Lakes Superior and Michigan. Preliminary estimates of heavy metal inputs to each of the lakes has been made. Concurrently, heavy metal inputs from the Canadian Basin have been examined by staff at the Canada Centre for Inland Waters.

ZZ IJC 769  
PLUARG 78-002

ZZ IJC 769  
PLUARG 79-002

PB 296849/AS

- # Drynan, W.R. and M.J. Davis. **Application of the Universal Soil Loss Equation to the Estimation of Nonpoint Sources of Pollutant Loadings to the Great Lakes.** Submitted to the International Reference Group on Great Lakes Pollution from Land Use Activities of the International Joint Commission. Windsor, Ontario, July 1978, 102 pp.

### Summary

This report describes the preliminary assessment of nonpoint sources of pollutant loadings to the Great Lakes using a computer model developed by the Midwest Research Institute (MRI) for the United States EPA, based on the Universal Soil Loss Equation (USLE). This model was also used to make a preliminary analysis of the feasibility of achieving costs. The more comprehensive "overview model", based on the unit area loads developed from the PLUARG Task C pilot watershed studies and land characteristics in the basin, was also developed to investigate cost-effective alternative programs for specific watersheds. The details of the latter model and its application are reported in another PLUARG Technical Report - **Management Information Base and Overview Modelling** and the PLUARG Final Report - **Environmental Management Strategy for the Great Lakes System.**

ZZ IJC 769  
PLUARG 78-003

Drynan, W.R. **Relative Costs of Achieving Various Levels of Phosphorus Control at Municipal Wastewater Treatment Plants in the Great Lakes Basin.** Technical Report to the International Reference Group on Great Lakes Pollution from Land Use Activities of the International Joint Commission. July 1978, 59 pp.

## Summary

The International Joint Commission suggested that a study be carried out to determine the impact of phosphorus control programs on municipal wastewater treatment, particularly with respect to sludge production and attendant costs for treatment and disposal. At the same time, the Research Advisory Board's Committee on Water and Wastewater Treatment was given a referral from the Water Quality Board to determine the feasibility of achieving concentrations of less than 1.0 mg/L "P" (total phosphorus) and as low as 0.1 mg/L "P" in the municipal wastewater treatment plant effluents. Consequently, this study was undertaken to evaluate, in as rigorous a manner as practical, the implications of alternative legislative restrictions on the allowable concentrations of phosphorus in detergents, on the effluents of municipal wastewater treatment plants and on the cost of building and operating these plants.

ZZ IJC 769  
PLUARG 78-004

# Marsalek, J. **Pollution Due to Urban Runoff: Unit Loads and Abatement Measures.**  
Submitted to the International Reference Group on Great Lakes Pollution from Land Use  
Activities of the International Joint Commission. Windsor, Ontario, October 1978, 37 pp.

### Summary

Annual unit pollutant loads from urban runoff were established and recommended for use in the PLUARG model. The recommended loads are based on both the APWA loads and the selected Ontario data. The APWA loads for BOD, nitrogen and phosphorus agreed fairly well with the loads derived from the Ontario data and formed a basis for the recommended loads. The loads recommended for suspended solids and selected metals were derived from the Ontario field data. As is obvious from the range of unit loads reported in the literature, the recommended loads are likely to contain uncertainties as high as several hundred percent.

Three levels of abatement of pollution due to urban runoff were proposed and the associated costs determined.

ZZ IJC 769  
PLUARG 78-005

## **WORKSHOP PROCEEDINGS**



- # **Proceedings of a Workshop on Water Quality and Land Use Activities.** Held at Guelph, Ontario, September 11-12, 1973. Sponsored by the International Reference Group on Great Lakes Pollution from Land Use Activities of the International Joint Commission, J.D. Wiebe, ed., Windsor, Ontario, 1974, 248 pp.

### Summary

This workshop was organized to draw upon the expertise and knowledge of scientists from a variety of disciplines to provide PLUARG with expert advice and assistance in refining its study plan. Included in the sessions were: the fate of pesticides and fertilizers applied to land and crops, pilot watersheds, river and groundwater transport phenomena, waste disposal on rural land and limnological processes in the Great Lakes.

ZZ IJC 769  
PLUARG 74-006

# **Proceedings of the Sandusky River Basin Symposium**, Held at Tiffin, Ohio, May 23, 1975. Cosponsored by Heidelberg College and Bowling Green State University. David B. Baker, William B. Jackson and Bayliss L. Prater, eds., 1975, 475 pp.

### Summary

The Sandusky River Basin Symposium, held at Heidelberg College in Tiffin, Ohio and jointly sponsored by Heidelberg College and Bowling Green State University, brought together more than 150 persons engaged in environmental research, monitoring and management, both in the Sandusky Basin and surrounding areas. The program scope and the purpose of the symposium indicated:

A considerable amount of ecological research and monitoring activity is taking place within the Sandusky River and Bay areas. The research ranges from studies of the geology, hydrology, and soils of the basin and bay to measurements of the biological and chemical characteristics of the river and bay. In this conference, the individuals who are involved in the entire scope of the above research efforts, as well as those involved with water quality management within the basin, will present their research results and current management practices.

The purpose of this conference is to provide an opportunity for the scientists engaged in ecological research and those engaged in management to exchange detailed information that will aid both in future work. The conference should also provide useful information to individuals working in other river basin studies and anyone interested in the relationships between ecosystem research and river basin management.

The symposium was successful in attaining many of these objectives, and the diversity and detail of environment-related studies underway in the Sandusky Basin and Bay areas was impressive. The historical perspectives of this region, as brought forth in papers by Trautman, Forsyth and Stuckey, created a useful foundation. The keynote address by Cummins, extending stream ecosystem theory to larger rivers, had significant impact on both ecosystem concepts and management application. The contributions of personnel in governmental agencies provided an overview of programs within which environmental planning and management take place.

ZZ IJC 769  
PLUARG 75-007

- # **Proceedings of a Workshop on the Fluvial Transport of Sediment-Associated Nutrients and Contaminants**, Held in Kitchener, Ontario, October 20-22, 1976. Sponsored by the Research Advisory Board of the International Joint Commission on behalf of the Pollution from Land Use Activities Reference Group. H. Shear and A.E.P. Watson, eds., 1977, 309 pp.

### Summary

Sponsored by the Research Advisory Board at PLUARG's request, this workshop was held to synthesize current research and to identify research needs on nutrient and contaminant transport *by* sediment within fluvial systems. Clarification was sought on the interrelationships of source, in-channel storage, resuspension and transport mechanisms with long-term, seasonal and single-event flows. Also included is an examination of the interaction of sediment and water chemistry on key nutrients and contaminants.

Recommendations and research needs are given.

ZZ IJC 769  
PLUARG 77-008



## **TASK 'A' REPORTS**

To assess problems, management programs and research and to attempt to set priorities in relation to the best information now available on the effects of land use activities on water quality in boundary waters of the Great Lakes.



- # International Reference Group on Great Lakes Pollution from Land Use Activities. **Summary Review of Pollution from Land Use Activities.** Windsor, Ontario, July 1975, reprinted September 1976, 66 pp.

### Summary

This report summarizes the findings of the Canadian and U.S. Task A investigations concerning land use/water quality relationships in the Great Lakes Basin.

ZZ IJC 769  
PLUARG 75-009

# International Reference Group on Great Lakes Pollution from Land Use Activities  
Task Group A (U.S. Section). **Management Programs, Research and Effects  
of Present Land Use Activities on Water Quality of the Great Lakes.** 2 vols.  
Windsor, Ontario, November 1974, 1052 pp.

### Summary

This report consists of a state-of-the-art assessment prepared by Task A (U.S.)  
for the following land use activities.

Vol. I A1: Residential areas  
A2: Commercial and industrial areas  
A3: Transportation  
A4: Extractive areas  
A5: Pesticides and herbicides  
A6: Nutrients  
A7: Erosion and sedimentation  
A8: Animal wastes  
A9: Intensive animal feedlots

Vol. II A10: Forestry  
A11: Recreation land  
A12: Undeveloped land  
A13: Liquid waste disposal  
A14. Solid Waste Disposal  
A15: Land fills (dredging activities)  
A16: Deepwell disposal  
A17: Management and control of land use/water quality problems

- # Castrilli, J.F. and A.J. Dines. **Control of Water Pollution from Land Use Activities in the Great Lakes Basin: An Evaluation of Legislative and Administrative Programs in Canada and the United States.** Windsor, Ontario, March 1978, 109 pp.

### Summary

This report presents a joint summary and comparative review of detailed separate studies carried out in Canada and in the United States of legislative, regulatory and administrative programs which address the control of pollution from land use activities. Principal agencies and levels of government with roles in each of nine land use categories identified by PLUARG are discussed. Comparative observations have been made with respect to the effectiveness of programs intended to prevent water pollution from land use activities.

Section 2 of this report contains a discussion of each land use activity. The first part of each of these land use discussions presents a summary description of the institutional framework relevant to that activity. The observations which constitute the second part of each are evaluative comments based on the background studies.

Section 3 contains a discussion of several policy issues which either have general relevance to the study, though not to any one category, or have special importance to several land use activities.

# Linton and Co., Inc. **The Legislative and Institutional Framework to Control Pollution from Land Use Activities in the United States Great Lakes Basins.** 3 vols. Submitted to PLUARG Task Group A by Linton and Co., Inc. under contract to the Great Lakes Basin Commission. Windsor, Ontario, April 1978, 993 pp.

- v.1 Summary Report, a Comparative Analysis, Federal Framework.
- v.2 States of Illinois, Indiana, Michigan and Minnesota.
- v.3 States of New York, Ohio, Pennsylvania and Wisconsin.

(A separate report containing only the Summary Report is also available).

### Summary

This study jointly undertaken by the United States and Canada, addresses the review and evaluation of the existing legislative/regulatory framework available for controlling pollution from land use activities. The study participants have performed the following tasks:

- (1) described the content of the existing legislation/regulation framework available at each level of government for controlling the nonpoint discharges of sediments, nutrients, pesticides and chemicals associated with the following land use categories: urban areas, transportation corridors, extractive operations, agriculture, recreational areas, forested areas, liquid, solid and deepwell disposal areas, shoreline landfilling activities lakeshore and riverbank erosion;
- (2) described the extent of the regulatory power, the commitment to develop and undertake programs and the degree of enforcement practised at each of the specified levels of government relative to pollution from land use activities;
- (3) identified other relevant governmental and non-governmental programs and policies which would have an indirect bearing on the control of pollution from land use activities;
- (4) identified those land use categories for which the four major pollutants (sediments, nutrients, pesticides and chemicals) are least controlled;
- (5) outlined, in terms of the present jurisdictional framework, what possibilities for future action are available to each level of government;
- (6) described the alternatives for the future evolution of this legislative/regulatory framework based on discussions with those persons actively working with the present framework and
- (7) coordinated the Canadian contractors and the United States to develop a standardized format for comparing the legislative and regulatory approaches taken in each country.

- # **Castrilli, J.F. Control of Water Pollution from Land Use Activities in the Canadian Great Lakes Basin: An Evaluation of Legislative Regulatory and Administrative Programs.** Submitted to PLUARG Task Group A (Canadian Section). Windsor, Ontario, 1977, 460 pp. (A separate document containing only the first chapter of this report is also available).

## Summary

This report is a study of government activity with respect to controlling water pollution from nonpoint sources (or land uses) in the Canadian Great Lakes Basin. It examines the legislation, regulations and non-statutory programs which are being (or which could be) used to control this form of pollution. It identifies the principal agencies and government levels with roles in this area and offers an evaluation of control efforts and policies to date.

Chapter One is an overview of the situation. It briefly reviews the technical/physical nature of the nonpoint pollution problem and provides a summary analysis of the institutional arrangements available for controlling the various land use impacts of water quality and resources. Findings in this chapter are based on the more detailed institutional review which is provided on a land use basis in Chapters Two through Ten.

Institutional mechanisms reviewed include planning, pollution control and fiscal and proprietary/management schemes, both legislated and non-legislated. The role of the public is considered as well as key judicial decisions affecting the nature and extent of legislation and its enforcement in this general area. Voluntary/advisory programs and educative initiatives are also noted.

PB 296868/AS

- number refers to 1st chapter only

ZZ IJC 769  
PLUARG 77-013

# Marshall Macklin Monaghan Ltd. **Evaluation of Remedial Measures to Control Nonpoint Sources of Water Pollution in the Great Lakes Basin.** Submitted to PLUARG Task Group A. Windsor, Ontario, October 1977, 159 pp.

## Summary

This study was undertaken to provide an evaluation of the structural/non-structural remedial measures available to control nonpoint sources of water pollution in the Great Lakes Basin. For the purposes of this study, nonpoint water pollution was defined as including all sources of water pollution with the exception of discharges from industrial operations and municipal sewage treatment plants. The latter two categories were classified as point sources.

Although the study was completed in Canada, it is expected that the findings will be utilized in both Canada and the United States.

The study was approached in two phases. In the first phase, the contractor inventoried and evaluated the remedial measures related to the control of sediments, nutrients, pesticides and chemicals associated with eleven land use categories. The evaluation included a description of the technique and a discussion of the frequency of use, source of design information, level of pollutant control achieved and the associated benefits and costs. This information is presented for each technique on a single catalogue page.

In order to avoid problems where a single remedial measure may be used to treat problems associated with a number of different land use activities, a system of cross references has been prepared in matrix form. By referring to this matrix, the user can quickly identify the remedial measures available to control any of the four pollutants associated with each of the designated land use activities. A page number is also included to direct the user to the correct catalogue entry.

The second study phase involved a review of those analytical techniques currently available to evaluate the application of individual remedial measures or combinations thereof in specific problem situations.

Information was collected from federal, provincial, state and local agencies as well as universities, research institutes and private industry.

- # Skimin, William E., Elizabeth C. Powers and Eugene A. Jarecki. An **Evaluation of Alternatives and Costs for Nonpoint Source Controls in the United States Great Lakes Basin**. Technical Report of the International Reference Group on Pollution from Land Use Activities of the International Joint Commission. July 1978, 351 pp.

### Summary

This report presents an evaluation of nonpoint source problems affecting the Great Lakes and estimated costs for a range of remedial control programs. The consideration of potential critical problem areas was limited to the following:

- 1) urban areas
  - stormwater runoff and combined sewer overflows;
  - construction site runoff and
  - runoff controls for new development.
  
- 2) agricultural areas
  - erosion and sedimentation and
  - animal waste disposal.
  
- 3) on-site waste disposal.

- # Powers, Elizabeth C. and Eugene A. Jarecki. **Survey of U.S. Great Lakes Basin Farmers Regarding Water Pollution from Agricultural Activities.** Survey by Statistical Reporting Services. Submitted to PLUARG Task Group A (U.S. Section). Windsor, Ontario, November 1977, 33 pp.

## Summary

The survey of farmers in the U.S. Great Lakes Basin regarding water pollution from agricultural activities was conducted in July 1977 to discover farmers' opinions concerning the effect on water quality of certain agricultural activities and farmers' attitudes concerning pollution abatement issues. In addition, farmers were asked about their use of various conservation practices and the factors which prompt this conservation activity.

Approximately 900 farmers were chosen to be interviewed using a stratified area sampling frame to ensure reliable representation of farmers in the region. Half of the farmers were interviewed in person, nearly 40% were contacted *by* telephone and the rest could not be contacted or refused to be interviewed. Results reflect activities and opinions of farmers in the U.S. Great Lakes Basin.

Analysis of survey results reveal:

1. field crops provide the main income for about half of the farmers in the U.S. Great Lakes Basin; most of the rest are principally livestock and poultry farmers; about 5% derive most of their income from fruits and vegetables. Nearly three out of four farmers own some livestock or poultry;
2. more than half of the farmers in the basin report gross annual sales of less than \$10,000. Many of the Great Lakes Basin farms may be small operations;
3. eight out of ten farmers mention newspapers and magazines as one of their sources of information on water pollution; seven out of ten identify radio or television;
4. nearly 90% of the farmers in the region follow some kind of conservation practice. The motivating factors are soil conservation and increased yield or production. Half of the farmers state that they are following a conservation plan; about 50% say they cooperate in their local soil conservation district and
5. most farmers believe that no relationship exists between farm fertilizers/pesticides, manure or eroded soil, and Great Lakes water quality. Only 19% are of the opinion that manure contributes to pollution of the Great Lakes; 32% believe that fertilizers and pesticides used in farming are pollutants and almost half consider eroded soil a contributor to Great Lakes pollution.

- # Bangay, Garth E. **Agriculture and Water Pollution - An Assessment of the Practices and Attitudes of Ontario Farmers.** Submitted to the International Reference Group on Pollution from Land Use Activities of the International Joint Commission. February 1979, 87 pp.

### Summary

As part of the overall study of the Pollution from Land Use Activities Reference Group, this survey was conducted to assist the Reference Group in the formulation of remedial measure recommendations which were presented to the International Joint Commission in July 1978. The Reference Group, which was charged with the responsibility of studying pollution of the Great Lakes from land use activities, had in the early stages of the study identified urban and agricultural land use activities as being of prime concern. Realizing that the successful implementation of remedial measures, especially in agriculture, would to a large extent rely on the voluntary cooperation of farmers, the Reference Group undertook this survey to provide them with much needed information on the agricultural community.

The survey was undertaken in the summer of 1977 and through the selection of a stratified random sample of Ontario farmers, interviewers were able to visit some 1755 farms and complete 1484 valid records. The study concentrated on gathering information in three different areas. Two of these dealt with specific problems associated with agriculture, erosion and sedimentation and livestock manure, and the third was directed towards the problem of implementing remedial measures.

ZZ IJC 769  
PLUARG 79-017

# International Reference Group on Pollution from Land Use Activities. **Reports of the United States Public Consultation Panels to the Pollution from Land Use Activities Reference Group.** Windsor, Ontario, March 1978, 148 pp.

### Summary

Early in 1977 PLUARG began a program of public information and public consultation, leading to the establishment of citizen panels in each of the states bordering the Great Lakes and throughout Ontario.

PLUARG's public consultation program marks the first time that public input has been sought prior to the completion of a reference group report to the International Joint Commission.

- # International Reference Group on Pollution from Land Use Activities. **Reports of the Canadian Public Consultation Panels to the Pollution from Land Use Activities Reference Group.** Windsor, Ontario, March 1978, 86 pp.

### Summary

These reports were wholly written, reviewed and approved by each of the eight panels. They are the result of a series of three meetings of each panel held during the fall of 1977. The reports reflect the hard work, dedication and genuine concern of the panelists to meet their Panelist Statement of Work, viz.

- 1) to consider the Pollution From Land Use Activities Reference Group reference, major associated issues and possible remedial measures;
- 2) to identify remedial action for PLUARG;
- 3) to attend three meetings;
- 4) to interact with group members and elicit responses;
- 5) to elect a chairman to conduct meetings and provide continuity;
- 6) to have access to all available reports and to PLUARG resource people;
- 7) to present to PLUARG by January 15, 1978 a written report stating concerns, findings and the panel's recommendations on remedial measures;
- 8) to evaluate the advisory panel process and
- 9) to have published the findings and recommendations stated in the panel reports to PLUARG and to make this volume available for general distribution.



## **TASK 'B' REPORTS**

To inventory land use and land use practices, with emphasis on certain trends and projections to 1980 and, if possible, to 2020.



- \* Crysler, Ralph and Keith Lathem. **Mine Tailings Disposal Sites Waste Disposal Sites, Non-Sewered Residential Areas and Land Fill Sites.** (Unpublished). Land Drainage Reference Study Task B2, Canada Department of the Environment. Willowdale, Ontario, 1974, 182 pp.

### Summary

This report, with its accompanying tables and maps, deals with the following parts of Task 82 Study Plan of the Land Drainage Reference Study:

- 1) mine tailing disposal sites;
- 2) waste disposal sites;
- 3) non-sewered residential areas and
- 4) landfill sites.

It describes the sources of data and the methods of data collection as well as describes certain gaps in the data and their sufficiency.

ZZ IJC 769  
PLUARG 74-020

# Doneth, John. **Materials Usage in the U.S. Great Lakes Basin.** Submitted to PLUARG Task Group B (U.S. Section) in cooperation with the Great Lakes Basin Commission. September 1975, 319 pp.

### Summary

This report provides an up-to-date inventory of production and/or usage within the United States portion of the Great Lakes Basin of certain materials applied to the land which can potentially reach the Great Lakes system through land drainage. The data on selected materials was collected by county, planning subarea and lake drainage area, then combined to represent the total U.S. Great Lakes Basin.

The study calculated the amounts of chemicals (herbicides, insecticides, and fungicides) used on crops. The types and acreage of various crops, pastures, vegetables and fruits were inventoried. The common rates of application were then applied to the acreage providing the calculations shown in this report.

The livestock manure produced was calculated. The amounts were based on an inventory of swine, cattle, sheep, horses, chickens and turkeys. The production in terms of nitrogen, phosphorus and potash were also calculated.

The commercial fertilizer used on farms was based on actual reports of use by state. Use by county was available for the corn belt states and was calculated for the other states. The amounts of nitrogen, phosphorus and potash in the fertilizer were likewise based on actual reports or calculated.

The amounts of lime applied were calculated based on actual use reports.

The salts (deicing compounds) applied to federal, state, county and municipal highways were calculated based on actual use reports.

- \* Gierman, David M. and Robert A. Ryerson. **Land Use Information for the Great Lakes Basin.** (Unpublished). Submitted to the Pollution from Land Use Activities Reference Group, Technical Committee B. 1974, 584 pp.

## Summary

The project reported here constitutes the Canadian Section of Task B1, Land Use Inventory, conducted as part of the PLUARG Task B. The results of this project are presented in tables and maps which were derived from an updated and expanded Canada Land Inventory.

The rationale of the land use classification is described first. The four subsequent sections provide technical details on the methodologies used to collect, compile, tabulate and finally map the data. The Tables of Data on Land Use compiled in accordance with the guidelines laid down by the Technical Committee of Task B are presented with the requested maps at the end of the report.

ZZ IJC 769  
PLUARG 74-022

# International Reference Group on Great Lakes Pollution from Land Use Activities. Land Use and Land Use Practices in the Great Lakes Basin **Joint Summary Report - as United States and Canada**). Windsor, Ontario, September 1977, 45 pp.

### Summary

This report summarizes the **Inventory of Land Use and Land Use Practices in the Great Lakes Basin**, including trends and projections to 1980, and to 2020, where appropriate.

Land uses are broken down for each lake basin as follows:

Area (Land and Water)	Forest
Residential	Outdoor Recreation
Commercial - Industrial	Wetlands
Cropland	Barren
Pasture	Water (Inland)

In addition, eight specialized land use categories are discussed and units quantified:

Mine Tailings Disposal Areas	Lakeshore and Riverbank Erosion
Liquid and Solid Waste Disposal Areas	Intensive Livestock (Operations)
Dredge Spoil Disposal	High Density Non-sewered Areas
Deepwell Disposal	Recreational Lands

Annual materials usages are presented for:

Agricultural Pesticides	Agricultural Manures
Commercial Fertilizers	Lime
	Road Salt

For more detailed information one should refer to the reports prepared for the United States part of the Great Lakes Basin in six volumes and the five-volume Canadian counterpart. The land use inventory and projections are to serve as the basis for extrapolating the data from the pilot watershed studies to the entire Basin in order to quantify loadings and identify and rank contributing areas and land uses.

# Great Lakes Basin Commission. **Inventory of Land Use and Land Use Practices in the United States Great Lakes Basin with Emphasis on Certain Trends and Projections to 1980, and Where Appropriate, to 2020.** 6 vols. PLUARG Task Group B (U.S. Section) Report. Windsor, Ontario, 1976.

v.1	Great Lakes Basin	March 1976 146 pp.
v.2	Lake Superior Basin	March 1976 214 pp.
v.3	Lake Michigan Basin	April 1976 408 pp.
v.4	Lake Huron Basin	April 1976 188 pp.
v.5	Lake Erie Basin	May 1976 295 pp.
v.6	Lake Ontario Basin	May 1976 226 pp.

### Summary

This report describes and quantifies, as appropriate, the Great Lakes Basin's geology, soils, minerals, climate, surface *and* ground water, vegetation, wildlife, and economic and demographic characteristics. It inventories available information on waste disposal operations, lakeshore and riverbank erosion, high-density non-sewered residential areas and recreational land uses, as well as materials application of agricultural chemicals, fertilizers, lime, animal wastes and salts on highways. Finally, future trends and projections are shown for the above categories.

PB 296855/AS  
Volume I only

ZZ IJC 769  
PLUARG 76-024

# International Reference Group on Great Lakes Pollution from Land Use Activities. **Inventory of Land Use and Land Use Practices in the Canadian Great Lakes Basin with Emphasis on Certain Trends and Projections to 1980, and Where Appropriate, to 2020.** 5 vols. PLUARG Task Group B (Canadian Section). Windsor, Ontario, 1977.

v. 1 Canadian Great Lakes Basin Summary	December 1977	125 pp.
v. 2 Canadian Lake Superior Basin	December 1977	55 pp.
v. 3 Canadian Lake Huron Basin	December 1977	93 pp.
v. 4 Canadian Lake Erie Basin	December 1977	75 pp.
v. 5 Canadian Lake Ontario Basin	December 1977	85 pp.

### Summary

The reports describe and quantify, as appropriate, the Canadian Great Lakes Basin's geology, soils, minerals, climate, surface and ground water, vegetation, wildlife, and economic and demographic characteristics. They inventory available information on waste disposal operations, lakeshore and riverbank erosion, high-density nonsewered residential areas and recreational land uses, as well as materials application of agricultural chemicals, fertilizers, animal wastes and salts on highways. Finally, future trends and projections are shown for the above categories.

- # Monteith, Timothy J. and Eugene A. Jarecki. **Land Cover Analysis for the United States Great Lakes Watersheds**. Submitted to PLUARG Task Group B. Windsor, Ontario, May 1978, 53 pp.

### Summary

A critical element in the Pollution from Land Use Activities Reference Group Study for the International Joint Commission is an up-to-date inventory of land use. Such an inventory was compiled for the U.S. Basin in 1973 and 1974 under Task B of PLUARG. The land use compilation was accomplished under contract with the United States Environmental Protection Agency by the Laboratory for Applications of Remote Sensing (LARS) of Purdue University, using LANDSAT I satellite data. The LARS work was carried out on a county basis with emphasis on urban, agricultural and silvicultural uses.

The LARS work was a state-of-the-art pioneering effort using satellite data on a large scale. While it offered a significant advancement in the technology, problems were left unsolved, particularly in defining urban areas. The results of this work are presented in the six-volume **Inventory of Land Use and Land Use Practices** (see p. TB-7).

As the PLUARG study developed, new needs arose in the area of land use inventories. A particular need was a land use or land cover analysis by watershed. For the overview modelling effort in particular, a subwatershed land cover inventory was essential.

In the spring of 1977 it was recognized that a land cover analysis by watershed was needed and that it was needed quickly. As the direction of the Reference Group developed so too did the technology for the utilization of LANDSAT satellite data. The computer technology and operator expertise had improved tremendously from the very first efforts made in the early 1970's. It was then decided by members of PLUARG Task B to seek good land cover estimates on a watershed basis.

The information presented herein is the result of this land cover analysis on a watershed basis. It must be recognized that this information was compiled using a more recent data base and a greatly advanced technology from that presented in the PLUARG Task B reports. Wherever possible the information presented here should be used in lieu of that presented in the Task B reports entitled **The Inventory of Land Use and Land Use Practices**. A detailed description of the methodology used here is presented in the Appendix, **Land Cover Classification**, by Thomas F. Westcott and Robert O. Breault.

- \* Deutscher, P. **The Usage of Biocides, Fertilizers, and Road Salts in the Great Lakes Basin: Projections to 2020.** (Unpublished). Submitted to PLUARG Task B-5-Land Use Forecasts. May 1976, 72 pp.

## Summary

The purpose of the study was to produce forecasts of materials usage relevant to "the transfer of pollutants to the Great Lakes System" through land drainage. Three categories of materials were examined: pesticides, fertilizers and road salts.

Pesticides are discussed in Chapter 1. The patterns of pesticide use *by* the various components of Ontario agriculture are examined along with trends in the volume of pesticide use. Trends in agriculture as a whole are evaluated inasmuch as they affect the pattern of pesticide use. Projections of the volumes of herbicides, fungicides and insecticides applied by Ontario farmers are made for the target years 1980, 2000 and 2020.

Fertilizers, which are discussed in Chapter 2, receive a cursory treatment relative to the other categories of materials. The agricultural scenario upon which the forecasts are based is essentially the same as that discussed in the chapter on pesticides, and Chapter 2 is limited to presenting information on trends in fertilizer use, forecasting fertilizer use **and** explaining the forecasting procedure.

Chapter 3 discusses and projects the use of salt as a tool for snow and ice control on roads and highways. The rather scarce data that are available on the use of deicing salt, past and present, are presented. The environmental and social problems that result from road salt use are discussed and alternatives to deicing salt are considered. Finally, forecasts of salt use are presented.

ZZ IJC 769  
PLUARG 76-027

- \* Sudar, A. **The Social and Economic Implications of Eutrophication in the Canadian Great Lakes Basin.** (Unpublished draft). Submitted to PLUARG Task Group B. January 1978, 29 pp.

### Summary

Eutrophication is neither altogether good nor altogether bad. The various human uses of Great Lakes water have different tolerances for the side-effects of eutrophication (excessive algae and aquatic plants). In the case of algae on shore properties, the tolerance is very low; reductions in property values occur with even slight amounts of algae present.

Water-oriented recreation also has a relatively low tolerance for eutrophication because its manifestations are so obvious to the human senses.

Industrial and power users have resolved one of their problems by the use of submerged intake pipes, but others may have to be resolved in the future.

Although Ontario Ministry of the Environment officials insist that no matter how eutrophic the lakes become the water can still be made potable, there must be a limit beyond which treatment is impractical, if not impossible. And though more research is needed to determine what this limit might be, the consequences of reaching it would certainly be disastrous.

The report also considers the fact that phosphorus moves easily from land to water, but there is no natural mechanism whereby it can be returned to the land. Before the Great Lakes Basin was settled and urbanized, there was little movement of nutrients from land to water and the system was in equilibrium. Now, phosphate fertilizer is imported to replace what is lost to the lakes, but a finite supply of phosphorus makes this a temporary solution.

The primary socio-economic justification for the reduction of phosphorus loadings to the Great Lakes seems to lie in the beneficial impacts of improved water quality on the recreation industry, shore property values and general aesthetic considerations.

ZZ IJC 769  
PLUARG 78-028

- \* Muir, T. **Commercial-Industrial Land Use Projections.** (Unpublished). Submitted to PLUARG Task B-5 Land Use Forecasts. January 1976, 11 pp.

Summary

For the purpose of this project, the commercial-industrial sector was defined as all economic activity in the Great Lakes Basin, excluding agriculture, forestry, fisheries and mining. The estimates derived in the study are as follows:

COMMERCIAL-INDUSTRIAL LAND USE PROJECTIONS  
(ACRES)

BASIN	1980	2000	2020
1	6,361	8,177	10,005
2	272	350	422
3	954	1,230	1,457
4	3,123	4,179	5,521
5	6,805	8,903	11,157
6	5,542	7,257	9,459
7	3,354	4,475	5,755
8	29,870	39,280	51,212
9	23,844	33,067	44,056
10	120,141	158,351	206,097
11	16,178	20,979	26,790

ZZ IJC 769  
PLUARG 76-029

- \* Sudar, A. **Urban Land Use Forecasts**. (Unpublished). Prepared for PLUARG Task B-5-Land Use Forecasts. May 1976, 46 pp.

## Summary

Urban land use studies are inevitably bogged down by the problems of data availability and boundary definition. A search for time series land use data in the Great Lakes Basin showed that available land use data are incomplete at any time and incompatible between surveys either of the same city at different times or of different cities. Variations in measurement technique, classifications and urban area further reduce the usefulness of these scattered data.

Consequently, the urban land use forecasts in this report are based on a cross-sectional analysis of the relationship between urban population and urban area. They are basically unconstrained, assuming that no more effective planning than exists and that the economy will continue to be the major determinant of the urbanization process.

Two different methodologies were used. The first is the constant land consumption rate method which is based on the assumption that any increments of urban population will occupy as much space per person as the current urban population. The second approach is the allometric method which assumes that as population increases, urban area also increases, but at a slower rate, reflecting a higher density and more intense use of land in larger cities. Finally, a preferred forecast is presented which combines the best attributes of both methods and is called the declining land consumption rate forecast.

ZZ IJC 769  
PLUARG 76-030

- \* Coleman, Dell E. **Land-use Forecasting Model: Overview and Methodology.** (Unpublished). Prepared for PLUARG Task B-5. July 1975, 25 pp.

## Summary

The task of Group 8-5 has been:

to identify and assess future trends in major land-uses, specialized uses, material usage, and related information which directly or indirectly may affect the drainage of pollutants into the Great Lakes, for the target years 1980, 2000, 2020. The forecasts should take into consideration various assumptions that could be made regarding technological development, changes in attitude of the Basin population and consequent policy and legal adaptations.

The report outlines the units of analysis chosen, the perceived interrelationships of the various sectors in the total problem, details of the methodologies in each area, details of the computer implementation, as well as estimates of when results are likely to be available for distribution.

ZZ IJC 769  
PLUARG 75-031

- \* Deutscher, Patrick. **The Path of Ontario Agriculture: Land Use Projections to 2020**. (Unpublished). Prepared for PLUARG Task B-5-Land Use Forecasts. May 1976, 84 pp.

## Summary

Forecasts of agricultural activity in the Canadian Great Lakes Basin form part of PLUARG Task B, Activity 5.

The first part of the report describes and assesses the economic, technological and political forces that have propelled Ontario agriculture to its present position. Special attention is given to assessing the forces currently operative, that will define the trajectory of agriculture in the future.

The second part of the report describes three sets of land use forecasts for Ontario agriculture. These are based upon trend projections, upon alternative assumptions of technological advance and upon the assumption that political or economic factors will force agricultural output to grow in step with population.

ZZ IJC 769  
PLUARG 76-032

- \* Coleman, D. E. **Ontario Recreation: A Forecast to 2020**. (Unpublished). Submitted to PLUARG Task Group B-5. December 1976, 23 pp.

### Summary

This report discusses recreation as it relates to land use. In particular, the trends in consumer expenditure on recreation are examined as an indicator of the future magnitude of recreational involvement. The author found that there is a trend toward more participation in recreational activities and use of recreational facilities such that the expenditure on recreational goods and services is likely to increase eight-fold by 2020. However, gaps in the knowledge base prevent accurate calculation of land areas associated with the increase. It has been estimated that 50% of the increase in recreational spending will be on acquiring land. Additional detailed investigations will be necessary to determine accurately the nature of the relationship between recreational demand and recreational land required.

ZZ IJC 769  
PLUARG 76-033

- \* Sudar, A. and P. Deutscher. **Land Use Change in the Canadian Great Lakes Basin 1971-2020**. (Unpublished). Prepared for PLUARG Task Group B-5 Land Use Forecasts. May 1976, 46 pp.

## Summary

This paper reconciles and integrates the urban, agricultural and recreational forecasts which were done independently as parts of the Pollution from Land Use Reference Group (PLUARG) Task B-5. The first section presents the methodology by which the land use forecasts were consolidated and the changes in land use identified. The second section describes land use in four alternative futures. The alternative futures are based on land use policy options and on divergent paths of agricultural productivity.

Two major types of land use change will be considered:

- 1) rural to urban and
- 2) shifts among the non urban uses (agriculture, woodland and recreation).

The first type of change is most critical from a planning perspective because it is irreversible. Once land has been converted to urban use, all other options are closed. The general pattern is that farmers are replaced by land speculators, developers, home builders and urban homeowners, in that order.

Land use exchanges are largely restricted to the non-urban uses. For example, in Toronto urban fringe approximates land shifted from extractive to scrub woodland and from scrub woodland to extractive. Similar exchanges and shifts occur between the agricultural subclasses (improved and unimproved farmland) and back and forth between agriculture and woodland.

ZZ IJC 769  
PLUARG 76-034

- \* L.J. D'Amore & Associates Ltd. **Social, Institutional and Technological Trends and Synergisms Affecting Water Resources Quality in the Canadian Portion of the Great Lakes Basin.** (Unpublished). Submitted to the Canada Centre for Inland Waters. Burlington, Ontario, July 1975, 71 pp.
  
- \* L.J. D'Amore & Associates Ltd. **The Knowledge Base.** Appendix to report entitled **Social, Institutional and Technological Trends and Synergisms Affecting Water Resources Quality in the Canadian Portion of the Great Lakes Basin.** (Unpublished). Submitted to the Canada Centre for Inland Waters. Burlington, Ontario, July 1975, 180 pp.

### Summary

This report on the "synergistics project" was prepared for the Social Sciences Division, Inland Waters Directorate, Ontario Region by L.J. D'Amore and Associates Ltd. It represents a partial contribution to two major and current studies by the International Joint Commission on water quality in the Great Lakes. These are the Upper Lakes Reference Group (Working Group A, Study Item IV) and the Pollution from Land Use Activities Reference Group (Task B-5). In both cases, the role of this report is to contribute to the identification and description of future trends affecting Great Lakes water quality from a social, institutional and technological perspective.

ZZ IJC 769  
PLUARG 75-035 S  
ZZ IJC 769  
PLUARG 75-035 K

- \* Sonnen, C.A. and P.M. Jacobson. **Estimates of Economic Activity in Regions of the Canadian Great Lakes Basin for the Period 1972-2020**. Series A, Volume I. Submitted to the Canada Centre for Inland Waters. Burlington, Ontario, December 1974, 121 pp.
- \* **Estimates of Economic Activity in Regions of the Canadian Great Lakes Basin for the Period 1972-2020**. Series A, Volume II. Submitted to the Canada Centre for Inland Waters. Burlington, Ontario, May 1975, 35 pp.
- \* **Estimates of Economic Activity in Regions of the Canadian Great Lakes Basin for the Period 1972-2020**. Series B. Submitted to the Canada Centre for Inland Waters. Burlington, Ontario, August 1975, 149 pp.

## Summary

Prepared for both PLUARG and the Upper Lakes *Reference* Group, these reports provide a preliminary estimate of economic activity in the Great Lakes drainage regions from the present through 2020. Figures for real domestic product (excluding housing but including 31 other industrial categories) provide the projected measure of such activity. This study utilized the CANDIDE "Canadian Disaggregated Interdepartmental Econometric" model to produce the estimates.

Two sets of estimates were made and denoted "Series A" and "Series B". The Series A estimates are based on a set of assumptions compatible with a continued trend in the development of the Service Industry. Volume I contains a discussion of the overall forecast methodology, major assumptions and projected results, as well as the estimates for the Upper Lakes Regions. Volume II contains only the estimates for the Lower Lakes Regions.

The Series B estimates embody certain assumptions that differ from those in Series A. These differences primarily affect the long-term prospects for the supply of certain basic commodities. The discussion contained in Series B outlines these major differences, and estimates for both the Upper and Lower Great Lakes Regions are presented together.

ZZ IJC 769  
 PLUARG 74-036 AI  
 ZZ IJC 769  
 PLUARG 75-036 AII  
 ZZ IJC 769  
 PLUARG 75-036 8





## **TASK `C' REPORTS**

To study intensively a small number of representative watersheds, selected to permit some extrapolation of data to the entire Great Lakes Basin and to relate contamination of water quality, which may be found at river mouths on the Great Lakes, to specific land uses and practices.



# Chesters, G. *et al.* **Pilot Watershed Studies Summary Report.** Windsor, Ontario. June 1978, 78 pp.

## Summary

One of the four principal tasks of PLUARG, Task C was to determine the characteristics and locations of diffuse sources of pollutants in the Great Lakes Basin and to assess their relative significance. A further objective was to quantify the processes involved in transmission of pollutants from these sources to the boundary waters. The Technical Committee appointed by PLUARG to meet Task C objectives planned and supervised eight "pilot watershed" programs, each of which included intensive water quality monitoring and a great variety of source evaluation and process studies. The Task C report incorporates major findings of these studies and is structured to provide: a) a description of land uses in the pilot watersheds and in the Great Lakes Basin, b) a rationale for the choice of parameters receiving greatest emphasis, c) an evaluation of unit area loadings for individual land uses in the pilot watersheds, d) an extrapolation of unit area loads to the watersheds of each lake, e) a ranking of hazardous land uses for different parameters, f) a discussion of information and factors useful in designing alternative remedial strategies and g) future research, monitoring and demonstration needs.

Additional special studies were carried out by Task C investigators and provided information on private waste disposal systems, sanitary landfills, stream-bank erosion and other diffuse sources of pollutants.

# Bahr, Thomas G. **Felton-Herron Creek, Mill Creek Pilot Watershed Studies, Summary Pilot Watershed Report.** Submitted to PLUARG Task Group C Technical Committee, Synthesis and Extrapolation Work Group. Windsor, Ontario. January 1978, 48 pp.

## Summary

### FELTON-HERRON CREEK

The general conclusions to be drawn from this study are that:

- (1) the type of crop selected is important in management of land irrigation systems for the prevention of NO<sub>3</sub>-N losses.
  - a) annuals such as corn do not take up much nitrogen during the early part of the growing season. Such crops, therefore, should be irrigated at rates that will just replace evapotranspirational.
  - b) perennial grasses are the most effective vegetation at removing nitrogen from wastewater.
  - c) legumes such as alfalfa are about as effective as perennial grasses at nitrogen removal;
- (2) soils are effective at phosphorus sorption so that phosphorus concentrations of water leaching past the root zone on irrigated sites approach background levels;
- (3) runoff from spray sites should be avoided and
- (4) mature beech-sugar maple forests are not efficient at removal of nitrogen from wastewater. Such mature forests should not be used for wastewater renovation.

### MILL CREEK

Persistent compounds such as the chlorinated hydrocarbons are apparently being transported to the lakes despite their lack of use for several years in the watershed. Transport of these compounds are tied closely with the movement of suspended sediment, thus it would seem that measures to control sediment movement would also control the movement of chlorinated hydrocarbons.

Atrazine and guthion do appear in Mill Creek, but their significance as a problem in the Great Lakes is unclear at this time. Misuse and accidents with pesticides can be expected no matter how strict a set of regulations is enforced. The only safeguard is to ban the manufacture and use of formulations that could cause long-term problems in the event of a single accidental introduction.

- \* Burton, Thomas M. and Thomas G. Bahr. **The Felton-Herron Creek, Mill Creek Pilot Watershed Studies, Final Report.** Submitted to PLUARG Task Group C. Chicago, Illinois. June 1978, 213 pp.

### Summary

Two land uses, fruit orchard farming and land application of municipal wastewater irrigation, were studied to assess the sources, forms and amount of pollutants that are transported from these areas to the boundary waters of the Great Lakes. The primary concern of the Mill Creek study was the movement of pesticides from fruit orchards, while that of the wastewater irrigation study (Felton-Herron Creek study) was the transport of nutrients.

Analyses were conducted for fifty-seven different pesticides on both suspended sediment and sediment dissolved in water in the Mill Creek study. Of the eight pesticides found in appreciable quantities, the major forms exported were the chlorinated hydrocarbons, although they have not been used for several years. Most of the pesticides were transported on suspended solids. The pesticides lost in order of amount lost were DDT, DDE, atrazine, dieldrin, DDD, simazine, aldrin and guthion. Most pesticides lost were associated with past farming practices, e.g. DDT, DDE and DDD or corn cultivation in the watershed, e.g. atrazine with guthion being the only major pesticide associated with fruit orchard farming lost from the watershed. It was lost in only very small amounts.

The Felton-Herron Creek study demonstrated that improper management of land application systems for recycling municipal wastewater can lead to appreciable loading of streams with all the major nutrients, especially nitrogen. Proper management of such systems will control these losses. Perennial crops and old field systems are efficient at the uptake of both nitrogen and phosphorus throughout the growing season and offer excellent wastewater renovation potential. Annual crops such as corn are not efficient at nitrogen uptake during the early growth phase (first five to seven weeks). After that, they too are efficient. Lake successional forests are not efficient at nitrogen uptake and losses to groundwater or runoff often approach input amounts.

ZZ IJC 769  
PLUARG 78-039

# Hetling, L.J. et al. **Genesee River Pilot Watershed Study, Summary Pilot Watershed Report**. Submitted to PLUARG Task Group C. Windsor, Ontario. March 1978, 73 pp.

### Summary

The Genesee River was monitored for stream flow and a variety of water quality parameters under a program sponsored by PLUARG Task C. An integrated sampling program was operated from March 1975 through June 1977. Twenty-eight stations covered the spectrum of land use, soil type and geologic development found in the watershed. Pollutants studied in detail were total phosphorus, suspended solids and chloride.

Results of the study suggest that water quality is not entirely dependent on land use; soil type, geology and geomorphology also have a strong influence on the amounts and forms of various pollutants transported by surface waters. The intensely-farmed areas in the central and northern portions of the watershed lie on calcareous soils. These areas contribute higher unit loads of phosphorus, chloride and suspended solids than does the remainder of the watershed. Areas of cultivated muck land produce elevated phosphorus unit loads, and excessive chloride production is identified with those regions having extensive salt mining operations.

Variations in river loading indicate that urban land is relatively more productive than agricultural land for the parameters studied. Forested land is the least productive. A portion of urban impact is associated with point source discharges particularly with respect to chloride and phosphorus. Suspended solids, as an urban point source, have little impact. Large chloride point sources are storm water runoff and phosphorus is contributed from municipal wastewater.

Transport of the pollutants is variable within reaches and over the watershed. Conservative dissolved constituents tend to be transported undiminished, while particulate and reactive materials may be subject to substantial processing. The nature of the system, however, makes it difficult to identify specific delivery ratios, though there is a displacement in transport time of particulate material. Depending on flow and specific reach, the displacement varies in time from days to months.

Generalized results are transferable, but the variability found indicates that specific numerical results are unique to an area. Unless a watershed with similar land use practices, soil types and geology can be identified, the results cannot be transferred. This limits extrapolation to very small areas where specific numerical results can be transferred or very large areas where generalized qualitative results are sufficient.

At the time that this bibliography went to press the **Genessee River Pilot Watershed Study, Final Report** had not yet been printed. It will be prepared by the New York Department of Environmental Conservation **in** response to an EPA grant requirement. It will eventually be available from the

Great Lakes National Program Office  
U.S. Environmental Protection Agency Region V  
536 S. Clark Street, Room 932  
Chicago, Illinois 60605.

ZZ IJC 769  
PLUARG 79-041

- # Konrad, John G., Gordon Chesters and Kurt W. Bauer. **Menomonee River Pilot Watershed Study, Summary Pilot Watershed Report.** Submitted to PLUARG Task Group C (U.S. Section). Windsor, Ontario. May 1978, 77 pp.

### Summary

The Menomonee River watershed has been instrumented to allow main-stem and tributary monitoring at fifteen locations. Furthermore, three of these and seven other study sites have been delineated permitting collection and analysis of drainage water from areas of predominantly one land use. An overland flow model (LANDRUN) has been developed, calibrated and verified for three subwatersheds in the Menomonee River Basin. Detailed land use inventories (Southeastern Wisconsin Regional Planning Commission - SEWRPC) are available for 1970 and 1975 allowing a capability for examining the impact of changing land use patterns on pollutional loadings. A prediction of land use changes planned to the year 2000 will be used to expand the time frame for the interpretation of changing land use patterns as they affect Great Lakes pollution. The land use inventory allows mapping in forty-two land use categories but these have been consolidated into thirteen categories for the PLUARG investigation.

The importance of the Menomonee River watershed data in meeting the goals of PLUARG are discussed and the extent to which Menomonee River watershed information and methodology is transferable to other sectors of the Great Lakes Basin is realistically evaluated.

**Menomonee River Pilot Watershed Study, Final Report.** Submitted to the U.S. Environmental Protection Agency and PLUARG Task Group D. 11 vols..  
Madison. Wisconsin. 1979.

- Volume I: Summary. Not yet printed.
- Volume II: **Land Use, Population and Physical Characteristics of the Menomonee River Watershed.** Submitted to the U.S. Environmental Protection Agency and PLUARG Task Group D. Madison, Wisconsin. September 1978. 94 pp.
- Volume III: Bannerman, R. et al. **Surface Water Monitoring Data.** Submitted to the U.S. Environmental Protection Agency and PLUARG Task Group D. Madison, Wisconsin. Sept. 1978, 305 pp.
- Volume IV: Novotny, V., M.A. Chin and H. Tran. **Description and Calibration of a Pollutant Loading Model-LANDRUN.** Submitted to the U.S. Environmental Protection Agency and PLUARG Task Group D. Madison, Wisconsin. September 1978, 176 pp.
- Volume V: **Groundwater Hydrology**
- Part I: Eisen. C.E. and M.P. Anderson. **Field Data Quantifying Groundwater-Surface Water Interaction.** Submitted to the U.S. Environmental Protection Agency and PLUARG Task Group D. Madison, Wisconsin. September 1978, 68 pp.
- Part II: Hoffer, R.N. and M.P. Anderson. **Potential Impacts from Land Use Activities.** Submitted to the U.S. Environmental Protection Agency and PLUARG Task Group D. Madison, Wisconsin. September 1978, 44 pp.
- Part III: Anderson. M.P. **Modeling and Extrapolation to Other Watersheds.** Submitted to the U.S. Environmental Protection Agency and PLUARG Task Group D. Madison, Wisconsin. September 1978, 26 pp.
- Volume VI: Andren. A.W. and T.R. Stolzenburg. **Atmospheric Deposition of Lead and Phosphorus on the Menomonee River Watershed.** Submitted to the U.S. Environmental Protection Agency and PLUARG Task Group D. Madison, Wisconsin. September 1978, 47 pp.
- Volume VII: Anderson, M.P., C.E. Eisen and R.N. Hoffer. **Groundwater Contributions to Surface Water Quality in the Menomonee River Watershed.** Submitted to the U.S. Environmental Protection Agency and PLUARG Task Group D. Madison, Wisconsin. August 1979, 138 pp.
- Volume VIII: Andren, Anders et al. **Inorganic Atmospheric Chemistry.** Submitted to the U.S. Environmental Protection Agency and PLUARG Task Group D. Madison, Wisconsin. December 1979, not yet printed.
- Volume IX: Not yet printed.
- Volume X: Bannerman. R., J.G. Konrad and D. Becker. **Effects of Tributary Inputs on Lake Michigan During High Flows.** Submitted to the U.S. Environmental Protection Agency and PLUARG Task Group D. Madison, Wisconsin. October 1979. 46 pp.
- Volume XI: Armstrong. D.E., J.R. Perry and D.E. Flatness. **Availability of Pollutants Associated with Suspended or Settled River Sediments Which Gain Access to the Great Lakes.** Submitted to the U.S. Environmental Protection Agency and PLUARG Task Group D. Madison, Wisconsin. July 1979, 77 pp. (See also ZZ IJC 769/PLUARG 79-115)

At the time that this bibliography went to press, Volumes I, VII and IX had not yet been printed. They will be prepared by the Wisconsin Department of Natural Resources in response to an EPA grant requirement. They will eventually be available from the

Great Lakes Program Office  
U.S. Environmental Protection Agency Region V  
536 S. Clark Street, Room 932  
Chicago, Illinois 60605

ZZ IJC 769  
PLUARG 79-043

# Logan, Terry J. **Maumee River Basin Pilot Watershed Study, Summary, Pilot Watershed Report.** Submitted to PLUARG Task Group C (U.S. Section). Windsor, Ontario. April 1978, 96 pp.

### Summary

The results of this study produced a number of important findings about pollution from land use in the Maumee River Basin and reemphasized what we already knew:

1. the basin is made up of fine-textured soils of high natural fertility which produce sediment during runoff in relation to their slope, internal drainage and susceptibility to sediment transport;
2. most of the basin is in intensive row crop agriculture where, for the most part, the soils are fall-plowed and bare from November to June;
3. much of the agricultural land is drained by subsurface tile or surface drains and served by a vast network of man-made or modified ditches;
4. the period of active sediment transport is in late winter or early spring and the severity of erosion and sediment transport is determined by soil moisture and snow melt conditions during the initial thaw;
5. phosphorus is the major pollutant from the Maumee River Basin and the high phosphate content of suspended sediments reflects the high phosphorus levels in basin soils and the enrichment of phosphorus in sediment due to clay enrichment during transport and adsorption of soluble phosphorus in the stream and
6. levels of pesticides and trace metals in the Maumee River were low and reflect background levels in basin soils and normal metal contributions from groundwater.

Logan, Terry J. and Robert C. Stiefel. **Maumee River Basin Pilot Watershed Study, Final Report.** 2 vols. Submitted to PLUARG Task Group C. March 1979, 300 pp.

### Summary

In Volume I of this report, **Watershed Characteristics and Pollutant Loadings**, five small agricultural watersheds and eight pilots in the Maumee River Basin of Ohio were monitored for losses of sediments and nutrients during 1975-1977. These results were compared with loadings from larger watersheds in the basin and their downstream tributary loads. Studies were also conducted on sediment transport, adsorption, adsorption-desorption of sediment-phosphorus and heavy metal and pesticide loss from the basin.

Volume II, **Sediment, Phosphate, and Heavy Metal Transport**, contains special studies on the mineralogy, chemistry and transport of sediment as well as pesticide and metal sediment transport.

At the time that this bibliography went to press, these volumes had not yet been printed. They will be prepared by the Ohio State University Research Foundation in response to an EPA grant requirement. They will eventually be available from the

Great Lakes Program Office  
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Region V  
536 S. Clark Street, Room 932  
Chicago, Illinois 60605

ZZ IJC 769  
PLUARG 79-045

# Hore, R.C. and R.C. Ostry. **Grand River, Ontario, Summary Pilot Watershed Report.** Submitted to PLUARG Task Group C. Windsor, Ontario. April 1978, 63 pp.

### Summary

The major sources of pollution in the predominantly agricultural Grand River Basin have been identified from the Task C studies.

Urban	metals, organic chemicals, bacteria, phosphorus
Point-sources	metals, organic chemicals, phosphorus, nitrogen
Transportation	lead, chloride
Private-water Disposal	phosphorus
Agriculture	sediment, phosphorus, nitrogen

Water-quality monitoring data collected under the PLUARG program during the period 1975-1976 in the Grand River watershed suggest that progressive pollution of the Grand River is occurring from the headwaters to its mouth at Lake Erie. The headwater areas are relatively clean. Pollutant loads increase consistently downstream in the central and lower regions of the watershed, reflecting the impacts of both the intensive agricultural activity and urban sprawl on the water quality of the receiving waters in these portions of the watershed.

Extrapolation of the pilot watershed data to unmonitored areas in the Great Lakes Basin is possible, provided the characteristics of the unmonitored areas are similar to those in the pilot watershed. In terms of extrapolation to other parts of the Great Lakes Basin, the critical diffuse sources of pollutant contribution have been identified as being agriculture and urban land uses and practices. Based on the Grand River watershed information, the most cost-effective remedial measures to moderate non-point sources of pollution in the Great Lakes Basin will be those that control pollutant runoff from agriculture and urban areas.

# Hore, R.C. and R.C. Ostry. **Saugeen River, Ontario, Summary Pilot Watershed Report**. Submitted to PLUARG Task Group C. Windsor, Ontario. April 1978, 56 pp.

### Summary

Water quality data collected under the PLUARG program during the period 1975-1976 indicate that while variations across the Saugeen River Basin are not dramatic, they broadly reflect increased agricultural activity in the lower reaches of the basin. Streams draining the headwater reaches which are mainly in swamp, non-productive woodland and permanent pasture, are of relatively better quality than the waters at the mouth of the basin. The pollutant impact of the Saugeen River Basin on the water quality of the Great Lakes is minimal.

The major sources of pollution from land uses studied in the Saugeen River Basin have been tentatively identified as follows:

Urban	metals
Point Sources	metals, organic chemicals, phosphorus, nitrogen
Transportation	lead, chloride
Private-waste Disposal	phosphorus
Agriculture	sediment, phosphorus, nitrogen

Extrapolation of the pilot watershed data to unmonitored areas in the Great Lakes Basin is possible provided the characteristics of the unmonitored areas are similar to those in the pilot watershed. In terms of extrapolation to other parts of the Great Lakes Basin, the critical diffuse sources of pollutant contribution have been identified as being urban and agricultural land uses and practices. Based on the pilot watershed information, the most cost-effective remedial measures for the Great Lakes Basin will be those that control runoff from agriculture and urban areas.

- # Ontario Ministry of the Environment. **Water Quality Data Collected for the Pollution from Land Use Activities Reference Group (PLUARG) Study 1975, 1976 and 1977.** Submitted to PLUARG Task Group C. 1978, 500 pp.

### Summary

The Ontario Ministry of the Environment developed a monitoring network in support of the PLUARG study. In addition to the monitoring sites for the specific land uses in support of Task C activities, main stem monitoring sites were also established at existing streamflow stations.

Samples were analyzed for some or all of the following parameters: counts of total and fecal coliforms, enterococci and background count; concentrations of suspended solids, total phosphorus, filtered reactive phosphate, total dissolved phosphorus, total Kjeldahl nitrogen, filtered (nitrate + nitrite) nitrogen, filtered ammonia nitrogen; levels of conductivity and turbidity; concentrations of total carbon, total inorganic carbon, total organic carbon, filtered organic carbon, filtered chloride, filtered alkalinity, filtered sulphate, filtered reactive silicate, filtered calcium, filtered magnesium, filtered potassium and filtered sodium; units of pH; concentrations of phenols, total zinc, total lead, total cadmium, total copper, total iron, total nickel, total chromium, total mercury and total arsenic. Limited available information on manganese, selenium, pesticides and PCB's can be obtained from the Ministry's Water Resources Branch offices in Toronto.

A basic annual summary, i.e. the number of samples and average concentrations is presented for each monitoring station. In addition to a verbal station location description, the Universal Transverse Mercator Grid (UTM) is provided along with a hydrologic (Storet-type) coding system.

ZZ IJC 769  
PLUARG 78-048

# Nicholson, J.A. **Forested Watershed Studies, Summary Technical Report.** Submitted to PLUARG Task Group C, Activity 2. Windsor, Ontario. December 1977, 23 pp.

### Summary

Many substances considered as water pollutants are natural products of the forest through geologic erosion, nutrient leakage, and organic material deposition. Research demonstrates that water yield will increase following harvesting and then decline with revegetation. Therefore, channel erosion and nutrient outputs will probably increase as well. The key questions are the amount of material available and the situations in which it could reach water bodies. We must, therefore, explore the area between potential and fact.

The land system, the type of disturbance and the distance of the activity from a water body are critical factors in this consideration. For example, scarification for regeneration in jack pine and black spruce types is becoming a relatively common practice. However, most of the disturbance is carried out on flat or gently rolling terrain where runoff is negligible, infiltration is maintained and revegetation is rapid. Therefore, pollution is not likely to occur. The harvesting system is also important in that clearcutting has a greater potential for disturbance than either strip or partial cutting.

Road construction on logging operations is sometimes a major source of sediment; however, a well planned road network can minimize problems, reduce delays and increase efficiency. Timing is critical, especially near streams and at crossings. Road construction should occur at low flow periods, approaches should be kept as flat as possible, and any sediment flow be prevented or trapped on land before it reaches the water. Grade lengths should be kept to a minimum with a maximum grade of 10%. The road erosion study at ELA indicated about 6% of the roads have problem areas but the erosion and deposition is restricted to the right-of-way.

Potential pollution areas are those in close proximity to water bodies and it is here that care should be taken. The key to control lies in good land management of all forestry operations that may create a disturbance in natural ecosystems. Knowledge of all the aspects of pollution potential from forestry is far from complete.

# Agriculture Canada, Ontario Ministry of Agriculture and Food and Ontario Ministry of the Environment. **Agricultural Watershed Studies, Great Lakes Drainage Basin, Canada; Final Summary Report.** Submitted to PLUARG Task Group C (Canadian Section) Activity 1. Windsor, Ontario. May 1978, 78 pp.

#### Summary

This report contains the results obtained by all of the projects conducted within the Canadian PLUARG Task C Agricultural Watershed study. The approach is presented along with summaries and discussion of data, and possible remedial measures for all the major water quality parameters are investigated. Extrapolation to unmonitored areas and remedial measures alternatives are discussed for total phosphorus and sediment.

The Agricultural Watershed Studies consisted of investigations into the relationships between agricultural land and water quality in the Great Lakes Basin. Monitoring of water quality and quantity at eleven small watersheds, representative of major agricultural regions of the Canadian Great Lakes Basin, was carried out for two years. Detailed studies on sediment, nutrients and heavy metals were carried out in some of the watersheds. All watersheds were characterized in detail.

In terms of the water quality parameters of greatest concern to PLUARG - total phosphorus and sediment - the higher the degree of intensive cultivation and/or the greater the area of fine-textured soils, the greater were the unit-area loads. These watershed characteristics accounted for most of the differences observed in the loads of total phosphorus and sediment among the study watersheds.

Consideration was given to remedial measures programs to reduce the contributions of pollutants from agricultural activities. Although several possible measures were identified, it is emphasized that localized variations in pollution sources, soil properties and landscapes, cropping systems and active pollutant-contributing areas make general application of remedial measures impracticable.

Monitoring and detailed studies were also carried out to determine the role of agricultural land as a source of other water quality parameters. It was concluded that applications of fertilizer and manure, and livestock operations adjacent to streams were contributing manure to the observed levels of the dissolved fractions of phosphorus (ortho-P) and nitrogen ( $\text{NO}_2 + \text{NO}_3$ ) in streams.

It was determined that agricultural activities were not influencing the quantities of heavy metals in streams, other than by way of increases in stream sediment loads, which resulted in increases in those fractions of the metal loads that were naturally associated with the sediment.

Other observed non-agricultural influences on water quality in the agricultural watersheds were: the contribution of rural housing to dissolved phosphorus levels; the presence in streams of herbicides from spraying of highway rights-of-way and the almost constant presence of the industrial organic toxicant PCB, believed to be primarily the result of atmospheric deposition.

ZZ IJC 769  
PLUARG 78-050

- # Sanderson, M. **Agricultural Watershed Studies, Great Lakes Drainage Basin. Precipitation - Quantity and Quality.** Submitted to PLUARG Task Group C (Canadian Section) Activity 1. *Windsor*, Ontario. September 1977, 137 pp.

### Summary

The objective of this part of the research was to provide accurate hourly values of precipitation during the course of the PLUARG study on the ten watersheds AG 1, 3, 4, 5, 6, 7, 10, 11, 13, 14.

For the first year of the PLUARG record, June 1975 to May 1976, precipitation was above average for most stations. AG 3, however, had slightly below average precipitation and AG 11 had average precipitation amounts. For the second year of record, June 1976 to May 1977, precipitation was everywhere below average for the gauged watersheds in southern Ontario. Most stations recorded approximately 80% of the average precipitation.

The precipitation charts for each station were also analyzed to provide information on the number of days with precipitation, heavy precipitation days and maximum precipitation in three hours, two hours and one hour.

- # Frank, R. et al. **Stream Flow Quality-Pesticides in Eleven Agricultural Watersheds in Southern Ontario Canada, 1974-1977**. Submitted to PLUARG Task Group C (Canadian Section) Activity 1. Windsor, Ontario. 1978, 174 pp.

### Summary

This project was designed to measure concentrations of pesticides in stream water leaving each of the eleven agricultural watersheds and to calculate actual amounts of pesticides leaving stream waters. These findings would then be correlated with the detailed information on pesticide use in the watersheds collected under Project 5, Land Use Activities, to determine unit area loadings.

Eleven watersheds were chosen for examination of water quality, each being selected because it resembled a unique but larger area of Ontario where agriculture was practised. These agricultural watersheds include those where the use of pesticides ranged from intensive to extensive and included the use of specific pesticides or groups of pesticides.

Twenty-six organic compounds were identified in stream water of which eighteen were parent compounds and eight were isomers and metabolites. The incidence of these contaminants in water varied from occasional to frequent.

ZZ IJC 769  
PLUARG 78-052

- # Frank, R. and B.D. Ripley. **Land Use Activities in Eleven Agricultural Watersheds in Southern Ontario Canada. 1975-1976.** Prepared for PLUARG, Task Group C (Canadian Section) Activity 1. Windsor, Ontario. March 1977, 176 pp.

### Summary

In this the final report of Project 5, Activity 1, Task C eleven mini-agricultural watersheds were surveyed by questionnaire to determine various land use parameters. Ten were surveyed in 1975 whereas AG-5 was surveyed in 1976. These selected watersheds were typical of larger areas in Ontario with respect to soil type, topography and agricultural activity.

The selected mini-watersheds were located in southern Ontario on ten larger watersheds draining into the Great Lakes: three drained into Lake Huron (Ausable River, Maitland River and Saugeen River), one drained into Lake St. Clair (Thames River), three drained into Lake Erie (Big Creek, Grand River and Hillman Creek) and three drained into Lake Ontario (Humber River, Shelter Valley Creek and Twenty Mile Creek).

ZZ IJC 769  
PLUARG 77-053

- # Acton, C.J., G.T. Patterson and C.G. Heath. **Soil Survey of Six Agricultural Sub-watersheds in Southwestern Ontario**. Submitted to PLUARG Task Group C (Canadian Section). January 1979, 219 pp.

### Summary

The primary objective of this project was to inventory the soils of the six agricultural subwatersheds chosen for detailed study (AG-1, 3, 4, 5, 10 and 13). The inventoried soils were interpreted for their agricultural capability and for their inherent ability to transmit pollutants to both surface water and groundwater systems.

The extent of soil series in each subwatershed as estimated in this project was compared to estimates obtained from reconnaissance soil survey reports published on a county basis. In general, the extent of poorly drained soils was much greater on the more detailed maps produced for this report. In addition, some changes in the description of soil parent materials were effected. Most changes were due to the greater level of detail allowed by a larger scale and by the system of mapping soil complexes rather than 'pure' units. Other changes were related to revisions in the definition of some soil series.

ZZ IJC 769  
PLUARG 79-054

- # Cameron, D.R. et al. **Nitrogen Movement in Tile-Drained Clay and Sandy Agricultural Watersheds**. Submitted to PLUARG Task Group C (Canadian Section) Activity 1, Project 13. Windsor, Ontario. October 1977, 97 pp.

### Summary

Two small watersheds were selected in southern Ontario near Leamington, and nitrogen additions and losses under different cropping and fertilizing practices were monitored during the 1974 to April 1977 period. Average stream  $\text{NO}_3\text{-N}$  concentrations  $4.9 \pm 3.2$  mg/L for the sandy watershed AG-13 where vegetable and tobacco production were the predominant crops. Average stream  $\text{NO}_3\text{-N}$  concentrations were  $3.6 \pm 4.2$  mg/L for the tile-drained clay watershed AG-01 where corn and soybean production dominated. Average dissolved  $\text{NH}_4\text{-N}$  concentrations were  $0.34 \pm 0.43$  mg/L for AG-13 and  $0.21 \pm 0.31$  for AG-01. Average total Kjeldahl nitrogen concentrations were similar;  $1.4 \pm 1.0$  mg/L for both AG-13 and AG-01.

Estimated average annual total nitrogen losses were 29 and 22 kg N/ha for AG-13 and AG-01, respectively, of which dissolved nitrogen accounted for 87% and 64% of the total nitrogen losses, respectively. Approximately 60% of the dissolved nitrogen losses occurred during February-March at which time 70% of the annual runoff occurred. The higher losses from the sandy watershed AG-13 are believed to be a reflection of greater fertilizer input and greater annual runoff.

Remedial measures which might help improve the conservation of nitrogen and reduce pollution from agricultural land include: careful use of soluble nitrogen fertilizers to meet crop needs only, deletion of the application of fall-applied nitrogen, encouragement of rotations that do not require high rates of fertilizer-nitrogen addition, encouragement of field cover crops to reduce leaching and establishment of grass or non-row crop buffer zones next to streams or where runoff is a problem.

ZZ IJC 769  
PLUARG 77-055

- # Neilsen, G.H., J.L. Culley and D.R. Cameron. **Nitrogen Loadings from Agricultural Activities in the Great Lakes Basin. Integration Report on Nitrogen.** Submitted to PLUARG Task Group C (Canadian Section) Activity 1. Windsor, Ontario. April 1978, 103 pp.

### Summary

A number of management methods already exist to reduce stream nitrogen loading. However, management studies such as those conducted across Ontario for PLUARG (1977) or within the Thames Valley Conservation Authority (1978) suggested that, with the exception of crop rotation, such methods were being used by a minority (10-20%) of farmers. Thus, expanded emphasis on conservation practices by agricultural extension workers could result in improved farm management and reduced stream nitrogen loading.

A number of these recommended practices may require special modification in Canada. For example, as a result of cool soil temperatures and large snowmelt runoff, no tillage and slow release fertilizers, respectively, may be less useful. Questions such as these could be researched at local agricultural research stations where the effectiveness of management practices for the control of nutrient losses could be evaluated as extensively as have been crop impacts on runoff and erosion.

Finally, it should be recognized that increased nitrogen use has resulted in large positive economic advantages for agriculture. Most important among these are the increased yields and economic returns associated with nitrogen fertilization and the resulting ability to produce these higher yields on a diminishing amount of cultivated land. Thus, institution of measures to reduce  $\text{NO}_3\text{-N}$  loss from fields should consider the effects that such measures would have upon achieving satisfactory production.

ZZ IJC 769  
PLUARG 78-056

- # Kowalenko, G.C. **Nitrogen Transformation Processes in Agricultural Watershed Soils**. Submitted to PLUARG Task Group C (Canadian Section) Activity 1, Project 11. Windsor, Ontario. April 1978, 98 pp.

### Summary

Soils were characterized with respect to the rates of biological processes important to nitrogen leaching considerations. Nitrification was shown to be a relatively fast process which was related to temperature and moisture content conditions. A regression equation including these environmental factors was derived for several groups of soils, depending largely on textural differences.

Mineralization was particularly influenced by environmental factors (temperature and moisture content) when soil (%C, %N, pH, etc.) and environmental factors were considered. An estimate of the amount of nitrogen produced by mineralization under field conditions suggested considerable nitrogen was released, depending on the soil type. Incorporation of plant residues alters the mineralization-immobilization pattern in soils considerably and is dependent on the content of the plant material. Organic amendments must be considered in the long term for nitrogen considerations because of changing mineralization-immobilization relationships.

Denitrification can progress very quickly if warm anaerobic conditions are met. The rates suggest that short but quantitatively large bursts of denitrification may be important in  $\text{NO}_3$  losses and these may occur during or immediately after rains.

Asymbiotic nitrogen fixation does not appear to be an important source of nitrogen in these soils.

Mineralization and denitrification appear to be two key processes to consider in addition to soil nitrogen leaching.

ZZ IJC 769  
PLUARG 78-057

- # Robinson, J.B., N.K. Kaushik and L. Chatarpaul. **Nitrogen Transport and Transformations in Canagagigue Creek.** Submitted to PLUARG Task Group C, Activity 1, Project 19A. Guelph, Ontario. June 1978, 62 pp.

### Summary

Agricultural activities are known to be a source of appreciable amounts of nitrogen contamination of both surface and ground waters. Much of this nitrogen enters water as nitrate. Fixed nitrogen is very reactive and undergoes a large variety of biological transformations, the kinds and rates of which depend largely on environmental factors such as the presence or absence of oxygen, temperature, etc. While these processes have been extensively studied in soils and, to some extent in lakes, little is known about their occurrence **in** streams. The degree to which nitrogen forms are subject to transformation processes while being transported in streams, particularly to sink processes such as denitrification, may significantly affect the degree to which agricultural activities contaminate receiving waters. The objective of this project was to determine the extent of denitrification in streams and to assess its effect on stream transport of nitrogen.

ZZ IJC 769  
PLUARG 78-058

- # Spires, A. and M.H. Miller. **Contribution of Phosphorus from Agricultural Land to Streams by Surface Runoff**. Submitted to PLUARG Task Group C (Canadian Section) Activity 1, Project 18. Windsor, Ontario. February 1978, 101 pp.

### Summary

The objective of this project was to develop a capacity for prediction of the amount of phosphorus carried to streams by surface runoff from agricultural cropland in Ontario.

The project has succeeded in developing relationships for estimation of total phosphorus concentration in surface soils in Ontario and for prediction of the phosphorus enrichment ratio. However, it has not been as successful in predicting the sediment load, the third parameter required for estimating the contribution of phosphorus. The difficulty in predicting the sediment load is due to difficulty in estimating the sediment delivery ratio.

Although sediment-associated phosphorus loss could be estimated, it was not possible to develop a relationship to predict dissolved phosphorus concentrations in runoff.

The study has improved our understanding of the processes involved in phosphorus loss from cropland and its transport to stream. Although the development of the predictive capacity has not been fully realized, the understanding obtained will greatly assist in interpretation and extension of the monitoring data from the Agricultural Watersheds Study.

ZZ IJC 769  
PLUARG 78-059

- # Miller, M.H. and A.C. Spires. **Contribution of Phosphorus to the Great Lakes from Agricultural Land in the Canadian Great Lakes Basin.** Submitted to PLUARG Task Group C (Canadian Section) Activity 1. March 1978, 55 pp.

### Summary

The contributions of phosphorus to the Great Lakes from agricultural land and the associated activities in southern Ontario have been estimated primarily from the information obtained from the monitoring data and the several detailed studies conducted in the representative agricultural watersheds. Because there is very limited agricultural activity in the northern Ontario portion of the Canadian Great Lakes Basin, the estimates made are thought to be valid for the total Canadian Great Lakes Basin.

ZZ IJC 769  
PLUARG 78-060

# Beak Consultants Ltd. **Effects of Livestock Activity on Surface Water Quality Final Report.** Submitted to PLUARG Task Group C (Canadian Section) Activity 1, Project 20. Windsor, Ontario. November 1977, 109 pp.

### Summary

The objective of this study is to evaluate the losses of nutrients and bacteria to surface water due to the effects of livestock activities in the Little Ausable River Sub-Basin (Watershed AG-3).

With respect to the export of nutrients and bacteria from different sub-basins or due to different livestock management factors, the following conclusions are made:

- 1) the annual export rate is 0.48 Kg P/ha/yr, 57 Kg N/ha/yr and 1.4 cfs/mi<sup>2</sup> of water;
- 2) for phosphorus, BEAK estimates that the export from non-livestock areas, i.e. controls is 0.33 Kg P/ha/yr. Export from livestock areas vary from this rate up to 2.3 kg P/ha/yr;
- 3) differences in export of nutrients cannot be attributed to type of livestock operations;
- 4) differences in phosphorus export between farms and bacterial contamination are to specific physical and management contamination attributable to specific physical and management factors;
- 5) compared with many large sized feedlots, all livestock operations in AG-3 are small to moderately sized (<500 individual/operation). For this scale of operation, phosphorus export appears to be linked more to the management of an agricultural operation rather than to the type and density of livestock;
- 6) with respect to seasonal effects, the greatest part of phosphorus. export occurs during the spring period from March 1 to May 31;
- 7) with respect to forms of nutrients, surface water stations export 60 to 85% of the total phosphorus as dissolved phosphorus; the greatest part of this is soluble reactive phosphorus. Tile drains export 80 to 100% of its phosphorus in the dissolved form all of which is soluble reactive phosphorus;
- 8) values for chemical parameters pH, conductivity, hardness and alkalinity are typical of a moderately hard water and
- 9) the geometric mean (i) of total coliforms ranges from 290 to 52000 per 100 mL, (ii) of fecal coliforms ranges from 9 to 8100/100 mL, and (iii) fecal streptococci ranges from 5 to 1100/100 mL for all stations.

ZZ IJC 769  
PLUARG 77-061

- # Robinson, J.B. and D.W. Draper. **A Model for Estimating Inputs to the Great Lakes from Livestock Enterprises in the Great Lakes Basin.** Submitted to PLUARG Task Group C, Activity 1. March 1978, 29 pp.

### Summary

To meet the need for estimating inputs of phosphorus to the Great Lakes from the livestock industry a model was developed to determine inputs from feed-lots and barn-lots, manure storages and winter-spread manure. Runoff originating from manure spread on unfrozen land is included in a model developed separately for cropland. A further source of livestock input, recognized but not included in the model, was direct inputs to streams by grazing cattle. An attempt was made to estimate this input separately.

ZZ IJC 769  
PLUARG 78-062

- # Patni, N.K. and F.R. Hore. **Pollutant Transport to subsurface and surface Waters in an Integrated Farm Operation.** PLUARG Special Study No. 22. February 1978, 79 pp.

### Summary

A study was conducted at the Greenbelt Farm of the Animal Research Institute of Agriculture Canada to determine pollutant transport to subsurface and surface waters in an integrated farm operation involving large-scale livestock operations.

The objectives of the study were:

- 1) to determine if subsurface pollutant transport in a small field could be extrapolated to a large field, other conditions such as manuring, cropping practice, soil characteristics, etc. being the same for both fields;
- 2) to determine the difference in pollutant transport in tile drainage water under a largely coarse-textured soil compared with a fine-textured soil under similar conditions of manuring and cropping practice and
- 3) to determine pollutant transport to surface water in a 594 ha drainage area under a closely controlled cropping operation.

ZZ IJC 769  
PLUARG 78-063

- # Gillham, R.W. et al. **Studies of the Agricultural Contribution to Nitrate Enrichment of Groundwater and the Subsequent Loading to Surface Waters.** Submitted to PLUARG Task Group C, Activity 1, Project 14. January 1978, 430 pp.

### Summary

This report describes detailed groundwater investigations conducted in a sub-region of the Hillman Creek (PLUARG AG-13) watershed. The objectives of the investigations were:

- 1) to determine the distribution in groundwater of nitrate and to relate this to the observed distribution of land use practices;
- 2) to obtain information on the mechanics of nitrate storage and transport in the groundwater zone;
- 3) to develop procedures for predicting the rates at which the nitrate which is presently in subsurface storage will be transported into streams that drain to the Great Lakes and
- 4) to develop relationships that can be used for extrapolation of at least some of the results from the detailed study area to other areas in the Great Lakes drainage system.

ZZ IJC 769  
PLUARG 78-064

# Gaynor, J.D. **Sources of Nutrients and Metals in Hillman Creek.** Submitted to PLUARG Task Group C (Canadian Section). April 1978, 66 pp.

### Summary

This study was initiated to quantify inputs of suspended solids, nutrients, soluble cations and metals in five subwatersheds of Hillman Creek; to relate the quantitative information for these inputs to land use in the subwatersheds and to present remedial measures which would reduce the magnitude of these inputs where necessary.

Two land uses, i.e. predominantly rural housing and agriculture were selected by the location of five sampling sites on the west branch of the Hillman Creek. The monitoring at these sites occurred from April 4, 1975 to March 10, 1976. The concentrations of the various parameters and discharges were determined periodically throughout the year and during rain and snow-melt events. Stream load and annual subwatershed loss were calculated from the concentration and discharge data at each site and statistical comparisons were made to determine significant inputs attributable to the land use.

ZZ IJC 769  
PLUARG 78-065

- # Hynes, H.B. and K.W. Dance. **Comparative Nutrient Budget of the Two Branches of Canagagigue Creek.** Submitted to PLUARG Task Group C, Project 19, Part B. Windsor, Ontario. February 1977, 42 pp.

### Summary

The quantities of drifting solid organic matter (S.O.M.) in two size particle ranges were sampled weekly for thirteen months at four stations on the upper reaches of the Canagagigue Creek. Two stations were located on each of the east and west branches of the Creek.

The particle size ranges sampled were 1.3 - 3.0 cm and 253 micron - 1.0 cm. The material within these size ranges was divided into recognizable fractions: green, coniferous, deciduous algae, detritus and aquatic animals. Nutrient analyses were conducted on monthly bulked fraction samples. S.O.M. was analyzed for the percentage of organic matter, the percentage of Kjeldahl nitrogen in the organic matter and percentage of total phosphorus in the organic matter.

Agricultural plant material was not found to contribute a significant amount of material to the stream.

The fraction which contributed the greatest quantities of S.O.M. and nutrients was that of detritus and algae in the particle size range 253 microns - 1 cm. This fraction contained organic detritus as well as quantities of inorganic material which had been churned up from the stream bed.

ZZ IJC 769  
PLUARG 77-066

- # Whitby, L.M. et al. **Sources, Storage and Transport of Heavy Metals in Agricultural Watersheds.** Submitted to PLUARG Task C (Canadian Section) Activity 1. 1978, 142 pp.

### Summary

The objective of this project was to determine and assess the relationship between concentrations of selected heavy metals in stream water, suspended sediments, bottom sediments and soils within selected agricultural watersheds, with the aim of elucidating storage and transport mechanisms for trace elements.

Soil profile samples of the major soil types of each of the six agricultural watersheds were obtained for nutrient and trace metal analysis. Analyses of total metal concentrations (As, Cd, Cr, Cu, Hg, Mn, Ni, Pb, Se, Zn, Al and Fe) and DTPA extractable metals (Cd, Cu, Ni, Pb and Zn), as well as total carbon, organic carbon, total nitrogen, total phosphorus and pH were performed. To demonstrate field variability and the effectiveness of our sampling system, six replicate soil samples were taken within the same soil pit for most sites. In addition, four soil pits within the same soil type separated by at least one mile were sampled in one watershed. The replicate soils were analyzed for total concentrations of Cr, Cu, Mn, Ni, Pb, Zb, Al, Fe, C and N. Composites of the A horizons from each major soil of each watershed were used for the extraction of HA's and FA's. Ultimate analyses, functional group analyses, chemical degradation and identification of products were performed on each sample.

ZZ IJC 769  
PLUARG 78-067

- # Wall, G.J., L.J.P. van Vliet and W.T. Dickinson. **Contribution of Sediments to the Great Lakes from Agricultural Activities in Ontario**. Submitted to PLUARG Task Group C (Canadian Section) Activity 1. April 1978, 41 pp.

### Summary

This report summarizes the results of a three-year study conducted in the Canadian Great Lakes Basin to ascertain the nature and extent to which agricultural land use contributes to the sediment load of the Great Lakes.

Localized variations in pollutant sources, soil properties and landscapes, sediment contributing areas and cropping systems make generalizations about remedial sediment control programs impossible. Erosion and transport of sediments from agricultural land is a site-specific problem requiring the implementation of site-specific remedial measures on the active contributing areas.

All estimates and observations in this report are based on one to two years of field data. The limited time base of the study should be considered in any application of the data.

ZZ IJC 769  
PLUARG 78-068

- # Wall, G.J., L.J.P. van Vliet and W.T. Dickinson. **Soil Erosion from Agricultural Land in the Canadian Great Lakes Basin**. Task Group C (Canadian Section) Activity 1, Projects 16 and 17. March 1978, 166 pp.

### Summary

This report describes the results of several integrated projects (Project 16: Erosional Losses from Agricultural Land and Project 17: Sediment Delivery Ratios in Small Agricultural Watersheds, and Sediment Integration Aspects) designed to further our understanding of the sources and magnitude of fluvial sediment derived from agricultural lands and delivered to the Canadian Great Lakes. Agricultural regions with high potential sheet erosion losses were intensively farmed with high percentages of row crops (beans, corn, horticultural crops). Rainfall-induced soil erosion losses showed considerable year to year variations and are not equally distributed throughout any given year. Winter soil erosion losses associated with snowmelt events can account for up to 25% of the total annual soil loss.

ZZ IJC 769  
PLUARG 78-069

- # M. Ihnat. **Agricultural Sources, Transport and Storage of Metals: Copper, Zinc, Cadmium and Lead Levels in Waters of Selected Southern Ontario Agricultural Watersheds.** Submitted to PLUARG Task C (Canadian Section) Project 98 Technical Report. Ottawa, Ontario. November 1978, 156 pp.

### Summary

The objective of Project 9 was to determine and assess the relationship between concentrations of selected heavy metals in stream waters, suspended sediments, bottom sediments and soils within selected agricultural watersheds draining into the lower Great Lakes, with the aim of elucidating sources, storage and transport mechanisms of these elements. In support of these goals, the main objective of the investigation was to obtain reliable analytical information regarding concentrations of Cu, Zn, Cd and Pb in waters and suspended sediments from the six watersheds: AG 1 (Big Creek), AG 3 (Upper Little Ausable River), AG 4 (Canagagigue), AG 5 (Holiday Creek, tributary of Middle Thames River), AG 10 (North Creek, tributary of Twenty Mile Creek) and AG 13 (west branch of Hillman Creek).

ZZ IJC 769  
PLUARG 78-070

- # Topp, G.C. **Physical Properties of the Soils of Agricultural Watersheds 1 and 13 Which Control Moisture Storage and Transport.** Submitted to PLUARG Task Group C (Canadian Section) Project 12. Ottawa, Ontario. 1978, 43 pp.

### Summary

The objectives of this study were two-fold. First, to make *in situ* and associated laboratory measurements of soil physical properties (hydraulic conductivity, bulk density and the desorption water capacity relationship), that govern the storage and transmission of water solutions. Second, to characterize or represent these soil properties so that they may be applied in the nitrogen and water transport simulation program of D.R. Cameron *et al* (Project 13). The wide variation in soil properties in the two watersheds meant that different field measurement methods were used in each watershed. It was assumed that the hydraulic conductivity was the major property controlling transmission of water and a number of attempts were made to measure it in both watersheds. In Watershed AG-1 the shrinking and cracking of the clay soil meant that cracks played an important role in the transmission of water and additional measurements were necessary. The water storage properties were measured in the laboratory.

ZZ IJC 769  
PLUARG 78-071

- # Coote, D.R. and F.R. Hore. **Pollution Potential of Cattle Feedlots and Manure Storages in the Canadian Great Lakes Basin**. Submitted to PLUARG Task Group C (Canadian Project 21 Project. Windsor, Ontario. August 1978, 131 pp.

### Summary

This report covers the period from the fall of 1973 to the summer of 1977, during which time a variety of research and monitoring activities were taking place under the auspices of the IJC Pollution from Land Use Studies. Two distinct studies were undertaken on the topic of the environmental impact of feedlots and manure storages. They were carried out consecutively: the first was concerned with surface water; the second with groundwater. The reports of these two studies are presented in this volume as two separate sections.

This report presents the results of a two-year study of runoff quality and quantity from two beef feedlots and two manure storage areas in southern Ontario. One of the feedlots was paved, while the other had an unpaved soil surface. One of the manure storages held solid (with bedding) manure, the other held semi-solid manure. Both were paved.

The study permitted the estimation of the pollutant loadings that feedlots and manure storages may yield in runoff. Data collected in an earlier air-photo survey of livestock operations in the Canadian Lower Great Lakes Basin were used to estimate the impact of runoff from feedlots and manure storages in the basin. It was concluded that the contribution of Total Phosphorus from livestock operations probably falls between 0.5% and 13% of the total Great Lakes Basin loadings of this pollutant now coming from agricultural areas.

ZZ IJC 769  
PLUARG 78-072

# Coote, D.R. and R. DeHaan. **Agricultural Watersheds Overview Data Analysis and Extrapolation**. Submitted to PLUARG Task Group C (Canadian Section) 1, Project 113. December 1978, 79 pp.

### Summary

There has been a persistent gap between the two most generally available forms of information on the effects of agriculture on water quality. These two forms of information are the results of small scale "pilot" studies and large scale river basin or lake loading analyses. The former are usually limited in terms of variability of soil, management and climatic conditions; the latter generally fail to distinguish between even distinctly different types of agricultural environments. The results of this study help to bridge the gap between these different approaches.

The role of soil particle size as a major influence on total phosphorus, organic nitrogen, zinc and atrazine loadings from agricultural land has been clearly indicated.

The influence of source material availability on stream loadings of the more water soluble contaminants in streams is evidenced by the loadings of soluble ortho-phosphorus and nitrate nitrogen which can be accounted for to a considerable degree by the inputs (fertilizer and manure) of phosphorus and nitrogen, respectively.

The results indicate that some materials, such as PCB and copper, are essentially unrelated to any aspect of agriculture. Control or reductions should not be expected through any remedial programs applied to agricultural activities.

Prediction equations based on statistical regressions of stream loadings on physical and management characteristics of the watersheds appear to be feasible for some water quality parameters such as total and soluble ortho-phosphorus, total nitrogen and nitrate (plus nitrite) nitrogen. Attempts to extrapolate regression equations for sediment (suspended solids) appear less satisfactory. For most other parameters, the extrapolation of regression equations would appear unreliable, though the occurrence of pesticides which are fairly specific to certain crops may be extrapolated by considering the distribution of the appropriate crops.

ZZ IJC 769  
PLUARG 78-073

- # Whiteley, H.R. and S.R. Ghate. **Hydrological Model Project - Agricultural Watershed Studies**. Submitted to PLUARG Task Group C (Canadian Section) Project 1.15. March 1978, 100 pp.

### Summary

A storm-event watershed model named the GAWSER (Guelph Agricultural Watershed Storm-Event Runoff) has been developed and a user's manual has been produced for it. The model produces stream flow rate hydrographs from rainfall and/or snowmelt intensity inputs. Two components of storm runoff are computed by the model. These are surface (overland) runoff and subsurface storm runoff. Flow in drainage tiles is included in, and is likely a major part of, subsurface storm runoff.

ZZ IJC 769  
PLUARG 78-074

# Veska, Eric. **Geochemistry and Hydrogeology of Agricultural Watershed No. 10 and Their Influence on the Chemical Composition of Water and Sediments.** Submitted to PLUARG Task Group C (Canadian Section) Activity 1, Project 23. Windsor, Ontario. August 1977, 119 pp.

#### Summary

The objective of this study was to examine the distribution of twenty elements in bottom and suspended sediments, and stream and well waters in Watershed No. 10, tributary of the Twenty Mile Creek on top of the Niagara Escarpment, Ontario. It was hoped that this study would determine the sources and causes for contaminants in surface and ground waters. These contaminants can often be correlated with soils, topography, geology or to some form of land use in relation to man's activities.

The trace element distribution patterns from 240 bottom sediment sampling sites performed during the months of June and July 1976 for the preliminary geochemical survey indicated that the north central sector of the North Creek Watershed is an area of high metal content.

A spring at the anomaly site seems to issue mainly from a dolomitic-shale bedrock source due to its characteristic water quality. The peculiar water chemistry was apparently derived from oxidation of sulphide minerals and dissolution of gypsum crystals present in the underlying, mineralized bedrock.

A chemical and textural study of the lithology of the well core sediments and bedrock drilled adjacent to the anomalous site revealed the migration path of the groundwater flow with respect to the selective mobility of certain elements in this secondary environment.

Thermodynamic evaluation of the ion speciation of the major chemical constituents from the anomalous spring and surface waters showed gypsum to be supersaturated in these anomalous spring waters. Downstream from the spring, the loss of the spring's carbon dioxide in attaining equilibrium with the atmospheric carbon dioxide resulted in the surface waters being supersaturated with respect to the carbonate minerals, such as calcite, aragonite, magnesite and dolomite.

Downstream from the spring, the minor constituents, such as the heavy metals, are co-precipitated with  $\text{CaCO}_3$ , complexed with the sulphate radical and other inorganic ligands and form aquo metal complexes. Time-wise, the relative heavy metal concentrations in these anomalous surface waters showed direct relationships with respect to precipitation and the surface water discharge of the North Creek waters.

This briefly summarized the origin and the geochemical history of the abnormality of the high metal values. The source of these high heavy metals are derived naturally from the dissolution of the bedrock mineral deposits, thus contaminating the groundwater discharge in the North Creek waters. The contribution of man's activities as a source of heavy metal contamination in these natural waters appeared to be negligible, since the implication of atmospheric pollution was proven to be minute.

ZZ IJC 769  
PLUARG 77-075

# Knap, Katherine M. and William F. Mildner. **Streambank Erosion in the Great Lakes Basin**. Submitted to PLUARG Task Group C. June 1978, 29 pp.

## CONCLUSIONS

### Joint Statements

1. The amount of sediment produced from streambank erosion can vary from basin to basin, season to season and year to year. It is also noted that the total amount of material eroded is not large when viewed on a global or continental scale.
2. When viewed relative to other sources of sediment, bank erosion does not appear to be a major contributor, accounting for 1 to 10% of the load in the U.S. study watersheds and 2 to 32% in the Canadian basin.
3. Total phosphorus is the most important chemical contributed from bank erosion. An estimated 426,000 kg of phosphorus are added to the Great Lakes each year from eroding banks.
4. While downstream sections of rivers were not specifically included in the Canadian study watersheds they were in U.S. study basins. There seem to be no reasons why loading rates on these areas should be higher or lower than other areas.

In the Canadian basins several other conclusions have been reached:

1. The source areas of bank erosion within each watershed can be highly variable and both point and non-point in nature.
2. From observations in the field a list of natural and cultural factors contributing to bank erosion has been compiled. Some of the main physical causes are sheet and rill erosion by overland flow and scouring by the stream often followed by slumping of the upper bank under gravity.
3. The above factors vary from area to area with some regions of the province having a combination of factors that would suggest higher or lower sediment yields from bank erosion.

# Mildner, William F. **Streambank Erosion in the United States Portion of the Great Lakes Basin.** Submitted to PLUARG Task C (U.S. Section) Activity 6. Windsor, Ontario. January 1978, 45 pp.

### Summary

This study was carried out on the Maumee River Basin. The concept used was to examine a 2% sample of the watershed. Sample areas 160 acres in size selected on a random basis were examined and the data expanded to the watershed. The field crew worked 1,182 hours and travelled 12,630 miles to visit 597 sample sites.

A worksheet was designed to provide a record of items of interest regarding streambank erosion and arranged in a manner to facilitate keypunching operations. Since this was a streambank erosion study, items on eroding bank height, length and average annual bank recession were included. It was thought that adjacent land use and soil series might correlate with eroding banks so columns were included on the worksheet for this information. Since an important part of the study was to recommend a program of treatment, columns were included for present and needed treatment. It was also thought that there might be some correlation between the absence of fencing adjacent to the streambank and bank erosion so this item was also included on the worksheet.

Each individual of the field crew was given the necessary maps to locate the sample areas and to identify the soil series. They were also given instructions for completing the worksheet and definitions of the terms to be used in the study.

On a volume basis, riverbank erosion is a minor portion of the sediment yield and chemical contribution to the Great Lakes.

ZZ IJC 769  
PLUARG 78-077

- # O'Neill, J.E. **Pollution from Urban Land Use in the Grand and Saugeen Watersheds.** PLUARG Task Group C (Canadian Section) Activity 3. January 1979, 55 pp.

### Summary

Under the IJC-PLUARG program, seven urban study areas in the Grand River and Saugeen River pilot watersheds were studied between 1974 and 1977, namely Kitchener - Waterloo - Cambridge, Schneider Creek, Montgomery Creek, Guelph, New Hamburg, Durham and Allan Park. The pollutants identified in runoff from these urban areas were: total phosphorus, metals (lead, copper, chromium), chloride, organic chemicals and bacteria. The pollutant problems were greatest (in terms of unit-area loads) in the most urbanized areas at the Schneider Creek, Montgomery Creek, Kitchener - Waterloo - Cambridge and Guelph sites. No significant pollutant contributions were measured in the least urbanized areas at New Hamburg, Durham and Allan Park.

The main sources of pollution in urban areas appear to be residential and commercial land and industrial point sources. A major pathway by which pollutants enter receiving waters in urban areas is thought to be the wash-off of accumulations of airborne-derived contaminants from impervious surfaces. Residential and industrial construction sites, where the vegetative cover has been removed, and areas where on-site protection measures have not been undertaken appear to be sources of greatly increased sediment and sediment-associated pollutant loads.

ZZ IJC 769  
PLUARG 79-078

# Avadhanula, M. Rao. **Pollution from Rural, Transportation, Extractive and Undisturbed Land Uses in the Grand and Saugeen Watersheds.** Submitted to PLUARG Task Group C (Canadian Section) Activities 3 and 4. March 1979, 60 pp.

### Summary

The effects of land drainage from rural land use, transportation corridors, extractive operations and undisturbed (under perennial vegetative cover) areas on the receiving water quality in the Grand River and Saugeen River pilot watersheds (Ontario) were investigated as part of the Task C activities under the Pollution from Land Use Reference Group (PLUARG) of the International Joint Commission. Water-quality and water-quantity data were collected during 1975 and 1976 from: eight rural watersheds: upstream and downstream of a major highway corridor, a sand and gravel pit, a limestone quarry and from two relatively undisturbed (wooded/idle) land areas in the Grand River and Saugeen River pilot watersheds. Based on the analysis of the data over a two-year period (1975-1976), the major sources of pollutants from these different land uses have been tentatively identified.

ZZ IJC 769  
PLUARG 79-079

# Chan, H.T. **Contamination of the Great Lakes by Private Wastes**. Submitted to PLUARG Task Group C (Canadian Section) Parts 1 and 2, Activity 3. December 1978, 269 pp.

### Summary

This study consisted of two parts: (1) field investigations of some existing private waste disposal systems and (2) estimation of pollutant loadings from systems in watersheds adjacent to the Great Lakes.

The objectives of the field investigations were: to study the quality of the ground water adjacent to private waste disposal systems, to estimate the attenuation of chemical pollutants by various soils, and on the basis of the findings obtained in the field, to review the guidelines set by the Ontario Ministry of the Environment pertaining to the design and construction of septic tank-tile field systems.

It was found that the attenuation of phosphorus by soils was usually excellent (>90%), the attenuation of nitrogen was good (about 30%) and the attenuations of sodium and potassium were moderate (about 50%). Generally, the guidelines pertaining to the design and construction of septic tank-tile field systems were found to be adequate.

The approach used in Part II was to collect data on the existing private waste disposal systems (PWDS) which may contribute pollutants to the Canadian portion of Lakes Ontario, Erie, Huron and Superior. The maximum potential pollutant loads from the PWDS were first calculated to obtain an estimate of the upper limit of potential loading. These calculations were performed for twenty-four watersheds in southern Ontario. The results for these watersheds were then summed to derive the total pollutant loading estimates to the Great Lakes in southern Ontario. For the Great Lakes bordering northern Ontario, the loading computations were performed on an individual county basis.

ZZ IJC 769  
PLUARG 78-080

- # International Reference Group on Great Lakes Pollution from Land Use Activities. **Quality Control Handbook for Pilot Watershed Studies.** Windsor, Ontario. 1975, revised June 1976, March 1977, 49 pp.

### Summary

This handbook is intended to give investigators associated with Task Group C studies under PLUARG the guidelines for quality control. These guidelines will ensure that the conclusions of the various investigators, and hence the summaries developed, are based upon comparable data. In addition, the program will aid investigators in ascertaining whether their needs for precision and accuracy are being met and will contribute to overall proficiency by providing opportunities for scientists to discuss solutions to common problems.

ZZ IJC 769  
PLUARG 75-081

# Dube, D. *et al.* **Data Quality Assurance for Watershed and Land Use Studies**. Windsor, Ontario. 1978, 33 pp.

### Summary

To ensure adequate quality control within its studies, PLUARG investigators took a number of actions. They developed a quality control handbook that described the necessary protocol to determine if sampling, sample handling, and sample analysis produced data of the necessary integrity to support specific study conclusions. In addition, they called for remedial actions when a laboratory was found to perform inadequately.

Subsequently, to meet the sample quality control requirement a quality assurance program was instituted. It was comprised of inter-laboratory analytical performance tests, blind replicate precision tests and the documentation of analytical methods and intralaboratory quality control procedures.

Fifteen interlaboratory analytical performance studies were conducted for nutrients, demand, minerals, metals and pesticides in water and for metals, nutrients and pesticides in sediments. In addition, similar ancillary studies were carried out by several Canadian laboratories. Several hundred blind field replicate samples were taken and analyzed. Data from these replicates were reviewed by principal investigators and staff of the IJC Great Lakes Regional Office. Each participating laboratory produced descriptions of its analytical methods and "in-house" quality control procedures. All data and documentation derived from the program were assembled by and are archived at the Regional Office. Almost all laboratories generated analytical data which were suitably compatible with other laboratories. The larger laboratories that generated the bulk of the data uniformly demonstrated the best compatibility. Most laboratories consistently demonstrated adequate recoveries on reference and spike materials in samples, and when a difficulty was found, remedial action was taken. The analyses of the blind field replicate samples demonstrated that sampling and analytical integrity had been adequately maintained to provide useful data for PLUARG studies. From all the various studies in the Quality Assurance Program, only two laboratories demonstrated analytical difficulties much of the time. Appropriate steps were taken to ensure that the findings from the studies supported by these laboratories did not affect the conclusions of the Task C Work Group.

The Quality Assurance Program was able to demonstrate that overall laboratories were able to produce analytical data which were adequate for the PLUARG Task C Watershed Studies. The program was successful in removing identified analytical difficulties in all but two laboratories. Appropriate steps were taken to ensure that data derived from the two laboratories did not affect the conclusions of the Task C Work Group. The program established that sampling procedures, sample handling and analyses were in control by use of field sample replicates (unidentified to the laboratory). Only 5% of the replicate results were not within acceptable ranges.

The program confirmed that laboratories producing the most data for the Watershed Studies also produced the most compatible data.

ZZ IJC 769  
PLUARG 78-082

- \* Onn, Dennis. **Point Source Studies**. (Unpublished). Submitted to PLUARG Task Group C (Canadian Section) Activity 4. November 1976, 3 pp.

### Summary

The purpose of this study is to measure the magnitude and significance of material inputs from municipal sewage treatment plant effluent and industrial sources entering the surface watercourse either directly or via the urban storm-sewer system.

ZZ IJC 769  
PLUARG 76-083

Bodo, B. **Loadings and Parameter-Flow Relationships.** (Unpublished). Submitted to PLUARG Task Group C (Canadian Section) Activities 1, 3 and 4. 1976, 27 pp.

## Summary

The purpose of this study is to estimate quantitatively the pollutant input into the Great Lakes system and to relate these estimates to the various land-use practices being examined under PLUARG Task C studies. These estimates are ultimately intended to provide a basis for basin-wide extrapolation of flux estimates.

The relationships between parameter concentrations and streamflow, as well as parameter mass flux computations at approximately thirty PLUARG sites selected from among the Grand, Saugeen and agricultural watersheds for the year 1975 have been summarized. Relationships between concentration and flow have been grouped into three general categories. Nutrients, metals and generally the particulate-associated parameters tend towards positive relationships in which concentration increases as flow increases. The "mineral" (sodium, sulphate, chloride, magnesium, etc.) parameters consistently exhibit the opposite trend to have any consistent relationships with flow. Varying degrees of scatter characterize most relationships which were investigated.

Loading estimates suggest that marked increases in the rates of contaminant flux occur from upstream to downstream sites on the Grand River. Significant increases in pollutant loads are observed below the urban complex of Kitchener-Waterloo, Guelph and Cambridge. These pollutant levels are sustained below the urban complex down to the mouth of the Grand River, suggesting that agricultural activity is also a major pollutant contributor in the lower reaches of the Grand River. The Saugeen Basin is a comparatively less polluted watershed, showing flux rates comparable to the upper and middle reaches of the Grand River. The agricultural watersheds vary considerably in pollutant outputs reflecting differences in type and intensity of agricultural activity. Some of these watersheds appear to be significant contributors of various pollutants, primarily nutrients. Flux estimates were derived by the IJC recommended approach.

ZZ IJC 769  
PLUARG 76-084

- \* Avadhanula, M. Rao. **Water Quality Studies, Fall Report.** Submitted to PLUARG Task Group C (Canadian Section) Activities 1, 3 and 4. November 1976, 24 pp.

## Summary

This report presents the progress achieved to date through the Activities 1, 3 and 4 of the PLUARG Task C study. Results summarized in this report correspond to the main objective of "obtaining the data on the inputs of pollutants" from the different land-use areas in the Grand, Saugeen and Wilton Creek Basins in Ontario.

Among the eleven agricultural watersheds included in the PLUARG study, Hillman Creek and the Little Ausable River sites (Ag.-13 and Ag.-3) contained the highest levels of  $\text{NO}_2 + \text{NO}_3$ . The highest total phosphorus concentrations were found in the downstream outlets of North Creek and Big Creek (Ag.-10, Ag.-1). Total phosphorus showed significant correlations ( $r$  values greater than .8) with ion, TKN and turbidity, whereas inorganic nitrogen had poor correlation values with phosphorus. Great consistency was observed in the water-quality data over the study period (1974, 1975, spring 1976).

In general, the results of the investigations under PLUARG confirm results derived from the analysis of the historic Grand River water-quality data. Marked seasonal trends and monthly variations in some parameter concentrations were observed in these data. The PLUARG data for the Grand River Basin exhibited water-quality deterioration at downstream stations. The concentrations of important nutrients (phosphorus and nitrogen) increased from the middle of the Grand River Basin and remained high all along the downstream main channel to the outlet. In comparison the collected water-quality data suggest that the Saugeen River, Wilton Creek waters are free from any significant pollution.

Multivariate analysis of the 1975 PLUARG water quality was undertaken. The sampling stations with high levels of pollutant inputs were located on the Nith River tributary, below the urban areas and the downstream reach of the Grand River main channel. A better water quality was found to be present in the Saugeen River.

Based on current information, it is tentatively concluded that the urban and agricultural land-use activities are the main sources of pollutant contribution in the Grand River Basin.

ZZ IJC 769  
PLUARG 76-085

- \* Coote, D.R. *et al.* **Agricultural Land Uses, Livestock and Soils of the Canadian Great Lakes Basin (South of Latitude 45 degrees N) A Report of the Activities of the Engineering Research Service and the Soil Research Institute as Part of Agriculture Canada's Contribution to the Implementation of the Great Lakes Water Quality Agreement, 1973-1974.** (Unpublished). Prepared in part for PLUARG, Task Group C (Canadian Section). June 1974, 133 pp.

## Summary

### Section I - "Preparation of Background Information for Agricultural Region Identification and Watershed Selection"

PLUARG's Agricultural Sub-Committee required certain information on which to base its collective selection of sites for Preliminary Agricultural Watershed Studies. This information was provided by the projects on classification and mapping of the soils, data obtained from Activity II below and data on climatic variability. These data were utilized to identify distinct "agricultural regions" within the lower Great Lakes Basin.

### Section II - "Soil Erosion and Fluvial Sedimentation in Southern Ontario"

A map was prepared indicating the distribution of predicted soil erosion losses from the predominant soil and agricultural regions of southern Ontario. Losses ranged from 0 to 15 tons/ac./yr. Watersheds located in regions of highest soil erosion loss from agricultural land included the Thames, Sydenham and Humber Rivers.

### Section III - "Livestock Feedlot and Manure Storage Runoff"

Two beef feedlots and two manure storage areas have been instrumented so that a record of rainfall and runoff can be obtained.

### Section IV - "A Selective Inventory of Livestock Operation in Southern Ontario"

An inventory of large livestock operations in southern Ontario has been carried out utilizing aerial photographs. More than 4,500 farms have been recorded, and an area of over 25,000 square miles has been surveyed during this inventory.

ZZ IJC 769  
PLUARG 74-086

# Ostry, R.C. **The Evaluation of the Effect of Some Waste Disposal Practices on Great Lakes Water Quality.** 1979, 40 pp.

### Summary

As part of the Ministry of the Environment's input to the Pollution from Land Use Activities Reference Group (PLUARG) program, studies were conducted on some waste-disposal of sewage sludge on agricultural sanitary landfilling, disposal of sewage sludge on agricultural land, private waste disposal, wastewater lagoons and irrigation, and point-source discharges. Excluding point-source discharges, the other waste-disposal practices appear to pose no serious environmental hazard, provided they are subject to proper site selection, design and operation. Soil attenuating mechanisms appear to be highly effective in restricting the migration of contaminants from most waste-disposal sites. The potential pollutants identified from existing waste-disposal practices in Ontario are summarized below:

1. sanitary landfilling - chloride, organic toxicants;
2. disposal of sewage sludge on agricultural land - nitrogen, phosphorus, metals, pathogenic organisms;
3. private-waste disposal - chloride, nitrogen, phosphorus;
4. wastewater lagoons and irrigation - nitrogen, phosphorus, metals and
5. point-source discharge - nitrogen, phosphorus, metals and organic toxicants.

Surface runoff carrying pollutants from existing waste-disposal sites was found to be of secondary importance. The principal mechanism of dispersing contaminants was by way of the ground-water system, ultimately leading to surface-water contamination.

With respect to point-source discharges, significant pollutant inputs were identified as contributing to water-quality impairment of the Great Lakes. For example, a combined municipal and industrial point-source discharge in the Grand River Basin comprises a significant proportion of the low flow or base flow in the river based on historic records (up to 80%). In terms of the total annual load monitored at the mouth of the Grand River, point-source discharges accounted for 37% of the phosphorus, 19% of the nitrogen, 11% of the lead, 25% of the zinc and 21% of the copper.

ZZ IJC 769  
PLUARG 79-087

# Ostry, R.C. **Data Collection Methodology Used in the Study of Pollution from Land Use Activities in the Grand River and Saugeen River Pilot Watersheds.** 1979, 70 pp.

#### Summary

Data-collection techniques employed in the Ministry of the Environment's PLUARG monitoring program were documented to ensure that the findings and conclusions based on these data could be compared and evaluated with data from other studies.

Water-quantity, water-quality and sediment-quality measurements conducted in the monitoring program were used to provide quantitative estimates of pollutant mass transport for the following uses:

agriculture, urban, transportation and utility, sanitary landfill, processed organic waste, extractive industries and private waste disposal.

Continuous records of water level were obtained from streamflow gauging stations and relationships between stage and discharge for each station were developed in order to compute continuous discharge. Rainfall intensity and daily, total rainfall measurements were obtained using a network of tipping bucket and standard rain gauges. Ground-water sampling points were installed and monitored to determine the impairment of ground-water quality in the vicinity of selected study sites. The sediment-quality monitoring program was designed to measure the quality of fluvial sediments and soils.

Emphasis in the water-quality monitoring program was placed on the collection of samples when surface runoff (resulting from rainfall events or snow and ice melt) transported pollutants from the surface of the land to the tributary channel. Water samples were collected in the vicinity of the investigated land-use activities to determine the pollutant contribution from that land use. In addition, the surface-water monitoring network was expanded to unmonitored areas of the pilot watersheds to trace the movement of pollutants to the boundary waters.

Soil analyses were undertaken to quantify the attenuation rates of nutrients, inorganic trace contaminants and organic trace contaminants on lands used for sanitary landfill, private waste disposal and the application of processed organic waste as fertilizer. Suspended-sediment quality was measured to determine the percentage of contaminants carried by sediment and to estimate the mass transport of some contaminants, i.e. PCB's, which often occur in water below the analytical detection limit. Measurement of bed-material quality was also undertaken to determine the degree of sediment impairment in the vicinity of the investigated land uses.

ZZ IJC 769  
PLUARG 79-088

## **TASK 'D' REPORTS**

To diagnose the degree of impairment of water quality in the Great Lakes, including an assessment of concentrations of contaminants in sediments, fish and other aquatic resources.



# Great Lakes Basin Commission. **Existing River Mouth Loading Data in the U.S. Great Lakes Basin.** Submitted to PLUARG Task Group D (U.S. Section). May 1976, 713 pp.

#### Summary

River mouth loading data from 550 tributaries to the Great Lakes have been identified. These data are related to pollution of the Great Lakes potentially derived from land drainage. Chemicals considered include nutrients, pesticides, heavy metals and refractory organics, i.e. persistent organics, such as PCBs, not normally classified as pesticides, both in solution and attached to particulate materials. In addition, water discharge and sediment loading data have been sought.

Water quality and identified flow data were also evaluated in terms of their adequacy for computing tributary loading to the Great Lakes. Adequacy of the data was based on the frequency of sampling, the duration of sampling and the station location, but not on the analytical quality of the data.

Of the 550 tributaries considered for possible river mouth loading data, approximately 30% were found to have sufficient water quality data to consider calculating annual loadings. About 14% of these tributaries were gauged at a representative river mouth gauging station. Of the 550 tributaries identified, 102 were considered to be major tributaries, the remaining being relatively minor streams that individually are not likely to have a major influence on the Great Lakes (except for possible local effects). Most of the major tributaries identified had sufficient water quality data to consider loading calculations, although a number of major streams did not have gauging stations at strategic river mouth locations. Those few major tributaries that lack water quality data tend to drain undeveloped areas, and it is not recommended that sampling programs be established on these streams as a first priority.

In general, there is a good water quality data record for Great Lakes' tributaries from the standpoint of monthly monitoring. Flow data generally lag behind water quality data in terms of the number of tributaries adequately monitored. The information available on many tributaries may lead to an underestimation of total loadings of at least some parameters due to the lack of data during high flow periods, when a large portion of the total annual loading can occur. Very few streams were found to have data available specifically on runoff events.

Because of the large area encompassed by the Great Lakes Basin and the vast amounts of tributary data which have been collected and continue to be collected, there is a need for greater coordination of data collection, storage and retrieval. There is also a need for collection of consistent data over the long-term period, especially event-type data, in order to assess the short-term as well as long-term variability of the hydrologic system.

ZZ IJC 769  
PLUARG 76-089

# Sonzogni, W.C. et al. **United States Great Lakes Tributary Loadings**. Submitted to PLUARG Task Group D (U.S. Section) Activity 2.3. Windsor, Ontario. January 1978, 187 pp.

### Summary

Annual loads to the Great Lakes from U.S. tributaries were estimated for total phosphorus, soluble ortho phosphorus, suspended solids, total nitrogen, nitrate nitrogen, ammonia nitrogen and chloride. Loads were calculated for water years 1975 and 1976 using all available data. All loads for monitored tributaries were calculated using the ratio-estimator calculation method, except for Lake Erie tributary loads which were obtained from the Lake Erie Wastewater Management Study. In order to provide complete coverage of the Basin, loads from unmonitored watersheds were estimated from unit area loads determined from similar and usually adjacent monitored watersheds.

While the estimated loads are believed to be based on the best available information, they are naturally subject to the limitations of the data and must be interpreted with these limitations in mind. A major source of error for the estimated loads of some tributaries is the lack of representative data over different flow regimes during the annual cycle. However, if the data are carefully interpreted with the limitations of specific situations in mind, much useful information can be obtained. Moreover, the loading information presented should serve as a foundation for expanding and improv<sup>9</sup> load estimates as more extensive and long-term data become available.

# Ongley, Edwin D. **Land Use, Water Quality and River Mouth Loadings: A Selective Overview for Southern Ontario**. Submitted to PLUARG Task Group D (Canadian Section) Activity 2.1. Windsor, Ontario, March 1978, 110 pp.

#### Summary

This report is based upon a long-term PLUARG program in the Department of Geography at Queen's University under the auspices of Canadian Task D, for the assembly, management and analysis of data holdings pertinent to the assessment of regional trends for the Canadian side of the Great Lakes. These assessments have in the past involved computations of tributary loadings of a variety of nutrients, solids, contaminants and other water quality attributes; the evaluation of routinely available data for the purpose of developing regional trends; the statistical analysis of water quality-land use relationships and the development both of file management and of analytical methods for Task D purposes. The work performed under this program appears in a series of reports to (Canadian) PLUARG Task D of the International Joint Commission.

This report, although limited to selected results of a statistical evaluation of phosphorus trends and of land use-water quality interactions, contains enough primary information to permit full understanding without recourse to earlier reports. The study is intended primarily as a source document to be used with other PLUARG information in the preparation of the final PLUARG report, dealing with evaluation of regional trends of loadings and land use linkages and the development of remedial strategies. Therefore, much of the information is presented with explanatory notes but with little detailed comment for, prior to receipt of technical reports from other PLUARG activities, detailed synthesis at this stage in terms of remedial programs would be premature. It should also be noted that many relationships found among variables are noted herein but left unexplained because they are beyond this writer's experience.

Although PLUARG is primarily interested in substantive results, the multivariate analysis of the Task D data bank held at Queen's University has provided insight into analytical procedures involving regional data sets. Therefore, in addition to substantive conclusions drawn from the analysis, methodological experience gained through care and handling of this data bank is germane to potential post-PLUARG activities. It seems likely that future land use-water quality models for regional public policy development will involve a statistical component in which data of the type used here are the best likely to be available for regional analysis.

In most of the work reported here, aggregate basin characteristics are compared with mean (usually mean annual) river-mouth load and/or concentration data. Although solids data, which are particularly susceptible to seasonal (and event) hydrologic variations, have been assessed for seasonal resolution, land use-water quality linkages are here assessed using mean annual data. Sufficient data do exist to explore seasonal linkages; however, there are good scientific and statistical reasons for refraining from doing so until the distributed data within individual basins can be fully exploited.

- # Seibel, Erwin, John M. Armstrong and Cheryl L. Alexander. **Technical Report on Determination of Quantity and Quality of Great Lakes U.S. Shoreline Eroded Material.** Submitted to PLUARG Task Group D (U.S. Section) Activity 1.1. September 1976, 292 pp.

### Summary

Over 3,438 kilometers (2,116 miles) of the U.S. Great Lakes shoreline have been classified as subject to erosion while another 780 kilometers (483 miles) are flood prone. Erodible bluffs and low plains occur along each of the U.S. Great Lakes coasts in varying degrees. The erosion process tends to be intensified during or just after periods of high water level. High lake levels prevailed during the early 1950's and again at the present time. While the effects of the increased recession rates are relatively unknown, one anticipated effect is an increase in the actual input of sediment to the Great Lakes from the U.S. shoreline. This study was undertaken as part of Task D (U.S.) Activity 1.1, which is designed to develop an estimate of the importance of shoreline erosion as a pollutant to the Great Lakes relative to other land associated pollutants.

Estimates of the annual volumetric contributions of eroded sediment created by bluff recession, have been derived in this study for about 44% of the erodible U.S. Great Lakes shoreline. Approximations of the input of the chemical components of the eroded material, generated from specific reaches along the U.S. coasts, have also been calculated. Both sets of values are dependent on the recession rates which were obtained from various reports and agencies. The methods by which the bluff recession rates were determined and the time intervals over which they are recorded are significant factors when evaluating the validity of the values derived for the volumetric contribution and the chemical input of the eroded material. Further extrapolation of the data to obtain the total quantity and quality of shoreline material eroded into the Great Lakes will be attempted in Activity 1.2 of Task D.

ZZ IJC 769  
PLUARG 76-092

- # Monteith, Timothy J. and William C. Sonzogni. **U.S. Great Lakes Shoreline Erosion Loadings**. Technical Report of the International Reference Group on Great Lakes Pollution from Land Use Activities. December 1976, 211 pp.

### Summary

This study provides an estimate of the total quantity and quality of material contributed to the lakes from shoreline erosion, which has generally been ignored as a source of land-derived pollutants to the Great Lakes. It completes Subactivity 1-2 of U.S. Task D, Pollution from Land Use Activities Reference Group (PLUARG). The general background for this report was developed in Subactivity 1-1(a), in which samples from the U.S. Great Lakes shoreline were collected and analyzed for chemical characteristics, and Subactivity 1-1(b), in which the available information on Great Lakes shoreline erosion rates was compiled.

The estimated sediment and chemical loadings from shore erosion in this report are only first approximations or order of magnitude estimates. The estimated loadings are primarily intended to show the relative magnitude of shore erosion loadings, particularly in comparison with other sources of sediment and chemicals to the Great Lakes.

ZZ IJC 769  
PLUARG 76-093

- # Thomas, R.L. and W.S. Haras. **Contribution of Sediment and Associated Elements to the Great Lakes from Erosion of the Canadian Shoreline.** PLUARG Task Group D, Activity 1 Technical Report. 1978, 57 pp.

### Summary

The primary base for this study of erosion of the Great Lakes shoreline is the detailed investigation conducted under the Canada/Ontario Agreement on Great Lakes Shoreline Damage. This study incorporated an assessment of long-term shoreline recession/accretion rates by photogrammetry between 1952 and 1973 and the short-term erosion rates during the high water levels of 1972 and 1973. For this latter part of the study shore erosion transects were established in the region from southern Georgian Bay to Pres'quille on Lake Ontario. Samples for analysis for PLUARG were collected from a number of these transects for analysis of texture, major and trace elements.

ZZ IJC 769  
PLUARG 78-094

- # Acres Consulting Services Ltd. **Atmospheric Loading of the Lower Great Lakes and the Great Lakes Drainage Basin.** Submitted to the International Reference Group on Great Lakes Pollution from Land Use Activities. March 1977, 79 pp.
- # **Atmospheric Loadings to the Great Lakes, a Technical Note.** Submitted to the International Reference Group on Pollution of the Great Lakes from Land Use Activities. September 1977, 17 pp.

### Summary

Acres Consulting Services Limited carried out scientific investigations of deposition of airborne material on the Lower Great Lakes and the entire Great Lakes Drainage Basin. This report is essentially an extension of the report, **Atmospheric Loading of the Upper Great Lakes**, 1975.

In that report, a mathematical model was developed that simulated, on a daily average basis, the meteorological transport, diffusion and deposition (loading) of atmospheric pollutant emissions from large sources in and around the Great Lakes Basin. Using the model, calculations were made of the loadings in 1974 of sixteen pollutants originating from thirty major emission regions in Canada and the United States. Emissions data were available only on an annual basis and it was necessary to assume that these were distributed uniformly throughout the year. Daily average meteorological data were used from a network of fourteen stations in the study area. The calculated loadings were then compared with loadings estimated from a network of shoreline, island and buoy precipitation chemistry stations.

Results from the two methods were in reasonable agreement on those pollutants for which relatively reliable atmospheric emissions data were available.

For this report, model estimates were required for Lakes Michigan, Erie and Ontario, as well as for the entire land drainage area in the Great Lakes Basin, subdivided into thirty-seven individual areas.

Projections were made of growth rates to the year 2000 for those industrial sectors that contribute the bulk of emissions (about 90% of the total).

A substantial effort was made to obtain data in both Canada and the United States on atmospheric emissions of polychlorinated biphenyls (PCB's) for input to the model. The information collected was judged to be insufficient to permit calculations of loadings. Consequently, populations of each emissions region were extracted from published data, and dimensionless distribution patterns were calculated on the assumption that PCB air emissions are related to population density.

# Gregor, D.J. and E.D. Ongley. **Analysis of Nearshore Water Quality Data in the Canadian Great Lakes, 1967-1973, Part 1.** Submitted to PLUARG Task Group D (Canadian Section) Activity 2.1. Windsor, Ontario. January 1978, 270 pp.

### Summary

An evaluation and analysis of nearshore water quality data has been undertaken. These data have been collected along the Canadian shoreline of the Great Lakes between 1967 and 1973 by the Ontario Ministry of the Environment.

The single most difficult problem in dealing with this data set is its high degree of spatial and temporal variability; therefore, considerable time and effort were expended in obtaining an appreciation of its complexities. This is achieved with detailed summaries of station and parameter sampling frequencies. Parameters which meet specific sampling frequency criteria are identified as being suitable for statistical analysis. However, only eight parameters, generally applicable to a description of the health of the nearshore zone, are considered in this report.

The data of each geographic region for each season and depth are summarized using parametric statistics. Analysis of variance is employed to test for significant seasonal and depth differences. Spatial water quality patterns are illustrated and temporal trends are evaluated. The results are discussed, interpreted and compared to previous studies in an attempt to provide a summary of water quality in the Canadian nearshore zone of the Great Lakes for the period 1967 to 1973.

ZZ IJC 769  
PLUARG 78-096

# Chesters, Gordon and Joseph J. Delfino. **Frequency and Extent of Wind-Induced Resuspension of Bottom Material in the U.S. Great Lakes Nearshore Waters.** Submitted to PLUARG Task Group D (U.S. Section) Activity 3.3b. Windsor, Ontario. June 1978, 111 pp.

#### Summary

An extensive literature review was conducted to estimate the frequency and extent of wind-induced resuspension in the U.S. Great Lakes nearshore zones and to identify nearshore areas of the U.S. Great Lakes where during certain times of the year, sediment characteristics and wind/wave conditions are especially conducive to resuspension of bottom sediments. Two major areas of literature search and information synthesis were explored: wind and wave characteristics and the properties of nearshore surficial sediments in the U.S. Great Lakes. Additionally, limited information on critical velocities and entrainment rates of sediments was evaluated.

The approach of this study to determine the frequency and extent of sediment resuspension was to utilize wave height and wave period data to calculate wave orbital velocities. Wave height data collected over a 10-year period by observers on Great Lakes vessels (SSMO, 1975) were coupled with wave period data obtained through wave-hindcasting techniques (Resio and Vincent, 1976-1978). Other sources of wave data were considered, but they were either judged incomplete because only some of the Great Lakes were covered or were in such a raw form that extensive computer time was required to synthesize them before they could be used. Such a computer effort was beyond the resources of this project.

It is important to consider the quality of nearshore sediment when designating critical areas. Using this criterion, critical areas in the U.S. Great Lakes nearshore zones are identified as Saginaw Bay (Lake Huron), the western Basin of Lake Erie, the southern segment of Lake Michigan and the Duluth-Superior and northern segments of Lake Superior. According to our estimates, large quantities of sediment are not resuspended in the northern zones of Lake Superior. However, this zone encompasses Silver Bay where taconite tailings are discharged. Obviously, resuspension of polluted bottom sediments will have a far greater impact on water quality than the resuspension of uncontaminated sediment.

It is important to remember that the predicted sediment resuspension reported is only a first approximation and extrapolation is only useful if further studies are conducted to verify (or disprove) these estimates.

ZZ IJC 769  
PLUARG 78-097

# Suns, K. *et al.* **Organochlorine and Heavy Metals Residues in the Nearshore Biota of the Canadian Lower Great Lakes**. Submitted to PLUARG Task Group D (Canadian Section) Activity 3.3. May 1978, 45 pp.

#### Summary

Dissolved organochlorine residue levels in the river waters were not significantly different between Oakville Creek and Grand River water samples.

Body-burden levels of polychlorinated biphenyls (PCB's), hexachlorobenzene (HCB), total 1,1,1-trichloro-2,2-bis (p-chlorophenyl ethane) ( $\Sigma$ DDT) and mirex were significantly higher in emerald shiners from the Oakville Creek estuary than shiners from the Grand River.

PCB residues in adult emerald shiners at both stations exceeded the proposed IJC guideline criteria for protection of wildlife.

Mirex and HCB residues were found only in the Oakville Creek estuary shiners.

ZZ IJC 769  
PLUARG 78-098

- \* Eadie, Brian J. **Effect of the Grand River Spring Runoff on Lake Michigan.** (Unpublished). Draft Report submitted to PLUARG Task Group D (U.S. Section) Subactivity 3.1. September 1976, 82 pp.

### Summary

A series of cruises in and around the Grand River plume were conducted during the spring runoff to determine the effect of high flow loadings on nearshore Lake Michigan. It was found that:

1. the plume was relatively small rarely extending beyond a 3 x 3 km area;
2. during spring runoff the river loads the lake at approximately twice the background rate;
3. an approximate plume residence or replacement time of one day leads to most materials acting in a conservative manner;
4. the river is loading the lake significantly in total suspended matter, nutrients and trace metals;
5. the river does not appear to be a source of PCB's and
6. real time coordination with NASA overflights did not prove successful, although the concept has significant potential for nearshore studies.

ZZ IJC 769  
PLUARG 76-099

Environment Canada and Ontario Ministry of Natural Resources. **Canada-Ontario Great Lakes Shore Damage Survey Technical Report.** October 1975, 97 pp.

Environment Canada and Ontario Ministry of Natural Resources. **Canada-Ontario Great Lakes Shore Damage Survey Coastal Zone Atlas.** March 1976, 732 pp.

## Summary

The current high water levels of the Great Lakes caused widespread damage to the shorelines, resulting **in** considerable loss of public and private property. In response to concern for shoreland properties, Environment Canada and the Ontario Ministry of Natural Resources entered into an agreement to survey the nature and extent of shoreline damage through erosion and inundation and to make preliminary recommendations with respect to shoreline management and planning. The findings, conclusions and recommendations are presented in this technical report.

A coastal zone atlas was produced to display cartographically shoreline parameters such as land use, land value, ownership, physical characteristics, shore protection and existing protection in damaged areas. The atlas utilizes aerial photographs from 1952-55 and 1973 and old survey records to quantify recession on the Great Lakes shoreline and presents these rates as histograms.

The survey was designed to collect and analyse data on the Great Lakes shoreline with respect to erosion and inundation damage as an initial step in identifying the alternatives for shoreline managements and planning.

This report deals with the portions of shoreline classified as erodible, extending from Port Severn on Georgian Bay to Gananoque on Lake Ontario. General and specific causes of erosion and inundation are examined along with the economic, engineering, environmental and social implications of the resulting losses. Possible alternatives or strategies to ameliorate shoreline damage are presented for future in-depth consideration. Recommendations are presented in respect to long-term protection, **in** shoreland management and planning, and in the development of studies to further explore these fields.

ZZ IJC 769  
PLUARG 75-100  
ZZ IJC 769  
PLUARG 76-100

- \* Ongley, Edwin David. **Hydrophysical Characteristics of Great Lakes Tributary Drainage, Canada**. 5 vols. (Unpublished). Submitted to PLUARG Task Group D, Activity 2, Subactivity 1. October 1974, 1,211 pp.

Appendix I: Geographical and Geomorphical Data (Volume 2)

Appendix II: Discharge Records (Volume 2)

Appendix III: Water Quality Records

Basin Index: Lake Ontario (Volume 3)

Basin Index: Lake Erie (Volume 4)

Basin Index: Lake Huron (Volume 5)

Basin Index: Lake Superior (Volume 5)

## Summary

Although the immense reservoir characteristic of the Great Lakes produces relative hydrologic stability, it also serves to retain and concentrate material discharging from tributary drainage. In view of diverse physical and cultural characteristics of the Great Lakes watershed, the purpose of this report is to provide data to enable identification of spatial patterns of river discharge and water quality for all Canadian tributaries draining into each of the Great Lakes. In addition, basic geologic and geomorphologic information is compiled for each tributary watershed. With the exception of Appendix I, the report omits data for tributaries draining to waterways connecting the Great Lakes.

Appendix I contains geographic, geomorphologic and landform description of basins included in Appendices II and III, plus basins added in 1973 to the provincial monitoring system. Appendices II and III, which tabulate discharge and water quality records, include all basins for which discharge and/or water quality data are available to December 31, 1972.

ZZ IJC 769  
PLUARG 74-101

- \* Ongley, Edwin D. **Hydrophysical Characteristics of Great Lakes Tributary Drainage, Canada: Evaluation of Loadings from Tributary Waters to the Great Lakes and Interconnecting Channels.** (Unpublished). Submitted to PLUARG Task Group D. February 1976, 227 pp.

### Summary

This report continues the work for PLUARG Task D and contains a contract work statement, "raw data sets" status report, and water quality and loadings calculations for interconnecting waterways.

It was recommended that Task D continue its assessment of loadings data both within the framework of concentration-discharge relationships and as additional PLUARG information becomes available. It has been noted that verification of surveillance data can be performed on only five watersheds and only for suspended sediment. It is imperative that other quality parameters be checked against the more exhaustive but temporally limited Task C data sets.

The Task D data bank is sufficiently complete to subject the data to multivariate analysis in order to examine linkages between water quality attributes and independent variables such as land use, overburden, geology, discharge, etc. These linkages will form the foundation for extrapolation (modelling) using the Task B future projections of land use.

ZZ IJC 769  
PLUARG 76-102

- \* Ongley, Edwin D. **Study of Statistical Evaluation and Update of Data Bank with Discharge and Water Quality Data for the Great Lakes Interconnecting Channels and Associated Tributaries.** (Unpublished). Submitted to PLUARG Task Group D (Canadian Section). March 1977, 91 pp.

### Summary

This status report includes a statement of data file organization, activities pertaining to statistical analysis, an overview of current work status and a summary of loadings data for the period of record to 1974. No effort was made to reproduce earlier information contained in the 1974 report.

ZZ IJC 769  
PLUARG 77-103

- \* Sydor, Michael and Gordon J. Oman. **Effects of Nemadji River Runoff on Lake Superior: Effects of River Inputs on the Great Lakes**. Submitted to the U.S. Environmental Protection Agency and PLUARG, Task Group D in fulfillment of Subactivities 3.1 and 3.3a. May 1977, 193 pp.

## Summary

Among the topics discussed in this report are: the extent of contamination from spring runoff, resuspension, effluent budgets, effluent identification through Landsat, chemical loading from spring runoff, long range effluent transport and accumulation, effluent dissipation to background levels, interstate transport of pollutants, separation of runoff and resuspension effects.

## CONCLUSION AND RECOMMENDATIONS

1. Landsat data for Lake Superior can be used in statistical determination of particulate loading due to runoff, erosion and resuspension. The availability of three satellites provides good statistics, low cost and a good opportunity for simultaneous ground truth data acquisition.
2. Numerical modeling of turbidity plumes, in correlation with remote sensing data, provides realistic results for dispersion and transport of pollutants to background levels.
3. Although monitoring of chemical loading through the use of remote sensing appears difficult, the use of satellite-borne instruments, specifically designed for water quality measurements, would be helpful. The present satellite and manned overflight data can be used in differentiating effluents in Lake Superior, and can be used in estimates of chemical loading for those parameters which show strong correlation with the optically-detectable parameters. Further correlation of chemical parameters with satellite data and optical parameters could be fruitful. The manned overflights have the advantage of narrower spectral resolution, but suffer from an additional need for correction due to angular dependence of atmospheric effects and the angular dependence of Mie scattering by suspended solids. Currently the lack of sufficient data representing nearly simultaneous sampling and overflights, prevents the realization of the full potential of remote sensing data in evaluation of water quality on a large geometric scale. Repeated low level overflights, such as were performed at the Nemadji site for April 9, could be helpful.

ZZ IJC 769  
PLUARG 77-104

- \* Sydor, Michael and G.J. Oman. **Effects of Nemadji River Runoff on Lake Superior**. (Unpublished). Submitted to PLUARG Task Group D (U.S. Section) Activities 3.1 and 3.3a. December 1977, 174 pp.

### Summary

Among the toxics discussed in this report are: the extent of contamination from spring runoff, resuspension, effluent budgets, effluent identification through Landsat, chemical loading from spring runoff, long range effluent transport and accumulation, effluent dissipation to background levels, interstate transport of pollutants, separation of runoff and resuspension effects.

ZZ IJC 769  
PLUARG 77-105

- \* Herdendorf, Charles E. and John E. Zapotosky. **Effects of Tributary Load in to Western Lake Erie During Spring Runoff Events.** (Unpublished). Submitted to PLUARG Task D U.S. Section Activity 3. . May 1977, 153 pp.

### Summary

Suspended sediments and associated chemical contaminants in western Lake Erie originate from at least four sources: land runoff and channel erosion via tributaries, resuspension of bottom sediments and erosion offshore material by wave action, vessel operation (including dredging) and atmospheric contributions. Because the Maumee River is one of the major contributors of sediment and chemical contaminants, the high level of these materials has been suspected of having a profound effect on the western basin of Lake Erie.

The results of the 1975 pilot study in Maumee Bay (NASA, 1975 and Herdendorf, 1975) demonstrated the advantages of coordinated shipboard/ aircraft surveys in obtaining information on the effects of river loadings and dispersal of tributary-derived pollutants. Information on the resuspension of sediments by wave action was also obtained during the pilot study. Based on the experience gained in 1975, the project was continued and expanded in the spring of 1976. This report deals with the preliminary results of the second year of this project.

The objective of the second year was to conduct comprehensive surveys of the Maumee and Detroit River mouths and adjacent areas of western Lake Erie immediately after ice "break-up" and to continue these surveys during the major tributary runoff events which affect the western basin. Following the major effects, cruises and overflights were planned to sample areas of tributary plumes, areas of major sediment resuspension, offshore areas of the western basin, island areas of the western basin and interface of the western and central basins of the lake.

These surveys were intended to establish the areas of direct tributary impact, the areas and amount of sediment resuspension and a chronology of western basin transport patterns, including the long-term transport of tributary inflow throughout the basin.

ZZ IJC 769  
PLUARG 77-106

- \* Bannerman, Roger, John Konrad and Don Becker. **Effects of Menomonee River Inputs on Lake Michigan During Peak Flow.** (Unpublished). Submitted to PLUARG Task Group D (U.S. Section) Activities 3.1 and 3.1a. August 1977, 78 pp.

### Summary

The effects of the combined inputs from the Menomonee, Milwaukee and Kinnickinnic Rivers on Lake Michigan water quality were investigated. Estimates of annual river loadings indicated the Menomonee River usually discharged less than half of the annual river loadings reaching the Milwaukee Harbor and the effect of the Menomonee River on Lake Michigan water quality could not be isolated from that of the Milwaukee and Kinnickinnic River. The study focused on the area around the Milwaukee harbor and the area was divided into four regions: the inner harbor, outer harbor, inshore zone and offshore zone. The inner harbor was bounded upstream by the point on the river where the lake and harbor seiche effects were no longer apparent and downstream by the outermost point of the shipping channel. The outer harbor was separated from the inshore zone by the breakwater and the inshore zone extended five kilometers into the lake. Water quality surveys were conducted in the study area during periods of high and low flow in the rivers. The parameter list included nutrients, solids and metals.

ZZ IJC 769  
PLUARG 77-107

- \* State University of New York College, Buffalo, Great Lakes Laboratory. **Effects of Genesee River Discharge and Wind-Induced Resuspension on the Nearshore area of Lake Ontario.** Submitted to the International Reference Group on Great Lakes Pollution from Land Use Activities. Buffalo, N.Y. December 1976, 69 pp.

## Summary

This report presents information from a PLUARG Task D 3.1 and 3.3 study concerning a chemical evaluation of discharges from the Genesee River and of wind-induced resuspensions in the Rochester region of Lake Ontario. The investigation also provided ground-truth for a remote sensing survey conducted simultaneously.

The objectives of the study were to:

1. survey the quality of water offshore of the Genesee River mouth following a high-flow event;
2. identify general distribution patterns and transport mechanisms of substances contributed by the river;
3. determine whether resuspension of sedimented materials is significant, relative to the tributary inputs of suspended material in the nearshore area of the river under study;
4. assess the general impact of wind-induced resuspension of suspended material on the water quality of the area under study and
5. evaluate the general impact of the tributary loading to the lake under event conditions.

ZZ IJC 769  
PLUARG 76-108

- \* National Aeronautics and Space Administration, Lewis Research Center. **Coordinated Aircraft/Ship Surveys for Determining the Impact of River Inputs on Great Lakes Waters - Remote Sensing Results.** (Unpublished). Submitted to the International Reference Group on Great Lakes Pollution from Land Use Activities. June 1977, 25 pp.

## Summary

Aircraft remote sensing has proved to be a productive technique for assessing the effects of pollution from land use activities. Summarized here are the overall remote sensing results for the coordinated aircraft/ ship survey program at the six study sites. Forty-seven overflights of the study areas have been reported, many of which were made during the spring period of maximum runoff. Also, twenty-five Landsat images were especially useful in revealing the extensive resuspension and/or shore erosion along the south shore of Lake Ontario and the west shore of Lake Michigan. The overall data acquisition record demonstrated that there are sufficient opportunities with cloud-free sky conditions over the Great Lakes such that a dedicated remote sensing system can meet the data requirements of extensive survey programs such as PLUARG.

ZZ IJC 769  
PLUARG 77-109

- # Gregor, Dennis J. and Walter Rast. **Trophic Characterization of the U.S. and Canadian Nearshore Zones of the Great Lakes**. Submitted to the Pollution from Land Use Activities Reference Group of the International Joint Commission. February 1979, 38 pp.

### Summary

The trophic classification of water bodies, as used in this report, refers to a comparison of the degree of fertility or eutrophication of water bodies, using a common scale or indexing system. This concept of a relative scale for the comparison of water bodies, or conditions within the same water body, is used for most trophic indexing schemes, with the major differences between schemes being the parameters chosen to formulate the index.

Many lake trophic indexing systems have been proposed by numerous researchers over the past several decades for the purpose of trophic state delineation, as well as for justification of nutrient control strategies.

As part of the activities of Task D, a trophic index was developed for comparison of the nearshore zone of the Great Lakes. This trophic index is based on a modification of Dobson and Chapra's (1977) approach to the offshore waters of the Great Lakes. The development of this index and its application to the nearshore waters is presented in this report.

ZZ IJC 769  
PLUARG 79-110

- # Rast, Walter and Dennis J. Gregor. **Report on Differences in Great Lakes Phosphorus Load Estimates.** Submitted to the Pollution from Land Use Activities Reference Group of the International Joint Commission. February 1979, 27 pp.

### Summary

A review was conducted of the 1976 Great Lakes phosphorus load estimates developed by the Pollution from Land Use Activities Reference Group (PLUARG), the Water Quality Board (WQB) and Task Group III (TG), the bilateral technical group which developed phosphorus Target Loads for the Great Lakes as part of the Fifth Year Review of the U.S.-Canadian Water Quality Agreement. The load estimates were examined to determine the sources of differences between estimates and, where possible, to explain the differences. A summary of the sources of information used by the three groups to develop the 1976 phosphorus load estimates is presented in this report.

ZZ IJC 769  
PLUARG 79-111

- # Sonzogni, William C. **Critical Assessment of U.S. Land Derived Pollutant Loadings to the Great Lakes**. Technical Report of the International Reference Group on Great Lakes Pollution from Land Use Activities. Submitted to PLUARG Task Group D (U.S. Section) Subactivity 3-4. March 1979, 179 pp.

### Summary

This report presents the findings of Subactivity 3-4 of the U.S. Task D portion of the Pollution from Land Use Activities Reference Group (PLUARG) study. The report reviews the degree of Great Lakes water quality impairment, which is known or thought to be caused by pollution from land drainage. It also summarizes and integrates the overall U.S. Task D effort. Further, the report examines certain critical questions that were not answered in the PLUARG final report but were recognized as essential to implementing the PLUARG recommendations.

Based on an extensive literature review, it was concluded that, while many studies have implicated land-derived pollution as a factor in the degradation of Great Lakes water quality, there is little conclusive evidence of direct effects. Nonpoint sources are obviously impairing the lakes, but it is often impossible to separate the effects of point and other sources to determine the specific role of nonpoint source pollution.

ZZ IJC 769  
PLUARG 79-112

- # Millard, E.S. *et al.* **Biomagnification of Atrazine in Lake Column Simulators.** Submitted to PLUARG Task Group D (Canadian Section). Burlington, Ontario. August 1979, 27 pp.

### Summary

Additions of atrazine at two treatment levels were made to four lake column simulators in each of two experiments. The lowest treatment in both experiments was sufficient to yield concentrations in the range (0-30 ppb) frequently measured in agricultural watersheds in late spring and early summer while the other was an order of magnitude higher. The amount of atrazine added at each treatment level was similar between experiments, but was applied over different lengths of time, fourteen days in the first experiment and five days in the second.

Atrazine was detected in most components of a simple food chain, but concentrations, particularly in fish, were not much higher than in water. Over 90% of the atrazine added could be accounted for by adding quantities found in open water of the upper and lower layers. The bulk of atrazine added remained in solution in the upper layer.

Neither impairment of photosynthesis by algae nor toxic effects to zooplankton and fish were apparent in column experiments. Atrazine does not appear to be a threat to the Great Lakes ecosystem in terms of either toxicity or bioaccumulation.

ZZ IJC 769  
PLUARG 79-113

- # Millard, E.S., C.C. Charlton and G.A. Burnison. **Availability of Phosphorus in Different Sources Entering the Great Lakes for Algal Growth**. Submitted to PLUARG Task Group D (Canadian Section). Burlington, Ontario. August 1979, 38 pp.

### Summary

The bioavailability of phosphorus in various sources contributing to loadings of this element in the Great Lakes was studied in lake column simulators. Loading of total phosphorus was equivalent between treatments that included river water, tertiary-treated sewage effluent, shoreline bluff material and Grand River suspended particulates. Growth response of algal communities to treatments was compared with the response to phosphoric acid. A background response due to phosphorus in the water which was used to fill the columns, and contaminating sources was also measured. Averages for total and soluble reactive phosphorus concentrations were similar between treatments, although obvious differences in growth response were observed. Sewage effluent produced an overall growth response equivalent to the phosphoric acid control, while river water had an overall response of 65% of the control. Response to bluff material was indistinguishable from that due to background sources. An inverse relationship existed between nitrate concentrations and phosphorus availability. The full response to the Grand River particulates and its control was probably limited by zooplankton grazing pressure. All other columns had declines in algal standing crops coincident with increases in numbers of *Bosmina* spp.

In bluff material, the high density of particles containing apatite phosphorus and the poor solubility of this compound led to a short residence time in the upper layer and low bioavailability of the phosphorus in this treatment. The impact of shoreline erosion on the Great Lakes in terms of phosphorus loading is negligible compared with municipal point-source and diffuse tributary loads of phosphorus. The cost-effectiveness of phosphorus control strategies proposed by PLUARG is increased in a relative sense when bioavailability of phosphorus is considered.

ZZ IJC 769  
PLUARG 79-114

- # Armstrong, D.E., J.R. Perry and D.E. Flatness. **Availability of Pollutants Associated with Suspended or Settled River Sediments Which Gain Access to the Great Lakes.** Submitted to PLUARG Task Group D. Windsor, Ontario. December 1979, 96 pp. (See also ZZ IJC 769/PLUARG 79-043).

### Summary

The purpose of this investigation was to evaluate the availability of certain elements, mainly phosphorus, transported to the Great Lakes by suspended sediment. Nitrogen was also investigated because of its importance as a nutrient element. Certain trace metals were included because of concern over their possible adverse effects on the Great Lakes.

Availability was estimated by chemical methods. For phosphorus, the chemical methods (NaOH extraction and anion exchange resin desorption) have been related to direct measurements of biologically-available phosphorus in the laboratory; for nitrogen, measurements were made of inorganic nitrogen (available) and an organic fraction which may be converted to inorganic nitrogen; for trace metals, measurements were made of the fraction readily desorbed (chelating cation exchange resin) and the fraction associated mainly with hydrous oxides (hydroxylamine hydrochloride extractable).

Samples were collected from five tributaries within the Great Lakes Basin, namely Genesee in New York, Grand in Michigan, Maumee in Ohio and Menomonee and Nemadji in Wisconsin. These tributaries, except the Nemadji, were also among the pilot watersheds used by the International Reference Group on Great Lakes Pollution from Land Use Activities to investigate pollutant loadings to the Great Lakes for the International Joint Commission. Samples were transported to the laboratory in Madison, Wisconsin for analysis. The suspended sediments were fractionated according to particle size, and chemical measurements were used to estimate the availability of phosphorus, nitrogen and trace metals in the suspended sediment. Samples of recession shoreline material were also analyzed for available phosphorus.

ZZ IJC 769  
PLUARG 79-115



## **STUDY PLANS**



- # International Reference Group on Great Lakes Pollution from Land Use Activities. **Detailed Study Plan to Assess Great Lakes Pollution from Land Use Activities.** February 1974, 148 pp.

### Summary

In this report PLUARG detailed the four tasks necessary to fulfill its study requirements.

Task A was to assess land use problems, management programs and research in an attempt to set priorities and recommend remedial measures in relation to the best current information on the effects of land use activities. Task B was to develop an inventory of land use and land practices with projections of trends to 2020. Task C was to conduct intensive studies of a number of representative watersheds in the Great Lakes Basin to relate conditions there to specific land uses and practices. Task D was to diagnose the degree of water quality impairment in the Great Lakes and to assess the concentration of contaminants in sediments, fish and other aquatic resources. The proposed schedule and description of activities, participating agencies and costs were also included in the report.

ZZ IJC 769  
PLUARG 74-116

- # International Reference Group on Great Lakes Pollution from Land Use Activities. **Supplement to the Detailed Study Plan to Assess Great Lakes Pollution from Land Use Activities.** Submitted to the Great Lakes Water Quality Board, International Joint Commission. August 1976, 119 pp.

#### Summary

The detailed Study Plan for the International Joint Commission's Pollution from Land Use Activities Reference Group was published in February 1974. Since that time the study participants have gained a better understanding of the specific requirements needed to meet the request of the IJC to assess the degree of impairment of water quality from land use activities in the Great Lakes system and to identify the sources of this pollution and recommend practicable remedial measures. While there have been no major shifts in emphasis in the study, many refinements of the original study plan have been made. This supplement to the study plan covers those refinements and expansions. Thus, a full understanding of the work being carried out under the PLUARG program can be gained from the February 1974 plan and this supplement.

ZZ IJC 769  
PLUARG 76-117

- # Coote, D.R. *et al.* **Detailed Plan for the Study of Agricultural Watersheds in the Great Lakes Drainage Basin - Canada, 1974-1975.** Prepared by PLUARG Task Group C (Canadian Section) Technical Committee, Agricultural Subcommittee. February 1974, 54 pp.

### Summary

An Agricultural Subcommittee was formed to prepare and implement a study plan to integrate the requirements of an agricultural study with those of the other Task C areas of interest.

Plans for a two-phase study were developed. The first phase would consist of the collection and analysis of data obtained by sampling and gauging from fifteen to twenty selected watersheds at their outlets. The second phase would consist of detailed studies of either individual pollutants or of individual land uses associated with agriculture. It was assumed that less than one-half of the original watersheds would need to have detailed studies conducted within them, and that the results of the preliminary phase would enable a rational selection of parameters and sites for inclusion in the detailed phase of the study.

This report describes the approach to the selection of agricultural watersheds and the progress with preparation of required information. The plan for implementation of the preliminary phase of the study with a proposed schedule of activities is included.

ZZ IJC 769  
PLUARG 74-118

- \* Wisconsin Department of Natural Resources, University of Wisconsin System Water Resources Center and Southeastern Wisconsin Regional Planning Commission. **Menomonee River Pilot Watershed Study, Work Plan.** (Unpublished). Submitted to the Pollution from Land Use Activities Reference Group and the U.S. Environmental Protection Agency. September 1974, 44 pp.

### Summary

The Menomonee River watershed has been selected for the study of the effects of urban-residential land uses undergoing rapid change. The overall objective of the Menomonee River watershed study is to investigate the effects of land drainage on the pollutional input to Lake Michigan and to develop a predictive capacity with respect to the sources, forms and amounts of pollutants reaching Lake Michigan.

The specific objectives of the Menomonee River watershed study are:

- a) to determine the levels and quantities of major and trace constituents including, but not limited to, nutrients, pesticides and sediment reaching or moving in flow systems likely to affect the quality of Lake Michigan water;
- b) to define the sources and evaluate the behavior of pollutants from an urban land use setting with particular emphasis on the impact of residential and industrial areas including utility facilities, transportational, recreational, agricultural and constructional activities associated with rapid urbanization and
- c) to develop the predictive capability necessary to facilitate extension of the findings from the Menomonee River watershed study to other urban settings leading to an eventual goal of integrating pollutional inputs from urban sources to the entire Great Lakes Basin.

Activities and decisions made in meeting the specific objectives of the Menomonee River watershed study will be carried out in such a manner as to interface effectively with objectives of Task D. Also included in this report are details of the study plan.

ZZ IJC 769  
PLUARG 74-119

- \* Ontario Ministry of the Environment, Water Resources Branch. **Work Plan for Task C, Activities 1, 3 and 4, Pollution from Land Use Activities Reference Group.** (Unpublished). Toronto, Ontario. October 1975, 130 pp.

## Summary

The purpose of this Work Plan is to provide the working details for the PLUARG studies (or parts of studies) in which the Ontario Ministry of the Environment (MOE) is involved under Task C. Discussed in this Work Plan are:

### Activity 1

Activity 1 relates to agricultural watersheds and is a cooperative study between Agriculture Canada (CDA), Ontario Ministry of Agriculture and Food (OMAF) and the Ontario Ministry of the Environment (MOE). The PLUARG **Detailed Study Plan** described the overall objective of the agricultural studies.

### Activity 3

Activity 3 involves the study of urban land development and use, transportation and utility systems, sanitary landfills, processed organic waste disposal, waste water lagoons and irrigation systems, landfill, extractive industries, private waste disposal and recreational land use.

### Activity 4

Activity 4 is primarily a monitoring program which consists of two functions - an extensive surveillance network and an intensive studies program.

This Work Plan emphasizes the collection of water quantity and quality data. It is hoped that the information contained herein will serve as a useful guide for other investigators involved in the PLUARG studies. Detailed information on the individual studies is contained in the Appendices and cited references. Revisions to the Work Plan may be necessary as the study progresses and required changes are identified.

ZZ IJC 769  
PLUARG 75-120

- \* Agriculture Canada, Ontario Ministry of Agriculture and Food and Ontario Ministry of the Environment. **Agricultural Watershed Studies, Great Lakes Drainage Basin, Canada; Detailed Study Plan, 1975-1976.** (Unpublished). Prepared for the International Reference Group on Great Lakes Pollution from Land Use Activities, Task Group C (Canadian Section) Activity I. October 1975, 123 pp.

Summary

Project No.	Title
1	Co-ordination, Data Handling and Transfer
2	Stream Flow Quantity (formerly project 3)
3	Stream Flow Quality - (A) Routine Water and Sediment Quality (formerly project 4)
4	Stream Flow Quality (B) Pesticides
5	Land Use Information
6A	Precipitation-Quantity (formerly project 2)
6B	Precipitation-Chemical Characteristics (formerly project 6)
7	Soil Survey
8	Nature and Enrichment of Sediments in Agricultural Watersheds: A Mineralogical and Physical Characterization
9	Agricultural Sources, Transport and Storage of Heavy Metals
10	Sources of Nutrients and Heavy Metals in Hillman Creek
12	Physical Properties of the Soils of Agricultural Watersheds 1 and 13 Which Control Moisture Storage and Transport
13	Mathematical Model of Nitrogen Transport in the Agricultural Watershed Soils
14	Studies of Agricultural Pollution of Groundwater and its Influence on Stream Water Quality in Two Agricultural Watersheds
15	Hydrologic Model
16	Erosional Losses from Agricultural Land
17	Sediment Delivery Ratios in Small Agricultural Watersheds
18	Contribution of Phosphorus from Agricultural Land to Streams by Surface Runoff
19A	Nitrogen Transport and Transformations in Two Branches of Canagague Creek
19B	Secondary Production and Organic Drift of Nutrients in Two Branches of Canagague Creek
20	Effect of Livestock Activities on Surface Water Quality
21	Feedlot and Manure Storage Runoff
22	Pollutant Transport to Subsurface and Surface Waters in an Integrated Farm Operation.

ZZ IJC 769  
PLUARG 75-121

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