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Fifth Progress Report to the International Joint Commission from the Upper Lakes Reference Group, July 1975

International Reference Group on Upper Lakes Pollution

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International Joint Commission
Canada and United States

Gentlemen:

Pursuant to Article VI, Section 1, subsection f (ii) of the Great Lakes Water Quality Agreement, and with reference to Section 16 of Directive Number 2 to the Great Lakes Water Quality Board, the Upper Lakes Reference Group takes pleasure in submitting a copy of its Fifth Progress Report to the International Joint Commission.

Respectfully submitted,

Canada

United States

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Chairman

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FIFTH PROGRESS REPORT
TO THE
INTERNATIONAL JOINT COMMISSION
FROM
UPPER LAKES REFERENCE GROUP

JULY 1975
FIFTH PROGRESS REPORT
TO THE
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UPPER LAKES REFERENCE GROUP
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The Upper Lakes Reference Group and its four Work Groups, its Coordinating Committee, and its Committee for Data Quality, continue their activities to fulfill the objectives of the Detailed Study Plan. This report is intended to update the International Joint Commission on progress of studies since the Fourth Semi-Annual Report. Meetings, membership and significant activities by the Reference Group and by each of the subordinate groups are detailed.
# TABLE OF CONTENTS

1. UPPER LAKES REFERENCE GROUP
   - Introduction and Summary ............................................. 1
   - Final Report .................................................................. 2
   - Project Reports ......................................................... 4

2. Technical Considerations
   - Areas of Pollution or Degradation ................................ 5
   - Segmentation .................................................................. 6
   - Water Quality Objectives ............................................... 6
   - Suspended Solids .......................................................... 7
   - Surveillance ................................................................... 8
   - Atmospheric Inputs ...................................................... 9

3. Reference Group Concerns
   - Lake Levels Regulation ................................................. 9
   - Vessel Waste Regulations ............................................. 9
   - Fisheries ....................................................................... 10

4. Other
   - Total Dissolved Solids .................................................. 11

## COORDINATING COMMITTEE

1. Task
2. Activities

## WORK GROUP A

1. Task
2. Activities
Project Reports - Study Item I
Forecasting Model - Study Item IV

WORK GROUP B
Task
Activities

WORK GROUP C
Task
Activities
  Point Source Inputs
  IAGLR Symposium

WORK GROUP D
Task
Activities
  Lake Superior
  Lake Huron

COMMITTEE FOR DATA QUALITY
Task
Activities

APPENDIX 1. MEMBERSHIP

Upper Lakes Reference Group
Coordinating Committee
Work Group A
Work Group B
Work Group C
Work Group D
Committee for Data Quality
APPENDIX 2. MEETINGS 31
APPENDIX 3. PREPARATION SCHEDULE FOR FINAL REPORT 33
APPENDIX 4. DETAILED OUTLINE OF FINAL REPORT 37
APPENDIX 5. PROJECT REPORTS IN INFORMATION DEPOT 59
APPENDIX 6. DISSOLVED LOADINGS FROM RESERVE MINING COMPANY 69
APPENDIX 7. GUIDELINES FOR DATA ASSESSMENT 73
APPENDIX 8. EVALUATION OF RESULTS OF INTERLABORATORY COMPARISONS 75

The technical analysis thus far shows that the water quality in Lakes Huron and Superior is generally good. However, areas of continuing concern are the persistent contaminants in fish, the inadequacy of the present suspended solids monitoring program, and the apparently significant loading from the atmosphere.

Issues raised by Reference Group members for consideration or early action are lake levels regulation and vessel wastes.

The scope of the Final Report is greatly dependent upon the early availability of specific numerical water quality objectives presently being developed by the Water Quality Board's Water Quality Objectives Subcommittee.

Present memberships of the Reference Group and its related Work Groups are given in Appendix 1. Meetings held since the Fourth Semi-Annual Report of September, 1974 are listed in Appendix 2.
INTRODUCTION AND SUMMARY

In the past year the Upper Lakes Reference Group has begun to realize some of the results of the two years of effort invested. Major administrative accomplishments were the development of the Final Report outline and preparation schedule, and the selection and orientation of authors; these are discussed in more detail below. Significant steps were taken to simplify the preparation of the Final Report and its content through the establishment of a Reference Group Report Series and Information Depots.

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Present memberships of the Reference Group and its related Work Groups are given in Appendix 1. Meetings held since the Fourth Semi-Annual Report of September, 1974 are listed in Appendix 2.
The Final Report of the Reference Group, which will answer the Reference Questions posed by the Governments, will be submitted to the International Joint Commission by June 30, 1976. This represents a six-month extension in the original reporting date; this extension has been approved by the Board and the Commission. The major conclusions and recommendations of the Final Report will be presented to the Board in March 1976. The preparation schedule, designed to meet these target dates, is presented in Appendix 3.

Subsequent to the development of a general outline, the Reference Group selected approximately one hundred individuals to author the Final Report, and commitments were obtained from their jurisdictions. An Author Workshop held at the Canada Centre for Inland Waters in February 1975 brought these persons together with the Reference Group members and Work Group Chairmen to present the scope of their assignments and to initiate their development. The products were a detailed composite outline of each subchapter of Volume II (Lake Huron and Georgian Bay) and Volume III (Lake Superior) and a proposed schedule for the preparation of each section.

After compilation, these were distributed for review, and have been the subject of critical scrutiny by the Reference Group, the Coordinating Committee, the Work Groups, the Editorial Committee, and many of the authors, to determine their adequacy for the Reference Group in answering the Reference Questions. The underlying philosophy and the rationale for each chapter, the content, and the length have been clarified and a general consensus reached. A copy of the present Outline, which retains flexibility as a working document, is presented in Appendix 4.
A short summary of the purpose and content of each chapter, and the proposed length, is:

Chapter 1 provides perspective on geography, population, economics, and land and water uses. Length = 100 pages (typed, double spaced text, and including tables, figures, and graphs).

Chapter 2 presents present criteria and programs. Length = 120 pages.

Chapter 3 quantifies loadings inputs by type of source. Length = 70 pages.

Chapter 4 presents data summaries to describe existing conditions for the nearshore waters. Length = 110 pages.

Chapter 5 presents data summaries to describe existing conditions for the open waters. Length = 180 pages.

Chapter 6 draws conclusions about the existence or the possible development of pollution or degradation, or the lack of problems. Length = 60 pages.

Chapter 7 compares these problems or the lack of problems against existing criteria and abatement programs. Length = 20 pages.

All data and reference information are to be compiled, reviewed, and statistically summarized in Chapters 3, 4, and 5, and not in Chapter 6. These chapters lay the basis to determine whether pollution or degradation exist or could develop, and it is Chapter 6 which will conclude whether
loadings and existing water conditions constitute a problem, and why; and whether trends may indicate an emerging problem.

The preceding chapters develop the technical basis to determine the adequacy of existing criteria and programs to abate or prevent present and developing pollution or degradation problems. Chapter 7 evaluates the adequacy of existing criteria and programs for specific problems and recommends additional jurisdictional and Commission criteria and programs. Chapter 7 also recommends nondegradation criteria and additional programs to meet and maintain these criteria.

The Board has recommended that authors not be identified in Volume I (Summary), and has reserved judgment for Volumes II and III until after the draft report has been received. The Reference Group has brought this to the attention of the Commission.

PROJECT REPORTS

The Reference Group developed six Study Items and identified more than 120 specific projects for investigation. More than half of these projects now have a draft report completed with the remainder scheduled for completion by the fall 1975. This schedule is consistent with the schedule developed to prepare the conclusions and recommendations.

The Reference Group recognized the need to make readily accessible to all individuals working on the Final Report all draft project reports described in the Detailed Study Plan and other related reports. Therefore, four Information Depots, coordinated by the Regional Office, have been established at the Regional Office, Windsor; Environmental Protection
Agency, Region V, Chicago; CCIW, Burlington; and Ministry of the Environment, Toronto. Each Depot contains in its permanent file general information germane for the author, project and related reports, drafts of Final Report subchapters, and other relevant non-ULRG files. A list of reports presently on file is given in Appendix 5.

The project reports being prepared from the Reference Group studies are now nearing completion and are intended to bridge the gap of jumping directly from loadings, existing conditions, and trends to conclusions by presenting a logical sequence of detailed steps to go from one to the other. To accomplish this, the Reference Group established a Report Series, based upon the following protocol:

1. Includes published or unpublished reports of Reference Group projects
2. Inclusion optional to the generating agency
3. Presented in Reference Group covers
4. Each report covered by a disclaimer which indicates that the generating agency, not the Commission, takes responsibility for the report material (the Reference Group will take responsibility only for its Final Report)
5. Reports available as working documents prior to Final Report but series not released until submission of Final Report
7. Series would be made generally available when released.

TECHNICAL CONSIDERATIONS

Areas of Pollution or Degradation
In order to establish baseline conditions, polluted or degraded areas had to be delineated. Failure to identify these areas could result in unnaturally high baseline values. Once these areas were designated, the Reference Group could also evaluate their size and propriety and recommend necessary programs and criteria to achieve compliance with the Water Quality Agreement.

The jurisdictions, through their membership on the Reference Group and the Board's Implementation Committee, have identified in sufficient detail all of the polluted or degraded areas.

Segmentation

The Reference Group recognized the need to describe the physical, chemical, and biological characteristics of the Upper Lakes, based upon morphological and limnological properties. Recognizing a fundamental material difference in water quality between the near shore and the open lake waters, the Reference Group has proceeded to develop a flexible protocol for segmentation. In the open lake waters, it is limnologically sound and computationally convenient to further segment the waters horizontally and vertically.

This segmentation concept was developed only for scientific or technical applications and is not amenable for the establishment of individual abatement programs.

Water Quality Objectives

The Board has authorized the Reference Group to use the specific water quality objectives being developed by the Water Quality Objectives Subcommittee as criteria to define
pollution. The objectives developed by WQOS and submitted to the Commission represent a monumental accomplishment. These objectives enable the Reference Group to more specifically answer the Reference Questions by providing a scientifically defensible numerical basis for its conclusions regarding possible pollution. However, the Reference Group has a continuing need for numerical objectives to be established by the Commission for the nutrient and the materials balance parameters, specifically, chloride, nitrogen, phosphorus, reactive silicates, total dissolved solids, and selected heavy metals. It is hoped that numerical objectives will be available for Reference Group use by December 1, 1975. If these objectives cannot be formulated, the Reference Group will utilize the most stringent jurisdictional criteria or the nondegradation criteria it is developing in response to the Reference Questions.

Suspended Solids

The Reference Group, with assistance from the Pollution from Land Use Activities Reference Group, has concluded that present information is not satisfactory to estimate the quantity of nutrients available to the Upper Lakes from suspended materials. These suspended materials enter the lakes from shoreline erosion and from tributaries. Most of these solid materials eventually settle to the bottom to form sediments. It is not known, nor can it be easily estimated what portion of the nutrients associated with these solids are (or may become) available to the biota. For example, about 1% of the 67,000 tons/day maximum loading of solids from Reserve Mining Company is dissolved; values are given in Appendix 6. What cannot be easily quantified is what portion of the remaining 99% may become available and under what conditions.
Surveillance

The Board has instructed the Reference Group to set the guidelines for, but not the details of, future surveillance and monitoring programs. The Reference Group will communicate its findings to the Surveillance Subcommittee and offer its expertise in program development.

Based upon the high quality of water found in the Upper Lakes, the Reference Group anticipates a minimum surveillance program to be developed along the following lines. The intensive surveys conducted as part of the Reference Group study will provide a basis for future surveillance programs by defining the behaviour of the lakes. Thus surveillance can be maintained through water intake sampling for the majority of physical, chemical, and biological parameters, and self-monitoring and reporting by point source dischargers. Low-level persistent or chronic contaminants are most easily detected by biomagnification. Therefore, fish collection and analysis program, for example, should be expanded over present levels. While whole-lake surveillance surveys are not needed, surveys and studies must continue to answer specific questions.

The one continuing concern of the Reference Group is the comparability and the reliability of the data collected. Assessment of sampling and analysis techniques, precision and accuracy, has been accomplished to the Reference Group's satisfaction. However, the lack of standard procedures and proven comparability remains as a major source of error. Standardized procedures should be developed by the Board's Surveillance and Data Quality Subcommittee prior to the initiation of any major studies.
Atmospheric Inputs

In response to preliminary results describing the magnitude of the atmospheric loading of nitrogen and phosphorus to the Upper Lakes with regard to point source inputs, the Reference Group has established informal liaison with the Commission's Air Pollution Advisory Board. The anticipated preliminary conclusions of the Reference Group may lead to recommendations regarding development or reassessment of present ambient and emission air quality criteria to consider their relevance to atmospheric loading to the lakes and their ability to protect water quality.

REFERENCE GROUP CONCERNS

Lake Levels Regulation

The state of Minnesota contends that the higher lake levels caused by regulation of Lake Superior by the U.S. Army Corps of Engineers is causing an increased degradation of water quality. The contention is that these higher lake levels increase the rate of erosion of red clay from the shoreline of western Lake Superior. Because the effects of red clay on water quality are being investigated in two Reference Group projects (D-36 and D-37), the Reference Group believes that this contention will be adequately resolved in the Final Report.

Vessel Waste Regulations

The province of Ontario petitioned the Reference Group to express concern to the Board about the U.S. proposal to continue to allow waste discharges from pleasure craft. The
concern is that U.S. regulations will invalidate the existing no-discharge regulations developed or which were being developed by the states, resulting in incompatibility, and noncompliance of U.S. owned boats with Canadian regulations.

Fisheries

The U.S. Food and Drug Administration, because of an improved regulatory posture, recently began seizing interstate shipments of Lake Michigan salmon (PCB contaminated) and chubs (Dieldrin contaminated). In addition, the State of Michigan recently announced a problem in Lake Superior with PCB residues in offshore, fat lake trout (siscowets) which are not normally subject to sport fishermen. These actions have increased the import of ongoing fishery contaminant studies in the Reference Group and reemphasized the need for broad-based, scientifically-sound programs of sampling and analysis (fish, water, and sediments) for the purpose of identifying and eliminating sources of contaminants and following the trends of contaminants in the Great Lakes.

Fishery agencies involved in the Reference Group resumed sampling this spring in order to fill gaps in last year's fish collections and augment the previous collections to better define the levels and geographic distribution of contaminants in Lakes Superior and Huron. In addition, EPA arranged for the development of a computer program for use at the Fish and Wildlife Service's Ann Arbor Laboratory, which will allow for automated storage, retrieval, and analysis of all ULRG fish contaminant data.

The history of changes in concentration levels of persistent contaminants, such as DDT, PCB's, dieldrin,
mercury, etc. in fish proves conclusively that voluntary control programs for PCB's are inadequate.

OTHER

**Total Dissolved Solids**

The Reference Group has adopted the proposed "Utilization of Specific Conductance Measurements in Place of Gravimetric Determination of Total Dissolved Solids for the Waters of the Upper Great Lakes", prepared by the Standing Committee on Analytical Sampling and Measurement Methods of the Research Advisory Board.
COORDINATING COMMITTEE

TASK

Analyze Reference Group Study Plan progress and problems, develop recommendations for action by the Reference Group.

ACTIVITIES

The Coordinating Committee continues to identify and more fully define concerns for and subsequent action by the Reference Group, and to provide a necessary link to expedite interactions among the Work Groups. The Coordinating Committee has been involved with many of the activities reported for the Reference Group and the Work Groups and especially those activities related to the development of the Final Report.

Fishery agencies involved in the Reference Group resumed sampling this spring in order to fill gaps in last year's fish collections and augment the previous collections to better define the levels and geographic distribution of contaminants in Lakes Superior and Huron. In addition, EPA arranged for the development of a computer program for use at the Fish and Wildlife Service's Ann Arbor Laboratory, which will allow for automated storage, retrieval, and analysis of all ULAB fish contaminant data.

The history of changes in concentration levels of persistent contaminants, such as DDT, PCB's, dieldrin,
WORK GROUP A

TASK

Develop background information and forecast future loadings.

ACTIVITIES

Work Group A activities are progressing satisfactorily. Significant accomplishments are detailed below.

Project Reports - Study Item I

Project reports prepared for Study Item I, background information on the basin and its population, have been completed for most topics. The reports have been entered into the Information Depots.

Forecasting Model - Study Item IV

The model for predicting future conditions of the Upper Lakes incorporates population and economic data as well as social, technological, and legal aspects. Preliminary output from the model is under review within the Work Group.

Work Group A has assessed the need to model additional parameters to forecast future inputs to the Upper Lakes; the number has been expanded from five to more than forty and includes those anticipated from future municipal and industrial growth. Forecasting will be done for each whole lake area and for eleven subareas.
WORK GROUP B

TASK

Main lakes studies.

ACTIVITIES

In order to make Work Group B more responsive to the task of writing its sections of the Final Report, the Chairmen formulated a revised membership, to include the principal authors of the Work Group B sections of the Final Report as well as other who are active as liaison with other sections of the Report.

The open lake studies of Work Group B have been completed in-so-far as the experimental measurements are concerned. The programs have, from early assessment, been successful in providing a comprehensive body of experimental measurements which will form the basis of the reference analysis. This data base covers the open waters of Lakes Superiors and Huron, Georgian Bay and the North Channel.

Data files have been interchanged between the agencies having common need for analysis or where measurement programs overlap. Data quality control through the analysis of common samples has been initiated. Preliminary results are available.

Preliminary analysis of data is underway in several agencies. Extensive discussions have been held towards deciding on the methods and techniques to be employed in
reporting the reference results. It has been proposed that segmentation of the lakes into quasi-homogeneous sections relative to morphological and limnological properties be accomplished for reporting purposes. Objective analyses are presently being carried out to determine the feasibility of this approach. It is expected that some form of segmentation will be employed to report reference values for all parameters which are subject to such treatment.
WORK GROUP C

TASK

Sources and characteristics of materials inputs

ACTIVITIES

Work Group C activities are progressing satisfactorily. Significant accomplishments are detailed below.

Point Source Inputs

For the Canadian portion of the Upper Lakes basin, Ontario has developed preliminary individual loadings values for more than forty parameters, for each municipality, industry, and tributary discharging directly into Lake Huron and Lake Superior, and has compiled summaries of the total loadings. Loadings summaries for U.S. sources and preliminary whole-lake materials balances have also been distributed for both lakes.

IAGLR Symposium

The International Association for Great Lakes Research has endorsed a symposium to present findings regarding atmospheric loadings to the Great Lakes, based in part upon the studies conducted under the Atmospheric Subgroup of Work Group C.
WORK GROUP D

TASK

Local effects studies

ACTIVITIES

Lake Superior

Canadian sample collection has been completed for all projects in Lake Superior. Project reports have been issued for studies carried out on St. Marys River, Nearshore Waters of Lake Superior, Jackfish Bay, Peninsula Harbour and Thunder Bay. Other project reports on Douglas Point Monitoring, Penetang-Midland Enrichment, Phytoplankton Monitoring, Black Bay and Pine Bay Baseline Studies, Nipigon Bay Point Source Investigation and Lake Superior Fisheries Studies are under preparation. An interim report will be issued on Nipigon Bay, Assessment of Pulp and Paper Discharge on the Biota, and further sampling will be undertaken in the spring to complement the report following the assessment of the effluent data after a condensate stripper is installed in the mill.

The U.S. nearshore water quality monitoring and fish contamination studies for Minnesota waters that were to be concluded in the fall of 1974 have been extended through the spring of 1975. The purpose was to better document the unexpected discovery of high concentrations of contaminants and to better establish the body burden. Fish collections for those species not collected in 1974 for Ontario waters
will also be included in the 1975 U.S. program. The report for the Lake Superior coastal zone is being prepared jointly by authors from Michigan, Minnesota, Wisconsin, and Ontario.

Lake Huron

The Canadian local effects surveys on Lake Huron nearshore monitoring could not be completed because of mechanical problems with the survey vessel. The sample collection were continued in the spring of 1975 for completing both this study and the Spanish River Mouth Study. Collection of samples for the Serpent River Mouth Study were also planned for the spring of 1975. Fish collection from the nearshore waters of Lake Huron and Georgian Bay and from St. Marys River is near completion.

The U.S. intensive studies of Saginaw Bay are continuing this spring. Additional vessel support is being provided by EPA. The model developed for Saginaw Bay is being verified. Data collection has been completed for the Michigan coastal zone. Reports of specific problem areas are being prepared. The remaining coastal areas are being segmented by their chemical characteristics.
COMMITTEE FOR DATA QUALITY

TASK

Validity of analytical data

ACTIVITIES

The Committee for Data Quality developed, and the Reference Group adopted, "Guidelines for Data Assessment", a procedure whereby data to be utilized for the Final Report will be reviewed to ascertain whether the conclusions and recommendations drawn are supportable by the data. A copy of the Guidelines is presented in Appendix 7. A report evaluating the results of the ongoing interlaboratory comparison studies for selected water quality and nutrient parameters is presented in Appendix 8.

The CDQ is attempting to document the sample collection and analysis methodologies employed by each individual jurisdiction for all parameters to establish the usability of the data, establish a measure of confidence in the data, and to facilitate the comparability of data from future studies. The CDQ is compiling all relevant intercomparison studies and documenting changes in methodologies since 1971.
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- 29 -
APPENDIX 2 MEETINGS

The Reference Group and its related Work Groups have held the meetings listed below since the Fourth Semi-Annual Report was submitted in September 1974.

October 3, 1974
Chairmen, ULRG and PLUARG, Ottawa

October 9
Work Group D, Canadian Section, Toronto

October 25
Work Group C, Atmospheric Subgroup, Windsor

October 30
Work Group A, Work Session for Study Item IV, Ann Arbor

November 5-6
14th Reference Group Meeting, Ottawa

November 19
7th Coordinating Committee Meeting, Windsor

December 11
6th Committee for Data Quality Meeting, Windsor

January 7-8, 1975
15th Reference Group Meeting, Romulus

January 23-24
Work Group A, Madison

January 30
Author Workshop Preview, Windsor

February 11-12
Author Workshop, Burlington

March 4
8th Coordinating Committee Meeting, Toronto

March 4
Work Group A, Work Session for Study Item IV, Ann Arbor

March 10
Work Group C, Atmospheric Subgroup, Toronto

March 19
Work Group B, Work Session for Final Report, Grosse Ile

April 22
9th Coordinating Committee Meeting, Toronto

April 23-24
16th Reference Group Meeting, Toronto

May 30
Segmentation Work Session, Windsor

June 13
Work Group A, Burlington

June 18-19
7th Committee for Data Quality Meeting, Windsor

June 24
10th Coordinating Committee Meeting, Chicago

June 24-25
17th Reference Group Meeting, Chicago
# APPENDIX 3 PREPARATION SCHEDULE FOR THE FINAL REPORT

## VOLUME II - LAKE HURON AND GEORGIAN BAY

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Completion of Literature Search</th>
<th>Accumulation of All Study Data</th>
<th>Detailed Outline and Preliminary Conclusions</th>
<th>Draft of Text to Work Group Chairmen</th>
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Schedules are identical as for the corresponding subchapters of Volume II, except as given below:

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Chapter Drafts to Editorial Committee and Reference Group
Completion of Editorial Committee and Reference Group Review
Revised Chapters Resubmitted to Editorial Committee and Work Groups
Final Draft to Reference Group
Draft Submission to I.J.C. and W.Q.B.

February 1, 1976
March 15, 1976
April 1, 1976
May 1, 1976
June 30, 1976

NOTE: The dates shown are the latest permissible deadlines. All authors are urged to complete their sections as early as possible. Work group chairmen should require earlier completion of chapters for which study data is available or not required.
APPENDIX 4 DETAILED OUTLINE OF FINAL REPORT

CHAPTER 1. Description of Study Area and Human Component

Characteristics, Including Historical and Future Trends

Summary

1.1 Physical Features - Lake Huron Basin by geographic units

1.1.1 Geology, Hydrogeology, Topography, Physiography
1.1.2 Climate
1.1.3 Hydrology
1.1.4 Soils and Vegetation
1.1.5 Wildlife

1.2 Population

1.2.1 Mississagi Basin East
1.2.2 Spanish-French Basin
1.2.2.1 Sudbury CMA
1.2.3 Muskoka - Severn Basin
1.2.4 Saugeen Basin
1.2.5 Lake Huron South Planning Subarea
1.2.5.1 Flint Standard Metropolitan Statistical Area (SMSA)
1.2.5.2 Bay City SMSA
1.2.5.3 Saginaw SMSA

1.2.6 Lake Huron North Planning Subarea

1.3 Economic Structure

1.3.1 General Economy

1.3.1.1 Mississagi Basin East
1.3.1.2 Spanish-French Basin
1.3.1.2.1 Sudbury CMA
1.3.1.3 Muskoka-Severn Basin
1.3.1.4 Saugeen Basin
1.3.1.5 Lake Huron South Planning Subarea
1.3.1.5.1 Flint SMSA
1.3.1.5.2 Bay City SMSA
1.3.1.5.3 Saginaw SMSA

1.3.1.6 Lake Huron North Planning Subarea

1.3.2 Agricultural Economy

1.3.2.1 Mississagi Basin East
1.3.2.2 Spanish-French Basin
1.3.2.3 Muskoka-Severn Basin
1.3.2.4 Saugeen Basin
1.3.3 Forest Resources
1.3.4 Mineral Industries

1.3.4.1 Mississagi Basin East
1.3.4.2 Spanish-French Basin
1.3.4.3 Muskoka-Severn Basin
1.3.4.4 Saugeen Basin
1.3.4.5 Lake Huron South Planning Subarea
1.3.4.6 Lake Huron North Planning Subarea

1.3.5 Commercial Fishing
1.3.6 Recreation

1.3.6.1 Mississagi Basin East
1.3.6.2 Spanish-French Basin
1.3.6.3 Muskoka-Severn Basin
1.3.6.4 Saugeen Basin
1.3.6.5 Lake Huron South Planning Subarea
1.3.6.6 Lake Huron North Planning Subarea

1.4 Land Uses

1.4.1 Mississagi Basin East
1.4.2 Spanish-French Basin
1.4.3 Muskoka-Severn Basin
1.4.4 Saugeen Basin
1.4.5 Lake Huron South Planning Subarea
1.4.6 Lake Huron North Planning Subarea

1.5 Water Uses

1.5.1 Water User Profile
1.5.1.1 Municipal Water Users
1.5.1.2 Industrial Water Users
1.5.1.3 Rural Water Users

1.5.2 Water Use Requirements - Present and Projected
1.5.2.1 Municipal Water Users
1.5.2.2 Industrial Water Users
1.5.2.3 Rural Water Users

1.5.3 In-Situ Water Use
1.5.3.1 Electric Power Generation
1.5.3.2 Commercial Navigation
1.5.3.3 Recreation
1.5.3.4 Other Uses
CHAPTER 2. Existing Water Quality Criteria, Standards and Pollution Abatement Programs

NOTE: The following outline represents generally an expected maximum depth of breakdown. However, it should be recognized that in some States and/or in the Province of Ontario, such depth of information does not exist (e.g. 2.3 Effluent Standards). In other cases it may be more detailed (e.g. 2.2 Receiving Water Quality Standards); thus the Final Report content may be at some variance from the outline below.

2.1 Summary

2.1.1 The Problem of "Semantics"
2.1.2 Receiving Water Quality Standards
2.1.3 Effluent Standards
2.1.4 Relationship of Receiving Water Quality and Effluent Standards
2.1.5 Definitions
   2.1.5.1 Water Quality Criteria
   2.1.5.2 Non-Degradation Criteria
   2.1.5.3 Mixing Zones
   2.1.5.4 Localized Areas
   2.1.5.5 Abatement Programs
   2.1.5.6 Non-Compliance

2.2 Receiving Water Quality Standards

2.2.1 U.S. Federal
2.2.2 State of Michigan
   2.2.2.1 Lake Huron
   2.2.2.2 Tributary Streams
2.2.3 Canada Federal
2.2.4 Province of Ontario
   2.2.4.1 Lake Huron
   2.2.4.2 Tributary Streams

2.3 Effluent Standards

2.3.1 U.S. Federal
   2.3.1.1 Municipal Effluents
   2.3.1.2 Industrial Effluents
2.3.1.3 Agricultural Discharges
2.3.1.4 Vessel Wastes
   2.3.1.4.1 Lake Huron
   2.3.1.4.2 Tributary Streams
2.3.2 State of Michigan
   2.3.2.1 Municipal Effluents
      2.3.2.1.1 Lake Huron
      2.3.2.1.2 Tributary Streams
      2.3.2.1.2.1 Individual Streams
   2.3.2.2 Industrial Effluents
      2.3.2.2.1 Lake Huron
      2.3.2.2.1.1 General Discharges
      2.3.2.2.1.2 Thermal Discharges
      2.3.2.2.1.3 Radioactive Discharges
      2.3.2.2.2 Tributary Streams
      2.3.2.2.2.1 General Discharges
      2.3.2.2.2.2 Thermal Discharges
      2.3.2.2.2.3 Radioactive Discharges
2.3.2.3 Agricultural Discharges
   2.3.2.3.1 Lake Huron
   2.3.2.3.2 Tributary Streams
2.3.2.4 Vessel Wastes
   2.3.2.4.1 Lake Huron
   2.3.2.4.2 Tributary Streams
2.3.3 Canada Federal
   2.3.3.1 Municipal Effluents
   2.3.3.2 Industrial Effluents
   2.3.3.3 Agricultural Discharges
   2.3.3.4 Vessel Wastes
      2.3.3.4.1 Lake Huron
      2.3.3.4.2 Tributary Streams
2.3.4 Province of Ontario
   2.3.4.1 Municipal Effluents
      2.3.4.1.1 Lake Huron
      2.3.4.1.2 Tributary Streams
   2.3.4.2 Industrial Effluents
2.3.4.2.1 Lake Huron
2.3.4.2.1.1 General Discharges
2.3.4.2.1.2 Thermal Discharges
2.3.4.2.1.3 Radioactive Discharges
2.3.4.2.2 Tributary Streams
2.3.4.2.2.1 General Discharges
2.3.4.2.2.2 Thermal Discharges
2.3.4.2.2.3 Radioactive Discharges

2.3.4.3 Agricultural Discharges
2.3.4.3.1 Lake Huron
2.3.4.3.2 Tributary Streams

2.3.4.4 Vessel Wastes
2.3.4.4.1 Lake Huron
2.3.4.4.2 Tributary Streams

2.4 Criteria or Regulations for Discharge of Other Pollutants
2.4.1 U.S. Federal
2.4.1.1 Solid Wastes
2.4.1.2 Shore Erosion and Sedimentation
2.4.1.3 Dredging
2.4.1.4 Spills

2.4.2 State of Michigan
2.4.2.1 Solid Wastes
2.4.2.1.1 Lake Huron Area
2.4.2.1.2 Tributary Basin
2.4.2.1.3 Other Areas

2.4.2.2 Shore Erosion and Sedimentation
2.4.2.2.1 Lake Huron Area
2.4.2.2.2 Tributary Basin
2.4.2.2.3 Other Areas

2.4.2.3 Dredging
2.4.2.3.1 Lake Huron Area
2.4.2.3.2 Tributary Basin
2.4.2.3.3 Other Areas

2.4.2.4 Spills
2.4.2.4.1 Lake Huron Area
2.4.2.4.2 Tributary Basin
2.4.2.4.3 Other Areas

2.4.3 Canada Federal
2.4.3.1 Solid Wastes
2.4.3.2 Shore Erosion and Sedimentation
2.4.3.3 Dredging
2.4.3.4 Spills

2.4.4 Province of Ontario
2.4.4.1 Solid Wastes
   2.4.4.1.1 Lake Huron Area
   2.4.4.1.2 Tributary Basin
   2.4.4.1.3 Other Areas
2.4.4.2 Shore Erosion and Sedimentation
   2.4.4.2.1 Lake Huron Area
   2.4.4.2.2 Tributary Basin
   2.4.4.2.3 Other Areas
2.4.4.3 Dredging
   2.4.4.3.1 Lake Huron Area
   2.4.4.3.2 Tributary Basin
   2.4.4.3.3 Other Areas
2.4.4.4 Spills
   2.4.4.4.1 Lake Huron Area
   2.4.4.4.2 Tributary Basin
   2.4.4.4.3 Other Areas

2.5 Non-Degradation Criteria
2.5.1 U.S. Federal
2.5.2 State of Michigan
   2.5.2.1 Statewide
   2.5.2.2 Lake Huron
      2.5.2.2.1 Coastal Waters (if applicable)
      2.5.2.2.2 Open Lake Areas (if applicable)
   2.5.2.3 Tributary Streams
      2.5.2.3.1 Individual Streams (if applicable)
2.5.3 Canada Federal
2.5.4 Province of Ontario
   2.5.4.1 Provincewide
   2.5.4.2 Lake Huron
      2.5.4.2.1 Coastal Waters (if applicable)
      2.5.4.2.2 Open Lake Areas (if applicable)
   2.5.4.3 Tributary Streams
      2.5.4.3.1 Individual Streams (if applicable)
2.6 Mixing Zones
   2.6.1 U.S. Federal
   2.6.2 State of Michigan
      2.6.2.1 Statewide
      2.6.2.2 Lake Huron
         2.6.2.2.1 Coastal Waters (if applicable)
         2.6.2.2.2 Open Lake Areas (if applicable)
      2.6.2.3 Tributary Streams
         2.6.2.3.1 Individual Streams (if applicable)
   2.6.3 Canada Federal
   2.6.4 Province of Ontario
      2.6.4.1 Provincewide
      2.6.4.2 Lake Huron
         2.6.4.2.1 Coastal Waters (if applicable)
         2.6.4.2.2 Open Lake Waters (if applicable)
      2.6.4.3 Tributary Streams
         2.6.4.3.1 Individual Streams (if applicable)

2.7 Localized Areas
   2.7.1 State of Michigan
      2.7.1.1 Lake Huron
      2.7.1.2 Tributary Streams
   2.7.2 Province of Ontario
      2.7.2.1 Lake Huron
      2.7.2.2 Tributary Streams

2.8 Existing Abatement Programs
   2.8.1 U.S. Federal
   2.8.2 State of Michigan
      2.8.2.1 Introduction
      2.8.2.2 Pollution Control Agency Programs
         2.8.2.2.1 Water Quality Programs
         2.8.2.2.2 Solid Waste Programs
         2.8.2.2.3 Other Related Programs
      2.8.2.3 Abatement Programs of Other State Agencies
      2.8.2.4 Water Pollution Control Program Plan
   2.8.3 Canada Federal
   2.8.4 Province of Ontario
      2.8.4.1 Introduction
2.8.4.2 Pollution Control Agency Programs
  2.8.4.2.1 Water Quality Programs
  2.8.4.2.2 Solid Waste Programs
  2.8.4.2.3 Other Related Programs

2.8.4.3 Abatement Programs of Other Provincial Agencies

2.8.2.4 Water Pollution Control Program Plan

2.9 Objectives Recommended by the IJC

2.9.1 Water Quality Criteria
  2.9.1.1 Lake Huron
    2.9.1.1.1 Coastal Waters (if applicable)
    2.9.1.1.2 Open Lake Waters (if applicable)
    2.9.1.1.3 Other Lake Areas (if applicable)
  2.9.1.2 Tributary Streams
    2.9.1.2.1 Individual Streams (if applicable)

2.9.2 Non Degradation Criteria
  2.9.2.1 Lake Huron
    2.9.2.1.1 Coastal Waters (if applicable)
    2.9.2.1.2 Open Lake Waters (if applicable)
    2.9.2.1.3 Other Lake Areas (if applicable)
  2.9.2.2 Tributary Streams
    2.9.2.2.1 Individual Streams (if applicable)

2.9.3 Mixing Zones
  2.9.3.1 Lake Huron
    2.9.3.1.1 Coastal Waters (if applicable)
    2.9.3.1.2 Open Lake Waters (if applicable)
    2.9.3.1.3 Other Lake Areas (if applicable)
  2.9.3.2 Tributary Streams
    2.9.3.2.1 Individual Streams (if applicable)

2.9.4 Localized Areas
  2.9.4.1 Lake Huron
    2.9.4.1.1 Coastal Waters (if applicable)
    2.9.4.1.2 Open Lake Waters (if applicable)
    2.9.4.1.3 Other Lake Areas (if applicable)
  2.9.4.2 Tributary Streams
    2.9.4.2.1 Individual Streams (if applicable)
CHAPTER 3  Sources and Characteristics of Materials Inputs and Projected Loadings

NOTE: The Outline for Chapters 3.1 - 3.9 is identical.

Introduction and Summary

3.1 Municipal and Industrial Wastes
   3.1.1 Description of the source category
   3.1.2 Quantitative estimates of the inputs of the Material Balance Parameters
   3.1.3 Quantitative estimates of the inputs of all other parameters of significance
   3.1.4 Description of the methods of estimation
   3.1.5 Evaluation of the accuracy of the estimates
   3.1.6 Estimate of future trends
   3.1.7 Other Comments

3.2 Land Drainage and Tributary Sources

3.3 Interlake Transport (including Lake Michigan)

3.4 Atmospheric Input Sources

3.5 Shore Erosion/Sediment Input (with reference to Lake Level Regulation)

3.6 Thermal and Radioactive Inputs

3.7 Dredging Activities

3.8 Vessel Waste Discharges (both commercial and pleasure)

3.9 Spills

3.10 Materials Balance and Calculations
   3.10.1 General Description of the Material Balance
   3.10.2 Comments on reasons for selecting the Material Balance Parameters
   3.10.3 Tabulation of Material Balance numbers by lake
   3.10.4 Discussion of the results
      3.10.4.1 Relative significance of the various inputs
      3.10.4.2 Confidence in the accuracy of the various input estimates
      3.10.4.3 Accumulation of materials in the lakes
      3.10.4.4 Major assumptions made
      3.10.4.5 Other items of note
CHAPTER 4. Water Quality Characteristics and Trends of the Coastal Zones, Embayments, and Connecting Channels

Summary

4.1 St. Marys River

4.1.1 Description of Study Area

4.1.1.1 Geology and Topography
4.1.1.2 Waste Disposal
4.1.1.3 Water Uses - as applicable

4.1.2 Limnology (Historical, Existing, and Trends)

4.1.2.1 Physical

4.1.2.1.1 Temperature, turbidity, pH, dissolved oxygen
secchi disk, colour, alkalinity, hardness, Eh
4.1.2.1.2 Water Movement (including transboundary)
4.1.2.1.3 Dispersions

4.1.2.2 Chemistry

4.1.2.2.1 Water - parameters discussed as applicable
including radionuclides
4.1.2.2.2 Sediment - parameters discussed as applicable

4.1.2.3 Aquatic Biology

4.1.2.3.1 Microbiology
4.1.2.3.2 Phytoplankton
4.1.2.3.3 Zooplankton
4.1.2.3.4 Benthos
4.1.2.3.5 Fish - metals and organic contamination

4.1.3 Summary of Existing and Developing Problems

Description of areas of non-compliance using agency criteria and IJC objectives (if available) using Chapter 6 headings

4.1.4 Abatement Programs (Effluent Requirements)

4.2 Penetang Midland

(Outline identical to Chapter 4.1)

4.3 Lake Huron Coastal - Coastline divided into five reaches: Straits of Mackinac to Saginaw Bay, Saginaw Bay to St. Clair River, St. Clair River to Cape Hurd, Cape Hurd to North Channel, and North Channel.

4.3.1 (Outline identical to 4.1.1)

4.3.2 Limnology (Discussion by reaches as above)

4.3.2.1 Physical

4.3.2.1.1 Water Movement
4.3.2.1.2 Thermal Regimes
4.3.2.1.3 Erosion, Suspended Sediments and Water Clarity
4.3.2.2 Chemical. Includes extensive tables, graphs, and charts with statistical characterization of data. Also includes horizontal and depth distribution and seasonal variations.

4.3.2.2.1 Nutrients
4.3.2.2.2 Dissolved Inorganics
4.3.2.2.3 Trace Metals and Organics
4.3.2.2.4 Sediments

4.3.2.3 Aquatic Biology (outline identical to 4.1.2.3) Includes extensive tables, graphs and charts with statistical characterization of data. Also includes species composition and abundance, and seasonal variations.

4.3.3 (Outline identical to 4.1.3)
4.3.4 (Outline identical to 4.1.4)

4.4 Saginaw Bay
(Outline identical to Chapter 4.1)

4.5 Exchange Mechanisms Between Near Shore and Main Lake Waters

4.5.1 Definition of nearshore region
4.5.2 Methods of estimating mass exchange
  4.5.2.1 Statistical - event oriented
  4.5.2.2 Deterministic - numerical models
  4.5.2.3 Quasi deterministic - dispersion modelling with finite elements
  4.5.2.4 Super position - point source information combined to give area characteristics
  4.5.2.5 Other methods - bacti as a tracer, bottom indicators for long term statistics, transposing data from other studies, embayments and harbours.

4.5.3 Application of methods to estimate exchanges for conservatives - sodium, chloride, conductivity
4.5.4 Application of methods to estimate exchanges for non-conservatives - total phosphorus, nitrogen, bacti
4.5.5 Relating local water quality problems with mass exchange estimates.
CHAPTER 5 Water Quality Characteristics and Trends of the Main Lakes

Summary

5.1 Physical Limnology (40 pages)

5.1.1 Introduction - physical setting, basin morphology (bathymetric chart, hypsographic curve)

5.1.2 Water budget - lake levels, run-off, outflow, over lake precipitation, lake evaporation, thermal expansion (1 figure, 1 table)

5.1.3 Thermal regime - mean for lakes (seasonal change in temperature, heat content, radiation, etc.) and characteristics of horizontal distributions (6 figures, 1 table)

5.1.4 Circulation and water movement - effect of wind, run-off, heating, mass transfer between lake segments, i.e. transboundary, etc. (10 figures)

5.1.5 Inter-lake water exchange - physical reasons (long term, oscillatory), residence time (6 figures)

5.1.6 Optical properties of Lake Waters. Might be incorporated into Chapter 5.1.3

5.2 Morphology and Sedimentology (15 pages)

5.2.1 Surficial sediment distribution in relation to morphology.

5.2.2 Baseline levels of major, minor, and trace element composition by sub-regions, including toxic materials.

5.2.3 Distribution of suspended solids including fibre material and radionuclides.

5.2.4 Inter-relationships of sediment texture, mineralogy and geochemical properties.

5.2.5 Sources, transport, and sinks of sediments as related to lake circulation.

5.2.6 Historical changes and loadings of specific contaminants.

5.3 Chemical Limnology (40 pages)

5.3.1 Introduction (basic chemical background of the lake, geochemistry of basin, mixing areas, etc.)

5.3.2 The baseline reference by lake segments.

5.3.2.1 Nutrient Chemistry (P, N, SiO₂, pH)

5.3.2.2 Major Ions (Cl, Mg, Ca, Na, K, TDS)

5.3.2.3 Trace Elements (Cu, Zn, Fe, Mn, Cr, Ni, Cd, Pb, et al.)

5.3.2.4 Toxic Substances.

5.3.3 Historical changes.
5.4 Aquatic Biology - Plankton Benthos

5.4.1 Introduction - importance of plankton and benthos as indicators of water quality on plankton-benthos community and rationale for community evaluation.

5.4.2 Present state of plankton-benthos community in the lake including phytoplankton, zooplankton and benthos.

5.4.2.1 species composition and seasonal abundance.
5.4.2.2 biomass indicators
5.4.2.3 community structure evidence of water quality.

5.4.3 Evidence for plankton-benthos interaction with other water quality parameters.

5.4.3.1 light, temperature, masses.
5.4.3.2 water chemistry, nutrients and dissolved O₂.

5.5 Microbiology (10 pages)

5.5.1 Introduction and methods.
5.5.2 Bacteriological characteristics of the main lake.
5.5.3 Causes and effects of observed bacterial contamination.

5.6 Fish (Quality Characteristics and Trends)

5.6.1 Status of Fish Stocks (brief review)
5.6.1.1 Current Status
5.6.1.2 Past Trends
5.6.2 Status of Fisheries
5.6.2.1 Recreational Fisheries
5.6.2.2 Commercial Fisheries
5.6.3 Contaminants in Fish from Offshore Waters
5.6.3.1 Historical Review of Past Data and Recognized Problems
5.6.3.2 Current Levels of Contaminants
5.6.3.2.1 Sampling stations and their relation to lake segments as defined by the limnologists
5.6.3.2.2 Fish movements and implications regarding the representativeness of sample data
5.6.3.2.3 Concentrations by contaminant and station
5.6.3.2.4 Statement of data quality

5.7 Summary (3 pages)

5.7.1 Introduction
5.7.1.1 Main Lake Field Program and Relation to Past Work
5.7.1.2 Reference Questions Addressed in the Program
5.7.2 Summary
5.7.2.1 Lake System Operation
5.7.2.2 Controllable and Uncontrollable Major Elements in the System
5.7.2.3 State of the System
CHAPTER 6. Existing and Developing Problems

Summary

6.1 Enrichment

6.1.1 Short introduction reviewing the current and historical treatment and assessment of enrichment of Lake Huron

6.1.2 Review of the established minimum use objectives/criteria that have been established and the specific mixing zones and localized areas.

6.1.3 Review of the various modelling techniques that will be applied to defining the condition of the lakes.

6.1.4 Application of the modelling techniques to the specific nearshore regions, and other areas which have been shown to exceed the water quality criteria to define the problems and provide recommendations for changes in loadings. (Data will be required from Chapter 3 & 4)

6.1.5 Defining the baseline conditions for the open lake and other regions in compliance with the established criteria, and developing the values for nutrients in the various segments, and the use of phytoplankton biomass and species composition to define non-degradation criteria.

6.2 Bacterial Contamination (Health Related Heterotrophs)

6.2.1 Introduction

6.2.1.1 General Description of the Problems

6.2.1.2 Objectives

6.2.1.3 Parameter Descriptions and Relevance

6.2.1.4 Methodology Problems

6.2.2 Existing Problems

6.2.2.1 Nearshore

6.2.2.2 St. Marys River

6.2.2.3 Penetang-Midland

6.2.2.4 Saginaw Bay

6.2.2.5 Others

6.2.3 Developing Problems

6.2.4 Summary

6.3 Metals Contamination (Breakdown by Individual Metals)

6.3.1 Introduction - Criteria for Metals

6.3.1.1 Drinking Water

6.3.1.2 Aquatic Life Toxicity and Protection Criteria

6.3.1.3 Fish Residues

6.3.2 Mercury

6.3.2.1 Background

6.3.2.1.1 Uses in Watershed

6.3.2.1.2 Sources and Transport

6.3.2.1.3 Persistence
6.3.2.2 Nondegradation or Reference Levels (If data show no problem areas, state so here and don't proceed further)

6.3.2.2.1 Water
6.3.2.2.2 Sediments
6.3.2.2.3 Fish
6.3.2.3 Existing Problems (in water, sediment, and/or fish)
6.3.2.3.1 Tributaries
6.3.2.3.2 Nearshore
6.3.2.3.3 Offshore
6.3.2.3.4 Interrelationships
6.3.2.4 Developing Problems

6.3.3 (For each other metal to be considered, the format of Chapter 6.3.2 will be repeated).

6.4 Organic Contaminants
(Outline is identical to that proposed for Chapter 6.3. Please refer).

6.5 Dissolved Solids

6.5.1 Definition (including a conversion chart to convert specific conductivity to dissolved solids).

6.5.2 Discussion of Open Lake Conditions
6.5.2.1 Existing Conditions and Impact on Water Use
6.5.2.2 Long-Term Trends (including loading)
6.5.3 Discussion of Problem Areas by Location (including source identification where possible and impacts on water use).

6.6 Suspended Solids

No specific studies were undertaken to elucidate the concentrations and distributions of suspended solids in the Upper Lakes. This section will attempt to compile all sources of pertinent information in an effort to provide a brief overview. Particular reference will be made to suspended amphibole fibers and to the impact of the Lake Superior red clays. A qualitative synopsis will be attempted by ERTS imagery to identify major sources of particulates derived from tributary sources. An analysis of the state of knowledge of the precipitation of calcium carbonate from lake water as evidenced by satellite imagery and geochemistry of the water will be included.

6.7 Spills and Other Disasters
(Outline to be provided by March 4th, 1975).

6.8 Lake Levels Regulation

6.8.1 Existing Regulation
6.8.1.1 Very brief history of regulation since 1921
6.8.1.2 Current regulation (includes present operation)

6.8.2 Existing Problems
6.8.2.1 St. Marys Rapids (gate operations)
6.8.2.2 Erosion (e.g. Red Clay)
6.8.2.3 Other Problems associated with high or low water levels
6.8.2.4 Others
6.8.3 Developing Problems
6.8.3.1 Crustal Movement
6.8.3.2 Possible Power Development
6.8.3.3 Others
6.8.4 Summary and Conclusions

6.9 Dredging
(Outline identical to that proposed for Chapter 3.7. Please refer)

6.10 Vessel Wastes
6.10.1 Discussion of Present Problems
Bacterial, aesthetic—including sanitary, bilge, ballast, and galley wastes (if information is available)
6.10.2 Statement of Significance of Other Waste Constituents
6.10.3 Control Programs and Expected Results

6.11 Thermal Inputs (Power Generation Effects)
6.11.1 Thermal Effects
6.11.1.1 Phytoplankton
6.11.1.2 Zooplankton
6.11.1.3 Benthos
6.11.1.4 Fish
6.11.1.4.1 Spawning
6.11.1.4.2 Nursery
6.11.1.4.3 Migratory Movement into and out of plumes
6.11.2 Entrainment and Impingement
6.11.2.1 Benthos
6.11.2.2 Fish
6.11.2.2.1 Adults
6.11.2.2.2 Larvae
6.11.2.2.3 Eggs
6.11.3 Regulatory Control
6.11.3.1 U.S. Federal
6.11.3.2 Canada Federal
6.11.3.3 States
6.11.3.4 Ontario
6.11.3.5 Future

6.12 Radioactivity
6.12.1 Power Generation
6.12.1.1 Atmospheric and Effluent Inputs
6.12.1.2 Food Chain

6.12.2 Mining and Milling of Uranium

6.12.3 Fuel Reprocessing

6.12.4 Regulatory Control
   - 6.12.4.1 Nuclear Regulatory Commission and EPA
   - 6.12.4.2 AECB
   - 6.12.4.3 Future Objective for Radioactivity

6.13 Pollution Effects by Water Use (Summary Discussion)
   - 6.13.1 Introduction
     - 6.13.2 Water Supply
       - 6.13.2.1 Municipal and Private
         - 6.13.2.1.1 Ontario
         - 6.13.2.1.2 Minnesota
         - 6.13.2.1.3 Wisconsin
         - 6.13.2.1.4 Michigan
       - 6.13.2.2 Industrial
         (breakdown by jurisdiction as in 6.13.2.1)
   - 6.13.3 Aesthetics and Recreation
     - 6.13.3.1 Aesthetics (by jurisdiction)
     - 6.13.3.2 Body Contact Recreation (by jurisdiction)
   - 6.13.4 Fish and Other Aquatic Life
     - 6.13.4.1 Fish
       - 6.13.4.1.1 Commercial Fishing (by jurisdiction or area)
       - 6.13.4.1.2 Sport Fishing (by jurisdiction or area)
     - 6.13.4.2 Other Aquatic Life (by jurisdiction or area)
   - 6.13.5 Other Uses (e.g. irrigation, navigation, etc.)
CHAPTER 7  Adequacy of Existing Water Quality Criteria and Abatement Programs

Summary

7.1  Comparison of existing water quality levels against existing jurisdictional criteria, and (when developed by WQOS) against possible new IJC criteria. No evaluation of criteria per se.

7.2  Adequacy of existing abatement programs to meet existing jurisdictional criteria and (when adopted) new IJC criteria.

7.3  Additional abatement programs necessary to meet existing jurisdictional criteria and (when adopted) new IJC criteria.

7.4  Summary of water quality conditions for definition of nondegradation criteria.

7.5  Additional programs necessary to meet nondegradation criteria, and cost.
VOLUME III - LAKE SUPERIOR

CHAPTER 1. Description of Study Area and Human Component Characteristics, Including Historical and Future Trends.

Summary

1.1 Physical Features - Lake Superior Basin by geographic units

1.1.1 Geology, Hydrogeology, Topography, Physiography
1.1.2 Climate
1.1.3 Hydrology
1.1.4 Soils and Vegetation
1.1.5 Wildlife

1.2 Population

1.2.1 Lake Superior East Planning Subarea
1.2.2 Lake Superior West Planning Subarea
1.2.2.1 Duluth-Superior SMSA
1.2.3 Kaministikwia Basin
1.2.4 Nipigon - Long Lac - White Basin
1.2.4.1 Thunder Bay
1.2.5 Magpie - Michipicoten - Montreal Basin
1.2.6 Mississagi West Basin

1.3 Economic Structure

1.3.1 General Economy
1.3.1.1 Lake Superior East Planning Subarea
1.3.1.2 Lake Superior West Planning Subarea
1.3.1.2.1 Duluth-Superior SMSA
1.3.1.3 Kaministikwia Basin
1.3.1.4 Nipigon - Long Lac - White Basin
1.3.1.4.1 Thunder Bay CMA
1.3.1.5 Magpie - Michipicoten - Montreal Basin
1.3.1.6 Mississagi West Basin

1.3.2 Agricultural Economy
1.3.2.1 Lake Superior East Subarea
1.3.2.2 Lake Superior West Subarea
1.3.2.3 Kaministikwia Basin
1.3.2.4 Nipigon - Long Lac - White Basin
1.3.2.5 Magpie - Michipicoten - Montreal Basin
1.3.2.6 Mississagi West Basin

1.3.3 Forest Resources
1.3.4 Mineral Industries
1.3.4.1 Lake Superior East Subarea
1.3.4.1 Lake Superior East Subarea
1.3.4.2 Lake Superior West Subarea
1.3.4.3 Kaministikwia Basin
1.3.4.4 Nipigon - Long Lac - White Basin
1.3.4.5 Magpie - Michipicoten - Montreal Basin
1.3.4.6 Mississagi West Basin

1.3.5 Commercial Fishing
1.3.6 Recreation

1.3.6.1 Lake Superior East Subarea
1.3.6.2 Lake Superior West Subarea
1.3.6.3 Kaministikwia Basin
1.3.6.4 Nipigon - Long Lac - White Basin
1.3.6.5 Magpie - Michipicoten - Montreal Basin
1.3.6.6 Mississagi West Basin

1.4 Land Uses

1.4.1 Lake Superior East Subarea
1.4.2 Lake Superior West Subarea
1.4.3 Kaministikwia Basin
1.4.4 Nipigon - Long Lac - White Basin
1.4.5 Magpie - Michipicoten - Montreal Basin
1.4.6 Mississagi West Basin

1.5 Water Uses

1.5.1 Water User Profile
1.5.1.1 Municipal Water Users
1.5.1.2 Industrial Water Users
1.5.1.3 Rural Water Users

1.5.2 Water Use Requirements - Present and Projected
1.5.2.1 Municipal Water Users
1.5.2.2 Industrial Water Users
1.5.2.3 Rural Water Users

1.5.3 In-Situ Water Use
1.5.3.1 Electrical Power Generation
1.5.3.2 Commercial Navigation
1.5.3.3 Other Uses
CHAPTER 2. Existing Water Quality Criteria and Abatement Programs. (Outline is identical to that proposed for Volume II, Chapter 2, except that where "Michigan" is considered, Wisconsin and Minnesota are also considered).

CHAPTER 3. Sources and Characteristics of Materials Inputs and Trends. (Outline is identical to that proposed for Volume II, Chapter 3. Please refer.)


4.1 Lake Superior Coastal (Outline identical to Volume II, Chapter 4.3)
4.2 Thunder Bay (Outline identical to Volume II, Chapter 4.1)
4.3 Duluth-Superior Harbor (Outline identical to Volume II, Chapter 4.1)
4.4 Nipigon Bay (Outline identical to Volume II, Chapter 4.1)
4.5 Silver Bay (Outline identical to Volume II, Chapter 4.1)
4.6 Exchange Mechanisms Between Near Shore and Main Lake Waters (Outline identical to Volume II, Chapter 4.5)
CHAPTER 5. Water Quality Characteristics and Trends of the Main Lakes.

(Outline is identical to that proposed for Volume II, Chapter 5).

CHAPTER 6. Existing and Developing Problems.

(Outline for each subchapter identical to that proposed for Volume II, Chapter 6, except for Chapter 6.2.2, given below. Please refer).

6.2.2 Existing Problems

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CHAPTER 7. Adequacy of Existing Water Quality Criteria and Abatement Programs.

(Outline identical to that proposed for Volume II, Chapter 7. Please refer).
## APPENDIX 5 PROJECT REPORTS IN INFORMATION DEPOT

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<thead>
<tr>
<th>PROJECT NO.</th>
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**ATMOSPHERIC STUDIES**

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See Also Related Report R-11 |
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APPENDIX 6 DISSOLVED LOADINGS FROM RESERVE MINING COMPANY

Estimates of the dissolved loading to Lake Superior from Reserve Mining Company at Silver Bay, Minnesota were prepared by Mr. A. G. Kizlauskas, EPA, Region V, Chicago.

The estimates include the increase in dissolved material in the process water between the raw water intake and the tailings launders, as well as the long-term leaching of the tailings after deposition in the lake. Dissolved loadings are given in the following table. They are based on the best short and long-term dissolution data available. Confidence in the estimates is "good" because of the good agreement among the studies performed or sponsored by the Reserve Mining Company and those performed by the EPA National Water Quality Laboratory, Duluth, Minnesota. A bibliography is presented.

The amphibole asbestos loading was researched by Dr. Philip M. Cook of the National Water Quality Laboratory. Dr. Cook based his estimate on the work performed by Dr. Donald Beamon of the Dow Chemical Company.

Because of the more limited data on the long-term dissolution of the taconite tailings, the seasonal variations of the final loadings could not be determined.
Final Estimate of Dissolved Loading to Lake Superior from the Reserve Mining Company at Silver Bay, Minnesota

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<td>Sodium</td>
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<td>Potassium</td>
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Note: neg. - negligible, less than 40 pounds/day
BIBLIOGRAPHY

The principal studies employed in the final determination of the dissolved loading to Lake Superior from the Reserve Mining Company were:


APPENDIX 7 GUIDELINES FOR DATA ASSESSMENT

The Committee for Data Quality (CDQ) of the Upper Lakes Reference Group (ULRG) has developed the following rationale and guidelines for assessing analytical data to be utilized in the preparation of the Final Report.

**BASIS**

The CDQ has documented sample collection and analysis methodologies for N, P, Cl, $SO_4^2-$, and $SI0_3^2-$, and subjectively evaluated each. These are presently being updated.

The CDQ has conducted and continues to conduct extensive interlaboratory comparisons to develop an adequate data base to assess the between-laboratory comparability of and confidence in analytical data. Smaller scale interjurisdictional comparisons were additionally initiated to augment the full intercomparisons. Some IFYGL intercomparisons will also be utilized.

A procedure has been developed to estimate the variability of analytical data from a given laboratory.

Past analytical data (to at least January 1971) has been evaluated internally by each laboratory, based upon the methodology evaluation, the intercomparison studies, and the precision measurements.

**MECHANISMS**

The CDQ recognizes that any data assessment can only be conducted by individuals within a jurisdiction, and on a case-by-case basis, although the basis for the assessment has been developed in large part through a group effort.
Consultation and assessment may be effected between:

1. The analyst (or laboratory) who produced the data and the project leader who requested the data
2. The analyst (or laboratory) and the Work Group Chairmen, on behalf of those authors of the Final Report who will be utilizing that data.

The purpose of the consultation is to ensure that the proposed interpretations can indeed be substantiated by the data utilized. This in no way implies that the analyst (or laboratory) will prepare the report; rather, this review is to ensure the quality of the report.

The liaison will be between the project leader or the author and the analyst. This will ensure proper within-laboratory evaluation of the data to be assessed.

**ASSESSMENT**

The data assessment will be based upon:

1. Documented sample collection and analysis methodology
2. Interlaboratory comparisons
3. Within-laboratory precision data
4. Within-laboratory evaluation of past data
APPENDIX 8 EVALUATION OF RESULTS OF INTERLABORATORY COMPARISONS

Introduction

The attached report provides an estimate of the extent to which data from certain laboratories, some of whom have participated in the Upper Lakes Reference Group program, can be considered compatible. The data was collected during 1974 using both reference solutions, prepared by J. Winter of EPA Methods Development and Quality Assurance Research Laboratory in Cincinnati, and 'stabilized' natural samples, provided by D. Payne of EPA Region V. The results were used to initiate discussions among analysts participating in the ULRG Committee for Data Quality to document and improve their analytical performance. They are released at this time as examples of the way in which results produced by analysts in regular communication can be expected to diverge, and by inference suggest the relative lack of agreement between analysts not in close communication. In this context close communication is synonymous with face-to-face meeting between the analysts.

The data reported by the various laboratories is not included nor are the outliers in the attached 'bulls-eye' figures identified for the following reasons.

1) The continuation of communication between analysts depends upon maintaining the participant's confidence that his reputation will not depend upon his matching the performance
of the best participants. His performance depends too much on the economic guidelines set by management and the availability of suitable staff, equipment and space under which his laboratory operates.

2) The performance, good or not so good, in any one study cannot be assumed to reflect the routine performance of the laboratory. In a number of cases a repeat analysis provided an acceptable result but in an equal number of cases the new result was also incorrect. This in spite of the fact that all the laboratories had some form of internal quality control. In some cases laboratories reporting only one significant figure were closer to the mean than laboratories reporting three figures.

3) In general, data from different laboratories should not be mixed without a far more intensive study of the actual inter-comparison between the laboratories involved for all the parameters of interest. In fact two of the laboratories carrying out just such a study have been able to document the extent to which data compatibility can change from one study to another due to any one of the sampling, sample handling, preservation and storage, or analytical calibration factors.

4) The assessment of data quality depends upon the use to which the data will be put. This requires close communication between the report writer and the analyst.

5) The planning of the sampling program must include an evaluation of existing technology prior to the initiation of
sampling, as well as the acceptability of data generated in the early phases of the program. The data in this report will not substitute for the lack of a preliminary evaluation.

6) The data in this report does not include variability resulting from non-analytical sources. Future programs would be well advised to include replicate sampling of about one in 25 sample sources to permit estimation of the effect of all sources of deviation.

**Reporting Practices**

In order to assist authors and data users in the interpretation of existing data the following discussion of significant figures may be of value in considering which laboratories best meet their data requirements. It should be kept in mind, however, that data storage systems may be designed in such a way that even this information source is lost.

It is frequently the custom of analysts to round off their data before reporting results to avoid implying that the precision of their analytical technique in any way reflects the reliability of the result as it relates to the actual environmental conditions from which the sample was taken. In most cases the data is reported to two significant figures, but, as will be shown below, this can cause the data user to over or underestimate the quality of the data.

The number of significant figures is based on the number of digits reported excluding decimal positioning zeros. Thus .00541, .541 and 541. all contain three significant figures. The number 541000. is ambiguous, depending on how many of the
zeros are for decimal positioning, and is best reported as 5.41 x 10^5 if three figures are significant or as 5.410 x 10^5 if four are significant.

Since the last significant figure can be expected to vary by at least ±1, an estimate of the implied maximum reliability can be made (e.g. ±1 in 541 is approximately 0.2%) as in the following table. (The decimal positioning can be adjusted to suit other ranges of numbers).

<table>
<thead>
<tr>
<th>Data reported in the range</th>
<th>Significant figures</th>
<th>Implied reliability</th>
<th>Quality of data</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 0.01 - 0.09</td>
<td>1</td>
<td>100 - 10%</td>
<td>very poor</td>
</tr>
<tr>
<td>b) 0.10 - 0.19</td>
<td>2</td>
<td>10 - 5%</td>
<td>poor</td>
</tr>
<tr>
<td>c) 0.20 - 0.99</td>
<td>2</td>
<td>5 - 1%</td>
<td>good</td>
</tr>
<tr>
<td>d) 1.00 - 1.99</td>
<td>3</td>
<td>1 - ½%</td>
<td>excellent</td>
</tr>
<tr>
<td>e) 2.00 - 9.99</td>
<td>3</td>
<td>&lt;½%</td>
<td>see below</td>
</tr>
</tbody>
</table>

The better analyst will attempt to report data to within a reproducibility of ±5% provided that

a) the detection limit of his analytical system permits this
b) the range of routine samples received in his laboratory permit the use of the best detection limit available.

c) the economics under which he operates permit him to set up two or more operating ranges if necessary
d) the samples as received can be aliquoted in a representative fashion to within 5%

Under these conditions, continuing the example in the above table, he would attempt to report to the nearest 0.005 in the range 0.10 to 0.19 and would probably round-off data to
the nearest 0.05 in the range 1.0 to 1.9 units. Results from replicate samplings strongly suggest for a variety of reasons that the practice of reporting three significant figures as in e) above cannot be justified except to more clearly define the second figure.

**Standard Deviation**

The actual data reliability is reported in units of standard deviation(s) as determined from the equation for variance $s^2$.

$$s^2 = \frac{\Sigma (Xi - \bar{X})^2}{(n-1)}$$

where $Xi$ = individual values  
$\bar{X}$ = average value = $(\Sigma Xi)/n$  
$n$ = number of values

For sufficient data which is "normally distributed" about the mean value ie distributed in a bell-shaped pattern equally on either side of the average so that increasingly deviant results occur with decreasing frequency, values outside $\bar{X} \pm 2s$ will occur less than 5% of the time. Experience has shown that this characteristic holds when a very large number of measurements are made by a single observer of a characteristic which is unchanging during the time of measurement.

Unfortunately there is no requirement that a small sample of data will display this normal distribution, or that apparent normal distribution of small samples of data will not mask a non-normal distribution of the total population, particularly when the total population is derived from
several observers who are each contributing their own personal bias.

Bias or systematic error usually remains undetected by the individual responsible for it because he has no independent standard for reference. However, Youden (1) developed a technique for separating the contribution of systematic error introduced between laboratories and King (2) has extended this technique to detect and control within-lab sources of systematic error which are the result of inadvertent improper calibration, or blank correction from day to day.

Any estimate of the overall analytical standard deviation must include the effect of between-run and between-lab systematic error, if the data user is to be provided with an adequate assessment of the data quality. At this point in time most of the available standard deviation information is based on within-lab, within-run replicates and is therefore inadequate. In many cases, the effect of systematic error is to approximately double the standard deviation.

Systematic error has its own normal distribution, and assuming the laboratory has no long term bias, cannot be corrected for unless the specific correction for a specific set of data can be determined. Thus a laboratory that is high today because of systematic error could be equally low tomorrow unless control over systematic error is part of their control system.
Conclusions

The final reliability of data depends on any number of factors over which the analyst has little direct control. Variability in the natural system being sampled as well as sampling, sample handling, storage and preservation techniques require a great deal of attention and consideration if the laboratory result is to reflect the condition of the system under study. Since the contribution of a well-controlled laboratory to the overall reliability is often very small, documentation of the source and extent of deviation was neglected in the past, particularly when analyses were performed for pollution control and waste treatment purposes. The choice of operating range was often premised on the assumption that there was no need for precise or accurate determination of environmental levels because they were so low relative to the waste inputs. Most of the laboratories participating in these studies were still operating under these premises.

When the goal becomes one of assessing environmental impact, i.e. what exactly are the baseline levels at present and to what extent are they likely to be affected by sources of pollution, much closer attention to detail is required. This has become most apparent to those laboratories directly involved in open-water and near-shore analysis of the Great Lakes. Data from even the recent past suddenly is inadequate because the lack of precision and/or sensitivity of analysis obscures any trends in baseline levels. New technology with improved sensitivity, precision and accuracy tends to show also that the earlier data is also inaccurate for determining
baseline levels.

The first response is to go back to the analyst and ask if there is any way the quality of the existing data can be improved. What correction should be applied to make a certain set of data useful? In general, no such correction can be determined. When, for example, special sampling equipment, or filtration in the field, is required, failure to do so can only be tolerated if, in fact, the answer does not matter. Good data can only be obtained by exerting excellent control over all facets of the operation, and this cannot be done after the fact. The average of imprecise and inaccurate data remains imprecise and inaccurate.

It is becoming increasingly important, both technically, economically and politically to look to the future use of data when planning large scale programs. Program planners must accept greater responsibility for provision of adequate samples for analysis. They must more adequately document the rationale for requesting certain parameters to justify the effort required by the analyst. Analysts must accept greater responsibility for providing and/or making better use of more precise and accurate technology, and for informing program planners when such is unavailable. Data management personnel must plan more adequately for storage, recall and manipulation of the data, taking into account the rapid strides being made in sampling and analytical technology. It is disconcerting to find that the computer is unable to store the extra decimal figure resulting from new technology.

Future data needs will only be met by producing the very best data now. If this is not possible the program should
be delayed and funds diverted to update techniques and/or equipment. False economy now can result in a completely valueless program within a short time of its completion. The most significant impetus to better data quality lies in increased communication between management, program planners, analysts, and data evaluators. The various committees for data quality provide the forum for such communication to ensure that both short and long term needs are recognized by all.

References


This evaluation is based on the Youden technique for separating random from systematic sources of variance given that several laboratories each provide a single analysis for each of two samples A and B. The following can be calculated:

\[ \overline{A} = \text{average result for sample A with variance } s_A^2 \]
\[ \overline{B} = \text{average result for sample B with variance } s_B^2 \]
\[ \overline{T} = \text{average result of } (A + B) \text{ with variance } s_T^2 \]
\[ \overline{D} = \text{average result of } (A - B) \text{ with variance } s_D^2 \]

From which can be determined, for \( s_A \) approximately equal to \( s_B \):

- **average overall variance:** \( s^2 = (s_T^2 + s_D^2 - s_A^2 - s_B^2)/2 \)
- **within-lab variance:** \( s_w^2 = (s_D^2)/2 \) approx.
- **systematic error variance:** \( s_e^2 = (s_T^2 - s_A^2 - s_B^2)/2 \) approx.

Confidence limits outside of which less than approximately 5% of the analytical results will normally be expected to fall can then be estimated:

- **a) for intra-laboratory data as** \( \pm 2s_w \)
- **b) for inter-laboratory data as** \( \pm 2s \)

In the attached graphs, two "bulls-eyes" have been drawn each with two confidence limit circles with radii of \( 2s_w \) and \( 2s \). The one on the left is derived from that data which was reported to the maximum level of precision, and which for each pair of results did not show "excessive" levels of random deviation. (In general the data was readily separable into two sets, one which agreed fairly closely on the concentrations of the two samples, and another which either did not agree or which were reported to fewer significant figures). The bulls-eye on the right in each figure includes all data that fell within the scale limits of the diagram. The scale was chosen whenever possible so that one division was approximately equal to the increment felt to be necessary for ULRG needs. The size of the bulls-eyes then reflects the extent to which the "good" and all labs together met these needs. In some cases the precision achieved by the "better" laboratories was not significantly better than that for all laboratories together because of the level of random deviation due to existing sampling and/or analytical practice. However, in other cases systematic error eg calibration and blank control, was a serious contributor to lack of agreement between even the best laboratories.
For many of the intercomparisons the between-lab performance of the better laboratories is comparable to or better than the within-lab performance of all the laboratories put together. This is generally related to the fact that to some extent no guidelines were set as to the level of precision required so that the laboratories were left free to determine, based on their routine work input, the number of significant figures to be reported. Thus a laboratory which rarely encountered chloride levels of less than 10 or 15 mg/l might not have, or provide, the facility to report to the nearest 0.1 mg/l even if a series of samples in the range 1 to 6 mg/l were received for analysis, because in their view there was no expressed demand for such sensitivity. On the other hand the ability to report an extra significant figure and thereby improve the precision of analysis did not guarantee freedom from significant bias. This is particularly noticeable in the sulphate and chloride intercomparisons.

Alkalinity:  - most labs reported to nearest 1 mg/l, confidence limits 3-4 mg/l  
  - random distribution of points suggests better precision not readily attainable at this time

Calcium, Magnesium, Sodium, Potassium

  - most labs reported to nearest 0.1 mg/l, confidence limits 0.5-1 mg/l  
  - Ca and Mg by EDTA titration data more suspect  
  - some small improvement in precision is desirable but not essential?

Chloride and Sulphate

  - most labs reported only to nearest 1 mg/l prior to studies  
  - most labs attempted to report to nearest 0.1 mg/l below 20 during these studies with varying success  
  - confidence limits even for the better labs are subject to systematic error  
  - although data for a single lab can be considered useful for trend analysis, extreme caution must be taken in mixing data from different labs, or in determining baseline levels  
  - certain laboratories may wish to withdraw their data or restrict its use

Total Kjeldahl Nitrogen

  - at levels below 1.00 mg/l confidence limits are no better than 0.05 mg/l  
  - at this time the methodology for digestion, and oxidation of the samples prior to analysis appears to be the most significant source of deviation. Better technology is required but fully automated analyses does not appear to be the entire answer for all types of samples  
  - there is no capability at this time to report reliably to the nearest 0.01 mg/l N
Total Phosphorus

- the confidence limits of about 0.003 mg/l for those labs attempting to report to the nearest 0.001 mg/l below 0.050 mg/l are surprisingly good.

Reactive Silicates (formerly Silica)

- there is strong evidence of relatively gross systematic error between laboratories.
- sample handling and preservation is not standardized from lab to lab, and data may have been obtained from either filtered or unfiltered samples.
- in spite of the above, the confidence limits for labs reporting to the nearest 0.1 mg/l are surprisingly better than 0.4 mg/l at levels less than 10 mg/l SiO₂.
- within lab precision can be much better than this but care must be taken in determining baseline levels or trends based on only one laboratory's results.

Dissolved Reactive Phosphates

- confidence limits are acceptable at 3 μg/l
- care must be taken in interpreting DRP data.

There is evidence from another study that analyses performed in the field indicate levels of 0.2 - 0.6 μg/l P in the St. Mary's and St. Lawrence Rivers, when results obtained at the central laboratory facilities, on field-filtered samples were found to be 2 and 20 μg/l P respectively.

Ammonia

- although results have been reported by some laboratories to the nearest 0.001 mg/l N the confidence limits of 0.02 not support interpreting such data to better than the nearest 0.005 mg/l N. Most laboratories did not report routinely to better than the nearest 0.01 prior to these studies.
- results are subject to error because of both sample instability and contamination by ammonia in the laboratory atmosphere.

Nitrate

- most laboratories did not report to better than the nearest 0.01 mg/l prior to these studies
- confidence limits would support reporting to nearest 0.005 mg/l where existing levels required better precision.
Labs

EPA Grosse Ile
EPA, Illinois, Chicago lab
EPA, Illinois, Champaign lab
EPA, Region V, Central lab, Chicago
Michigan Dept. of Natural Resources, Lansing
Great Lakes Research Division, U. of Michigan, Ann Arbor
Chicago City
Ohio State Dept. of Health
Ohio State University
DePaul University
Lake Survey Center, NOAA, Detroit
Wisconsin Dept. of Natural Resources, Madison
Minnesota Dept. of Health, Minneapolis
Great Lakes Fishery Laboratory, USFWS
Great Lakes Laboratory, Buffalo
Environmental Research Group Inc., Ann Arbor
Indiana State Board of Health

Canada Center for Inland Waters, Burlington
Inorganic laboratory
Shipboard laboratory

Ontario Ministry of the Environment
Toronto Central Laboratories
London Regional Laboratory
Thunder Bay Regional Laboratory
<table>
<thead>
<tr>
<th></th>
<th>( A \pm S_A )</th>
<th>( B \pm S_B )</th>
<th>( B )</th>
<th>( n )</th>
<th>( A \pm S_A )</th>
<th>( B \pm S_B )</th>
<th>( B )</th>
<th>( n )</th>
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<td>14.1 1.1</td>
<td>54.6 1.7</td>
<td>2.6</td>
<td>12</td>
<td>14.2 1.9</td>
<td>54.7 2.5</td>
<td>2.4</td>
<td>14</td>
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<td><strong>Calcium</strong></td>
<td>8.8 0.40</td>
<td>35.6 0.52</td>
<td>1.0</td>
<td>7</td>
<td>8.8  .53</td>
<td>36.3 3.69</td>
<td>*</td>
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<td><strong>Magnesium</strong></td>
<td>1.9 0.12</td>
<td>8.4 1.14</td>
<td>*</td>
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<td>2.28 0.28</td>
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<td>4.34 0.16</td>
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<td>28.3 3.0</td>
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<td>44.7 3.7</td>
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*most laboratories reported to better than the nearest 0.01 mg/l. Due to these studies confidence limits may impact reporting to nearest 0.005 mg/l where maximum levels required better precision.*
<table>
<thead>
<tr>
<th></th>
<th>&quot;better&quot; laboratories confidence limits</th>
<th>all laboratories confidence limits</th>
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<td>2.42</td>
<td>0.045</td>
<td>0.094</td>
</tr>
<tr>
<td>2.63</td>
<td>0.16</td>
<td>0.26</td>
</tr>
<tr>
<td>2.75</td>
<td>0.19</td>
<td>0.35</td>
</tr>
<tr>
<td>4.49</td>
<td>0.25</td>
<td>0.19</td>
</tr>
<tr>
<td>4.47</td>
<td>0.20</td>
<td>0.44</td>
</tr>
</tbody>
</table>
CHLORIDE

0.1 mg/L

0.2 mg/L

0.2 mg/L

0.2 mg/L

3.63

2.39

19.8

4.34

7.43

8.21

14.15

11.56
TOTAL KJELDAHL NITROGEN

0.02 mg/l

0.206

0.240

0.167

0.170

0.1 mg/l

4.45

3.82

5.68

6.17

0.02 mg/l

div.

div.

div.

div.
Total Phosphorus

0.002 mg/l

0.0241

0.0154 0.0154

0.005 mg/l

0.154

0.05 mg/l

0.181 0.181

0.002 mg/l
div.

0.0273

0.0873

0.0292

0.05 mg/l
div.

1.76

1.61
REACTIVE SILICATES

0.1 mg/l
---
div

2.42

2.47

2.47

2.63

2.63

0.02 mg/l
---
div

0.1 mg/l
---
div

0.1 mg/l
---
div

4.47

4.49

4.49