

Report to the
Great Lakes Water Quality Board

**Nonpoint Source
Pollution Abatement
in the Great Lakes Basin
An Overview
of Post-PLUARG Developments**

A Report Submitted by the
Nonpoint Source Control Task Force
of the Water Quality Board
of the International Joint
Commission

August 1983
Windsor, Ontario

Table of Contents

CHAPTER	TITLE	PAGE
	LIST OF TABLES AND LIST OF FIGURES	v
	ACKNOWLEDGEMENT	vii
	PREFACE	ix
	EXECUTIVE SUMMARY	1
1.0	INTRODUCTION	17
2.0	POST-PLUARG OVERVIEW OF GREAT LAKES BASIN NONPOINT REMEDIAL PROGRAMS	21
2.1	U.S. Programs	22
	2.1.1 Post-PLUARG Program Activity	22
	2.1.2 Effectiveness in Terms of Reducing Levels of Target Parameters	28
	2.1.3 Highlights of Successful Programs	29
	2.1.4 Major Reasons for Success and Failure	31
2.2	Canadian Programs	33
	2.2.1 Post-PLUARG Program Activity	33
	2.2.2 Effectiveness in Terms of Reducing Levels of Target Parameters	34
	2.2.3 Highlights of Successful Programs	42
	2.2.4 Major Reasons for Success and Failure	43
3.0	AN EVALUATION OF NONPOINT REMEDIAL PRACTICES IN THE GREAT LAKES BASIN	45
3.1	Agriculture	45
3.2	Urban	56
4.0	SOME MAJOR SCIENTIFIC AND TECHNICAL ISSUES HAVING DIRECT IMPACT ON NONPOINT REGULATORY PROCESS	65
4.1	Priority Management Areas Identification	65
4.2	Transport and Transformations of Point and Nonpoint Source Phosphorus	66

Table of Contents - cont'd.

CHAPTER	TITLE	PAGE
4.3	Phosphorus Bioavailability	66
4.4	Status and Evaluation of Pesticide Impacts on the Water Quality of the Great Lakes	68
4.5	Wind Erosion as a Source of Water Pollution	69
4.6	Tools for Evaluation of Remedial Measures	69
5.0	RESPONSE TO PLUARG RECOMMENDATIONS	75
6.0	CONCLUSIONS	89
6.1	Programs	89
6.2	Practices	91
6.3	Issues	91
7.0	RECOMMENDATIONS	95
APPENDIX I	Detailed Description of Canadian Programs	97
APPENDIX II	Control Measures and Practices	105
APPENDIX III	Urban	115
APPENDIX IV	Supporting Documents Recommended for Additional Reading	127
MEMBERSHIP LIST		129

List of Tables and List of Figures

TITLE		PAGE	
TABLE	2.1	Governmental Functions	23
	2.2	Full& Part-time Soil and Water Conservation Districts (SWCD) Employees	25
	2.3	Programs Relating to Control of Nonpoint Pollution in the Great Lakes basin (Ontario)	35
	2.4	Landowners Participation in Subsidy and Demonstration Programs	41
	3.1	Evaluation of Technology for "Rural" Nonpoint Pollution Control	48
	3.2	Summary of Ranges of Unit Area Loads of Selected Materials by Land Use from Pilot Watershed Studies vs. U.S. National Urban Runoff Program (NURP) Data	59
FIGURE	3.1	Agricultural Control Measures and Practices	46
	3.2	Erosion Control Measures	60
	3.3	Managerial Practice for Urban Runoff Quality Control	62
	3.4	Structural Measures	62

Acknowledgement

The Nonpoint Source Control Task Force expresses its gratitude to the members of the Water Quality Programs Committee and the Water Quality Board for their continued support.

The Task Force acknowledges the valuable input received from the following consultants: Mr. Art Bos, London, Ontario, Mr. D. R. Cressman, Ecologistics Limited, Waterloo, Ontario, Mr. E. D. Driscoll, E. D. Driscoll & Associates, Oakland, New Jersey, Mr. Lance Marston, Harbridge House, Inc., Washington, D.C.

The Task Force is thankful to Ms. Pat Bonner for critical reading of the manuscript and Ms. Mary Ann Morin for typing it.

Finally, the Task Force wishes to extend its special thanks to Dr. M. H. Sadar for his valuable contribution towards the completion of this report.

Preface

As stated in Annex 3 of the Great Lakes Water Quality Agreement of 1978, the signatories were expected to confirm the future phosphorus loads to the Great Lakes within 18 months after the date of entry into force of the said Agreement. The subsequent negotiations on the addendum to Annex 3 of the Agreement remain inconclusive to date. This long delay in reaching agreement on future phosphorus loads was, until very recently, the principal reason for the lack of a major initiative to address nonpoint pollution issues by the Water Quality Board of the International Joint Commission. During its 13th meeting held at Toronto on January 27-28, 1982, the Water Quality Programs Committee of the Water Quality Board recommended that a Nonpoint Source Control Task Force be established. Consequently, the Water Quality Board set up a 14 member Task Force (seven members each from the United States and Canada) and approved the following terms of reference:

"Under the guidance of the Nonpoint Source Coordinators, the Nonpoint Source Control Task Force will assist the Water Quality Programs Committee in evaluating the progress of the jurisdictions in controlling nutrients and other pollutants from nonpoint sources to meet the terms of the Great Lakes Water Quality Agreement of 1978, with particular reference to Article VI, Section 1(e) and 1(d) concerning eutrophication.

Specific functions of the Task Force will be to:

- (A) Review the state-of-the-art concerning management of nonpoint sources and act as a communication link with the jurisdictions on nonpoint source related activities. This would require the following:
 - 1. Identify and evaluate the effectiveness of nonpoint source control programs and practices that are being conducted within the jurisdictions. This would include an assessment of their effectiveness in reducing nutrient and sediment loads, their areal extent, ease and acceptability of implementation and cost-effectiveness.
 - 2(a). Identify the areas in the Great Lakes where nonpoint sources contribute a significant portion of nutrients causing problems.
 - 2(b). Identify the watersheds or the portions thereof contributing to these areas.
 - 2(c) Review and identify criteria for determining priority management areas within the watershed where the implementation of remedial measures will provide the greatest benefit versus costs.

3. Identify and prioritize matters that need to be addressed in order to improve nonpoint source management, including:
 - (a) review information regarding bioavailability;
 - (b) review tributary monitoring;
 - (c) review watershed modelling, sediment delivery and sediment transport;
 - (d) review recent and continuing changes in agriculture that may affect nonpoint source loadings.
 4. Recommend further actions, if any, that the Water Quality Programs Committee/Water Quality Board should consider or should recommend that the Parties consider.
 5. Prepare and submit reports to the WQPC through the NPS Coordinators.
- (B) Undertake a key role in reviewing the management plans developed by the two Parties."

The Task Force held its first meeting on August 26, 1982 at the IJC Regional Office in Windsor and decided to undertake an in-depth analysis of the nonpoint pollution situation in the Great Lakes Basin. The Task Force acquired the services of four consultants for the timely completion of the following assignments:

1. Evaluation of Nonpoint Remedial Programs - Ontario
2. Evaluation of Nonpoint Remedial Programs - United States
3. Evaluation of Agricultural Nonpoint Source Technology
4. Evaluation of Urban Nonpoint Remedial Measures

The Task Force was aided by the consultants' reports and the additional material prepared by its members as listed in Appendix IV, for compiling its report to the Water Quality Board of the International Joint Commission.

Executive Summary

INTRODUCTION

Nonpoint sources of pollution within the Great Lakes basin have been recognized as a significant, in some cases, critical factor in pollutant loadings. It has become clear that achievement of the phosphorus reduction targets of the 1978 Great Lakes Water Quality Agreement is not feasible without significant reductions in nonpoint source phosphorus.

In 1972 the Pollution From Land Use Reference Group (PLUARG) of the International Joint Commission (IJC) was established for the purpose of determining the levels and causes of pollution from land use activities and recommending appropriate remedial actions. PLUARG reported its findings and recommendations to the IJC in 1978. As a result, the IJC forwarded a set of recommendations to the Parties in 1980. To date there has been no formal response from either Parties to these recommendations. Despite this lack of formal response, it is apparent that some activities related to nonpoint source pollution control have been initiated by various agencies and groups throughout the basin since PLUARG submitted its recommendations.

In 1981, the Board established a Nonpoint Source Control Task Force to review and evaluate the effectiveness of these activities in reducing nonpoint pollution during the past five years. In its report to the Water Quality Board, the Task Force has provided an overview of the post-PLUARG state-of-the-art in terms of the extent of implementation and effectiveness of various nonpoint programs in the Great Lakes basin. The report also reviews various scientific and technical issues which were identified by PLUARG and which require further investigation and the status of PLUARG's recommendations. Copies of this report are available from the IJC Great Lakes Regional Office.

The following summarizes the Nonpoint Source Control Task Force's assessment of post-PLUARG developments, and presents its recommendations for further action.

NONPOINT PROGRAMS

The Task Force found that a variety of programs have evolved since PLUARG. It also appears that the need for nonpoint source control programs has increased during the period due to intensifying use of farm land that increased soil erosion. Cash grain and monoculture farming operations have been replacing the more comprehensive operations that were the norm in the 1940's. This has been accompanied by an increasing reliance by farmers on complex technology including elaborate equipment and greatly increased use of chemicals.

In the past, environmental problem emphasis has largely been directed at point sources which were more concentrated and under individual responsibility. Program administrators have held to the belief that nonpoint sources were not controllable, or only so at large public expense and that there was not adequate legislative and regulatory basis for control. The special demonstration projects have shown many of these beliefs to be in error. It is apparent that agricultural nonpoint sources are controllable, at much less expense than anticipated. Many controls can be put in place through voluntary acceptance by farm operators. The major need is to bring these points before program administrators and legislators to secure continued state/provincial and federal support of demonstration projects and increased support for basic delivery programs at the state/provincial and local level.

CANADIAN PROGRAMS

In Canada there has been no action taken to develop a comprehensive program to address nonpoint sources of water pollution in the Great Lakes basin. There are, however, a number of programs which address some of the concerns raised by PLUARG. These programs can be subdivided into: a) short duration watershed management studies, demonstrations or data base development; b) ongoing field services; c) special interest group activities; and d) policies, legislation or guidelines.

The main increase in activity in support of the PLUARG recommendations has been through Ontario's special basin studies and one large-scale demonstration project. Most of these have been conducted on an interagency basis.

Since the beginning of 1980, the level of expenditure on basin studies has averaged about \$1.5 - 2.0 M per year. The largest projects in the Great Lakes basin have been the Thames River Implementation Committee (TRIC), Grand River Implementation Committee (GRIC), Toronto Area Watershed Management Strategy (TAWMS), Lake Simcoe Environmental Management Project (LSEMP), and Stratford/Avon Region Environmental Management Project (SAREMP). The prime focus of most of these projects has been the improvement of in-stream water quality; little recognition has been given to the Great Lakes water quality. The Thames and the Grand River watersheds together account for over half the area of the Canadian portion of the Lake Erie basin. Most of these basin management studies address both rural and urban nonpoint sources. In the case of TAWMS, there is a decided urban emphasis. The recent occurrence of elevated nearshore bacteria levels has resulted in more resources being committed to this study. The early initiatives taken in these studies will provide a useful base for an expanded non-point program.

To date, the Thames River Implementation Committee (TRIC) program has been one of the most successful in Ontario. It addressed the issue of diffuse source pollution and encouraged better land use practices through public education and demonstration projects. As a result of the program, more farmers have begun using soil conservation practices. Most importantly, this short-term program has been converted to an ongoing program of diffuse source control by the Upper Thames Valley Conservation Authority. As well, this Authority has tripled landowner participation in its Conservation Services Program in the last three years. Emphasis is on field erosion control and the program is actively advertised and promoted in the priority management areas identified as part of the overall study.

Although TRIC is the only agricultural watershed study that has evolved into an active implementation program, several other basin studies have the potential to follow its example. SAREMP, LSEMP and South Nation River Basin Development Study (SNRBDS) are in the various stages of identifying problems, and remedial measures. The five-year GRIC study has produced some excellent background research and computer models. Priority management areas are now being defined and remedial measures are being evaluated in sub-watersheds.

To date the most important nonpoint pollution abatement efforts are confined to local and provincial levels of government. The federal government has restricted its efforts to research related to management of the overall eutrophication issue including nonpoint problems. Involvement in the nonpoint areas has focussed on plot scale evaluation of tillage practices and the development of a methodological framework for identifying priority management areas.

In addition, a joint federal/provincial research program is ongoing with studies concentrated in the identification and quantification of hazardous substances in urban runoff. Studies are also carried out aimed at strengthening the control mechanisms of pollutants entering the municipal sewer systems.

In Ontario, the field services program has primarily been directed towards sustaining crop productivity by controlling soil erosion. Recently, there has been some increase in the fiscal resources available to cost-share structural methods of soil erosion control and for manure storage (SCEPAP). While the program provides funding for engineering design of erosion and sediment control structures, there is no provision for similar expertise to deal with sheet and rill erosion problems. Technical assistance to farmers, of the type available to American farmers through the county staff of the Soil Conservation Service, does not exist. There is only a handful of qualified extension specialist in the Ontario Ministry of Agriculture and Food (OMAF) to handle erosion related concerns in the 39 counties in the basin.

The Ontario Ministry of Natural Resources (OMNR) through its watershed based conservation authorities also contributes resources to erosion control. Most of these resources are directed towards streambank erosion and tree planting which have minor benefits to water quality.

Except for a gradual increase in expenditure by conservation authorities and an increase in grant funds under the SCEPAP or OMAF, the level of effort by the provincial government in direct services to farm operators in the area of soils and crops has remained relatively stable since PLUARG.

Despite the existence of the comprehensive watershed studies and the field services program, the number of landowners participating in conservation programs has been quite low as presented in the following table. Interest amongst farmers remains high. What is needed now is a long-term comprehensive program with sufficient funding to allow for attainment of program objectives.

Landowners Participation in Subsidy and Demonstration Programs

PROGRAMS	Approximate No. Of Participating Landowners In 1982
Soil Conservation and Environmental Protection Assistance Program (OMAF)	140
"erosion"	140
"manure storage"	630
Conservation Services (Conservation Authorities)	815
Thames River Implementation Committee	<u>115</u>
	<u>1,700</u>

Program activity in both the Canadian and the United States portion of the basin has focussed mainly on agricultural soil conservation with control of pollution as a secondary benefit and, in particular, those related to crop production. In comparison, there are fewer program activities that relate to nonpoint source pollution from urban areas because of the relatively minor loadings from those sources identified.

In Ontario, special interest groups such as the Soil Conservation Society of America (Ontario Chapter), Soil and Crop Improvement Assoc., Canadian Federation of Agriculture, Municipal Engineers Assoc., etc. continue the important process of increasing urban and rural landowner's understanding of nonpoint pollution. Most significantly, the farmers are now playing a major role in pressing the government to develop appropriate programs and policies.

In terms of the effectiveness of programs in dealing with loadings of nonpoint source problem parameters to the Great Lakes, there is little evidence of success. Most programs do not have a monitoring component for assessing results. However, given the very low level of program effort to date and the limited adoption of best management practices by most basin farmers and municipalities, significant progress cannot be anticipated.

In the policy area the provincial government is developing urban stormwater management policies which, if implemented, will provide a focus for stormwater management as well as erosion and sediment control. Implementation of the policy will facilitate integration of urban runoff quality and quantity controls where necessary. An Erosion and Sedimentation Co-ordination Committee representing five provincial ministries is also developing a set of recommendations to the Cabinet Committee on Resource Development for an erosion control strategy for the province.

Analysis of existing relevant programs has shown a number of key weaknesses which must be rectified if improvements to Great Lakes water quality are to be realized. A lack of Great Lakes specific loading objectives, inadequate funding and staff, inconsistent planning procedures and lack of program evaluation are among the main shortcomings. In Canada, the necessary program components exist to implement a nonpoint program. What is clearly needed is an assignment of lead responsibility amongst the many agencies and jurisdictions involved, the provision of long-term funding support and the development of a comprehensive plan.

UNITED STATES PROGRAMS

In the United States, there is no comprehensive program for the control of nonpoint sources of pollution. There are, however, large scale soil conservation programs but they are not primarily focussed upon water quality. Some shifts in emphasis within the program have been made to address areas of high erosion rates. Water quality benefits have been discussed but such benefits have been given relatively low priority. Four federal programs have directly addressed nonpoint source control. The Lake Erie Wastewater Management Study (5M), the Great Lakes Demonstration Grant Program, (20M), the nation wide Rural Clean Water Program, (70M) and the nation wide Water Quality Management Program (400M) which included the National Urban Runoff Program.

During the past two fiscal years there has been no new congressional funding for these water quality programs except for one half million per year in the Demonstration Program. The Lake Erie Wastewater Management Study (LEWMS) concluded that federal funding should be provided to support a major nonpoint source program in the Lake Erie basin, but there has been no government response to date. Resources for USDA soil conservation programs within the Great Lakes basin have been declining over the past several years due to budget reduction and inflation. Approximately 10M per year in soil conservation cost-sharing funds are expended within the basin.

In the United States, there is a well established federal structure for the delivery of technical and financial assistance to the agricultural segment of society. A long history of co-operation by the federal agricultural agencies working at the county level with state and local groups has assisted greatly in implementing the projects. The federal programs most often mentioned were the cost-sharing programs of the Agricultural Stabilization and Conservation Service (ASCS), technical assistance from the Soil Conservation Service (SCS), and the information and educational activities of the Co-operative Extension Service (CES). The physical presence of employees of these agencies at the local level and their credibility as knowledgeable of local problems and solutions is a positive aspect.

Both ASCS and SCS are making program adjustments to focus existing resources to solve identified natural resource problems. The SCS is targeting a percentage of their budget to high erosion areas and a portion of this money can be used for water quality problem areas. However, none of the high erosion areas initially identified by SCS were in the Great Lakes basin. Targeting within USDA programs to date appears to be shifting resources to erosion problems but not necessarily to water quality problems. However, two of the Rural Clean Water Program (RCWP) projects are in the basin. Targeting of resources speeds changes in priorities and can move needed resources to key problem areas. But it must also be recognized that this results in resources being

removed from existing programs. In addition to geographic shifts, a significant change has taken place in the practices supported away from production related practices toward resource protection. For example, this has resulted in a shift from tile drainage support in 1978 to conservation tillage support in 1982. In contrast, the Co-operative Extension Service, as an agency, appears to have made relatively little change in their priorities.

The gradual shift from structural to management practices has increased the need for timely input of management advice since the increased interest in reduced tillage requires close co-operation and counsel with new users because of weed and insect problems. This has been emphasized by the results of the USDA demonstration projects, all of which have cited the need for strong information and education programs.

Directly addressing water quality, the U.S. EPA Water Quality Management Program supplied monitoring, evaluation and planning using funds appropriated from 1973 to 1981 through grants to states and regional agencies. It helped to provide a technical base of water quality information, helped to increase public and political awareness of nonpoint source issues and has been given credit for influencing the enactment of nonpoint abatement programs in Wisconsin, Minnesota, and Ohio. Although Section 208 has not been funded during the present fiscal year, water quality management activities are being supported at a reduced level through federal grants to the states under Sections 205 and 106.

In addition to the basic USDA agricultural conservation programs, a series of special demonstration projects have been created using resources from the basic programs and the Rural Clean Water Program to stimulate adoption of farming practices that are beneficial to water quality. The projects have been supported by the Rural Clean Water Program, the Special Agricultural Conservation Program and the Model Implementation Program.

For the specific purpose of addressing water quality impacts of nonpoint source control, a series of demonstration and special programs have taken place in the Great Lakes basin over the past several years. These include the Great Lakes Demonstration Grant projects funded under Sections 108(a) and 104 of the Clean Water Act such as Black Creek, Indiana; Washington County in southeastern Wisconsin; the Red Clay project in northern Wisconsin and Minnesota; Tuscola County on Saginaw Bay in Michigan, and multi-county projects in northwestern Ohio. The largest single Great Lakes project is the Lake Erie Wastewater Management Study under Sections 108(d) and (e) of the Clean Water Act.

All of these projects have made extensive use of USDA field staff. These efforts led directly to the present three year tri-state accelerated conservation tillage projects underway in 31 counties, and indirectly to the Wisconsin Fund program for support of nonpoint source control. The Wisconsin program includes an urban element to deal with construction erosion, septic field failures, and urban runoff. The program is also supporting the development of priority watershed plans for implementation using state funding.

The current interest in reduced tillage in the basin and throughout the United States has resulted in the establishment of a Conservation Tillage Information Center at Ft. Wayne, Indiana. The Center has as its mission the collection and dissemination of information on alternative tillage methods, farmer experiences and acreage under various types of tillage.

The various demonstration projects have not only documented the water quality impacts of various practices, but have provided valuable lessons in obtaining implementation. They have shown that local units of government, when provided clear objectives, funds and expertise can very effectively achieve implementation because of several strengths. A local focus provides credibility, a central point for communication and co-ordination, a sense of local pride and heightened awareness of water quality and stimulates local resources and energies. In short, federal and state programs become more effective than the sum of their parts because of integration and stimulation through local effort. Another vital component of the demonstration programs was the provision of on-site technical assistance to the farmer on his own land.

At the project level, these projects have developed a common desire by agencies to work together to solve a defined problem, although many of the projects mentioned initial delays until a consensus developed on the problem to be addressed and the method of solving it. Most of the projects were for relatively short times. Final reports from the projects were in agreement that all the participants were enthusiastic and wished to continue. This confirms the PLUARG recommendation for project activity as a method of focussing attention and resources to an identified problem.

There is also general agreement that only critical areas need to be addressed. These critical areas and sources are not uniformly distributed on the landscape. This understanding has evolved during the demonstration projects.

The reasons cited for problems were four: lack of clear problem definition; lack of clear identification of the critical source areas; lack of prioritization; lack of good evaluation criteria. The key to good evaluation rests with a clear definition of the target pollutant and the sources. This permits a quantifiable goal to be established that allows the evaluation to take place.

Most of the basic delivery programs upon which nonpoint source pollution control rests are continuing to lose financial support. The decline in funding for soil conservation and nonpoint sources is part of an overall decline in state and federal program support.

In the United States there is an institutional framework available around which a viable nonpoint source program could be developed. There is also the basis for creating the working tools, e.g. the Lake Erie Wastewater Management Study, the 1981 Farm Bill authorizing special area designation and existing authorities under the Clean Water Act.

Urban runoff problems in the United States are being addressed at the federal level by the Nationwide Urban Runoff Program (NURP). Urban runoff in this case does not include combined sewer overflows since they are considered to be point sources. The program was funded as a special category of the Section 208 Water Quality Management Program and is nearing completion. It is expected to provide valuable information on the effectiveness of various management practices on water quality. However, there are presently no federally funded water quality programs in the United States to share in the cost of controlling urban runoff.

AGRICULTURAL PRACTICES - CANADA/UNITED STATES

Through continued research, application and adaption, further improvements in the effectiveness of remedial practices have been made since PLUARG.

In total, 26 managerial, vegetative and structural practices have been reviewed, both in terms of changes in technology and degree of application within the Great Lakes basin since PLUARG.

Although extensive application of most individual remedial practices has not yet occurred, it is possible to identify some of the most successful practices by examining the results of various United States and Canadian watershed studies. The principle factor influencing the successful implementation of remedial practices is the attitude and acceptance of the farmer. Those practices which increase agricultural production and/or profit have been the most adopted.

Conservation tillage systems can have a major impact on Great Lakes water quality improvement with minimal effect on agricultural profitability. The real cost of long-term implementation is low but incentives are generally required in the short-term to initiate implementation to overcome resistance to change. However, because of energy savings there is often a net economic advantage from conservation tillage over conventional methods. Accordingly, conservation tillage systems have been the major focus of agricultural nonpoint source research in recent years and are gaining wide acceptance both in the United States and Canada.

The adoption of these practices, however, is an exception to the otherwise slow rate of change. However, demonstration projects in localized areas have improved the information base on implementation costs, effectiveness, benefits and rural acceptance relative to that available to PLUARG in 1978. This information has shown that generally the costs of control measures, even some of the structural types, are less than the estimates presented by PLUARG. It has also been shown that some of PLUARG's Level 2 and 3 practices may be economically feasible in cases where there are direct benefits to agriculture through a reduction in the cost of production.

Between 1966 and 1981 agricultural use of less persistent pesticides nearly tripled. The environmental impacts of the chemical usage have been localized but there is a continuing need to monitor the presence of these materials in the Great Lakes ecosystem. There remains conflicting opinion as to whether the adoption of conservation tillage will increase pesticide usage.

Implementation of nonpoint source remedial practices has not met the PLUARG recommendations, nor subsequently, the 1980 IJC recommendations. There has been no widespread attempt to broaden existing information, education and technical assistance programs to meet the needs of the Great Lakes Water Quality Agreement. Cost-effective practices such as fertilizer, pesticide and tillage management should be given priority for implementation.

URBAN PRACTICES - CANADA/UNITED STATES*

On a lake-wide basis, pollution from urban surface runoff is generally not considered to be a significant problem; however, it may be for nearshore, embayment areas.

The U.S. EPA concentrated on the refinement of problem definitions and quality control technologies evaluation. Minor activities on policy development and technology application are carried out at the state/local level. On the Canadian side, the Provincial Government is mounting a major effort in the development of urban drainage policies and an implementation strategy. As part of this activity technical guidelines have been prepared detailing drainage design practices, erosion and sediment control measures as well as procedures for formulation of cost-effective pollution control strategy when dealing with multiple point and nonpoint sources. The implementation facilitates integration of quality and quantity controls where necessary to maximize benefits, and will co-ordinate agencies and municipal activities in this area. In addition, some federal-provincial research and technology evaluation is ongoing to further define pollutant loadings from urban runoff, with particular emphasis on hazardous contaminants. Several watershed management studies are carried out to formulate cost-effective solutions to address site-specific water quality problems with some components of technology evaluation and demonstration.

Since PLUARG, a number of new methodologies have been developed and others have been updated to provide for better planning and evaluation of urban nonpoint source controls. These planning and evaluation methodologies are mainly computer models.

Improvements, principally by Canadian users, have been made in several models for use in evaluating the performance of control devices and addressing the quantity aspects of urban runoff for both the detailed design and planning. Examples include OTTSWMM and OTTHYMO developed at the University of Ottawa.

The Nationwide Urban Runoff Program of EPA has also provided planning level models. One of these addresses receiving water impacts resulting from intermittent, variable storm runoff pollutant loads. The other estimates the long-term average performance of recharge of sedimentation retention basins.

* Urban runoffs as described in this report do not include overflows from combined storm and sanitary sewer systems.

Remedial measures have also received further study. Among those which affect only the quality of urban runoff, i.e. scheduled chemical applications, catchbasin cleaning and street cleaning, only the latter has received detailed attention. In the NURP program, the effectiveness of street cleaning was found to be highly site-specific in reducing urban nonpoint source loads.

When carried out under normal manner and frequency, such practice may not be effective in the Great Lakes area.

Among those measures which affect both quantity and quality, retention basins have received most of the attention and have been studied both in Canada and the United States. Retention and recharge basins operating when properly designed for quality control, have shown to be capable of significant reductions in pollutant loads.

ISSUES

1. Priority Management Areas

Only a small number of nonpoint programs have been targeted to those areas of the landscape which contribute a disproportionately large share of the total pollution load. With a continued scarcity of resources, it will be necessary for governments to identify their priority management areas and target their resource expenditures accordingly.

2. Transport and Transformations

Assessment of priorities for implementing point and nonpoint source management practices must consider the issues of phosphorus and sediment transport through streams and their subsequent delivery to the Great Lakes.

3. Phosphorus Bioavailability

Phosphorus from nonpoint sources is not as bioavailable as that from point sources. However, both must be addressed in establishing cost-effective remedial strategies and making management decisions.

4. Pesticides

The use of toxic chemicals for pest control purposes have increased substantially in the Great Lakes basin over the last decade. Although the governments have either banned and/or severely restricted the use of persistent organochlorines, their replacements, and especially herbicides, are being used with greater frequency and in greater quantities.

Pesticide levels in some tributaries of the Great Lakes, especially those situated in close proximity to the areas of application, are of special concern. Another matter of even greater concern is the contamination of groundwater resources by the numerous chemicals used generously for pest and weed control purposes.

5. Wind Erosion

Wind erosion of soils in the Great Lakes basin is seen as a factor affecting lake loadings of sediment and phosphorus. Fortunately, some of the remedial measures designed to reduce soil erosion by water are effective in dealing with erosion caused by wind.

6. Evaluation of Program Effectiveness

Since PLUARG there have been changes in the monitoring of Great Lakes tributaries in order to provide more accurate assessments of total pollutant loadings. These changes include a greater emphasis on sampling toxic contaminants and runoff events which transport a disproportionate share of the total nonpoint load.

Long-term tributary monitoring is extremely important in order to provide the necessary data to calibrate watershed models and to evaluate the long-term effectiveness of programs. Over the short-term even well designed tributary monitoring programs will not be sufficiently sensitive to detect the initial changes in pollutant loads.

Measurement of changes in management practices and their location on the landscape will have to be monitored to determine progress in the short-term and explain long-term changes in tributary loads.

The Great Lakes Overview Model, developed under PLUARG, was the first attempt to estimate phosphorus loading reductions which could be achieved under different remedial measures strategies. Today a number of more refined approaches to watershed modelling are available and should be actively pursued in order to provide a basis for assessing expected reductions in nonpoint pollutant loads.

CONCLUSIONS

The Task Force finds that cost-effective management practices and implementation programs are generally available and have been demonstrated in the Great Lakes basin. Sufficient technical knowledge exists to support implementation of programs to reduce nonpoint sources of pollution to the Great Lakes. As called for by PLUARG, there is a continued need for the development of a comprehensive management strategy to control pollution from land runoffs in the Great Lakes basin.

As a result of an extensive review of programs, practices and issues surrounding the management of nonpoint sources of water pollution, the Nonpoint Source Control Task Force concludes that the basic recommendations developed by the PLUARG and presented in its July 1978 final report remain valid. The Nonpoint Source Control Task Force is concerned that with the exception of surveillance, the governments have not formally responded to the PLUARG recommendations. There have been, however, a number of local initiatives directed towards reducing erosion and sedimentation and addressing site-specific water quality problems. It is doubtful if these efforts will become part of a cohesive and coordinated program to deal with nonpoint loadings to the Great Lakes until the Parties fulfill their commitments under Annex III of the Great Lakes Water Quality Agreement of 1978.

In developing the co-ordinated programs, it is important to take into account that pollutant loadings from urban runoff generally do not constitute a significant problem on a lakewide basis.

Programs

1. Improving Great Lakes water quality has not been a specific objective of many of the existing nonpoint programs in Canada and the United States. Agricultural programs are primarily directed towards the prevention of soil erosion and their main objective is to preserve topsoil and maintain or improve agricultural production. Urban stormwater management has been primarily directed towards flow quantity control. Although pollution control has not been maximized, this has not hampered the success of individual projects. However, the lack of a comprehensive overall management strategy, including a method for evaluating program success, has made it difficult to assess their cost-effectiveness in meeting Great Lakes water quality objectives.
2. Successful nonpoint source projects have required multi-agency involvement at the earliest stages of planning through to implementation and evaluation. The most successful programs have established a formal framework for involvement and a clearly defined lead agency. Programs which have ignored these concepts have not had widespread success. Adoption of the lead agency concept has improved overall accountability for program design and achievements and assisted in bringing together divergent viewpoints in a constructive manner.
3. Demonstration projects conducted in specific geographic areas have been highly successful in achieving local implementation and in quantifying reductions in sediment and phosphorus losses. Factors which have lead to project success include:
 - Providing a focus which enrolls local support through a sense of responsibility, provides credibility, enhances communication, builds local leadership and generally creates vitality.
 - Providing a point of focus for federal and state/provincial programs which when integrated around specific objectives can produce results exceeding the sum of individual agency efforts.
 - Setting specific objectives which are understood and supported by the project personnel and the affected communities.
 - Providing equipment for experimental use on the farmer's own land and actual experience with the management practice on a small scale together with providing direct hands-on, in-the-field technical assistance to assure understanding and acceptance by the farmer.
 - Providing demonstration sites throughout the project area so that many owners see the practice being used by people they know, on familiar land.

4. The success of some local/regional government agencies in taking the initiative after PLUARG is admirable, but the area effected has been small.
5. Extensive background data bases exist in the PLUARG pilot watersheds, the western Lake Erie watersheds, and a few other locations. Such watersheds provide an opportune area for the priority implementation of remedial measures to assess and demonstrate their overall effectiveness.
6. United States baseline (long-term) soil conservation programs are operating with diminishing resources and lack of a clear priority focus on water quality or benefits to the Great Lakes. Decreased resources also reduce the support that the baseline programs can give to special projects.
7. In the United States, the policy of shifting responsibility from federal to state levels has, with few exceptions, not resulted in increased state resources.
8. Loadings of phosphorus from urban stormwater runoff are relatively small compared to other sources. Therefore, no remedial programs are necessary, nor is such a program cost-effective on a basin-wide basis to control phosphorus and other pollutants from urban nonpoint source runoff. Loadings of heavy metals (e.g. lead and zinc) may represent an important source of pollutants in some harbours, estuaries and nearshore areas and thus further assessment is needed.
9. Inclusion of water quality concerns in urban stormwater management and erosion control at local, regional and provincial/state levels for developing areas are effective means of reducing sediment and phosphorus loadings.

Practices

1. Although the Parties have failed to address nonpoint source problems to the extent and in the manner recommended by PLUARG, significant progress has been made in developing cost-effective practices for reducing soil erosion and limited but important progress has also been made in implementation.
2. Several approaches, particularly those tillage practices leaving crop residues on or near the soil surface, have been demonstrated to be more cost-effective than reported by PLUARG. In many cases greater profit is achieved using these measures as compared to conventional tillage practices.
3. The level of interest in alternative tillage practices is growing in both the United States and Canada. Voluntary adoption of reduced tillage practices is increasing in both countries.

4. Final determination of the most cost-effective remedial measure options will depend on site characteristics, marketing options and relative net economic returns to the farm operation. Thus a remedial measure program will involve consideration of a variety of practices tailored to the individual needs of each farm operation.
5. The most cost-effective way to deal with urban drainage problems, in terms of both quality and quantity, is through adoption of land use, master drainage and stormwater management planning. At the master drainage planning stage of a land development, water quality concerns can be addressed together with quantity problems. If quality control is necessary, suitable designs and practices can be incorporated into the stormwater management plans to integrate both quantity and quality control thus minimizing costs and maximizing benefits (e.g. modifications to the design of stormwater detention/retention facilities to accommodate quality control as well.)
6. Erosion control can be cost-effective in providing water quality benefits, particularly during the land disturbing stage of development.

RECOMMENDATIONS

The Nonpoint Source Control Task Force recommends that:

1. The International Joint Commission renew its request to immediately ask the Governments to implement the PLUARG recommendations and to complete their negotiations on Annex 3. Further, agencies and governments should develop and implement policies and funding mechanisms in support of an accelerated nonpoint program e.g. Ontario's Urban Drainage Policy and Guidelines and funding for the 10-year accelerated conservation tillage program identified in the LEWMS 1982. The Commission is also asked to act independently to plan and fund a greater effort to make governmental agencies and the public aware of the PLUARG recommendations and their individual responsibility in the management of the Great Lakes ecosystem.
2. That the Governments provide sufficient time and resources to ensure that programs have clearly defined goals and objectives, assess the nature and extent of the problem, prioritize problem areas, provide for demonstration, identify the most cost-effective remedial measures, provide technical assistance and adequate resources and provide for ongoing monitoring and evaluation.
3. That areas within watersheds which have a higher potential to deliver pollutants be identified and that implementation of measures in these areas receive priority attention.
4. That an effective information and education effort to create a better awareness of remedial measures and their benefits and provision of adequate technical assistance be a part of any implementation effort. This will ensure timely adoption and the long-term success of the program.

5. That implementation of remedial practices be, at least in part, focussed on a demonstration watershed approach (e.g. PLUARG pilot watersheds and western Lake Erie tributaries) which will provide a basis for adequate monitoring and evaluation of program success.
6. That overall effectiveness of nonpoint source control programs in attaining phosphorus target loads be evaluated through simulation modelling, surveys of the extent of implementation of agricultural practices and tributary monitoring.
7. That developing urban areas be guided by a master drainage plan and stormwater management plans which make integration of quality as well as quantity controls possible at the design stage of proposed urban drainage systems to maximize benefits. Urban erosion and sediment control programs should be implemented at the time of land disturbance.
8. That studies of urban harbor, estuary and other nearshore problem areas include analysis of urban runoff to determine whether it contributes significant loadings of problem pollutants.
9. That monitoring of surface and groundwater for pesticide residues and their metabolites be expanded in those areas of the basin where pesticides use is most intense.
10. That there be greater emphasis on event sampling of tributaries with follow up interpretation in order to provide the International Joint Commission and the Parties with an up-to-date assessment of nonpoint loadings.
11. That studies be initiated and/or expanded pertaining to nonpoint issues and especially those identified in this report.

1. Introduction

This report reviews the present state of programs and means of controlling nonpoint sources of pollutants in the Great Lakes Basin within the United States and Canada. It has been prepared in response to the Terms of Reference (see Preface) adopted by the Water Quality Board based upon Article IV, Sections (d) and (e) of the 1978 Great Lakes Water Quality Agreement between the United States and Canada. The report focusses on the changes that have taken place since completion of the Pollution From Land Use Activities Reference Group (PLUARG) report in 1978. Although the Task Force attempted to address the full range of pollutants throughout the Great Lakes Ecosystem, it found that most new information relates to programs and practices affecting sediment and phosphorus loading from agricultural sources.

The Task Force concentrated on loadings from land runoff and only briefly examined airborne pollutants. Nonpoint sources from airborne deposition provide widely varying proportions of contaminants and the air source is particularly significant for some parameters, such as lead and PCBs. Specific practices to reduce airborne deposition were not examined, but it is likely that many practices designed to control erosion from rainfall will reduce wind erosion as well.

Reduction of nonpoint sources must be achieved if the phosphorus target loads for Lake Erie, Lake Ontario and Saginaw Bay are to be met. Even with total elimination of phosphorus from point sources the target load reductions established will not be met without reductions in nonpoint sources.

PLUARG was a major international co-operative effort undertaken from 1972 to 1978, charged with conducting an intensive investigation into the pollution of the Great Lakes System from land use activities. The resulting studies provided the most exhaustive review conducted up to that time, and thus remain the most definitive data base and reference source for many aspects of nonpoint source pollution in the Great Lakes. The PLUARG final report contained a comprehensive set of recommendations which, if implemented, would considerably curtail nonpoint sources of pollution.

However, despite the magnitude of the published scientific output and the submission of a management-oriented report in 1978, the United States and Canadian Governments have not yet responded formally to the PLUARG recommendations.

The 1978 United States/Canada Great Lakes Water Quality Agreement refers to PLUARG in Annex 3 where it calls upon the Parties, in co-operation with the state and provincial governments, to establish load allocations and compliance schedules for phosphorus "taking into account the recommendations of the IJC arising from the Pollution from Land Use Reference." One of the purposes of this report is to review these recommendations in light of the findings of a large

number of demonstration projects and additional research which has been undertaken since PLUARG submitted its report.

PLUARG was the first of three steps sponsored by the IJC focussed on the extent and character of the nonpoint source problem and the opportunities for abatement. The second step was formation of the Phosphorus Management Strategies Task Force (PMSTF) which was charged with responding to several issues perceived as barriers to adequately addressing phosphorus management and seen by some as a reason to delay revision of Annex 3. The issues included:

- confirmation of the existing phosphorus loads to each lake;
- confirmation of the phosphorus target loads;
- the question of phosphorus bioavailability;
- costs and technologies for phosphorus control.

While unable to present definitive answers in each case, the PMSTF was able to characterize the level of uncertainty surrounding such contentious issues as the phosphorus target loadings. It proposed a staged approach to further phosphorus management in the Great Lakes Basin, stressing that low cost measures should be implemented immediately. Adoption of this approach was seen as minimizing the social cost of policy error and providing ample opportunity for the inclusion of new information as it became available.

The present Nonpoint Source Control Task Force is the third step taken by the IJC toward the goal of effective control of phosphorus and resulting eutrophication. It is now obvious that the Parties have the necessary information and tools to address the problem, including the fact that low cost measures are effective and available. It is the firm conviction of the Task Force that there is no legitimate reason for further delay in modifying Annex 3 and proceeding to achieve the necessary load reductions.

The Task Force observed the success of programs for control of point sources and reviewed the similarities and differences between point source and nonpoint source programs.

Point source control programs have benefitted from:

- (i) available institutional structures through which remedial measures could be implemented;
- (ii) established funding arrangements;
- (iii) minimal social inconvenience except indirectly through taxation;
- (iv) available, easily understood and proven technology to affect change; and
- (v) widespread public awareness of point source pollutants causing water quality problems.

Implementation of nonpoint source programs, on the other hand, faces the following difficulties:

- (i) lack of a clearly defined institutional structure, overlapping institutional responsibilities and jurisdictional rivalries;
- (ii) almost total lack of funding arrangements, especially in the area of non-structural remedial measures which do not require large capital outlays;
- (iii) reliance upon voluntary adoption of new measures and practices by the rural farm population, traditionally characterized by individuality and conservative response;
- (iv) technologies which, in many cases, are not well demonstrated either for ease and cost of implementation or effectiveness in dealing with identified problems; and
- (v) lack of public awareness and difficulty of showing the relationship between water quality problems and nonpoint sources which are diffuse and periodic in nature.
- (vi) lack of a clearly defined source which can be treated and upon which an agreed to effluent limitation or standard can be applied.

The physically and institutionally diffuse and complex nature of the nonpoint source problem shows a need for a systematic approach on a wide scale. This need for a broad perspective leads very logically to an ecosystem approach for addressing nonpoint sources. This approach is in many respects reflected in the PLUARG report "Environmental Management Strategy for the Great Lakes Basin". In the past, in the absence of a systems approach, the design of pollution control programs has been approached through overly simplified cost accounting. PLUARG itself was seriously hampered by this tradition and in its final report provided crude estimates of the costs of further phosphorus reductions without being able to provide data on related benefits. These early estimates, based on very limited empirical data, exaggerated the costs of implementation and did not adequately reflect the associated non-water quality benefits.

The importance of recognizing the interconnected nature of actions in the Great Lakes ecosystem is illustrated by events since the completion of PLUARG. Many of the subsequent initiatives to reduce nonpoint pollution loads to the lakes have been successful in gaining voluntary adoption of measures benefitting water quality, in large part due to non-water quality benefits associated with the measures. It is also true that the practices themselves must be carefully examined to determine secondary ecosystem impacts and the existence of other related problems in order to comprehend the larger picture.

The Task Force concludes that sufficient information exists about the costs, benefits and interrelationships of nonpoint source control measures to support initiatives that will begin to solve the problems caused by nonpoint sources. The solutions only await the attention and action of the Parties and their jurisdictions.

2. Post-Pluarg Overview of Great Lakes Basin Nonpoint Remedial Program

This chapter addresses the present status of nonpoint source programs with emphasis on changes that have taken place since completion of the PLUARG studies. To accomplish this, independent consultants were retained to assemble information and provide reports to the Task Force for their information.

Programs in the United States and Canadian portions of the Great Lakes Basin must address similar agronomic and climatic conditions. However, the programs exist within range of substantially different institutional frameworks. In the United States, the Federal Government plays a relatively strong and direct role, particularly in agricultural programs where locally based Federal employees provide much technical assistance to farmers while maintaining various formal and informal working relationships with State and local officials. In Canada, the province provides the lead for technical assistance although there are a number of successful co-operative efforts involving both federal and provincial agencies.

The Task Force found that a variety of programs have evolved since PLUARG. It also appears that the need for nonpoint source control programs has increased during the period due to intensifying use of rural land. Cash grain and monoculture farming operations continue to replace the more comprehensive operations that were the norm prior to the 1940's. This has been accompanied by an increasing reliance by farmers on complex technology including elaborate equipment and greatly increased use of agricultural chemicals; e.g. herbicides.

In examining nonpoint source control programs, the Task Force found it useful to distinguish between longstanding baseline programs and special projects. Data on program characteristics were collected by the Task Force consultants through use of personal/telephone interviews and the literature.

Both countries have Extension personnel who provide information and educational information to individual landowners. The United States has a longstanding effort by the Federal Government in the area of soil and water conservation. This is supported by special purpose conservation districts in each county as a unit of State Government. The United States also has had a cost-sharing program for conservation practices which is funded by the Federal Government but delivered and managed at the county level.

In Canada, soil conservation programs which declined from a peak during the 1950's are now enjoying a resurgence in support due to both a demonstrated impact on agricultural production and water quality. This has resulted in the development of new cost-sharing programs by agricultural agencies to encourage widespread implementation of soil conservation programs. Soil and water conservation efforts in Canada have also been focussed through the 36 Conservation

Authorities covering the southern half of the province. These agencies are organized on a watershed basis which enables them to link soil and water problems within a logical and consistent framework. Programs implemented within these authorities are highly responsive to local priorities.

With respect to urban areas, in Canada, the province and local/regional level governments play a major role in land use planning and urban development while in the United States nearly all regulatory authority over land use is given to local governments. There is a complex network of institutions and programs which affect nonpoint source pollution, particularly in the case of agriculture. Table 2.1 provides a simplified picture of some of the main points of interest.

2.1 U.S. PROGRAMS

2.1.1 Post-PLUARG Program Activity

A major difference between the United States and Canada is in the existing Federal structure for the delivery of technical and financial assistance to the agricultural segment of society. Many of the respondents to the survey made in the preparation of this report noted that the existence of a "base" program in the United States was a definite advantage. The final reports for many of the demonstration projects, both in and out of the Basin, noted that the long history of cooperation by the Federal agricultural agencies working at the county level with state and local groups assisted greatly in implementing the projects.

Base Programs

The Federal programs most often mentioned were the cost-sharing programs of the Agricultural Stabilization and Conservation Service (ASCS), technical assistance from the Soil Conservation Service (SCS), and the information and educational activities of the Co-operative Extension Service (CES). The loan program of the Farmers Home Administration (FmHA) was less frequently mentioned. The physical presence of employees of these agencies at the local level and their credibility as knowledgeable of local problems and solutions is a positive aspect.

The assistance provided by Federal agricultural agencies to the "base" level programs in each state has been a slow but steady decline. This is the result of inflation and actual declines in budgets. For example, the conservation operations staff years for SCS in Ohio declined from 204 in 1978 to 181 in 1982. Cost-share funds available from ASCS in the Basin were about \$10 million in 1980 and \$11 million in 1981. However, this is somewhat misleading since it includes funds allotted to special projects. The cost-share funds available in Ohio from ASCS from 1980 were \$4.486 million and dropped to \$3.928 million in 1983. These figures include special project funds. Counties without special projects had a reduction. The overall reduction in Ohio since 1960 has been close to \$2 million per year.

TABLE 2.1. Governmental Functions

FUNCTION	FEDERAL		STATES*	PROVINCE	LOCAL**
	U.S.	CA.	U.S.	CA.	U.S.& CA.
Research	High	High	Low	-	-
Technical Assistance					
Crops	High	High	Medium	Low	***
Pests	High	High	Medium	Low	***
Fertilization	High	High	Medium	High	***
Soil Conservation	High	Low	Low to Med.	Low	***
Education and Information	High	Med.	Low	Medium	***
Grant/Loan Funds	High	Low	Low	Medium	***
URBAN					
Research	Med.	Low	Low	Low	-
Technical Assistance	Low	-	Medium	Medium	Low
Education and Information	Low	-	Medium	Medium	Low
Grant Funds	Low	Med.	Low	Low	-

Key: High, Medium or Low refers to a highly subjective assessment of the extent of activity.
A dash indicates virtually no activity.

* All states participate in the co-operative Extension program which provides one or more agents per county to provide information and education. Some states, such as Ohio, also have state employees who work full time in soil conservation programs.

** Including conservation authorities in Canada and soil and water conservation districts in the United States.

*** Local assistance is provided by county and university based federal employees, in some cases answering to locally elected soil and water conservation district boards. Some districts also have their own employees who provide technical assistance to farmers.

Both ASCS and SCS are making major program adjustments to focus existing resources to solve identified natural resource problems. The SCS is targeting a percentage of their budget to high erosion areas and a portion of this money can be used for water quality problem areas. However, none of the high erosion areas initially identified by SCS were in the Great Lakes Basin. Targeting of resources speeds changes in priorities and can move needed resources to key problem areas, but it must be recognized that resources are being removed from existing programs. The cost-share program of ASCS has remained at about the same level from a dollar standpoint. There was a decline of 19 percent in the "regular" cost-share dollars in Ohio during the last five years.

Targeting within USDA programs to date appears to be shifting resources to erosion problems but not necessarily to water quality problems. In addition to geographic shifts a significant shift has taken place in the practices supported. A Federal shift in priorities away from production related practices toward resource protection has resulted in a shift from tile drainage support in 1978 to conservation tillage support in 1982. For example, sod waterways, permanent vegetative cover and conservation tillage received over half of the 1982 cost-share funds from ASCS in Ohio.

Program adjustments by Federal agencies are slow to take place, in part because major policy changes often occur through incorporation in the budgeting process and the Federal budgeting process operates over a two-three year period. This slowness to adjust has positive and negative effects. Federal policy for the past four-six years has been towards reduced funding, deregulation, and decentralization. This effort has been strongly advocated in the past several years. The overall result to date has been a decline in actual support for the Federal agricultural agencies but with a stronger focus in problem solving. In spite of the slow rate of change, significant shifts have taken place within agricultural programs, particularly those of the Soil Conservation Service and the Agricultural Stabilization and Conservation Service.

The Extension Service has made few shifts in their priorities. This may be partly because federal funds support only a share of the employees' time at the local level, giving the Federal Extension managers only limited control over policy and field staff. Federal policy shifts can have an effect, but not as directly as with the other Federal agricultural agencies. Also, since Federal funding is declining, the local share represents an increasing percentage of program support. The economic situation of agriculture in recent years has made it difficult for the Extension Service to shift from production type programs toward conservation when increasing percentages of program support comes from state and local sources.

A series of demonstration and special type projects have taken place in the Basin. These projects were generally small areas with emphasis on agricultural pollution control. The gradual shift from structural to management practices has increased the need for timely input of management advice. The increased interest in reduced tillage requires close co-operation and counsel with new users because of weed and insect problems. This has been emphasized by the results of the USDA demonstration projects, all of which have cited the need for strong information and education programs.

Just adding responsibility for new programs to existing staff is not effective since most Extension employees are fully employed with existing programs and unable to accept additional responsibilities. When new funds were provided for additional Extension employees they worked effectively, increasing the support for the projects goals. Several projects chose to hire and train their own project employees to provide this assistance. This option was also generally successful. It apparently did not make any significant difference for whom the information and education people worked as long as the employees were not burdened with other agency functions. Employment by the agricultural agency provided access to technical and administrative support, but direct hiring by the district ensured that the employee was not diverted to address other job functions.

State and local support for agricultural agencies is reflected in the support for soil and water conservation districts. The number of employees of districts has not varied significantly between 1978 and 1982 (Table 2.2). The financial support to districts indicates a moderate increase over the period. Most of this increase is coming from local county support.

TABLE 2.2. Full & Part-time SWCD Employees*

	Indiana	Michigan	New York	Ohio	Wisconsin	TOTAL
1978	94	97	143	245	130	709
1979	98	104	128	262	125	717
1980	107	107	157	257	132	757
1981	107	102	178	290	122	799
1982	117	93	153	288	116	769

* Source National Association of Conservation Districts (NACD)

The picture is relatively clear for the baseline programs. There has not been a significant increase in either funding for implementation or any overall increase in technical assistance since 1978 in the United States portion of the Great Lakes Basin with respect to the combined functions of Soil and Water Conservation District work force. Some states indicated a small increase in technical assistance, while the SCS has had a nationwide reduction of about 2,000 employees in the same period.

The funding shifts made by Federal agencies have generally been made by redirecting existing funding to support new efforts. This has reduced the funding for the existing program. This is viewed by many local agricultural groups as a net decrease for what they consider to be an already under-funded effort. The notable exception has been the experimental Rural Clean Water Program administered by ASCS which has had a funding level of \$70 million authorized in 1980 and 1981. However, it was not funded during 1982.

An important non-implementation base level program in the United States is that of the U.S. Geological Survey which maintains gauging stations on tributaries throughout the Great Lakes Basin. These provide long-term flow records and limited data on water quality.

In addition to the USDA programs and funds for implementation through grants, loans, technical assistance and information, the EPA water quality management program has supported planning, monitoring and evaluation. The program was most active in the late 1970's. It helped to provide a technical base of water quality information, helped to increase public and political awareness of nonpoint source issues and has been given credit for influencing the enactment of nonpoint abatement programs in Wisconsin, Minnesota, and Ohio. Section 208 has not been funded during the present fiscal year, but water quality management activities are being supported at a reduced level through federal grants to the states under Sections 205 and 106.

Demonstration and Special Projects

A series of demonstration and special programs have taken place in the Great Lakes Basin over the past several years. Some have been specific to the Basin and focussed on water quality impacts, usually at the applied research level. Programs limited to the basin include the Great Lakes Demonstration Grant projects funded under Sections 108(a) and 104 of the Clean Water Act. Such projects include Black Creek, Indiana; Washington County in Southeastern Wisconsin; the Red Clay project in northern Wisconsin and Minnesota; Tuscola County on Saginaw Bay in Michigan, and multi-county projects in northwestern Ohio. Specific Great Lakes programs also include the Lake Erie Wastewater Management Study under Sections 108(d) and (e) of the Clean Water Act, and to some extent the PLUARG pilot watershed studies. The projects have included the gathering of a great deal of water quality data and have supported an evolution of thought and experience leading to the selection of cost-effective low cost measures and methods of implementation within the Great Lakes Basin.

Of the programs that have evolved from this experience, two are most noteworthy: 1) The Lake Erie initiative that began with careful quantification of the water quality impacts of many different practices in Black Creek, and quantification of costs and benefits of conservation tillage by the Lake Erie Wastewater Management Study. These efforts led to the present three years tri-state accelerated conservation tillage projects underway on 31 counties; 2) the Wisconsin Fund program for support of nonpoint source control projects which evolved in large measure from the PLUARG pilot watershed study on the Menominee River and the Washington County Demonstration Project. Their program also includes an urban element to deal with construction erosion, septic field failures, and urban runoff. The State is also moving on a planned schedule of implementation of priority watersheds utilizing state funding.

In addition to the programs specific to the Great Lakes, national scale programs have supported important projects within the Basin: The Special Accelerated Conservation Program (ACP) provided funding for a project on Saginaw Bay while the Model Implementation Program (MIP) funded two projects just outside of the basin which have provided particularly useful results. The special ACP Saginaw Bay project and a MIP project near Indianapolis addressed alternative tillage

while a MIP project in upper New York provided useful information on low cost measures for managing dairy cattle wastes. The EPA Water Quality Management (WQM) program (Section 208) supported a variety of nonpoint source monitoring and evaluation projects, two of the most intensive of which were a Saginaw Bay project in support of the special ACP project and the Southeastern Wisconsin Water Quality Management Plan. The latter project provided good integration of point and nonpoint source concerns.

The Section 208 Water Quality Management planning process which was completed in the late 1970's helped to increase public and political awareness of nonpoint source issues. It has been given some credit for influencing the enactment of nonpoint abatement programs in Wisconsin, Minnesota, and Ohio.

Many state officials interviewed were not sure of the effect of the demise of planning funds through Section 208, but were anticipating maintaining a low level of effort to keep their water quality management plans current. Most states are using Section 205 and some Section 108 funds for this purpose.

The amount of new resources expended on these projects, while many millions of dollars, has been relatively small and much has been accomplished by stretching and combining existing resources.

Two experimental Rural Clean Water Program projects have been funded in the Basin. These added significant levels of financial assistance. These projects are two of 21 in the United States. They are located in Michigan and Wisconsin. Both are in their third year of operation of a projected 10-year program. Monitoring and evaluation is a work element of each project.

The various demonstration projects have not only documented the water quality impacts of various practices, but have provided valuable lessons in obtaining implementation. The projects have shown that local units of government, when provided clear objectives, funds and expertise can very effectively achieve implementation because of several strengths. A local focus provides credibility, a central point for communication and co-ordination, a sense of local pride, and stimulates local resources and energies. In short, federal and state programs become more effective than the sum of their parts because of integration and stimulation local effort. Another vital component of the demonstration programs was the provision of on site technical assistance to the farmer on his own land.

The current interest in reduced tillage in the Basin and throughout the United States has resulted in the establishment of a Conservation Tillage Information Center at Ft. Wayne, Indiana. The Center has as its mission the collection and dissemination of information on alternative tillage methods, farmer experiences and acreage under various types of tillage. The Center is a subsidiary organization of the National Association of Conservation Districts and is supported by industry and governmental agencies.

Urban runoff problems in the United States are being addressed at the federal level by the

National Urban Runoff Program (NURP). It was funded as a special category of the Section 208 Water Quality Management Program and is nearing completion. Several projects are located within the Basin, one of which is a part of an unusually comprehensive program of monitoring, evaluation and implementation at Irondequoit Bay, adjacent to Rochester, New York. The Irondequoit program includes remediation of both urban and agricultural sources and combines many federal aid programs.

Several agencies investigated the water quality impacts of nonpoint source runoff during the peak of the Section 208 WQM program. The best example is the southeastern Wisconsin Regional Planning Agency which successfully modelled nonpoint impacts in the areas streams and is continuing its involvement in current intensive studies of the Milwaukee Harbor-Estuary Area. The Wisconsin legislature has given the agency substantial authority over extension of sewer service and urban development based upon its studies and plans.

NURP is expected to provide valuable information on the effectiveness of various management practices on water quality. However, there are presently no federally funded water quality programs in the United States to share in the cost of controlling urban runoff.

2.1.2 Effectiveness in Terms of Reducing Levels of Target Parameters

The effectiveness of various management practices in controlling phosphorus has been quantified at test plot and field scale. However, it has not been possible to measure the reductions in loadings at tributary mouths resulting from implementation of nonpoint source control practices. This is not surprising since relatively little change in practices has occurred within any one watershed. However, it is questionable whether it will ever be possible to quantify a direct cause-effect relationship between tributary loads and the adoption of control practices because of the many large variables that impact tributary loads. Some of the variables are: changes in other phosphorus sources; the amount, intensity, duration and distribution of precipitation; antecedent conditions; degree of plant cover; temperature; condition of stream biota; stream flow conditions, etc. It should be possible to document change over a long time period, but for most purposes reductions are best estimated based upon plot and field scale data projected to a watershed scale with some adjustment for stream processing. Consensus recommendations from the United States projects suggest a combination of chemical, physical, and biological monitoring be done along with simulation modelling to determine project impacts.

Most of the agricultural demonstration projects addressed phosphorus removal as a function of sediment control. The mechanism of phosphorus transport adsorbed to sediment, primarily the clay fraction, has been clearly demonstrated. Phosphorus transported in this fashion is not all biologically available. Estimates of availability vary from 25-40% and availability varies from one portion of the Basin to the other. It is thought to be a function of the soil types relating to their parent material and clay content.

A significant portion of the phosphorus is also transported in the dissolved form but differs greatly among soils. The typical conservation practices that have been used in the demonstration

projects have little impact on the removal of this fraction. The control measures that have proven to be the most effective in reducing dissolved phosphorus are those management practices that incorporate phosphorus into the soil and reduce the amount of phosphorus applied to the land to the level needed for optimum crop yield.

There is sufficient data available to make some definite statements about the effectiveness of nonpoint source controls of phosphorus and to provide confidence in using them. It will be necessary to utilize the existing data on practice effectiveness and make projections on basin effectiveness in the short run. The Lake Erie Wastewater Management Study did utilize projections of the effect of reduced tillage on adapted soils in the Basin and concluded that significant phosphorus reductions to Lake Erie would result. This practice would appear to be very cost-effective in the Erie Basin. A three-year demonstration is now underway as a result of their findings. It is focussed in the western basin which indicated the greatest potential for reduction.

For urban runoff, an intensive program of monitoring of the target parameters has just been completed by the National Urban Runoff Program (NURP). Preliminary results indicated that the quantity of most of the target parameters were within the range estimated by PLUARG in 1978. The levels for total phosphorus were not as great as estimated, but it was also found that the effectiveness of many of the control practices were not as high as originally estimated.

Two control mechanisms were studied in the NURP program. The first involved detention basins, which were estimated to be 33% effective in removing event loads of total phosphorus. The second was street cleaning. Although the overall results have not been fully evaluated, the effectiveness of this mechanism is not expected to be very high.

There are good reasons to consider the use of provisions for additional design criteria for the removal of phosphorus and other parameters when constructing urban storm water disposal systems. This is particularly true when these parameters are causing in stream or nearshore impaired water. The impact of these parameters, particularly of phosphorus, is not as great as originally thought.

There appears to be little basis for costly remedial measures to control pollutants from urban runoff. However, low cost preventative measures such as good urban planning and protection of natural resources such as wetlands, and flood plains will yield water quality benefits together with flood control, recreational and aesthetic benefits. Intensive measures may be justified in local areas having specific water quality problems with eutrophication or contamination from heavy metals or other toxic substances.

2.1.3 Highlights of Successful Programs

The nonpoint source agricultural demonstrations in the Great Lakes Basin have been individually successful, but have not measurably reduced phosphorus transport to the lakes. The fact that they cover only limited areas of the total basin precluded large scale reductions, at least as of the present date.

The value of the demonstrations has been in the quantum jump in knowledge about what effective agricultural pollution control projects should consider and can accomplish. From this standpoint, all of the projects can be classed as highly successful. A notable success has been the heightened awareness of general water quality concerns by people living in the project areas. This attention focussed on the effects in local streams and rivers. The primary reason for the project may have been an effort to reduce phosphorus loads to the Great Lakes, but the effective reasons for adoption of practices were closer to the project site and more visible to the participants. For example, correction of an animal concentration where large amounts of runoff was carrying manure to the local waterways was viewed as very positive.

On a broader scale, the collective effect of the projects has been to heighten public awareness of water quality concerns and types of conservation practices which reduce sediment and phosphorus loadings. It is now generally accepted that water quality improvement in agricultural watersheds will not be as expensive as perceived by PLUARG. Federal policy shifts to emphasize water quality in the baseline programs located in the demonstration areas were very positive. The Lake Erie Wastewater Management Study was successful in this regard. The follow-up effort by the Great Lakes National Program Office, EPA, in funding the reduced tillage program in the western Lake Erie Basin built upon and expanded this awareness.

At the project level, there developed a common desire to work together to solve a defined problem, although many of the projects mentioned initial delays until a consensus developed on the problem to be addressed and the method of solving it. Most of the projects were for relatively short times. Final reports from the projects were in agreement that all the participants were enthusiastic and wished to continue. This confirms the PLUARG recommendation for project activity as a method of focussing attention and resources to an identified problem.

Successful projects also resulted in a better identification of problem areas and their treatment needs. There was also general agreement that only critical areas needed to be addressed. This understanding evolved during the projects since many began their implementation before these areas were identified, and adjustments were made during the program. It was important that projects take time in the early stages to establish clear priorities and more complete identification of critical areas.

The success of this project approach in the United States rests on one major theme: building a consensus around a shared set of objectives. The objectives of each participant may not be entirely the same, but they must be compatible. The most successful projects have resulted from the efforts of concerned individuals who found the resources to solve problems. They have not come about as the result of any one statute or appropriation.

A successful program has evolved in the western basin of Lake Erie. Present activities include very active projects in 31 counties of the tri-state area which have become known locally as Accelerated Conservation Tillage (ACT) projects. They are funded by Demonstration grants by U.S. EPA provided to county Soil and Water Conservation Districts for equipment and technical assistance. However, the funding is only a small part of the story. There is major support from the

USDA baseline programs and from the State of Ohio. There are 31 SWCD boards of directors and innumerable farmers involved. Also, the projects are based upon 10 years of experience beginning with quantifying and updating water quality and biological impacts of numerous BMPs in the EPA Black Creek project; information obtained from PLUARG; extensive demonstration of the cost-effectiveness of conservation tillage in Honey Creek as part of the U.S. COE Lake Erie Wastewater Management Study; demonstration of ridge tillage in Defiance County Ohio; demonstration of county-wide acceptance of conservation tillage based upon equipment and technical assistance without cost-sharing; and finally, the present multi-county projects.

During 1982, 11,379 acres in 902 sample fields were managed using conservation till or no-till as part of the program in 18 counties. A large increase is expected during 1983 as those counties gain momentum and the 32 additional counties complete a full year.

2.1.4 Major Reasons for Success and Failure

For the baseline programs, lack of success is in a sense indicated in each respect in which the project approaches have succeeded, i.e. the projects have accomplished things not done by the base programs. However, it should be recognized that most of the projects made major use of the base programs and built upon them. The primary factors that appear to detract from the base programs are: lack of priorities and focus resulting in widely diffused efforts; lack of a comprehensive reporting system to record accomplishments, particularly water quality; resistance to change; and the fact that personnel in the agencies are charged with responsibility for doing too many things at once which does not allow time enough for additional priorities.

The reasons cited by most of the demonstration projects for any lack of the success are four: lack of clear problem definition; lack of clear identification of the critical areas; lack of prioritization; lack of good evaluation criteria.

All demonstration projects reviewed showed ability to generate interest and accelerate implementation. Some cited early startup problems until all the participants had agreed upon "who was going to do what". This question of role was mentioned not as a hindrance or problem but more in the context of a necessary step in the organization of a project. All agreed that a period of time should be allowed at the beginning of each project before they were required to begin implementation. It was also agreed that some agency should be given a leadership role and that a full-time co-ordinator or manager was needed.

The lack of good problem definition was a common problem in implementation projects. Many of the projects were in areas where previous planning efforts had identified a high potential for water quality problems but the enthusiasm to begin work on the land handicapped attempts to focus and redefine efforts. This also made it difficult to evaluate whether they were solving the main problem. The lack of a clear definition of the problem and agreement on it left the project without a basis for determining success.

The lack of clear definition of the problem also created difficulty in determining the critical

areas or sources of the problem. This led to lack of prioritization of the pollution sources. Most of the projects realized this during the course of the implementation. They found it difficult to make these adjustments during the project period because the information and education efforts were already set and participants were co-operating based on the original emphasis of the program.

The pressure by the funding agencies to have immediate accomplishments often affected the ability to focus on problems. Funding agencies often lacked consistent policies and guidelines for the effort. Many began work on the perceived problem only to discover later that it was not as significant or that other problems were also present. This meant that many practices were planned or installed that were not effective or not in the proper location to be most cost-effective for solving the identified problems. The result was an acceleration of the traditional program in the area rather than one focussed on water quality problems specifically. Most projects reduced the members of practices utilized during the project life. Good work was accomplished but it was not focussed in the way that the project sponsors had envisioned.

A good information and educational effort was an important part of each project. All projects enjoyed a high level of success in creating interest in the program by the potential participants. Not all utilized the Extension Service, often because of a reluctance or inability to accept additional workload. All projects indicated that this work would best be done by the Extension Service with technical assistance provided by Districts and the SCS.

They were satisfied that an effective job was done. Several said that interest was still increasing at the time they were required to terminate their efforts. This was due to the limits of the funding period that was required by law for demonstrations. The Rural Clean Water Program has established a five-year program for writing contracts and a 10-year implementation to avoid this situation.

The overall conclusions from the survey of the projects and from their final reports has been a high degree of satisfaction with their ability to implement a special type project. An initial period to establish what is to be done, who is to do it, and the location and numbers of sources to be treated was found to be a major need. All staff expressed a concern that most of their efforts were at the expense of their existing program. Many projects were able to hire additional people, but still relied heavily on the staff of the baseline programs.

While phosphorus reduction was a general goal of all of the projects, none of the USDA projects had as a focus the reduction of loads to the Great Lakes with the exception of the Rural Clean Water Program projects. The EPA projects and the Corps of Engineers' Lake Erie Wastewater Management Study and Wisconsin projects clearly focussed upon Great Lakes phosphorus control. Although sediment reduction was used as a criteria of success in the USDA projects, very few did a good job of identifying the quantity of sediment reduced. This was primarily because the funding agencies did not require it. There is now a change in Federal policy that puts a much higher emphasis on evaluation and the Rural Clean Water Program projects now require yearly evaluations and progress reporting.

The key to good evaluation rests with a clear definition of the target pollutant and the sources. This permits a quantifiable goal to be established. The evaluation of most of the projects reviewed is based on qualitative criteria. The projects all considered themselves to have been successful in this sense. All agreed that they would go about things differently if they were to have the opportunity to another project. They were satisfied that the project approach was sound but also cautioned that the project area not be too large to allow good consensus on what needed to be done and the work concentrated so that progress could be observed in a relatively short time frame.

At the outset of this Section, it is stated that most of the basic delivery programs upon which nonpoint source pollution control rests, are continuing to lose financial support. This is in the face of public opinion polls which consistently demonstrate deep support for water quality and soil conservation. There are many factors which contribute to this situation, only a few of which are mentioned here. The decline in funding for soil conservation and nonpoint sources is part of an overall decline in state and federal program support. Since many of the agricultural nonpoint programs have historically been heavily federally funded, loss in federal spending hits these programs hard.

In the past, environmental problem emphasis has largely been directed at point sources which were more concentrated and under individual responsibility. Program administrators have held to the belief that nonpoint sources were not controllable, or only so at large public expense and that there was not adequate legislative and regulatory basis for control. The special demonstration projects have shown many of these beliefs to be in error. It is apparent that agricultural nonpoint sources are controllable, at much less expense than anticipated. Many controls can be put in place through voluntary acceptance by farm operators. The major need is to bring these points before program administrators and legislators to secure continued state and federal support of demonstration projects and increased support for basic delivery programs at the state and local level.

2.2 CANADIAN PROGRAMS

2.2.1 Post-PLUARG Program Activity

Programs within Canada's jurisdiction can be grouped for evaluation purposes as follows: a) ongoing field services to farmers; b) short duration watershed, soil and technology water management studies, demonstrations or data base development; c) policies, legislation or guidelines; and d) special interest group activities.

In case of "field services programs", most of the effort in the programs reviewed is directed at the soils and crops area. The major purpose of these programs is to sustain crop productivity by controlling soil erosion. The level of activities, however, remains fairly constant without significant additions of technical support staff or funds. Similarly, programs of fertilizers, pesticides and livestock residuals management are not generally targeted to areas of high priority in terms of water quality impact.

The main focus of nonpoint pollution abatement activities in the Province of Ontario has been the tributary watershed studies. Some of these efforts are in fact a continuation of pre-PLUARG initiatives and are mainly structured to improve instream water quality and in the case of metropolitan Toronto to improve nearshore water quality. The resultant improvement to the Great Lakes water quality, if any, is essentially a by-product of such endeavours.

No significant new legislation to address the nonpoint issue has been introduced. Policies and technical guidelines for dealing with urban stormwater management and for controlling erosion and sedimentation are currently being formulated by the provincial government.

Special interest groups such as the Soil Conservation Society of America (Ontario Chapter), Soil and Crop Improvement Association, Canadian Federation of Agriculture, etc. continue the important process of increasing urban and rural landowners' understanding of nonpoint pollution. Most significantly, the farmers are now playing a major role in pressing the government to develop appropriate programs and policies.

The most important nonpoint pollution abatement efforts are confined to local and provincial levels of government. The federal government essentially plays very minor role by providing some research dollars.

As in the United States portion of the basin, program activity has focussed mainly on agricultural nonpoint sources of pollution and, in particular, those related to crop production. In comparison, there are few program activities that relate to nonpoint source pollution from urban areas. There are two provincial programs of significance, the Ontario Ministry of Natural Resources' (OMNR) Stream Rehabilitation Program and Ontario Ministry of the Environment's (MOE) Provincial Water Quality Monitoring Network. The remaining programs are specific to regions or localities within the province. Of the above three, only the OMNR and MOE programs operate on a priority area basis.

All of the Canadian rural and nonpoint programs that were evaluated are summarized in Table 2.3 and a detailed description of these programs is given in Appendix I.

2.2.2 Effectiveness in Terms of Reducing Levels of Target Parameters

There is no evidence to suggest that the Canadian nonpoint remedial programs, in total, have been particularly effective in reducing loadings of the target parameters to the Great Lakes Basin. Monitoring of program results is rarely carried out. No information is collected to document the level of adoption. Consequently, it is virtually impossible to quantify the effectiveness of programs in reducing loadings. However, given the type and level of effort that has been expended so far, it is quite apparent that there has been virtually no reduction of nonpoint source pollutants to the Great Lakes since the submission of PLUARG recommendations.

Most attention has been directed towards sediment and phosphorus loads. Although other target parameters have been recognized as being problems by most programs, few significant attempts have been made to deal with them effectively.

TABLE 2.3. Programs Relating To Control Of Nonpoint Pollution In The Great Lakes Basin (Ontario)

PROGRAM CATEGORY	AGENCY	NAME OF PROGRAM	Primary Focus Of Programs									Services			Resources		Effectiveness								
			Erosion		Sediment	Phosphorus	Nitrogen	Trace Elements	Organic Compounds	Microorganisms	Problem Definition	Data Base	Cost-Sharing	Technical Assistance	Education	Monitoring	Total \$/yr (000's) x	Staff Time(man-years)	Use of Priority Areas	Monitoring	Load reductions	\$/ha Problem Areas	# ha treated	# Cooperators	
			Field	Stream/Ditchbank																					
<u>AGRICULTURE</u>																									
<u>Field Services</u>																									
<u>Soil & Crops</u>	Federal Provincial O.M.A.F.	Soil Conservation & Environmental Protection Assistance Program	*	*	*	*	*					*			1,000 ('83)	-	N	N	?	?	?		1982		
	M.N.R.	Advisory Services Strategic Plans for Ontario Fisheries Conservation Services	*	*	*	*	*			*		*	*	*	- 150	11 10	N Y	N Y	?	?	?	?	?	?	
	<u>Regional & Local conservation Authorities (24 in Southern Ontario)</u>	Conservation Services		*	*	*	*					*	*	*	1,018	37	P	N	?	?	?	?	?	815	
	Soil & Crop Improvement Assn. (39 counties)	Education	*		*	*							*		68	-	N	N	?	?	?	?	?	?	
<u>Fertilizers</u>	Provincial O.M.A.F. O.M.A.F., M.O.E.	Soil Testing Sewage Sludge Implementation Committee				*	*		*	*		*	*	*	269 ?	7 ?	N Y	N Y	- ?	?	?	?	?	15,700 ?	

* - Applicable
 N - Not applicable
 ? - Unknown
 x - Includes grant money and in some cases operational funds

Table 2.3 - cont'd.

PROGRAM CATEGORY	AGENCY	NAME OF PROGRAM	Primary Focus Of Programs								Services				Resources		Effectiveness							
			Erosion		Sediment	Phosphorus	Nitrogen	Trace Elements	Organic Compounds	Microorganisms	Problem Definition	Data Base	Cost-Sharing	Technical Assistance	Education	Monitoring	Total \$/yr (000's) x	Staff Time(man-years)	Use of Priority Areas	Monitoring	Load reductions \$/ha	Problem Areas	# ha treated	# Cooperators
			Field	Stream/Ditchbank																				
<u>AGRICULTURE</u>																							1982	
<u>Livestock Residuals</u>	<u>Provincial</u> O.M.A.F.	Soil Conservation & Environmental. on Assistance Program				*	*					*	*	*		2,500		Y	N	?	?	?	?	628
	<u>Regional & Local</u> Conservation Authorities (5 in Southern Ontario)	Conservation Services		*	*							*	*	*		?	?	P	N	?	?	?	?	
<u>Pesticides</u>	<u>Provincial</u> M.O.E.	Clean Up						*					*		*	?	?	N	Y	?	?	?	-	
	O.M.A.F.	Integrated Pest Management Program						*					*		*	?	21	N	Y	?	?	?	8,000	
<u>Studies, Data Bases and Demonstration Programs</u>	<u>Federal</u> Environment Canada	<u>Watershed Processes & Modelling</u>																						
	Canada Dept. of Agriculture	Priority Management Area Methodology Development & Application	*		*					*	*		*			50	1	Y	Y	?	-	-	-	
		Sediments & Phosphorus transport modelling & monitoring	*		*	*				*						60	4.0	-	Y	?	-	-	-	
		Watershed Modelling	*		*	*				*	*					400	1.0	-	Y	?	-	-	-	
	<u>Provincial</u> M.O.E.	Provincial Water Quality Monitoring program			*	*	*	*	*	*	*					1,500	22	Y	Y	?	-	-	-	

- * - Applicable
- N - Not applicable
- ? - Unknown
- x - Includes grant money and in some cases operational funds

Table 2.3 - cont'd.

PROGRAM CATEGORY	AGENCY	NAME OF PROGRAM	Primary Focus Of Programs								Services					Resources		Effectiveness						
			Erosion		Sediment	Phosphorus	Nitrogen	Trace Elements	Organic Compounds	Microorganisms	Problem Definition	Data Base	Cost-Sharing	Technical Assistance	Education	Monitoring	Total \$/yr (000's) x	Staff Time(man-years)	Use of Priority Areas	Monitoring	Load reductions	\$/ha Problem Areas	# ha treated	# Cooperators
			Field	Stream/Ditchbank																				
<u>AGRICULTURE</u> <u>Studies, Data</u> <u>Bases and</u> <u>Demonstration</u> <u>Programs -</u> <u>Cont'd</u>	O.M.A.F. <u>Inter-Agency</u>	Demonstrations (Plant Industry Branch Cooperators	*	*								*		*		?	2	Y	Y	?	?	?	158	
		Stratford/Avon Environmental Project		*	*	*	*	*	*	*	*	*		*	*	148	2.3	Y	Y	?	6	-	-	
		Thames River Implementation Committee	*	*	*	*	*	*	*	*	*	*	*	*	*	263	8	Y	Y	N	??/	?	?	115
		Grand River Basin Water Management Study			*	*	*	*	*	*	*	*	*	*	*	?	?	Y	Y	N	?	?	-	-
		Lake Simcoe Environmental Management Project				*	*			*	*					450	6	N	N	Y	?	-	-	
		South Nation River Basin Development Study	*	*	*	*	*			*	*	*				?	?	Y	Y	N	?	-	-	
		Lucknow River Basin Study			*	*	*			*	*					-	-	Y	N	N	?	?	-	-
		Belgrade Creek Study	*	*	*	*	*									?	?	N	Y	N	?	?	?	
		Rondeau Bay W Master Erosion Plan	*	*	*						*	*	*	*	*	35	?	Y	Y	Y	?	-	-	
		Assessment of Potential Water Quality Problems from Agricultural Manure Handling & Storage Systems				*	*			*	*					?	0.25	Y	N	N	?	-	-	
		Great Lakes Ecosystem Rehabilitation Group									*		*	*	*	?	?	N	N	?	?	-	-	
		Canada Soil Survey									*					?	6	-	-	-		-	-	
		Cropland Soil Erosion - Estimated Cost to Agriculture in Ontario	*	*	*	*					*					?	?	-	-	-		-	-	

- * - Applicable
- N - Not applicable
- ? - Unknown
- x - Includes grant money and in some cases operational funds

Table 2.3 - cont'd.

PROGRAM CATEGORY	AGENCY	NAME OF PROGRAM	Primary Focus Of Programs								Services			Resources		Effectiveness										
			Erosion		Sediment	Phosphorus	Nitrogen	Trace Elements	Organic Compounds	Microorganisms	Problem Definition	Data Base	Cost-Sharing	Technical Assistance	Education	Monitoring	Total \$/yr (000's) x	Staff Time(man-years)	Use of Priority Areas	Monitoring	Load reductions	\$/ha Problem Areas	# ha treated	# Cooperators		
			Field	Stream/Ditchbank																						
<u>URBAN</u> <u>Legislation/</u> <u>Policies/</u> <u>Guidelines</u>	<u>Federal</u> <u>and</u> <u>Provincial</u> M.O.E.	Model Polices for Urban Drainage Mgmt. on Great Lakes Water Quality		*	*	*	*	*		*			*	*			5									
	<u>Regional & Local</u> Town of Oakville	Storm Drainage Policies & Criteria			*								*			?	?	Y	N	N	?	?	?			
	Borough of Scarborough	Guidelines for Storm Water Management			*								*			?	?	Y	N	N	?	?	?			
	Grand River Conservation Authority	Storm Water Management Guidelines											*			?	?	N	N	N	?	?	?			
	City of Markham	Storm Water Management Policy											*			?	?	Y	N	N	?	?	?			
	Metro Toronto and Region Conservation Authority	Storm Water Management Program			*								*			100	?	Y	N	N	?	?	?			
	City of Kitchener City of Burlington	Urban Drainage Policy Storm Drainage Program			*	*							*	*		15 ?	? ?	Y Y	N N	N N	? ?	? ?	? ?			

* - Applicable

N - Not applicable

? - Unknown

x - Includes grant money and in some cases operational funds

Table 2.3 - cont'd.

PROGRAM CATEGORY	AGENCY	NAME OF PROGRAM	Primary Focus Of Programs									Services				Resources		Effectiveness							
			Erosion		Sediment	Phosphorus	Nitrogen	Trace Elements	Organic Compounds	Microorganisms	Problem Definition	Data Base	Cost-Sharing	Technical Assistance	Education	Monitoring	Total \$/yr (000's) x	Staff Time(man-years)	Use of Priority Areas	Monitoring	Load reductions	\$/ha Problem Areas	# ha treated	# Cooperators	
			Field	Stream/Ditchbank																					
<u>URBAN Special Basin Studies</u>	<u>Federal</u> <u>Provincial</u> M.O.E.	----- Lucknow River Drainage basin Study- Surface Water Hydrology, Quality & Hydrology			*	*	*	*	*	*	*					?	?	Y	N	Y	?	-	-		
		Toronto Area Watershed Management Strategy Study			*	*	*	*	*	*	*	*				240	6	Y	N	Y	?	-	-		
		Rideau River Storm Stratford/Avon River Environmental Management Project				*	*	*	*	*	*	*				300	2	Y		Y	-	-	-		
	<u>Regional & Local</u> <u>Inter-Agency</u> Grand River Implementation Committee	Water Management Study ----- Urban Nonpoint Source Pollution and Control			*	*	*	*	*	*	*	*				100	2	Y		Y	-	-	-		
																								1982	

- * - Applicable
- N - Not applicable
- ? - Unknown
- x - Includes grant money and in some cases operational funds

Only certain of the Ontario Ministry of Agriculture & Food (OMAF), MOE, OMNR and conservation authority programs have actually implemented remedial measures. However, the majority of these are operated on a first-come, first-serve basis with only three or four concentrating on priority problem areas.

The general level of participation of private landowners in conservation programs has been quite low. Table 2.4 summarizes the available data for farmer participation in subsidy and demonstration programs.

TABLE 2.4. Landowners Participation In Subsidy And Demonstration Programs

Programs	Approximate No. of Participating Landowners In 1982
Soil Conservation and Environmental Protection Assistance Program (OMAF)	
"erosion"	140
"manure storage"	630
Conservation Services (Conservation Authorities)	815
Stream Rehabilitation Program (SPOF)	20
TRIC	<u>115</u>
	1720

Several programs such as the manure storage part of the Soil Conservation and Environmental Protection Assistance Program (SCEPAP) and the streambank stabilization and tree planting parts of Conservation Services program may have limited impact on the nonpoint source loads. The number of landowners participating in government sponsored programs related to nonpoint source control is probably in the neighbourhood of 1,000. It is known that many farmers are adopting soil conservation practices on their own, but since no data are collected in Ontario on the use of such measures, it is impossible to assess the level of adoption.

Relative to the potential for future assistance of farmers in applying solutions to erosion control, the OMAF allocation for 1983 of \$1 million would assist 135 farmers if each applied for the full subsidy. In 1982, 140 received erosion control subsidies. By 1984, the number could increase to 270, a very small portion of the farming community.

With the elimination of available funding under the new SCEPAP, opportunities for education and demonstration have been severely cut back.

2.2.3 Highlights of Successful Programs

The most successful programs have taken a systematic approach by first defining goals and objectives, then determining the type and extent of the problem, prioritizing problem areas, identifying the most cost-effective remedial measures and, finally, implementing the recommended practices in high priority areas. A public information program is usually a component of well-accepted programs and monitoring of results is an important tool in assessing the effectiveness of remedial measures.

To date, the Thames River Implementation Committee (TRIC) program has been one of the most successful in Ontario. It addressed the issue of diffuse source pollution and encouraged better land use practices through public education and demonstration projects. As a result of the program, more farmers have begun using soil conservation practices. Most importantly, this short-term program has been converted to an ongoing program of diffuse source control by the Upper Thames River Conservation Authority. As well, this Authority has tripled landowner participation in its Conservation Services Program in the last three years. Emphasis is on field erosion control and the program is actively advertised and promoted in the priority management areas identified as part of the overall study.

Although TRIC is the only agricultural watershed study that has evolved into an active implementation program, several other basin studies have the potential to follow its example. SAREMP is near completion and LSEMP and SNRBDS are in the early stages of identifying problems and problem sites. The five-year GRIC study has produced some excellent background research and computer models. Priority management areas are now being defined and remedial measures are being evaluated in subwatersheds.

The Maitland Valley Conservation Area identified target areas and, in co-operation with landowners, OMNR and MOE, completed remedial measures in two subwatersheds. Monitoring of sediment loads and fish populations is being done to assess the effectiveness of the project.

The Essex Region Conservation Authority is implementing a plan to demonstrate conservation tillage practices and methods of controlling field erosion. This may evolve into an active Conservation Services Program similar to that of the Upper Thames River Conservation Authority.

With the Stratford/Avon Environmental Management Project and the Rideau River Stormwater Management Study close to completion, the TAWMS is the only on-going active study directed towards urban sources of nonpoint pollution. It is also using the step-by-step sequence of watershed planning, but is dealing with severe problems as they are discovered. This is a recently-initiated program that will focus on monitoring of results and plans to include public education as a main component of the project.

2.2.4 Major Reasons for Success and Failure

It has already been demonstrated that successful programs follow a natural sequence through planning, implementation and monitoring of results. Most successful programs have two other aspects in common: they are initiated by multi-agency forces and they are adequately funded.

The multi-agency approach ensures that a holistic view to problems and solutions is taken. Inclusion of all interest groups during the study process facilitates later implementation and acceptance. However, it is essential that a single agency is designated as the lead agency to ensure that the study progresses. Ideally, a rigorous schedule with well-defined deadlines is developed so that the study evolves into action and does not become an academic exercise.

Abatement of nonpoint sources of pollution can be relatively expensive. Each problem site individually contributes little to the problem, but the cumulative results are of great magnitude. Remedial measures must be applied to all areas with a high potential to deliver pollutants within a specific geographic area if any significant reductions in loadings are to be realized.

The primary reason for failure of most programs to achieve their potential is omission of the planning or implementation stages. Several programs implement remedial measures without defining priority areas or determining which types of measures will best achieve the desired results. Significant amounts of money are often spent in low priority areas, with insignificant results.

Many programs seem to have trouble moving from the planning stage to implementation. Some continue to study *ad infinitum* while others simply end with a set of recommendations. Typically, the recommendations suggest that some other agency should implement the program, or no mechanism for funding is devised, and the program goes no farther.

3. An Evaluation of Nonpoint Remedial Practices in the Great Lakes Basin

A post-PLUARG review of nonpoint source management measures was conducted. One of the major considerations for reviewing both the agricultural and urban practices was to note the relevant experience gained in Canada and the United States.

Due to the lack of a comprehensive inventory related to the adoption of these measures, the review has concentrated on the advances in the state of the art since PLUARG with emphasis on those measures viewed as being most cost effective. This review has used the PLUARG report entitled "Evaluation of Remedial Measures to Control Non-Point Sources of Water Pollution in the Great Lakes Basin" by Marshall, Macklin, Monaghan as a reference point on which to base comparisons.

3.1 AGRICULTURE

Remedial control practices are needed because row crop production and mono-culture crop production have steadily increased and conventional management practices cause soil erosion. The greater use of herbicides, pesticides and fertilizer increase the potential to lower water quality. The use of larger machinery and current soil management practices cause soil compaction and decrease water infiltration.

The review of available technology for rural nonpoint pollution control examined 3 categories of practices - managerial, vegetative and structural. Figure 3.1 lists the 26 practices that were evaluated.

The evaluation took into account the range of conditions under which each practice is considered applicable. It identified the basic mechanisms by which pollution is reduced, the relevant pollutant types and the relative effectiveness of each in reducing sediment, phosphorus, pesticide and nitrogen loads from both a site-specific and a basin-wide perspective. As well, the approximate cost, benefits to agriculture and general advantages and disadvantages were estimated. Finally, a general statement was made on the apparent level of adoption of each practice since PLUARG.

As noted above, there is only sparse information about the types and numbers of remedial practices being applied in the basin. A general indication is available from subsidy applications and the observations of extension agencies through their respective demonstration programs. A new "Conservation Tillage Information Center" established recently in the United States has begun to provide improved data on tillage and its use. Each of the practices listed in Figure 3.1 has been

FIGURE 3.1. Agricultural Control Measures And Practices*

I MANAGERIAL PRACTICES

A. MATERIAL

1. Commercial Fertilizer and Livestock Manure Management
2. Pesticide Management
3. Remote Location of Livestock Facility from Water-course

B. CONSERVATION TILLAGE PRACTICES

4. Reduced Tillage Systems
5. Ridge Plant Systems
6. Zero Tillage Systems
7. Timeliness of Tillage

II VEGETATION

8. Crop Rotation (sod-based)
9. Contour and Strip Cropping
10. Cover Crops
11. Buffer Strips
12. Windbreaks
13. Double Cropping Systems

III STRUCTURAL

14. Grassed Waterway
15. Terraces
16. Surface Water Diversions
17. Drop Inlet Structures
18. Sediment Basin
19. Stable Ditchbank Construction and Regular Maintenance
20. Armoured Bank Protection
21. Tile Drainage
22. Livestock Manure Storage
23. Feedlot Runoff Control
24. Excluded or Limited Livestock Access to Watercourses
25. Adequate Control of Milkhouse Wastes
26. Critical Area Planting

* See Appendix II for a brief description of each individual practice.

implemented in the Great Lakes Basin but not to the extent that they have caused observable changes in water quality at a watershed scale. Many of the practices are only just gaining acceptance through education. Practices which have enjoyed increased levels of adoption since PLUARG include livestock manure storage, zero tillage systems (United States only), reduced tillage systems, ridge-planting, grassed waterways, windbreaks (Ontario only), and terraces. Practices which have undergone reduced use are timeliness of tillage, crop rotation (sod-based) and strip cropping.

Although extensive application of most individual remedial practices has not yet occurred, it is possible to identify some of the most successful practices by examining the experiences of various United States and Canadian watershed studies. The principle factor influencing the successful implementation of remedial practices is the attitude and acceptance of the farmer. Those practices which are perceived to bring the greatest benefit to agricultural production and/or profit have been the most adopted.

Conservation tillage systems can have a major impact on Great Lakes water quality improvement with minimal effect on agricultural profitability. Thus the real cost of long-term implementation is low. Incentives are generally required in the short term to initiate implementation to overcome resistance to change. However, because of energy savings there is often a net economic advantage from conservation tillage over conventional methods. Accordingly, conservation tillage systems have been the major focus of agricultural nonpoint source research in recent years and are gaining wide acceptance both in the United States and Canada.

While it is generally acknowledged that conservation tillage systems minimize sediment and nutrient losses from cultivated land, especially when implemented on soils with a high potential to deliver sediments and nutrients to water courses, there is disagreement whether conservation tillage will increase use and/or loss of pesticides. However, continued monitoring and research is required to provide early warning of any emerging difficulties.

While non-structural tillage practices are viewed as a major component of a nonpoint source management program, selected structural practices, such as grassed waterways and in some cases, terracing, despite their higher initial costs, have also proven to be successful. Implementation of these measures effects viable, site-specific, long-term solutions with immediate impact on difficult problem sites.

An evaluation of the general effectiveness of various practices in reducing sediment, phosphorus and pesticide loads is summarized in Table 3.1. It is important to recognize that many remedial practices are site-specific and that the sites on which they are applied can undergo erosion rates of varying orders of magnitude.

TABLE 3.1. Evaluation Of Technology For "Rural" Nonpoint Pollution Control

Control Practice	Where Applicable	How Pollution Is Reduced	Pollutant	Effectiveness (% Reduction)		Cost To Implement	Benefits To Agric.	Advantages	DisAdvantages	Changes Since PLUARG
				On Site	Gr. Lakes Basin					
1. Commercial Fertilizer and Livestock Manure Management	all cropland and pasture	ensures that nutrient application is optimized prevents excessive buildup of nutrients minimizes nutrient loss to environment	Total Phosphorus (T.P) Total Nitrogen (T.N.)	50-90% (reduction of losses of applied fert)	Slight 5%	Slight profit to slight cost \$0/kg of TP reduced	High	maximize Profits and optimize input costs highly cost- effective	may be minor inconvenience in storage & handling for barnyard manure extra time & effort to have soil samples & special mix fertilizer split applications	no significant change in commercial fert mgmt slight progress in manure mgmt
2. Pesticide Management	all cropland	-minimize possible loss to environment ensures pesticide application is optimized reduced availability	All pesticides (Pest.)	50-90%	Slight	Slight profit to slight cost	Moderate to high	maximize profits & optimize input costs highly costeffective direct impact on in stream water quality	scouting is required	slight improvement in pesticide management
3. Remote Location of Livestock Facility From Water-course	future construction of livestock facilities	reduces soluble and insoluble P reduces amount of N to groundwater	T.P.	90-100%	Slight	Slight (for future const.)	Low	permanent solution to problem very effective in improving in stream water quality Permanent solution to problem requires only education for new facilities	long transition period required to implement	little if any change

Table 3.1 - cont'd.

Control Practice	Where Applicable	How Pollution Is Reduced	Pollutant	Effectiveness (% Reduction)		Cost To Implement	Benefits To Agric.	Advantages	DisAdvantages	Changes Since PLUARG
				On Site	Gr. Lakes Basin					
4. Reduced Tillage Systems	all cropland	reduces soil detachment and loss transport soil and absorbed chemicals are reduced	Suspended Solids (S.S.) T.P. Pest.*	40-90%	Very High (20- 60%)	Slight +\$2 to -\$2/kg of T.P. reduced	Highly effective in sustaining long-term crop productivity	reduced erosion maintains productivity applicable on wide range of soils improves soil structure reduces labor, time, fuel & machinery wear	may require increased use of pesticides skills must be learned may require new equipment Not applicable to all soils	slight but significant increase in interest and implementation through demonstration projects
5. Ridge Plant Systems	on level, imperfectly & poorly drained fine-textured soils for row crop production	reduces soil detachment and loss transport soil and absorbed chemicals are reduced	S.S. T.P. Pest.	40-60%	Slight to Moderate (<20%)	capital expense for ridge planter and cultivator overall capital expense is less costs/ac. reduced very cost-effective for P -\$2-+2/kg T.P. reduced	High	provides an alternate method for residue mgmt & tillage system selection	requires too much mgmt & technical assistance extra time new equipment new skills	slight but significant increase in interest & implementation through demonstration projects
6. Zero Tillage Systems	on highly erodible well-drained coarse to medium textured soils	reduces loss of soil & water, thus minimizing loss of nutrients and pesticides	S.S. T.P. Pest.	50-95%	High (U.S.) Slight to moderate (Cdn.)	capital expense for planter reduced overall capital expense increased net return	Moderate where applicable	allows a means to produce crops on land subject to severe soil erosion reduced erosion	may require a change in mgmt of fert. & pesticides new equipment	slight but significant increase in interest and implementation through demonstration projects

* T.P. and Pesticides reduction varies with Suspended Solid reduction and type of soil.

Table 3.1 - cont'd.

Control Practice	Where Applicable	How Pollution Is Reduced	Pollutant	Effectiveness (% Reduction)		Cost To Implement	Benefits To Agric.	Advantages	DisAdvantages	Changes Since PLUARG
				On Site	Gr. Lakes Basin					
6. Zero Tillage Systems - cont'd.						on suitable soils (\$-2-+2/kg) T.P. reduced		maintains productivity earlier planting easier to harvest very cost- effective for phosphorus	may increase pesticide use nitrogen management is critical	
7. Timeliness Tillage	all cropland	reduces loss of soil & water, thus minimizing loss of nutrients and pesticides	S.S. T.P. Pest.	5-30%	Slight	Slight	Moderate	extremely cost-effective ease of tillage better tilth maintenance of Productivity	heavy workload in spring	slight decline
8. Crop Rotation(sod-based)	all cropland with live-stock enterprise	reduces loss of soil & water, thus minimizing loss of nutrients and pesticides	S.S. T.P. Pest.	20-50%	Slight to moderate	High cost-effective for phosphorus reduction	Moderate	improved soil tilth increased infiltration reduced soil exposure improved weed & insect control	may increase outlay need sale or on farm use of hay reduction in cash sales increased labor not cost-effective for P reduction	decrease in use

Table 3.1 - cont'd.

Control Practice	Where Applicable	How Pollution Is Reduced	Pollutant	Effectiveness (% Reduction)		Cost To Implement	Benefits To Agric.	Advantages	DisAdvantages	Changes Since PLUARG
				On Site	Gr. Lakes Basin					
9. Contour & Strip Cropping	on cropland with 2-8% slope (long simple slopes) Strip cropping on crop- land with 8-15% slope	reduces loss of soil & water, thus minimizing loss of nutrients and pesticides	S.S. T.P. Pest.	50%	Slight	Slight (\$30-\$50/kg total phosphorus reduced)	High	allows row- crop production on sloping areas	inconvenience must use sod for strip cropping & thus requires use for hay some loss of production due to point rows	slight decrease in strip cropping little change in contouring
10. Cover Crops	all cropland areas	reduces loss of soil & water, thus minimizing loss of nutrients and pesticides	S.S. T.P. Pest. T.N.	40-60%	Moderate	Moderate (\$100-\$200/kg Total P. reduced)	Moderate	improves soil structure may reduce input costs (e.g. legumes provide nitrogen) protection against sheet erosion increases soil productivity	immediate cost-benefit may be low	increase in awareness & a slight increase in implementation in Ont. reduced in U.S.
11. Buffer Strips (filter strips)	all areas where streams & open channels exist	provides stabilization of erosion vulnerable areas	S.S. Adsorbed P	30-50% (from field)	Slight	Moderate (\$16/kg P reduced)	Moderate to high	maintains stability of banks removes sediment easy to install	does not address sources of pollutants removes land from production does not control soluble nutrients or P attached to clay particles	increased slightly

Table 3.1 - cont'd.

Control Practice	Where Applicable	How Pollution Is Reduced	Pollutant	Effectiveness (% Reduction)		Cost To Implement	Benefits To Agric.	Advantages	DisAdvantages	Changes Since PLUARG
				On Site	Gr. Lakes Basin					
12. Wind-breaks	most cropland especially important in organic and coarse-textured soils	reduces wind velocities near soil surface	S.S.	50-75%	Slight	Moderate	High	Preserves yield & quality of crops	takes land out of production O&M on permanent breaks	moderate increase in use awareness in Ontario stable to slight decrease in U.S.
13. Double Cropping Systems	where growing season permits, two crops to be seeded and harvested the same year	provides vegetative cover over much of the growing season	S.S.	5-10%	Slight	Slight	Moderate	maximum use of land increases profit margin eliminates one or more tillage operations	returns expected from 2nd crop depends on weather conditions requires high level of mgmt.	no change in Ontario. slight increase in U.S.
14. Grassed Waterway	up to 80% of the cropland	safely conducts water overland prevents erosion of soil	S.S.	60-80%	Slight	Moderate (\$50/kg T.P. reduced)	Moderate	permits land to be row cash-cropped ease of crossing with equipment can be harvested for hay	small% of land taken out of production requires maintenance difficult to establish	slight to moderate increase in use
15. Terraces	on slopes up to 12%	reduces long slopping areas to shorter areas, thus reducing velocity of water runoff reduces soil loss	S.S.	30-50%	Slight	High \$30-40/kg	High	permits use of more intensive cropping system reduces downstream flood peaks increased income	may be minor inconvenience to farming operations will take some land out of production	slight increase in use in Ontario moderate increase in U.S.

Table 3.1 - cont'd.

Control Practice	Where Applicable	How Pollution Is Reduced	Pollutant	Effectiveness (% Reduction)		Cost To Implement	Benefits To Agric.	Advantages	DisAdvantages	Changes Since PLUARG
				On Site	Gr. Lakes Basin					
16. Surface Water Diversions	on slopes up to 12% above feedlots on any slope	reduces water velocity reduces soil loss diverts water away from highly erodible areas & areas that contain a high concentration of potential pollutants	T.P. S.S. Pest. T.N.	30-60%	Slight	Slight to moderate	Slight	widely adaptable	interferes with cultivation soluble P is not controlled outlets may be a problem maintenance required high cost	slight increase in use
17. Grade Stabilization Structures	anywhere local gradient change exists at gully headlands	prevents localized gulying ponds water hence dissipates high velocity flow	S.S.	75-90%	Slight	High	High	highly effective in local erosion control	does not address the cause of the problem no effect on soluble pollutants requires technical assistance	slight increase in use
18. Sediment Basin	downstream from major ditch construction	decrease velocity of water in channel (allows settling of suspended particles)	S.S.	40-60%	Slight	High	Slight	effective easy to install reduces coarse soil transport	does not affect soluble pollutants does not address the cause of the problem	slight increase in use
19. Stable Ditch-bank Construction & Regular Maintenance	all open channels	protects the unstable areas from soil erosion	S.S.	50-75%	Slight	High	Moderate	reduces long-term costs maintain an outlet for tile drainage system	incurs a regular cost for maintenance	slight increase in use

Table 3.1 - cont'd.

Control Practice	Where Applicable	How Pollution Is Reduced	Pollutant	Effectiveness (% Reduction)		Cost To Implement	Benefits To Agric.	Advantages	DisAdvantages	Changes Since PLUARG
				On Site	Gr. Lakes Basin					
20. Armoured Bank Protection	all channel banks that are subject to water erosion due to excess volumes and velocity	provides localized protection, reducing soil loss	S.S.	50-75%	Slight	High (<\$800 kg T.P. reduced)	Moderate	very effective in control of soil erosion locally prevents loss of land visually pleasant controls a high delivery source	expensive	slight increase in use
21. Tile Drainage	all cropland with imperfect to poor drainage	increases water infiltration, hence reduces surface runoff	S.S.	5-10%	Slight	High (>\$450 kg P reduced)	High	highly cost effective increases yields permits timely tillage makes reduced tillage practical	may increase loss of soluble P & pesticides to groundwater may increase downstream flood peaks concentrations of some pollutants	slight increase in use
22. Livestock Manure Storage	all livestock operations within approx. 120m of an open channel or watercourse	reduces feedlot runoff eliminates spreading of manure on wet or frozen soil conditions	T.P.	50-75%	Moderate	High	High	direct control convenient to operate	relatively high cost concentrates work load can increase potential for movement if managed improperly	moderate increase in use

Table 3.1 - cont'd.

Control Practice	Where Applicable	How Pollution Is Reduced	Pollutant	Effectiveness (% Reduction)		Cost To Implement	Benefits To Agric.	Advantages	DisAdvantages	Changes Since PLUARG
				On Site	Gr. Lakes Basin					
23. Feedlot Runoff Control	all livestock operations within approx. 120m of an open channel or watercourse	eliminates contaminated feedlot runoff	T.P.	50-75%	Slight-moderate	Moderate	Moderate	controls soluble nutrients relatively low cost	may require physical movement of facility	slight increase in use
24. Excluded or Limited Livestock Access to Water Courses	wherever livestock have access to land adjacent to open water-courses	eliminates sediment detachment due to bank trampling decrease defecation in streams	S.S. T.P.	50-90%	Slight	High	Slight	improves in-stream water quality through direct control	inconvenient may require the use of alternate watering facilities maintenance of fencing	slight increase in use
25. Adequate Control of Milkhouse Wastes	all dairy operations	eliminates direct pollutant input	- toxic cleansing chemicals	70-90%	Slight	Moderate	Low	directly improves in-stream water quality	costly (low agricultural benefit)	minimal
26. Critical Area Planting	all land	stops detachment reduces transport	Sediment Adsorbed P	50-95%	Slight	High >\$150/ kg reduced	High	land utilized has low agricultural production site is usually difficult to cultivate	take land out of production not cost-effective for phosphorus reduction	increased as a result of PCK program in the U.S.

Note: Descriptions of each control practice may be found in Appendix II.

Information gathered to date has also shown that present cost estimates for many practices, even some of the structural ones, are less than those provided by PLUARG. It has also been shown that some of PLUARG's Level 2 and 3 practices* may be economically feasible in cases where there are direct benefits through a reduction in the cost of production. Therefore, some of these can legitimately be considered Level 1 practices which are assigned minimal cost.

The implementation of most agricultural nonpoint source control practices has been very slow. However, demonstration projects in localized areas have improved the information base on implementation costs, effectiveness, benefits and rural acceptance relative to that available to PLUARG in 1978. The rapidly increasing acceptance of conservation tillage practices are an exception to the otherwise slow rate of change.

Implementation of nonpoint source remedial practices has not met the PLUARG recommendations, nor subsequently, the 1980 IJC recommendations. There has been no widespread attempt to broaden existing information, education and technical assistance programs to meet the needs of the Great Lakes Water Quality Agreement. Low-cost, cost-effective practices such as fertilizer, pesticide and tillage management do not require further extensive evaluation and should be given priority for implementation.

3.2 URBAN

Urban runoff problems characterization and control technology are under continuing development. In Canada, these activities were initiated in the 70's largely under the Canada-Ontario Agreement Research Program which was set up as a result of the Canada-United States Agreement. In the United States, the 208 Program provided the impetus. Since 1978, the U.S. EPA has carried out the "Nationwide Urban Runoff Program" to confirm pollutant loadings from PLUARG studies and to further evaluate the efficiencies and application of control technologies. Their results, together with those parallel studies carried out in Canada, form the basis of discussion in the following sections as well as in Appendix III.

Based on existing data, it would appear that, in general, on a lakewide basis, pollution from urban runoff does not have a major impact on water quality. For example, it has been estimated that approximately 3% of the total phosphorus loadings to the Great Lakes comes from urban runoff and approximately 7% of the nonpoint total phosphorus is considered to be from urban sources. In addition, the phosphorus concentration in urban runoff is generally low, thus rendering its control not cost-effective. Further information about pollutant loadings are reserved in Appendix III.

*Level 1 - It is defined by PLUARG as sound management on all agricultural lands (10% phosphorus reduction).
Level 2 - Level 1 measures plus buffer strips, strip cropping, improved municipal drainage practices, etc. depending upon the region (25% phosphorus reduction).
Level 3 - Level 2 measures at a greater intensity of effort (40% phosphorus reduction).

Although a larger portion of the loadings of some persistent toxic organics (e.g. PCBs) and heavy metals (e.g. lead) to the Great Lakes are believed to be coming from urban sources, their exact proportion relative to other point sources and atmospheric inputs, as well as their significance to the environmental impact have yet to be determined. As concentrations biomagnify through the food chain route, there is concern over the long-term accumulation of these persistent substances in the ecosystem and their adverse human health effects. Needless to say more research is needed in these vital areas. Solids have been found to be a very effective medium for transport of trace metals in urban runoff. Thus the removal of solids could significantly reduce the pollutant loadings to the Great Lakes from urban runoffs.

At this stage, across-the-board control of urban runoff to improve Great Lakes water quality is not recommended, except to reduce erosion and sedimentation during construction. Most of the sediments from urban sources come from land disturbing activities during land development. Sediment control measures during construction have been well developed and are considered to be cost-effective, particularly "good housekeeping" type practices. Consequently, this type of control should be implemented on an across-the-board basis.

Good housekeeping practices at all auto service stations, fleet vehicle maintenance areas and materials storage areas would be locally beneficial, easily implemented and benefit water quality. Limiting phosphorus in laundry detergent is also significant for reducing it from unsewered portions of urban areas, as well as point source.

In site-specific cases, such as large urban areas draining to limited receives or nearshore embayment areas or public beaches on the Great Lakes, contribution from urban runoff can be significant. Under these conditions, each case has to be evaluated separately, and an overall pollution control strategy formulated to develop the best combination of measures to control all sources (which could include urban runoff control) to meet local water quality criteria.

On the other hand, problems with urban runoff quantity appear to be widespread, and are usually caused by the change of land use. During the past decade, innovative technologies and designs have been developed to address the quantity problems. These technologies have already been demonstrated to be workable in a number of municipalities. In a lot of cases, control measures that deal with quantity will also, to a varying degree, have quality control benefits. For this reason, both types of control, when required, can often be integrated to cut costs.

The most effective way to deal with stormwater management is to use a combination of good planning and innovative control practices. Recent developments indicate that the trend is to use the Master Drainage Planning* to incorporate urban drainage management into land

* A plan to define and recognize watershed constraints in a large urban development, and to provide an overall optimum drainage scheme to satisfy these constraints.

development schemes at an early stage, and follow up with stormwater management planning** incorporating consideration of the Major-Minor Drainage System concept for drainage design. These steps will ensure that urban runoff will be controlled adequately. Most importantly, at the master drainage planning stage, if water quality control is also needed, it can be integrated with quality control to maximize benefits. For example, according to Nationwide Urban Runoff Program (NURP) data, detention ponds designed for quantity control generally have low performance efficiency for quality control. Removal efficiency for total phosphorus (TP) is in the range of approximately 33%. Thus if high TP removal is also required, the pond has to be specially designed. In this way, one pond can do both jobs at some extra costs instead of building a second pond for quality control purposes at a different time and full construction cost. Control measures such as those mentioned above should be aimed largely at new development because the planning and design stage is best for implementing cost-effective measures.

The following urban runoff control practices are classified into three general categories: erosion control, managerial and structural. An evaluation of these practices, although somewhat limited in scope due to the lack of field data, is nevertheless presented in Table 3.2. More details can be found in Appendix II. The objective of this section is to provide an updated evaluation of urban runoff control practices, emphasizing any changes or advances since publication of an earlier evaluation by PLUARG in 1977. This section is organized to serve as a supplement, and not as a replacement for IJC Report 77-014, "Evaluation of Remedial Measures to Control Non-Point Sources of Water Pollution". Most of the information provided by the 1977 report is still current and useful to planners.

3.2.1 Erosion Control Measures for Sediments

These measures take the form of practices which stabilize erodible surfaces, provide more favorable routing of runoff flows, or attenuate rates of flow. Figure 3.2 lists those control practices, described in detail in the 1977 PLUARG report, which fit this category. Catalog numbers from the 1977 Application Matrix are provided to facilitate further reference for details. The measures listed would apply principally to newly developing urban areas, and only in unique circumstances to areas which already developed.

As discussed earlier, the successful application of such measures is quite likely to prevent or resolve more localized problems, and less likely to have a substantial effect on reducing overall pollutant mass loads from the total urbanized area of the Great Lakes basin. Erosion control can have an important influence on protection of ecosystem habitat as well as reductions in concentrations of some pollutants in water bodies immediately influenced by such areas. Other benefits, not directly related to ecosystem protection, include the maintenance of more desirable aesthetic conditions.

** A plan to provide conceptual and/or design details of drainage components of a development (typically a subdivision), and indicate how constraints and requirements set out in the master drainage plan will be met.

TABLE 3.2. Summary Of Ranges Of Unit Area Loads Of Selected Materials By Land Use From Pilot Watershed Studies vs U.S. NURP Data

Land Uses ^a	Annual unit area loads (Kg/ha/yr)							
	Suspended Solids	Total Phosphorus	Filtered Reactive Phosphorus	Total Nitrogen	Lead	Copper	Zinc	Chloride
I RURAL								
General Agriculture	3 - 5,600	0.1 - 9.1	0.01 - 0.6	0.6 - 42	0.002 - 0.08	0.002 - 0.09	0.005 - 0.3	10 - 120
Cropland	20 - 5,100	0.2 - 4.6	0.05 - 0.4	4.3 - 31	0.005 - 0.006	0.014 - 0.064	0.026 - 0.083	10 - 50
Improved Pasture	30 - 80	0.0 - 0.5	0.02 - 0.2	3.2 - 14	0.001 - 0.015	0.021 - 0.038	0.019 - 0.172	-
Forest/Wooded	1 - 820	0.02 - 0.67	0.01 - 0.10 ^b	1 - 6.3	0.01 - 0.03	0.02 - 0.03	0.01 - 0.03	2 - 20
Idle/Perennial	7 - 820	0.02 - 0.67	0.01 - 0.07	0.5 - 6.0	0.01 - 0.03	0.02 - 0.03	0.01 - 0.03	20 - 35
Sewage Sludge	-	0.02	0.01	11	0.01	0.005	0.2	10
Wastewater Spray	-	-	-	-	-	-	-	-
Irrigation	-	0.2 - 1.4	0.1 - 1.3	2.2 -370	-	-	-	40- 160
II URBAN								
General Urban	210 -1,750	0.3 - 2.1	0.05 - 0.3	6.2 - 10	0.14 - 0.5	0.05 - 0.13	0.3 - 0.6	130 - 380
Residential	620 ^c - 2,300	0.4 ^c - 1.3	0.2	5 ^c - 7.3	0.06	0.03	0.02	1.050
Commercial	50 - 830	0.1 - 0.9 ^c	0.02 - 0.08	1.9 - 11 ^c	0.17 - 1.10	0.07 - 0.13	0.25 - 0.43	10 - 150
Industrial	400 - 1,700	0.9 ^c - 4.1	0.3	1.9 - 14 ^c	2.2 - 7.0	0.29 - 1.3	3.5 - 12.0	-
Developing Urban	27,500	23	0.1	63.0	-	-	-	75 -160
NURP*(U.S.)Kg/ha/yr	480	0.9	0.32(sol.)	-	0.49	0.09	0.41	-
NURP**(U.S.)tons/yr (metric)	720,000	1,350	480	-	735	135	615	-

Note: * Median values, based on 35 in/yr of rainfall.

** Based on 1.5 million hectares of urbanized areas in the Great Lakes Basin.

Conclusions: A - Approximately 3% of the total loading of "TP" from urban sources.

B - Approximately 7% of the nonpoint source loading of "TP" from urban sources.

C - 1983 data confirms the 1973 data (the same range).

FIGURE 3.2 EROSION CONTROL MEASURES

Catalogue Number	Measure Description
1	Chemical Soil Stabilizers
11	Conservation Construction Practices
12	Temporary Mulching and Seeding Stripped Areas
13	Conservation Cultivation Practices on Steep Slopes Temporary
14	Diversions - Steep Slopes and Temporary Chutes
15	Temporary Check Dams - Small Swales and Water Courses
16	Seeded Areas Protected with Organic Mulch
17	Seeding Areas Protected by Netting or Matting
21	Surface Water Diversion (Protection of Erodible Areas)
22	Terraces (Diversion Terraces)
39	Grassed Outlets
77	Check Dams
82	Riprap Bank Protection
83	Protection of Culvert Outlets, Chute Outlets, etc.
101	Gabion Baskets
102	Miscellaneous Erosion Control Fabrics and Materials

General applicability of erosion control remedial measures is both practical and feasible, and is particularly effective during construction phase. Legal and institutional approaches have been well proven to be workable. In the United States, erosion and sediment control requirements have been successfully applied by a number of States.

In Ontario, the upcoming Urban Drainage Policy will require province-wide control of erosion and sediments during construction phase of developments. In Ontario, the PLUARG recommendation that erosion and sediment control programs be improved to reduce sediments from land surfaces to the Great Lakes, is consistent with the concept of applying these measures. Because appropriate erosion control measures are so highly site-specific, the mix of practices applied to date may not be particularly relevant guides for future activities. In any event, information on preferred erosion control measures in areas with implementation plans in force is not readily available.

3.2.2 Managerial Practices Quality Control

The techniques selected for inclusion in this category are those which concentrate on removing or reducing pollutants at source before allowing them to get into runoff. These practices are usually considered to have lower cost than structural measures. Figure 3.3 lists these measures.

Reduction of chemicals such as pesticides, fertilizers and highway de-icing salts, etc. have been discussed in the 1977 PLUARG Report. Lawn fertilizer and pesticide usage would be controlled through public information programs, the results of which would be quite difficult to assess and document. As a result, there is no basis at present for describing "performance" of this measure. Nevertheless, these measures will have additional materials conservation benefits.

Reduction in road salt application, and partial substitution with sand, is more amenable to broad scale implementation because local government agencies are responsible for application. Studies on the reduced use of road salt have been carried out in both Ontario and Wisconsin in an attempt to determine feasible alternatives.

Studies on Catch Basin Cleaning have generally concluded that, with adequate maintenance, they can provide appreciable removals of certain pollutants in storm runoff from urban streets. However, there is no evidence of general application of this measure for quality control purpose at this time.

Stream cleaning, vacuum or mechanical broom street sweeping has received considerable emphasis in the past as a managerial measure having the potential for broad scale reduction in urban stormwater pollutant loads. Recent study results indicate that the effectiveness of this practice is highly site-specific. When carried out in a normal manner and frequency, such a control may not be effective in the Great Lakes area.

FIGURE 3.3. Managerial Practice For Urban Runoff Quality Control

Catalogue Number	Measure Description
24	Pesticide Application Methods
-	Fertilizer Application Methods
96	Reduce/Eliminate Highway De-icing Salts
25	Alternatives to Chemical Application
58	Street Cleaning
108	Catch Basin Cleaning

* Catalogue Nos. refer to the 1977 PLUARG Report entitled "Evaluation of Remedial Measures to Control Non-Point Sources of Water Pollution in the Great Lakes Basin".

FIGURE 3.4. Structural Measures

Catalogue Number	Measure Description
3	Dutch Drain
4	Porous Pavement
5	Precast Concrete Lattice Blocks and Bricks
6	Seepage or Recharge Basins (single use)
7	Recharge-Detention Storage Basins (Multi-use)
8	Seepage Pits or Dry Wells
9	Pits, Gravity Shafts, Trenches, Tile Fields
10	Pressure Injection Wells
81	Sediment Basins
98	Miscellaneous Methods to Reduce Storm Runoff

3.2.3 Structural Measures

The techniques included in this category are usually remedial measures and most of them, when properly designed, can afford both quantity and quality control of runoff. Some measures (e.g. ponds) can further be designed for recreational and aesthetically pleasing purposes as well. Figure 3.4 lists some of these measures. Performance efficacy data of some of these measures from recent studies are shown in Appendix II. Of particular interest is that retention-recharge type device which appears to be quite effective in reducing solids, bacteria and heavy metals.

3.2.4 Comparison of PLUARG and NURP Loading Data

The range, from Table 3.2, of suspended solids, total phosphorus, lead, copper, and zinc shows that between the NURP and PLUARG data, there are no significant differences. It can be concluded that both estimates are accurate. While there has been a five-year lapse between the PLUARG and NURP work, nothing can be said as to whether or not the loads are more or less. The table compares annual unit area loads for the above-mentioned pollutants. Median values are present from the NURP work and compared to ranges from the PLUARG study. The median values all fall within the ranges. Because of the nature of this type of monitoring and analysis, this indicates little, if any, significant difference in estimated unit loads.

When annual urban runoff loads for total phosphorus from the entire Great Lakes Basin were compared between the two studies, they both showed that urban runoff accounted for approximately 7% of nonpoint load and 3% of the total load. There is no comparable data available for other pollutants at this time. Due to recent phosphorus controls at major municipal wastewater treatment plants, urban runoff is now likely more than 3% of the total load.

4. Some Major Scientific and Technical Issues Having Direct Impact on Nonpoint Regulatory Process

The PLUARG studies identified a number of unresolved questions about nonpoint sources of pollution. Subsequent research has provided answers for some of these, but others still remain unanswered. The major outstanding technical and scientific issues that require further work are discussed briefly in this chapter. A more detailed treatment of each subject can be found in the appendices listed at the end of this report. Copies of all the background documents included in the list are available on request from the IJC Great Lakes Regional Office at Windsor, Ontario.

4.1 PRIORITY MANAGEMENT AREAS IDENTIFICATION

Priority management area identification is a process whereby areas that are actively contributing pollutants to surface or groundwater supplies are identified for the purpose of establishing priorities for remedial efforts. The priorities for nonpoint pollution control can be established on the basis of cost-effectiveness in terms of pollutant reductions per dollar invested.

In the 1978 PLUARG recommendations to the IJC, it was stressed that the management of nonpoint pollution sources required both a comprehensive management strategy and a methodology to identify priority management areas to be treated. Further, it was recommended that regional priorities for implementing management plans be based upon the water quality conditions within each lake, the potential contributing areas identified by PLUARG and the most hydrologically active areas (areas which contribute pollutants directly to surface and/or groundwater because of their proximity to streams or aquifer recharge areas) found within these potential contributing areas.

The validity of the concept of potential contributing areas and hydrological active areas has been reinforced by the findings of several studies in Canada and the United States since the PLUARG recommendations. However, the application of the concept to nonpoint pollution control management programs has not been without its difficulties. Specifically, some technical, scientific and agency issues that require further work if nonpoint source reduction targets are to be met.

There is a need to refine methods for defining potential contributing areas and hydrologically active areas. Current methodologies for defining these problem areas vary substantially among agencies and in some cases the quality of the output remains suspect due to the quality of input data. Refined hierarchal methodologies which should: be applicable for widespread use in the Great Lakes Basin, reflect the seasonal delivery of pollutants to the lakes, and can be applied to all pollutants of concern.

Further, there is a need to standardize methods and criteria employed to assess the success of nonpoint pollution control programs. Monitoring and modelling techniques must be re-designed and implemented in such a way that meaningful results can be achieved.

Both technical and administrative personnel from all concerned agencies need further education in the merits of priority management approaches to nonpoint pollution control. To deliver a priority management program, concerned agencies require non-traditional approaches where staff, funds and services are allocated to selective priority areas rather than on a universal first-come, first-serve basis.

4.2 TRANSPORT AND TRANSFORMATIONS OF POINT AND NONPOINT SOURCE PHOSPHORUS

Transport and transformation processes in streams mediate the delivery of phosphorus from point and nonpoint sources to receiving bodies. The characteristics of point and nonpoint source phosphorus loading to streams favor different mechanisms for transport and transformation. Point source phosphorus, which is largely dissolved, is loaded to streams at a relatively constant rate throughout the year. The base-flow stream conditions during which most of the point source phosphorus is discharged are characterized by generally low suspended particulate concentrations. The generally favored substrate for interaction with dissolved phosphorus during these periods is the stream bed. Stream beds have a high capacity for removing dissolved phosphorus derived from wastewater, particularly during low-flow periods.

Conversely, nonpoint source phosphorus loading is generally associated with the relatively short periods of overland flow. The elevated levels of suspended sediment associated with overland flow are the major substrate for interactions with dissolved phosphorus. Clay-sized particles are of particular interest due to their higher capacity per unit mass for phosphorus exchange than larger-sized particles. Since clay-sized particles require less energy for transport than larger-sized particles, they account for the great proportion of the particulate phosphorus transported by streams.

Future water quality management planning efforts in the Great Lakes Basin will probably involve the projection of water quality benefits from implemented practices. Issues of phosphorus and sediment transport through streams and intervening ponds, lakes and embayments prior to their delivery to the Great Lakes, will influence the assignment of areas to which water quality benefits will accrue. Projection of local benefits to the conveyance network, such as lower dredging costs or a reduction in the eutrophication of impoundments, will likely influence implementation strategies. Based upon transport-system-specific considerations, general assumptions concerning the conservative/non-conservative transport of phosphorus and sediment between watershed source and the Great Lakes can be made for management planning purposes. A number of models are available to assess phosphorus and sediment behavior in specific streams and intervening impoundments.

4.3 PHOSPHORUS BIOAVAILABILITY

A number of strategies have been developed to control phosphorus inputs to the Great Lakes, but they give little attention to the portion of the total phosphorus which is actually available for plant growth. Although IJC's PLUARG and Phosphorus Management Strategies Task Force recognized phosphorus bioavailability as an issue, neither recommended how phosphorus

bioavailability should be considered in management plans.

Based on extensive research, dissolved inorganic phosphate is known to be the most readily bioavailable form of phosphorus. Other forms, such as phosphorus associated with particulate matter (sediment), are bioavailable only through conversion to inorganic phosphate. However, since particulate associated phosphorus is a major component of nonpoint source inputs, the amount and rate of conversion of particulate phosphorus to dissolved inorganic phosphorus is critical. Chemical extraction techniques that have been correlated with algal uptake studies have proven to be effective for estimating potential bioavailability.

Because bioavailability of phosphorus depends on the characteristics of the receiving water as well as on the forms of phosphorus, a standard working definition is necessary. Therefore, it is recommended that potentially bioavailable inorganic phosphorus be defined as the amount of inorganic phosphorus a P-deficient algal population can utilize over a period of 48 hours or longer. Studies indicate this corresponds to the dissolved inorganic P in an unfiltered sample plus the inorganic particulate P that is extracted with 0.1 N NaOH (soil/solution ratio 1:1,000).

As mentioned, once suspended sediments enter lakes, the rate of release of inorganic phosphorus from suspended sediment depends on the dissolved inorganic phosphorus concentration in the lake water and nutrient status of the algae, as well as on factors such as algal species present, temperature, pH, and the availability of light and other essential nutrients. Hence, the location of a particle upon being delivered to a lake affects whether potentially bioavailable phosphorus actually becomes bioavailable. For example, particles that rapidly settle out of the light zone where photosynthesis can occur may become unavailable to algae. However, resuspension, especially in shallow waters, may reintroduce particles into the photic zone.

It is now clear that, in general, no more than 40% of the suspended sediment total P from Great Lakes tributaries is potentially bioavailable. For northwestern Ohio tributaries that carry a large sediment load into Lake Erie, about 25% of the sediment phosphorus is potentially bioavailable. Most of the sediment phosphorus in these tributaries is contributed by agricultural and urban runoff. Phosphorus coming from point sources, such as municipal treatment plants, often is considerably more bioavailable. Point sources that discharge directly to the lakes are especially important as sources of bioavailable phosphorus.

Certain management practices may affect the bioavailability of phosphorus derived from different sources, but information is sketchy. For example, applying fertilizer at rates no higher than required for optimum plant growth could reduce losses of soil with bioavailable phosphorus. Conservation tillage presents a major question, since, although it will reduce particulate phosphorus losses from farmland, the overall affect on bioavailable phosphorus has received little study.

Finally, from a lake management perspective, potentially bioavailable P is most likely to be fully utilized in comparatively shallow systems, such as Saginaw Bay, lower Green Bay and part of Lake Erie, where resuspension is likely to keep particulate phosphorus in a position for algal uptake. For these waters an abatement program directed at total phosphorus is still recommended. Phosphorus controls limited to readily bioavailable sources would be most effective for the deeper Great Lakes, where resuspension of sedimented particulate material is minimal. Such controls might focus on municipal sewage treatment plants that discharge directly to the lakes.

It is also important to realize that phosphorus control, and more specifically bioavailable phosphorus control, is but one part of an overall ecosystem strategy. Though the amount of bioavailable phosphorus loads reduced by conservation tillage may be considerably smaller than the total phosphorus loads reduced, the value of conservation tillage is not negated. For example, conservation tillage keeps valuable soil in place and reduces sediment (a pollutant in its own right) inputs to the lakes. A large scale conservation tillage program and subsequent monitoring of the ecosystem impacts is a logical next step in a nonpoint pollution control management strategy.

4.4 STATUS AND EVALUATION OF PESTICIDE IMPACTS ON THE WATER QUALITY OF THE GREAT LAKES

The United States and Canadian regulatory processes to control the manufacture and use of persistent pesticides have resulted in gradually decreasing levels of endrin, dieldrin, DDT and, to a lesser extent mirex, in the Great Lakes Basin. However, levels of other persistent chemicals, particularly PCBs, have remained at relatively constant levels.

During the late 1960s and throughout the 1970s, acreage treated with herbicides and insecticides increased more than threefold. Even greater increases were seen in the amounts of herbicides applied to corn, soybeans and wheat; the principal crops in the Great Lakes Basin. With high percentages of cropland already receiving treatment, pesticide use may expand only as total cropland increases or cropping practices such as no-tillage warrant increased application per acre. Several researchers, and agricultural officials have expressed concern that more traditional methods of pest and weed control, e.g. rotations and tillage, are being replaced with greater reliance on chemical control. While higher agricultural prices in 1979-1981 led to increases in cropland acreage in the Great Lakes Basin, lower prices in past years and acreage reduction programs in the United States have halted this climb, at least temporarily.

It is more likely that changing practices rather than net increases in cropland will affect pesticide use. Emphasis by both governments on conservation tillage, particularly no-tillage, for erosion and nutrient control will affect existing pesticide practices. Researchers disagree as to whether conservation tillage will increase pesticide use significantly. There is, however, agreement that in case of pesticides which have low solubilities (less than 1 ppm) and/or clay-binding capabilities, conservation tillage will reduce losses in proportion with erosion reduction. Unfortunately, even though pesticide concentrations in sediments are much higher, most pesticides are lost in water because sediments comprise such a small percentage (by weight or volume) of runoff. Reduced use of pesticides requiring incorporation may create conditions for increased

pesticide loss unless total runoff is reduced through conservation tillage. Wider use of integrated pest management (IPM) which emphasizes the use of pesticides on the basis of need rather than as a routine preventative strategy should reduce the total amount of pesticides available for runoff.

While less persistent insecticides and herbicides are being used increasingly on agricultural cropland in the Basin, their impact on the Great Lakes appears small. Significant losses of these chemicals will occur, and may increase both in frequency and total amount, but their effects generally will be limited to surface and ground waters in the immediate vicinity of the losses. The toxicity of these pesticides, alone or in combination, is still significant and may affect the Great Lakes through habitat impairment in tributary rivers and streams. The most serious effects of pesticides on the Great Lakes System appear to be the presence of persistent chemicals in the sediments of several rivers and major areas of Lake Ontario.

4.5 WIND EROSION AS A SOURCE OF WATER POLLUTION

The environmental factors which influence the amount of wind erosion occurring in an area are soil type, climate, and vegetative cover. Soil particle size ultimately determines the type of soil movement during wind events. Soil movement may be - suspension, saltation or creep, methods of movement which occur with particles of less than 0.1 mm, 0.05 to 0.5 mm, and 0.5 to 1 or 2 mm diameter, respectively.

Methods to control wind erosion are designed to reduce the amount of soil movement occurring on cultivated land. However, little information exists on wind erosion as a source of water pollution. Fine clay and organic matter are two constituents which are easily transported by wind. These constituents will carry the nutrients and adsorbed pesticides which can result in concentrated loadings in the areas of deposition.

As more information becomes available, the quantitative significance of wind erosion as a source of water pollutants may be better defined. In the meantime, it would appear that wind erosion must be considered as a possible source of water pollutants to the Great Lakes and other large lakes.

4.6 TOOLS FOR EVALUATION OF REMEDIAL MEASURES

There are two basic approaches that can be used to determine effectiveness of remedial measures: water quality monitoring and modelling.

Water quality monitoring is essentially the measurement of water quality over time and space via a planned sampling program. It generates "real" data that provide a direct measurement of water quality conditions at the time of sampling. A properly designed and operated monitoring network is a valuable tool that can be used to address a variety of water quality issues.

Modelling involves the use of mathematical equations which represent cause and effect relationships within real world physical, chemical and biological systems. Basic to water quality models is the selection of rate equations for each modelled process. At least two sets of field data are usually collected in the development phase of a model. One data set is used for calibration. Once calibrated, a "simulation" is made against the second data set, and based on the favourable outcome of the test, the model is said to be verified. Once the model is operational, selected input factors (e.g. remedial practices) can be varied while holding the remaining factors constant and the effect on the predicted results (e.g. nonpoint source loads) examined.

4.6.1 Tributary Monitoring

Based on the work reviewed, it can be concluded that two types of rivers exist - event response rivers where suspended sediment concentrations and sediment adsorbed parameters increase with increasing flow, and stable response rivers where suspended sediment and adsorbed parameter concentrations do not increase with increasing flow. Each river type requires its own sampling strategy. High flow events must be sampled on event response rivers to obtain reliable suspended sediment and total phosphorus flux estimates with errors in the range of 10 to 20%. If these events are not sampled, fluxes will be underestimated by 15 to 20%. Event sampling is not as important for event response rivers which are impacted by point sources. For stable response rivers and parameters which do not change with flow, event sampling is not required.

Event sampling programs will not be sufficient to measure changes brought about by diffuse source control programs. For example, the conservation tillage program recommended by the Lake Erie Wastewater Management Study is estimated to reduce the United States diffuse source phosphorus load by 32% after 20 years. The reduction is estimated to be 9% after three years, and 22% after five years. In light of the type of error obtained by event sampling and the natural variation that is seen in event response rivers, there is no way a 9% change can be measured. Even a 32% change would be difficult to attribute to the program.

Daily sampling has been carried out at selected Canadian and United States tributaries; however, for the majority of Great Lakes tributaries even a daily sampling program probably will not measure improvements in the initial years after the implementation of programs to control nonpoint source pollution.

The changes on the land will be gradual and the changes showing up in the phosphorus transport will be slower yet. Even after the program has taken effect (i.e. for Lake Erie, after seven years 90% of the projected total reduction will have occurred, resulting in a 29% reduction in the present diffuse source load), one year of sampling will not reveal attributable change. At least five years of data will be required to adequately characterize the phosphorus transport.

4.6.2 Modelling

Several models can be used to estimate program effect, both before and after a program is implemented.

Some of the most commonly used models are listed below:

1. SWMM - (Storm Water Management Model); Reference 2.
2. STORM - (Storage, Treatment, Overflows and Runoff Model); Reference 3;
3. ANSWERS - (Areal, Nonpoint Source Environmental Response Simulation); Reference 4;
4. USLE - (Universal Soil Loss Equation); Reference 5;
5. HEC 6 - (Hydrologic Engineering Centre); Reference 6;
6. HSPF - (Hydrologic Simulation Program - Fortran); Reference 7;
7. WATERSHED - Reference 8; and
8. Great Lakes Overview Model - Reference - Personal communication from G. Bangay, Canadian Co-Chairman of the Task Force.

There is no model presently available which represents the erosion and transport processes on watersheds larger than 150 square miles.

4.6.3 Monitoring of Progress

The following points should be considered by those designing a system to monitor program effectiveness.

1. Monitoring networks can be designed that will assess the effectiveness of remedial measures on the land in reducing phosphorus loads to the lakes.
2. Probably the most demanding factor to be considered in the design of the above-mentioned network is sampling frequency.
3. In the initial years of program implementation the magnitude of the expected reduction of phosphorus loads will probably be small in comparison to the inherent variability in phosphorus loads. Tributary monitoring cannot be used to detect the small initial changes in annual phosphorus loads.
4. The ability of existing monitoring networks in the Canadian and United States Great Lakes Basin to detect larger changes on event-response rivers can be improved by increased sampling frequency and the use of event-sampling strategies.

5. Land monitoring and modelling could be used in the initial years of the program when changes in phosphorus loads are difficult to detect by normal monitoring techniques. It can also be used in the later years to relate changes in tributary loads to changes on the land. For example, one approach would be to measure the number of acres which adopt remedial practices and/or calculating the reduction in gross erosion by using the Universal Soil Loss Equation. Monitoring the number of acres which change to conservation tillage can be done on a county basis by the local Soil and Water Conservation District in the United States and by agricultural representatives (Ontario Ministry of Agriculture and Food) in Canada.

4.6.4 Conclusions

Tributary monitoring is not sensitive enough to measure the early effects of a diffuse source phosphorus control program. Another approach is to forget about relating initial changes on the land to changes in the lake. Assume the improvement on the surface of the land will result in improvements in the lake and measure progress by measuring changes on the landscape. There has been sufficient research on plots to know what practices work in reducing sediment and phosphorus, and that improvements will eventually show up on the lake. However, there will be some time lag before a river system establishes a new equilibrium which can be translated into reduced pollutant loads to the lake. In addition, initial adoption rates will be low. The only way to measure a 5% implementation of conservation tillage in the year it occurs will be to measure it on the landscape.

Annual variability in phosphorus transport resulting from different hydrologic conditions can be greater than 100%. The error in a tributary loading estimate, based on a good event sampling program, will be 10-20%. There is no way that the early accomplishments in a diffuse source program will be measured at the river mouth. Measurement of changes in management practices and their location on the landscape will have to be monitored to determine progress in the short-term and explain long-term changes in tributary loads. River mouth monitoring of tributaries with sufficient historical data can be used to monitor changes which occur after the programs are in place for several years. River mouth monitoring, based on an event sampling format, has however been identified as a necessary element of the International Surveillance requirement for calculating annual water quality parameters of the Great Lakes, a matter not addressed by this report.

REFERENCES

1. Clark, J. C., "A Ratio Estimator for Estimating Tributary Loadings," in "Quality Control Handbook for Pilot Watershed Studies," International Reference Group on Great Lakes Pollution from Land Use Activities, Windsor, Ontario, March 1977.
2. Treunert, E., A. Wilhelms, and H. Bernhardt, "Effect of the Sampling Frequency on the Determination of the Annual Phosphorus Load of Average Streams", Hydrochem, hyd. geol. Mitt, Vol. I, pp. 175-198, March 1974.

3. Hetling, L. J., G. A. Carlson, and J. A. Bloomfield, "Estimation of the Optimal Sampling Interval in Assessing Water Quality of Streams," *Environmental Modeling and Simulation*, EPA 600/9-76-016, pp. 579-582, July 1976.
4. Yaksich, S. M. and F. H. Verhoff, "Sampling Strategy for River Pollutant Transport", *Journal of the Environmental Engineering Division*, ASCE, Vol. 109, No. EE1, February 1983, p. 219.
5. Verhoff, F. H. and S. M. Yaksich, "Storm Sediment Concentrations as Affected by Land Use, Hydrology, and Weather", *Journal of Environmental Quality*, Vol. 11, No. 1, January-March 1982, pp. 72-78.
6. Verhoff, F. H. and D. A. Melfi (1978), "Total Phosphorus Transport During Storm Events." *Journal of the Environmental Engineering Division*, ASCE, Vol. 104, p. 1021.
7. Verhoff, F. H., D. A. Melfi, and S. M. Yaksich (1979), "Storm Travel Distance Calculations for Total Phosphorus and Suspended Materials in Rivers," *Water Resources Research*, Vol. 15, pp. 1354 (1979).
8. Verhoff, F. H. and D. A. Baker (1980), "Moment Methods for Analyzing River Models with Application to Point Source Phosphorus", *Water Research*, 1980.
9. U.S. Army Corps of Engineers, Buffalo District, Lake Erie Wastewater Management Study Final Report, Buffalo, New York, September 1982.
10. Storm Water Management Model Study, Vol. I-III. Environment Canada and the Ontario Ministry of the Environment, Canada-Ontario Agreement Great Lakes Water Quality Res. Reports # 47, 48 and 62 (1976/77).
11. Storage, Treatment, Overflow Runoff Model. Computer Program 723-S8-L7520, Users Manual, July 1976.
12. Beasley, D. B., and L. F. Huggins, "ANSWERS Users Manual", Agricultural Engineering Department, Purdue University, West Lafayette, Indiana, 1980.
13. U.S.L.E. In-Service Training Seminar for OMAF, October 1977, University of Guelph.
14. NEC 6, Scour and Deposition in Rivers and Reservoirs, Users Manual, March 1977.
15. Johanason, R. C., J. C. Inhoff, and H. H. Davis, 1980. Users Manual for HSPF, Hydrologic Simulation Program - Fortran, Environ. Res. Lab., Athens Georgia, 30613, USA.
16. Monteith, T. J., T. M. Heidtke, R.A.C. Sullivan, and W. C. Sonzogni, "WATERSHED Handbook, a management technique for choosing among point and nonpoint control strategies", Great Lakes National Program Office, U.S. EPA.

17. Lake, James and James Morrison, "Environmental Impacts of Land Use on Water Quality, Final Report on the Black Creek Project", U.S. Environmental Protection Agency, Chicago, IL, October 1977.
18. Allen County Soil and Water Conservation District, "Planning and Evaluating BMP's, Black Creek Project", Brochure, Fort Wayne, IN.
19. Indiana Heartland Model Implementation Project, "Insights into Water Quality, Status Report", March 1981.
20. Adams, T. R., U.S. Army Corps of Engineers, Buffalo District, Personal Communication.

5. Response to PLUARG Recommendations

Over two years have passed since the PLUARG recommendations were officially transmitted to the Governments by the International Joint Commission (IJC). The Parties have so far made no official response to the International Joint Commission concerning their positions on these recommendations. This situation exists despite the broad based support for the PLUARG recommendations evident through its own intensive public consultation process and further confirmed through the Commission's own Post-PLUARG hearings.

Likewise, the two Governments have failed to complete negotiations on Annex 3 of the 1978 Great Lakes Water Quality Agreement. Confirmation of the target loads for the lakes and allocation of further phosphorus loading reductions are viewed by this Task Force as being fundamental to the resolution of the current impasse on the PLUARG recommendations.

After a thorough review of the programs and practices of the Parties, it is the Task Force's position that with the exception of surveillance, there has been no direct response by the Governments. This lack of a direct response, while impeding overall program co-ordination and implementation, has fortunately not prevented government agencies and non-governmental groups from undertaking a number of individual activities. These programs and activities along with the original PLUARG recommendation which they most closely support are briefly discussed in this chapter.

RECOMMENDATIONS

1. *Development of Management Plans*

PLUARG recommends Management Plans, stressing site-specific approaches, to reduce loadings of phosphorus, sediments and toxic substances derived from agricultural and urban areas, be prepared by the appropriate jurisdictions within one year after the International Joint Commission's recommendations are transmitted to the governments. PLUARG further recommends that a mutually satisfactory schedule for the reduction of nonpoint source loadings be annexed to the revised Great Lakes Water Quality Agreement.

Management plans should include:

- i) A timetable indicating program priorities for the implementation of the recommendations;*
- ii) Agencies responsible for the implementation of programs designed to satisfy the recommendations;*
- iii) Formal arrangements that have been made to insure inter- and intra-governmental co-operation;*

- iv) *The programs through which the recommendations will be implemented by federal, state and provincial levels of government;*
- v) *Sources of funding;*
- vi) *Estimated reduction in loading to be achieved;*
- vii) *Estimated costs of these reductions; and*
- viii) *Provision for public review.*

No action to develop comprehensive plans has been undertaken. In Canada, a number of comprehensive watershed management studies have been undertaken which address some of the criteria raised by PLUARG. In the United States, water quality management plans have been completed for various states and sub-state areas, but they are not specifically oriented to reducing loadings to the Great Lakes except for the Lake Erie Wastewater Management Study.

2. Planning

PLUARG recommends that governments make better use of existing planning mechanisms in implementing nonpoint source control programs by:

- i) *Insuring that developments affecting land are planned to minimize the inputs of pollutants to the Great Lakes; and*
- ii) *Insuring that planners are aware of and consider PLUARG findings in the development and review of land use plans.*

In Canada, the Planning Act, the Environmental Assessment Act, the Environmental Protection Act (EPA) and the Federal Environmental Assessment and Review Process (EARP) provide a means for addressing nonpoint pollutants during the planning stages of major land developments. Both the EPA and the EARP, due to their more restricted application, are not seen as having the potential to make a major impact on nonpoint source loadings. The Planning Act, while more all-encompassing, is not actively used to address such problems. An urban drainage policy statement is being considered under the Planning Act.

A number of urban municipalities have developed guidelines and criteria for limiting pollutant loadings during construction of new developments. However, the Province of Ontario has no uniform policies.

In the United States, regional and statewide water quality management plans have been developed to address both point and nonpoint sources of pollution, agricultural sources in particular. However, they are quite uneven in the extent they deal with nonpoint sources and none specifically address loadings to the Great Lakes. The Lake Erie Wastewater Management Study specifically addressed lake loadings and stands as the most comprehensive study of agricultural sources in the Great Lakes Basin.

At the request of the Environmental Protection Agency, the six Great Lakes States have developed statewide nonpoint source control strategies.

3. Fiscal Arrangements

PLUARG recommends that a review of fiscal arrangements be undertaken to determine whether present arrangements are adequate to insure effective and rapid implementation of programs to control nonpoint pollution. Such a review should include:

- i) Determination of the availability of grants, loans, tax incentives, cost-sharing arrangements and other fiscal measures;*
- ii) Determination of whether or not the terms of financial assistance programs are conditional upon the implementation of nonpoint source remedial measures.*
- iii) Determination of the extent to which various financial assistance programs are conditional upon the implementation of nonpoint source remedial measures.*

There is no evidence to suggest that there has been an overview of Canada's fiscal arrangements concerning nonpoint pollution control programs. Two provincial inter-ministerial groups, the Urban Drainage and the Soil Erosion and Sedimentation committees have recently reviewed provincial funding of programs and are expected to make recommendations to the Ontario government in the near future. Members of the same committees provided input and consultation to developing the Soil Conservation and Environmental Protection Assistance Program.

In the United States, no comprehensive review of fiscal arrangements has occurred; however, several studies have addressed fiscal problems of individual programs. In general, United States conservation and environmental programs are receiving less money. Nonpoint sources have received a very small share of water quality management funds. Soil conservation funding for water quality purposes has received low priority within the U.S. Department of Agriculture, although the shift from structural measures to tillage practices is providing improved benefits to water quality.

Most states provide substantial annual appropriations to support local soil and water conservation districts and co-operative extension programs.

4. Information, Education and Technical Assistance

PLUARG recommends that greater emphasis be given to the development and implementation of information, education and technical assistance programs to meet the goals of the Great Lakes Water Quality Agreement. This emphasis should include:

- i) Development of broad programs, through school systems, the media and other public information sources, describing the origins and impacts of pollutants on the Great Lakes and alternative strategies that should be followed by the public and government agencies to prevent water quality degradation;*

- ii) *Initiation of more specific programs to improve the awareness of implementors and those working in and for government, emphasizing the need for the further control and abatement of nonpoint pollution; and*
- iii) *Strengthening and expanding existing technical assistance and extension programs dealing with the protection of water quality, including rural and urban land management practices.*

In Canada, one conservation authority has undertaken a successful program of information, education and technical assistance (Upper Thames). A few other authorities have made some attempts in this area, including programs aimed at the primary and secondary school level, providing exhibits at fall fairs and other public events, etc. The level of effort varies widely among authorities but is generally a small percentage of their total budgets.

Many county level soil and crop improvement associations have increased their education efforts on soil conservation matters. The Ontario Ministry of Agriculture and Food (OMAF) has increased staff available for erosion-related extension and education purposes. Two films on soil erosion have been produced and are in great demand for showing at local meetings.

In the United States, soil conservation is strongly supported by the field staff of the Soil Conservation Service (SCS) which provides technical assistance; the field staff of the Cooperative Extension Service (CES) which provides education and information; the research segments of both SCS and CES; cost-sharing funds from the Agricultural and Stabilization and Conservation Service (ASCS) and other forms of support from various other USDA organizational units. Very little of this support is directed specifically toward water quality, however, it has water quality benefits associated with it.

In addition to soil conservation *per se*, several major demonstration programs in the United States and water quality management planning have greatly increased knowledge and awareness of nonpoint source pollution. Special projects have greatly increased the availability of technical assistance in several regional areas. Several states and counties have prepared comprehensive conservation tillage guides and the state of Ohio holds five to 10 regional conservation tillage workshops each year.

The International Joint Commission, through its Great Lakes Regional Office has been disseminating an information piece on citizen action for reducing pollution from land use activities as well as a display about land use pollution since 1978, and is in the final stages of developing a slide-tape program from loan distribution to groups.

5. Regulation

PLUARG recommends:

- i) *That the adequacy of existing and proposed legislation be assessed to insure there is a suitable legal basis for the enforcement of nonpoint pollution remedial measures in the event that voluntary approaches are ineffective; and*

- ii) *That greater emphasis be placed on the prevention aspects of laws and regulations directed toward control of nonpoint pollution.*

In Canada, some new regulations are in place to reduce nonpoint sources of pollution. A few municipalities have by-laws and guidelines for sediment runoff from construction sites; and under the Ontario Environmental Assessment Act certain types of development require environmental impact statements.

Most conservation authorities control and inspect development in floodplains and restrict filling. The Ontario Waste Management Corporation (OWMC) is formulating guidelines for industrial waste management.

OMAF and OWMC are the only agencies with programs that encompass all of southern Ontario. Each municipality develops its own runoff control criteria, however, not all have mapped floodlines and hazard lands and few have done this for entire watershed. Moreover, many agencies and types of development are exempt from the Environmental Assessment Act.

Experience has indicated that farmers are more receptive towards the adoption of a nonpoint source management program once they are made aware of the advantages to their own operations and the free technical assistance available.

In urban areas there has been little attempt to promote policies of controlling pollution at source before it enters urban runoff.

In the United States, many municipalities have enacted sediment control and runoff regulations as part of their subdivision review authority. Statewide sediment control laws have been passed in several of the Great Lakes States but they appear to be having little effect. In the 1983-84 revisions to the Federal Clean Water Act it is expected that an amendment or amendments regarding abatement of nonpoint sources of pollution will be developed.

6. Regional Priorities

- i) *The water quality conditions within each lake;*
- ii) *The potential contributing areas (PCA) identified by PLUARG; and*
- iii) *The most hydrologically active areas (HAA) found within these potential contributing areas.*

Coincidentally, in Canada, most of the work in managing nonpoint sources has occurred in the Lake Erie Basin. This is largely because of interest in local water quality concerns or agricultural production problems, and not an expressed concern for Great Lakes water quality.

Several agencies have identified priority areas. OMAF has ranked counties according to the cost of erosion to agriculture, but has not prioritized its funding accordingly. Though the Lands Directorate of Environment Canada has mapped areas prone to erosion and likely to deliver

sediments to waterbodies in southwestern Ontario, no evidence shows that federal priorities or programs have been influenced.

The Thames River Implementation Committee (TRIC) study used the mapped priority areas as a basis for guiding implementation of remedial programs. The Grand River Implementation Study (GRIC) study utilized PLUARG data in its computer simulations of potential nonpoint loadings and embarked on a federally assisted program to identify priority management areas within the watershed.

With the exception of TRIC, GRIC and Environment Canada, few agencies or studies have utilized the concept of potential contributing areas. The objective of most agencies is to meet MOE water quality criteria in streams under their jurisdictions. Few are concerned with potential impacts upon the Great Lakes.

In the United States, the demonstration projects of the Environmental Protection Agency's Great Lakes Demonstration Grant Programs have addressed nonpoint source problems in each of the Great Lakes. EPA has focussed much of its demonstration grant resource in Lake Erie Basin where a series of projects and the Corps of Engineers' Lake Erie Wastewater Management Study have focussed resources on identifying and implementing effective low cost measures for the control of phosphorus from nonpoint sources. Focussing the projects in the high phosphorus clay soils of the western basin was clearly in response to a water quality priority. However, within the selected watersheds the emphasis has been on obtaining successful demonstrations rather than seeking out the fields with the highest unit loads. The assumption is that the entire western basin is a hydrologically active area and that once successfully demonstrated, low cost measures will be adopted throughout the area.

At the state level, Wisconsin has a well-developed priority system for selecting its nonpoint source grant projects. Other Great Lakes states have identified their priority problem areas as part of their state nonpoint source strategies.

7. Control of Phosphorus

PLUARG recommends that phosphorus loads to the Great Lakes be reduced by implementation of point and nonpoint programs necessary to achieve the individual lake target loads specified by PLUARG.

It is further recommended that additional reductions of phosphorus to portions of each of the five Great Lakes be implemented to reduce local nearshore water quality problems and to prevent future degradation.

While the Governments have moved to meet the phosphorus effluent requirement at sewage treatment plants of 1 mg/L, the target loadings have not been met due to deficiencies in the nonpoint program. Target loadings set forth in the 1978 Agreement by the two governments remain unconfirmed.

The Toronto Area Watershed Management Study and the Rondeau Bay Study have both

been developed in part in response to degradation of an important nearshore water resource. The extent of support to implement recommendations of these studies is unknown.

In the United States, point source control has made excellent progress. Nonpoint source controls have also progressed, particularly in the Lake Erie Basin. Also, the Water Quality Board and International Joint Commission are focussing attention on phosphorus control problems in three Areas of Concern: (geographic area where specific water quality objectives under the Agreement are violated) Green Bay, Saginaw Bay and the Maumee River/Western Lake Erie area.

8. Control of Sediment

PLUARG recommends that erosion and sediment control programs be improved and expanded to reduce the movement of fine-grained sediment from land surfaces to the Great Lakes system.

Reductions in soil erosion from cropland and streambank have received the most attention. OMAF's financial assistance program is designed to reduce erosion on farmland thereby maximizing net production returns. The program still lacks a major resource commitment to planning, technical assistance/demonstration and evaluation to ensure widespread adoption and implementation in priority areas over the long-term.

Conservation Services Programs have increased the amount of effort devoted to erosion control and sedimentation, but most remedial work focusses on the erosion of streambanks, a relatively minor source of sediments to the Great Lakes System. Only UTRCA and ERCA have programs to reduce sedimentation from field erosion. The UTRCA is also the only conservation authority that conducts most of its remedial measures in priority problem areas.

There is no evidence to show that a significant reduction of sediment loadings to the Great Lakes Basin has been accomplished.

In the United States, the U.S. Department of Agriculture's soil conservation programs continue to operate with increasing emphasis on control through tillage practices. The Great Lakes Demonstration Grant Program of EPA and the Lake Erie Wastewater Management Study of the Corps of Engineers both stress sediment control as a means of controlling phosphorus loads to the lakes. Some sediment control regulations have been adopted by state and local governments as reported above.

9. Control of Toxic Substances

PLUARG recommends the following actions be taken to reduce inputs of toxic substances to the Great Lakes:

- i) Control of toxic substances at their sources;*
- ii) Closer co-operation of both countries in the implementation of toxic substances control legislation and programs;*

- iii) Proper management and ultimate disposal of toxic substances presently in use;*
- iv) Identification and monitoring of historic and existing solid waste disposal sites where there is an existing or potential discharge of toxic substances, and the implementation of control programs at those sites as needed; and*
- v) Joint expansion of efforts to assess the cumulative and synergistic effects of increasing levels of these contaminants on environmental health and the rapid translation of these assessments into refined water quality objectives, other environmental objectives and, wherever possible, tolerable loads. For certain toxic substances, a zero load will be necessary.*

More attention has been directed towards toxic substances since PLUARG. The Ministry of the Environment has been active in controlling discharge of toxic substances at active and abandoned sites and is cleaning up known problem areas. The Ministry of the Environment is also conducting studies on toxic substances in several Ontario cities and in the Niagara River. The Toronto Area Watershed Management Strategy Study is concerned primarily with toxic substances and is rectifying problems as they are discovered.

The Parties have co-operated in a limited number of joint studies on toxic substances, particularly the program to reduce loadings to the Niagara River. However, there are differences between the two in the types and concentrations of chemicals that may be utilized. Problems concerning safe transport of hazardous chemicals within each country have yet to be solved, and there has been no agreement on policies for transporting substances across the border.

The use of persistent pesticides, e.g. DDT, dieldrin, after World War II resulted in widespread environmental problems in the Great Lakes Basin. In addition, local manufacturing or processing of some pesticides, e.g. mirex, caused regional contamination problems in the lakes system. Since the early 1970s, however, the United States and Canadian Governments have moved to ban or severely restrict the uses of these chemicals -- resulting in gradually declining contaminant levels in fish and wildlife.

However, between 1966 and 1981 agricultural use of less persistent herbicides and insecticides nearly tripled, with most agricultural cropland receiving treatment. Environmental impacts of this chemical usage have been localized, but monitoring by both the United States and Canada since 1978 have increasingly identified levels of these chemicals in tributaries to the Great Lakes, particularly Lakes Erie and Ontario. There is conflicting opinion as to whether the adoption of conservation tillage will increase pesticide usage. Both this question, and the short and long-term impacts of less persistent herbicides and insecticides usage need further study.

The Ontario Pesticides Act has removed many toxic substances from the market and has made it mandatory that only trained personnel can apply such compounds. However, most agricultural uses are exempt and do not require personnel to be licensed.

Organochlorines migrating from industrial waste sites are still creating problems. Their regulation will eventually come under the jurisdiction of the Ontario Waste Management Corporation. The OWMC, in conjunction with the Ministry of the Environment, is starting to embark on a program to identify historic and existing waste disposal sites. OWMC has identified areas suitable for hazardous waste facilities and a site-specific search is in progress. A study of the potential in Ontario for reduction, reuse and recycling of hazardous and other industrial wastes has been commissioned by OWMC and the Ministry of the Environment has been active in promoting recycling.

Few joint efforts to assess cumulative and synergistic effects of contaminants. This aspect of toxic substances is still poorly understood, but both the federal and provincial governments are conducting research in this field. Water quality objectives continue to be refined as impacts upon water quality and aquatic biota are better understood.

In the United States, many of the most persistent and bioaccumulative pesticides have been banned from use and biodegradable alternatives have replaced them. However, the overall quantity of pesticides in use has steadily increased.

In the United States legislation enacted since PLUARG has rapidly changed toxic substances regulation. The Toxic Substance Control Act addresses the manufacture and use of compounds, the Resource Conservation and Recovery Act addresses the transport and disposal of toxic substances and the so-called Superfund Program addresses clean up of hazardous waste sites. The combined effect is regulation of virtually every aspect of toxic substances.

10. Control of Microorganisms

PLUARG recommends that epidemiological evidence be evaluated to establish applicable microbiological criteria for body contact recreational use of water receiving runoff from urban and agricultural sources.

No changes in criteria have been established.

11. Agricultural Land Use

PLUARG recommends that agencies which assist farmers adopt a general program to help farmers develop and implement water quality plans.

This program should include:

- i) A single plan developed for each farm, where needed;*
- ii) Consideration of all potential nonpoint source problems related to agricultural practices, including erosion, fertilizer and pesticide use, livestock operations and drainage; and*
- iii) A plan commensurate with the farmers' ability to sustain an economically viable operation.*

None of the agencies mandated to assist farmers have adopted a program which is directed towards developing individual farm water quality management plans. Assistance programs are generally offered on a first-come, first-serve basis and are largely restricted to the provision of fixed cost-share funds emphasizing the construction of structural remedial measures.

In the United States, major change is underway in tillage practices as described elsewhere in this report. The greatest changes are occurring in the western Lake Erie basin under the stimulus of changing technology, changing economic conditions, education and assistance programs. Some address soil conservation and some (EPA and COE) address water quality, but are focussing on conservation tillage. Similar EPA and USDA projects and programs operating elsewhere are encouraging tillage practice changes.

12. Urban Land Use

PLUARG recommends the development of management plans for controlling urban stormwater runoff. These plans should include:

- i) Proper design of urban stormwater systems in developing areas such that the natural stream flow characteristics are maintained; and*
- ii) Provision for sediment control in developing areas, and control of toxic substances from commercial and industrial areas.*

Because of the expense of up-grading existing systems, stormwater management plans should deal primarily with new development. Old development should be improved only if it is creating severe problems in a localized area.

In Canada, urban sources of nonpoint pollution have received very little attention. Most provincial and watershed agencies addressed problems associated with excessive stormwater runoff and have taken the position that urban nonpoint sources of pollution are negligible compared to agricultural sources. Agencies have tended to identify phosphorus and sediments as the key problems, and have ignored compounds such as phenols, PCBs, mercury and lead which originate almost exclusively from urban areas.

With the assistance of provincial and watershed agencies on urban nonpoint sources of pollution, several municipalities have developed comprehensive stormwater management policies, guidelines and plans. These plans are designed to minimize flooding, sediment and related pollutant loads from new developments. However, the lack of design criteria, inadequate planning tools and limited surveillance and enforcement, limit the effectiveness of these initiatives.

In urban areas there has been little attempt to promote policies of controlling pollution at its source before it enters urban runoff.

The Toronto Area Watershed Management Study is dealing with urban nonpoint sources of pollution on a "sewershed" basis. Management plans and guidelines will be formulated for each basin and severe problems will be addressed as they are found.

In the United States, urban land use is the jurisdiction of local government. A number of municipalities have passed sediment control ordinances and are conducting land use planning to protect water quality. The Water Quality Management Program funded under Section 208 of the Clean Water Act provided support for major water quality planning efforts at regional and state levels during the late 1970's. Many of the resulting plans were linked to land use. The best example of this is in southwestern Wisconsin. There all extensions of sewer service into new areas must be consistent with the regional land use/water quality plan on a site-specific basis. Unfortunately, such strong programs are uncommon.

13. Wetlands and Farmlands

PLUARG recommends the preservation of wetlands, and the retention for agricultural purposes of those farmlands which have the least natural limitations for this use.

In Ontario, OMAF recognizes and promotes the value of preserving prime agricultural land through the use of its foodland guidelines. The fact that these are only guidelines has limited their overall effectiveness in reducing the loss of prime agricultural land. Over the past two years the Ontario Ministry of Natural Resources has been developing a policy statement for conserving important wetlands. In support of this policy statement, Environment Canada and the Ontario Ministry of Natural Resources have jointly developed a wetland evaluation system to be used to determine the relative value of wetlands when making land use planning decisions. Environment Canada has also mapped the areas of wetlands dating from pre-settlement time until the present to determine rate of loss of this important resource. Maps will be provided to local jurisdictions. A number of wetland acquisitions have been made but acquisition programs are hampered due to lack of fund and long-term management. A number of studies directed at improving our understanding of key wetlands have also been undertaken.

In the United States, the Dredge and Fill permit program based upon Section 404 of the Clean Water Act requires that a permit be obtained from the U.S. Corps of Engineers before any wetland can be dredged or filled. Two presidential executive orders are of note; order 11988 addressing flood plain management and order 11990 addressing the protection of wetlands. Also, the U.S. Department of Agriculture has a formal policy; regulation 9500-3 concerning prime agricultural lands, wetlands and flood plains.*

14. Local Problem Areas

PLUARG recommends that the International Joint Commission, through the Great Lakes Regional Office, insure that local levels of government are made aware of the availability of PLUARG findings, especially as they relate to local area problems, to assist them in developing and implementing nonpoint source management programs.

* 1982-83 Biennial Report of the Dredging Subcommittee of the Water Quality Board also has a chapter on "Great Lakes Wetlands."

PLUARG data was disseminated to conservation authorities and is available at major libraries. It is questionable if this information was effectively presented at the county level and certainly not at the township level. The IJC could not promote the PLUARG recommendations nor could it assist directly the local agencies in identifying and solving nonpoint source problems as such actions are the responsibility of the signatories to the 1978 Great Lakes Water Quality Agreement - Article VI(1e).

15. Review of Implementation

PLUARG recommends:

- i) The International Joint Commission insure regular review of programs undertaken for the implementation of recommendations from this reference; and*
- ii) That nonpoint source interests be represented during these reviews.*

The actions of this Task Force represent the first formal review by the IJC of the activities of the governments in support of the PLUARG recommendations. However, IJC through its Boards and Windsor Office actively participated in the Post-PLUARG reviews conducted by the Great Lakes Basin Commission.

16. Surveillance

PLUARG recommends that tributary monitoring programs be expanded to improve the accuracy of loading estimates of sediment, phosphorus, lead and PCBs. Sampling programs:

- i) Should be based on stream response characteristics, with intensive sampling of runoff events, where necessary; and*
- ii) Should be expanded to include toxic organic compounds, toxic metals and other parameters as may be defined in the future.*

Further, the role of atmospheric inputs should be considered in the evaluation of Great Lakes pollution, with special consideration given to determination of the sources of major atmospheric pollutants.

Efforts should be made to improve the co-ordination between data collection and data user groups, and agreements established regarding data collection standards and accessibility.

PLUARG further recommends that the adequacy of U.S. Great Lakes nearshore and offshore water surveillance efforts be examined.

In Ontario, the Saugeen River (L. Huron), Thames River (L. St. Clair) and the Grand River (L. Erie) are sampled intensively for a full range of toxic organics and metals.

Atmospheric pollutants are monitored in the Canadian portion of the Basin at 16 sites for nutrients in major ions and Cu, Pb, Zn, Fe and Cr. The sampling network has been expanded since 1978 to include each of the Great Lakes Basins. Both bulk and wet deposition are monitored. The period of record remains too short to make loading estimates for the individual lake basins with confidence. Data sets are made available annually to the International Joint Commission.

Tributary monitoring data are released in an annual report. The most recently available data - for 1980 - pertaining to toxic substances could not be analyzed and interpreted for this report due to resource and time limitations. In the absence of such analysis and interpretation, its significance to the health of the Great Lakes ecosystem remains unknown.

In the United States, the Geological Survey (USGS) maintains an extensive system of stream gauging stations which record flow levels and some limited water quality data. Each state conducts water quality monitoring at key tributary mouths. Traditionally, the states have gathered monthly grab samples and submitted the data to the Great Lakes Regional Office of the Commission where annual loads have been calculated using the Beale ratio estimator. During the past two years additional sampling of high flow events on key tributaries has been supported by the EPA Great Lakes National Program Office (GLNPO) in order to verify the loading estimates. A program of fish tissue and sediment sampling in the tributary mouth areas is also being conducted by GLNPO using gas chromatography/mass spectroscopy scans in order to locate toxic contamination problems.

17. Role of the Public

PLUARG recommends that the International Joint Commission establish a comprehensive public participation program at the outset of future references.

No new references have been made to the Commission since this recommendation was made to the Governments in 1980.

6. Conclusions

The Task Force finds that cost-effective management practices and implementation programs are available and have been demonstrated in the Great Lakes Basin. Sufficient technical knowledge exists to support implementation of programs to reduce nonpoint sources of pollution to the Great Lakes.

As a result of an extensive review of programs, practices and issues surrounding the management of nonpoint sources of water pollution, the Nonpoint Source Control Task Force concludes that the basic recommendations developed by the PLUARG and presented in its July 1978 final report remain valid. The Nonpoint Source Control Task Force is concerned that with the exception of surveillance, the governments have not formally responded to the PLUARG recommendations. There have been, however, a number of local initiatives directed towards improving erosion and sedimentation control and addressing site-specific water quality problems. It is doubtful if these efforts will become part of a cohesive and coordinated program to deal with nonpoint loadings to the Great Lakes until the Parties fulfill their commitments under Annex III of the Great Lakes Water Quality Agreement of 1978.

6.1 Programs

1. Successful nonpoint source projects have required multi-agency involvement at the earliest stages of planning through to implementation and evaluation. The most successful programs have established a formal framework for involvement and a clearly defined lead agency. Programs which have ignored these concepts have not had widespread success. Adoption of the lead agency concept has improved overall accountability for program design and achievements and assisted in bringing together divergent viewpoints in a constructive manner.
2. Demonstration projects conducted in specific geographic areas have been highly successful in achieving local implementation and in quantifying reductions in sediment and phosphorus losses. Factors which have lead to project success include:
 - Providing a focus which enrolls local support through a sense of responsibility, provides credibility, enhances communication, builds local leadership and generally creates vitality.
 - Providing a point of focus for federal and state/provincial programs which when integrated around specific objectives can produce results exceeding the sum of individual agency efforts.
 - Setting specific objectives which are understood and supported by the project

personnel and the affected communities.

- Providing equipment for experimental use on the farmer's own land and actual experience with the management practice on a small scale together with providing direct hands-on, in-the-field technical assistance to assure understanding and acceptance by the farmer.
 - Providing demonstration sites throughout the project area so that many owners see the practice being used by people they know, on familiar land.
3. The success of some local/regional government agencies in taking the initiative after PLUARG is admirable, but the area effected has been small.
 4. Improving Great Lakes water quality has not been a specific objective of many of the existing nonpoint programs in Canada and the United States. These programs are primarily directed towards the prevention of soil erosion and their main objective is to preserve topsoil and maintain or improve agricultural production. Although pollution control has not been maximized, this has not hampered the success of individual projects. However, the lack of a comprehensive overall management strategy, including a method for evaluating program success, has made it difficult to assess their cost-effectiveness in meeting Great Lakes water quality objectives.
 5. Extensive background data bases exist in the PLUARG pilot watersheds, the western Lake Erie watersheds, and a few other locations. Such watersheds provide an opportune area for the priority implementation of remedial measures to assess and demonstrate their overall effectiveness.
 6. United States baseline (long-term) soil conservation programs are operating with diminishing resources and a lack of clear priority focus on water quality or benefits to the Great Lakes. Decreased resources also reduce the support that the baseline programs can give to special projects.
 7. The policy of shifting responsibility from the United States federal to state levels has, with few exceptions, not resulted in increased State resources.
 8. Loadings of phosphorus from urban stormwater runoff are relatively small compared to other sources. Therefore, no remedial programs are necessary nor such programs are cost-effective on a basin-wide basis to control pollutants from urban nonpoint source runoff. Loadings of heavy metals (e.g. lead and zinc) may represent an important source of pollutants in some harbors, estuaries and nearshore areas and, therefore, further assessment is needed.

9. Inclusion of water quality concerns in urban stormwater management and erosion control regulations by local, regional, state and provincial planners for developing areas are effective means of reducing sediment and phosphorus loadings.

6.2 Practices

1. Although the Parties have failed to address nonpoint source problems to the extent and in the manner recommended by PLUARG, significant progress has been made in developing cost-effective practices for reducing soil erosion and limited but important progress has also been made in implementation.
2. Several approaches, particularly those tillage practices leaving crop residues on or near the soil surface, have been demonstrated to be more cost-effective than reported by PLUARG. In many cases greater profit is achieved using these measures as compared to conventional tillage practices.
3. The level of interest in alternative tillage practices is growing in both the United States and Canada. Voluntary adoption of reduced tillage practice is increasing in both countries.
4. Final determination of the most cost-effective remedial measures will depend on site characteristics, marketing options and relative net economic returns to the farm operation. Thus a remedial measure program will involve consideration of a variety of practices tailored to the individual needs of each farm operation.
5. The most cost-effective way to deal with urban drainage problems, in terms of both quality and quantity, is through adoption of land use planning, master drainage planning and stormwater management planning. At the master drainage planning stage of land development, water quality concerns can be addressed together with quantity problems. If quality control is necessary, suitable designs and practices can be incorporated into the stormwater management plans to integrate both quantity and quality control minimizing costs and maximizing benefits e.g. modifications to the design of stormwater detention/retention facilities.
6. Erosion control practices can be cost-effective in providing water quality benefits, particularly during the land disturbing stage of development.

6.3 Issues

1. **Priority Management Areas**
Only a small number of nonpoint programs have been targeted to those areas of the landscape which contribute a disproportionately large share of the total pollution load.

2. With a continued scarcity of resources, it will be necessary for governments to identify their priority management areas and target their resource expenditures accordingly.
2. **Transport and Transformations**
Assessment of priorities for implementing point and nonpoint source management practices must consider the issues of phosphorus and sediment transport through streams and their subsequent delivery to the Great Lakes.
3. **Phosphorus Bioavailability**
Point and nonpoint sources of phosphorus are bioavailable and both must be addressed in establishing cost-effective remedial strategies and making management decisions.
4. **Pesticides**
The use of toxic chemicals for pest control purposes have increased substantially in the Great Lakes Basin over the last decade. Although the governments have either banned and/or severely restricted the use of persistent organochlorines, their replacements, and especially herbicides, are being used in greater frequency and also quantity.

Pesticide levels in some tributaries of the Great Lakes, especially those situated in close proximity to the areas of application, are of special concern. Another matter of even greater concern is the contamination of groundwater resources by the numerous chemicals used generously for pest and weed control purposes.

5. **Wind Erosion**
Wind erosion of soils in the Great Lakes Basin is seen as a factor affecting lake loadings of sediment and phosphorus. Fortunately, some of the remedial measures designed to reduce soil erosion are effective in dealing with wind erosion.
6. **Evaluation of Program Effectiveness**
Since PLUARG there have been changes in the monitoring of Great Lakes tributaries in order to provide more accurate assessments of total pollutant loadings. These changes include a greater emphasis on other parameters and towards sampling runoff events which transport a disproportionate share of the total nonpoint load.

Continuous tributary monitoring is extremely important in order to provide the necessary data to calibrate watershed models and to evaluate the long-term effectiveness of program success. Over the short-term even well designed tributary monitoring programs will not be sufficiently sensitive to detect the initial changes in pollutant loads.

Measurement of changes in management practices and their location on the landscape will have to be monitored to determine progress in the short-term and explain long-term changes in tributary loads.

The Great Lakes Overview Model, developed under PLUARG, was the first attempt to estimate phosphorus loading reductions which could be achieved under different remedial measures strategies. Today a number of more refined approaches to watershed modelling are available and should be actively pursued in order to provide a basis for assessing expected reductions in nonpoint pollutant loads.

7. The degree of uncertainty for the above issues has been reduced to a level where aggressively pursuing widespread implementation of a nonpoint source management program can proceed with assurance of cost-effective improvement in water quality as well as associated resource conservation benefits.

7. Recommendations

The Nonpoint Source Control Task Force recommends that:

1. The International Joint Commission renew its request to immediately ask the Governments to respond to the PLUARG recommendations and to complete their negotiations on Annex 3. Further, agencies and governments should develop and implement policies and funding mechanisms in support of an accelerated nonpoint program e.g. Ontario's Urban Drainage Policy and Guidelines and funding or the 10-year accelerated conservation tillage program identified in the LEWMS 1982. The Commission is also asked to act independently to plan and fund a greater effort to make governmental agencies and the public aware of the PLUARG recommendations and their individual responsibility in the management of the Great Lakes ecosystem.
2. That the Governments provide sufficient time and resources to ensure that programs have clearly defined goals and objectives, assess the nature and extent of the problem, prioritize problem areas, provide for demonstration, identify the most cost-effective remedial measures, provide technical assistance and adequate resources and provide for ongoing monitoring and evaluation.
3. That areas within watersheds which have a higher potential to deliver pollutants be identified and that implementation of measures in these areas receive priority attention.
4. That an effective information and education effort to create a better awareness of remedial measures and their benefits and provision of adequate technical assistance be a part of any implementation effort. This will ensure timely adoption and the long-term success of the program.
5. That implementation of remedial practices be, at least in part, focussed on a demonstration watershed approach (e.g. PLUARG pilot watersheds and western Lake Erie tributaries) which will provide a basis for adequate monitoring and evaluation of program success.
6. That overall effectiveness of nonpoint source control programs in attaining phosphorus target loads be evaluated through simulation modelling, surveys of the extent of implementation of agricultural practices and tributary monitoring.
7. That developing urban areas be guided by a master drainage plan and stormwater management plan which make integration of quality as well as quantity design possible at the design stage of proposed urban drainage systems to maximize benefits. Urban erosion and sediment control programs should be implemented at the time of land disturbance.

8. That studies of urban harbor, estuary and other nearshore problem areas include analysis of urban runoff to determine whether it contributes significant loadings of problem pollutants.
9. That monitoring of surface and groundwater for pesticide residues and their metabolites be expanded in those areas of the basin where pesticides use is most intense.
10. That there be greater emphasis on event sampling of tributaries with follow up interpretation in order to provide the International Joint Commission and the Parties with an up-to-date assessment of nonpoint loadings.
11. That studies be initiated and/or expanded pertaining to nonpoint issues and especially those identified in this report.

Appendix I

DETAILED DESCRIPTION OF CANADIAN PROGRAMS

In the field services category a number of programs are related to soils and crops. In April, 1983 OMAF discontinued its Farm Productivity Incentive Program (FPIP) and, in its place, introduced a five-year, \$25.5 million Soil Conservation and Environmental Protection Assistance Program. The soil conservation component has a budget of \$1 million for 1983 and \$2 million for each of the next four years.

The program provides a 50% subsidy to a maximum of \$7,500 for structural erosion control measures such as grassed waterways, gully reclamation, chute spillways, terraces, contours and diversions. The subsidy program allows for hiring of a consulting engineer to prepare appropriate designs but provides no funds for additional staff. Soil and crop management conservation practices are not eligible for the subsidy and the education and demonstration component of the FPIP has been dropped.

In 1982, the FPIP provided grants totalling about \$200,000 to 140 farmers for erosion control and \$200,000 for education and demonstration projects. More funds were available, but too few farmers applied. Those who did apply, represent only about 1.7% of the Ontario farmers in the Great Lakes basin. A major question remains as to whether the newly expanded program will meet with any greater level of success. The main objectives of the program are to provide assistance to producers in controlling soil erosion, sustain crop productivity and protect water resources. However, program funds are not directed to priority contributing areas. Therefore, any improvement in water quality should be considered an accidental benefit.

In addition to its capital grants program, OMAF provides staff support (about two person-years) for demonstration projects sponsored by county farm groups such as the Ontario Soil and Crop Improvement Association. It has reallocated about 11 person-years of staff time to the erosion control area since PLUARG to cover extension and administration activities. There is, however, no full time technical staff assigned to this activity. Some of this staff time has supported inter-agency special basin study and demonstration projects. OMAF funds have also helped to support research in conservation tillage.

Twenty-one of Ontario's conservation authorities have Conservation Services Programs which provide technical and financial assistance for erosion control on private land. The Upper Thames River Conservation Authority has actively promoted its program in a priority area, but the remainder operate on a first-come, first-serve basis. Remedial practices are generally directed toward streambank stabilization and tree planting; only two authorities (Essex Region and Upper Thames River Conservation Authorities) have field erosion control assistance programs for water quality improvement purposes.

The amount of money and effort that conservation authorities expend on erosion control

programs has increased since PLUARG, in spite of relatively constant overall budgets. In 1982, approximately 27 person-years of technical assistance were devoted to erosion programs, although most of the effort was directed at streambank erosion problems. In 1983, the total Conservation Services Program budget for southern Ontario conservation authorities is about \$2 million, an increase of 22% over 1982.

The Ontario Ministry of Natural Resources has initiated a program to rehabilitate and enhance fish habitat in priority areas, and offers cost-sharing arrangements to landowners participating in the program. Typical management practices include streambank stabilization measures, instream structures to improve fish habitat and reduce sediment loading from adjacent fields.

In 1982, about 32 km of stream were treated through co-operation with about 20 landowners. The total annual program budget is \$150,000. Staff support comes both from head office and district office; the level in any one year depends on the number of active projects.

There have been no significant changes in fertilizer management since PLUARG. The OMAF continues to offer a free service to farmers in testing soils and recommending fertilizer and lime application rates. About 15,700 farmers (about one-quarter of the total) in Ontario use the service annually. The annual growth rate is about 5%. Likewise, the activities of the Sewage Sludge Implementation Committee in guiding the use of sewage sludge as fertilizer on farmland continue as before. Research on land disposal of sewage sludge, initiated prior to 1972 under provisions of the Canada-Ontario Water Quality Agreement, has continued.

The primary livestock residuals program is the manure storage facility component of OMAF's Soil Conservation and Environmental Protection Assistance Program. Eligible farmers may receive a 33.3% grant, up to \$5,000, to construct manure storage facilities and alternate water sources for livestock. The purpose of this program is to protect water quality by decreasing runoff from inadequate manure storage. The 1983 budget is \$2.5 million, with \$3.5 million planned for each of the following four years.

Also, a few conservation authorities provide subsidies for restricting cattle access to streams.

Agricultural pesticide field programs include advice to farmers under the Integrated Pest Management Program (IPMP) and various publications of OMAF. The IPMP began after the PLUARG study had ended and has had very little influence on water quality. MOE continues to respond to pesticide-related incidents on a site-specific basis. It is also active in cleaning up old landfills sites and has upgraded its water quality monitoring system to include analysis of more pesticides and more sampling stations.

In investigating the effects of land use activities on the Great Lakes system, PLUARG undertook intensive studies of land uses, characteristics and management practices in several representative watersheds in Canada and the United States. These pilot watershed studies were undertaken in six major drainage basins and in 11 smaller agricultural watersheds in southern

Ontario. These studies were fundamental to PLUARG in developing its conclusions about problem identification and remedial measure recommendations.

At the completion of PLUARG this valuable research and monitoring framework was abandoned without further consideration as to its possible role during the implementation of a nonpoint source management program. Because of the intensive study which took place in these watersheds, there was a much clearer understanding of the priority areas which needed to be treated to reduce pollutant loadings. The excellent baseline monitoring data on which success of remedial programs in reducing pollutant loads could have been measured is still available.

Serious consideration should be given now to utilizing some of this earlier investment of resources as a means to accelerate program implementation and evaluation.

The category of studies, data base and demonstration program activities has experienced considerable activity since PLUARG. However, most activities have been directed at instream water quality problems, a few at nearshore Great Lakes water quality problems, and others at the problem of erosion impacts on long-term soil productivity.

None of these programs was specifically mounted to address the problem of water quality on a lake-wide basis in any of the Great Lakes. A few acknowledge the fringe benefits to Great Lakes water quality from better management of land runoff. However, in no case does the rationale or justification for remedial action explicitly take into account the need for, or the magnitude of such benefits.

Of the program activities listed, only one, Thames River Implementation Committee (TRIC), is an education-demonstration (implementation) program. The remainder are designed to define and characterize problems and to recommend strategies for their resolution or serve a routine water quality monitoring function.

Following a water management study by MOE of the Thames River Basin, an inter-agency three-year work program was established in 1980 under the TRIC to further address issues of flood control and water quality. About 95% of a \$788,000 budget was used to encourage better land management practices and thus reduce pollution from rural diffuse sources. Public education and demonstration projects were carried out; about 100 farmers participated in conservation tillage and other soil conservation practice demonstrations. In co-operation with this program, the Lands Directorate of Environment Canada developed and applied a procedure for area-wide definition of priority management areas.

In 1982 the inter-agency Grand River Implementation Committee (GRIC) completed a five-year study of water quantity and quality problems in the Grand River watershed. It recommended a comprehensive management program including measures for controlling nonpoint source problems, both in urban and rural areas. It recommended six priority rural areas in which more work should be undertaken to define priority management areas and evaluate alternative nonpoint source management measures.

The Lake Simcoe Environmental Management Project is another inter-agency study. It is designed to estimate phosphorus loadings to the Lake Simcoe-Couchiching system, evaluate agricultural and urban sources of pollution, predict future loadings and identify appropriate measures to reduce these loads. About 70% of the three-year, \$650,000 study budget is directed at nonpoint source problems. The study is to be completed in 1984.

The Stratford-Avon River Environmental Management Project is a three-year, inter-agency study that was initiated in 1980. Through a water sampling program, the study has estimated the role of various remedial measures on loadings of nutrients and sediments and, ultimately, on reducing eutrophication, bacterial concentrations, sediments and toxicants. Recommendations which address rural and urban point and nonpoint sources of pollution have been prepared for public comment. Mapping of priority management areas is also complete.

The Rondeau Bay Watershed Master Erosion Control Plan was initiated in the fall of 1982 and completed early in 1983. The plan for reducing soil erosion and heavy sedimentation from cropland in the Rondeau Bay area was prepared under the direction of a Steering Committee of local farmers with funding from MOE and OMNR.

The study determined the extent and types of sediment and erosion problems, and identified the steps necessary to correct the problems. Detailed goals, objectives and strategies were presented for bringing priority problems to an acceptable level of control. The Committee further recommended that a full-time person be provided to give technical assistance to this program.

The Oshawa Second Marsh Baseline Study. In 1983 Environment Canada completed a two-year study of the Oshawa Second Marsh and the adjoining watersheds of Farewell and Harmony Creeks. Sedimentation of the Second Marsh has been identified as a priority problem requiring attention. To this end a detailed mapping of watershed soil erosion dating from pre-settlement of the watershed has been completed. This information, together with the identification of priority management areas, will enable the targeting of a comprehensive erosion and sediment control program.

The Provincial Water Quality Monitoring Network (PWQMN) was established in 1964 to provide compliance and surveillance data on inland waters in Ontario. Presently, about 45% of the stations in the PWQMN are located downstream of known or suspected water quality problem areas, such as sewage treatment plants, industrial discharges, mines, urbanized areas and major transportation corridors. Approximately 19% of the stations are located in agricultural and wooded or idle areas. The remaining 36% are situated at, or near, the mouths of rivers and streams and, thus, indicate aggregate water quality from a variety of land uses in the respective basins.

The outlets of 63 major tributaries to the Great Lakes representing 75% of the Canadian basin area are monitored for routine physical, chemical and bacteriological parameters. Load estimates for these rivers are provided annually to the Great Lakes Water Quality Board of the International Joint Commission. In response to the PLUARG recommendations concerning

surveillance, the Enhanced Tributary Monitoring Program was established in 1979 at 15 key Great Lakes tributaries to obtain a better data base, to improve the precision of tributary load estimates of phosphorus, sediment, lead and PCBs, and to establish procedures to optimize future Great Lakes tributary sampling. Sample collection frequency ranges from 12 times per year at most routine stations, to more than 100 times per year at some high priority stations.

In 1982, MOE spent approximately \$1,500,000 on this monitoring program. Program implementation required about 22 man-years of staff time.

In 1975, a Memorandum of Agreement was signed by the governments of Canada and Ontario establishing the Canada/Ontario Cost Share Agreement on Water Quantity Surveys. The Agreement provided for the co-ordinated and standardized collection of streamflow data in Ontario to facilitate resources planning and management. The Agreement called for the classification of all water quantity survey stations as either federal, federal-provincial or provincial, with the annual operation and maintenance costs borne by the responsible party.

In 1981, the streamflow network included 432 stations, with 216 (50%) classified as federal, 38 (9%) federal-provincial, and 180 (41%) classified as provincial. Water quantity data generated by this network are essential to the preparation of Great Lakes tributary load estimates which are provided annually to the Great Lakes Water Quality Board of the International Joint Commission. Continued support of the above two programs is essential if the IJC is to continue to have available and accurate assessment of Great Lakes pollutant loadings.

In addition to the above programs, other relevant post-PLUARG activities relevant to nonpoint source problems are the watershed plans being prepared especially by some conservation authorities. These include a water quality monitoring study in sub-basins of the Ausable-Bayfield by MOE and Maitland Valley Conservation Authorities and the Lucknow River Basin study by MOE. The Ausable-Bayfield Conservation Authority carried out a study of water quality problems from manure handling and storage, and the Maitland Valley Conservation Authority carried out a monitoring study of the Belgrave Creek in association with a project under Stream Rehabilitation Program.

A multi-agency federal program management group, the Great Lakes Working Group, has allocated \$250,000 per year for programs related to the eutrophication issue in the Great Lakes. These resources have been utilized as an incentive to encourage watershed processes and modelling work. Program areas include:

- A. Priority Management Area Methodology Development and Application. Gross soil erosion has been mapped for the entire area of the Thames watershed. This information has been used in combination with physiographic information to classify areas according to their potential for delivering eroded soil to the streams. This program was expanded to include portions of the Grand River Basin during 1983.
- B. Sediment and Phosphorus Transport and Modelling. Detailed monitoring of a

number of tributaries in southwestern Ontario is being carried out to provide a calibration of the methodology used to identify Priority Management Areas and to improve our assessment of phosphorus transport from agricultural areas.

- C. Watershed Modelling. As part of the overall program, the Great Lakes Overview Model developed during PLUARG is being updated with a more accurate spatial data base in the Thames Basin. The model will be used to assist in predicting the effects of varying nonpoint source management programs on the phosphorus load delivered to the Great Lakes.

The Great Lakes Ecosystem Rehabilitation Working Group has been developing rehabilitation strategies. The Ontario Institute of Pedology and OMAF have estimated costs to agriculture in southern Ontario due to cropland erosion and mapped these at a county level. Also, the Ontario Institute of Pedology with funds from the provincial and federal governments continues to upgrade old soil surveys in southern Ontario.

- D. Legislation, Policy and Guidelines

None of the policies introduced since 1980 have brought any significant change to nonpoint sources of pollution. The only current activity that could lead to new policy or management practices is the Erosion and Sedimentation Co-ordinating Committee (ESCC). The Committee was formed to address the problems of accelerated loss of agricultural topsoil and streambank erosion and associated sedimentation.

ESCC is an inter-ministerial committee established under the Land Use Committee of the Ontario Cabinet Committee on Resource Development (CCRD). Its primary task is to clarify provincial ministerial responsibilities for planning and implementing erosion and sedimentation control programs in the Province of Ontario. The Committee has representation from the Natural Resources, Environment, Agriculture and Food and Municipal Affairs and Housing ministries.

To date the Committees' activity has yielded a number of background studies including: "Erosion and Sediment Control Program Status" (ESCC, 1981); "Inter-ministerial Program Co-ordination, Co-operation and Liaison" (ESCC, 1982); and "Cropland Soil Erosion-Estimated Cost to Agriculture in Ontario" (Wall and Driver, 1983). A report currently under preparation and review outlines a strategy for soil erosion and sedimentation control for Ontario. It is anticipated that a presentation will be made to CCRD by fall 1983.

Among the activities of special interest groups, the Ontario Institute of Agrologists and the Soil Conservation Society of America have prepared position papers regarding soil conservation and are urging action by government. Some county Soil and Crop Improvement Associations carry out field trials and demonstrations of soil conservation practices. The interest level of farmers in soil conservation is growing at a rapid rate. In general, groups of farmers, especially in southwestern Ontario, have outpaced government in taking leadership in this area. The local initiative to form a Soil Conservation District in Huron county is a good example.

URBAN

As noted earlier, the urban component of nonpoint sources has received relatively little attention compared with rural sources since PLUARG. The activities have centred mainly around problem characterization, watershed planning, technology demonstrations and policy development. Also, more attention has been given to the management of peak flows than to the quality of urban runoff.

Most of the relevant studies have been conducted under the Canada-Ontario Agreement Urban Drainage Subcommittee. This information is now being used as a basis for developing a provincial policy statement on urban drainage.

The Toronto Area Watershed Management Strategy (TAWMS) is the most comprehensive urban runoff study currently in progress. The objectives of this study include the preparation of long-term plans for reducing nonpoint sources of pollution, immediate abatement of problems that may endanger public health, and reduction of pollutant loadings to Lake Ontario. Target parameters are the heavy metals, organic compounds, micro-organisms and nutrients. There is relatively little emphasis on sediment control, except when suspended solids are considered to be a source of other pollutants. Any reduction in loading is considered desirable, but the long-term goal is to achieve water quality that meets the MOE guidelines.

The study is being conducted by MOE with involvement from the municipalities and the Metropolitan Toronto and Region Conservation Authority. The target areas of approximately 600 square kilometres is in Metropolitan Toronto. The five-year study was initiated in April 1981 and is to be completed by March 1986.

The Stratford/Avon Environmental Management Project has a large urban drainage program element. Through monitoring of urban runoff quality from selected catchment areas, inflow and infiltration in sewer systems, STP effluent, etc., contribution of pollutants from various urban sources can be assessed. Urban sources assessment, when integrated with rural sources assessment, will form the basis for an optimal control strategy for the watershed.

Rideau River Stormwater Management Study mainly deals with abating the bacteriological contamination of the lower reach of the river which has necessitated the closing of bathing beaches. In this Study, various contributing urban sources were assessed, and the optimum control strategy formulated. In addition, stormwater detention pond technology for quality control purposes was evaluated and demonstrated.

Environment Canada and MOE are jointly conducting studies of toxic and hazardous substances from urban runoff. Seven study areas have been investigated in four cities (Burlington, Cornwall, Hamilton and Sarnia) and runoff from Fort Erie, Niagara Falls and Welland will be monitored as part of the Canada-United States Niagara River Study.

The Grand River Implementation Committee has recently completed a study entitled "Urban

Nonpoint Source Pollution and Control". The objectives of the study were to: assess current nonpoint pollutant loads from major urban centres in the Grand River watershed; estimate future loadings; evaluate present and future impact of loadings, and identify required remedial measures.

The report concluded that nutrient inputs from urban runoff were small compared to agricultural diffuse sources and sewage treatment plants. Five general recommendations were presented for improving water quality in small urban basins.

At present, the main initiatives in developing guidelines and policies for urban drainage have been at the municipal level. The main objective of municipal policies and guidelines is to reduce the risk of flooding by ensuring that new developments install adequately designed stormwater control measures. The developer is normally expected to comply with the guidelines at his own expense. Some of the guidelines also include general suggestions for reducing sedimentation during construction. Coincidentally, many of these measures implemented to reduce the quantity of urban runoff bring improvements in water quality.

The regions of Halton and Waterloo have Ecological and Advisory Committees which evaluate development proposals and assess their potential environmental impact. The committees are comprised of public servants, concerned citizens and environmental experts. Neither committee has formulated any specific policies relevant to nonpoint pollution, but all potential sources of stream loadings are considered when decisions are made.

At the provincial level, the primary initiative regarding policies for urban stormwater management rests with the Urban Drainage Policy Implementation Committee (UDPIC), a subcommittee of the Water Management Committee of the Cabinet Committee on Resource Development. Membership on the committee includes the representatives of Municipal Affairs and Housing, OMNR and MOE, Municipal Engineers Association of Ontario and the Association of Conservation Authorities.

The committee is preparing Provincial Urban Drainage Policies which are intended to provide a comprehensive approach to stormwater management and to ensure that cumulative downstream effects of development are controlled and that individual developments are designed to provide an adequate level of convenience and protection (ESCC 1981). Apparently, the UDPIC will be producing a technical document describing appropriate techniques of erosion and sediment control during construction.

Also relevant to this aspect of nonpoint source controls is the directive to conservation authorities from the Conservation Authorities and Water Management Branch of OMNR regarding watershed plans. In preparing watershed plans, authorities are expected to facilitate the evaluation of municipal master drainage plans. Issues to be addressed will include, among others, impacts of changes in streamflow on erosion and conservation of natural resources.

Appendix II

CONTROL MEASURES AND PRACTICES

1. Commercial Fertilizer and Livestock Manure Management

Good management means fertilizing according to soil tests, at the optimum times and using the best fertilization methods along with alternatives or supplements to fertilizers, including barnyard manures and various grass-legume additives.

The application of plant nutrients to soils beyond what is needed and recommended should be rigorously discouraged. This practice does little good for agricultural productivity while ensuring that excessive amounts of various nutrients, both in the soluble and adsorbed form are available, to the ecosystem. The proper timing and incorporation of manures and commercial fertilizers will aid considerably in reducing unnecessary nutrient loss from soils, through percolation, denitrification and runoff.

2. Pesticide Management

Proper management of pesticides requires minimizing the rate of and optimizing the method and timing of their application and using those with minimum persistence and volatility.

This practice also includes pest monitoring to improve the efficiency of various pesticides and other alternatives and/or supplements to chemical control of pests. Safe handling, storage and disposal of pesticides and their containers is a necessary part of their best management. The correct selection and management of all aspects of pesticide use will lead to further enhancement of the water quality of the Great Lakes. Often a combination of mechanical cultivation and use of disease resistant crop varieties will aid significantly in pesticide management.

3. Remote Location of Livestock Facility From Watercourse

PLUARG estimated that 50% of Ontario livestock facilities are within 122 m of a watercourse. The range of distances from 30.5 m to 122 m has been estimated as a general average required for complete filtering of excreted phosphorus from feedlots. In certain very specific instances, this "critical distance" may fall outside the range.

By zoning, or simply educating the farm community against locating livestock feedlots within the critical distance of a surface water channel, loading of all livestock P inputs may be significantly reduced.

4. Reduced Tillage Systems

Most tillage is a soil-structure degrading process. Hence reducing or minimizing tillage benefits soil structure. Inherent in a reduced tillage system concept is the opportunity to better manage crop residues. Any system that will allow residues to be left on or near the soil surface, or incorporated into the topsoil, rather than into the subsoil is of direct benefit to soil and water conservation. Greatest benefit is obtained from surface residues which protect soil from the force of falling rain, while increasing infiltration and reducing runoff.

This section includes such systems as plow-plant, disc-plant, the use of chisel and modified-chisel plows, proper selection and use of moldboard plows and the consideration of alternative tillage systems such as strip tillage as well as minimizing the depth of tillage and ensuring across-slope or contour tillage.

5. Ridge Plant Systems

In the ridge plant system also referred to as till plant and ridge tillage, normally a pre-formed ridge is made during cultivation or after harvest of the previous crop. Spring seedbed preparation, planting and applications of fertilizers and pesticides may be done in one pass over the field.

During the subsequent growing season, one or two cultivations are performed to control weeds and remake the ridges for the next year (optional to make ridges after harvest).

An estimated 30 to 80% of the residue is left on the surface to control erosion. Ridge plant systems help prevent soil detachment by rain and soil transport by runoff.

6. Zero Tillage (No-tillage or Slot Plant) Systems

Crops are planted without prior seedbed preparation. During planting, a small slit or punch hole is opened for seed placement. The slit is made by a fluted or ripple coulter positioned just in front of the seed opener on the planter. Angled discs or narrow chisels may also be used. Chemical weed control rather than inter-row cultivation is essential. Seed may be planted into residue from chemically killed sod, in corn, soybean or cereal stubble or during double-cropping of rowcrops after a cereal grain. Virtually no residue is buried by the planting pass which makes the system one of the best for soil conservation purposes.

7. Timeliness of Tillage

Timing is important to maintain residue cover as long as possible and in providing proper conditions for conservation tillage since maximum plant response is desirable.

Therefore, tillage should be timed to minimize erosion potential either through fall, winter and spring runoff, i.e. fall vs. spring plowing or tillage just prior to planting, to prevent needless

exposure of finely tilled seedbeds to rainfall runoff and crusting. Further, tillage should be timed to avoid excessively wet conditions, during both primary and secondary operations, to obtain proper shattering action of machinery and avoid compaction. Optimum moisture conditions are when the soil moisture level is below the "lower plastic limit".

8. Crop Rotation (sod-based)

Crop rotation is a planned succession of row, cereal and/or forage crops in any given farm field, generally on an annual basis.

Residues and vegetative cover prevent detachment and transport of sediment and associated pollutants. A short rotation interval may have the greatest benefit, i.e. wheat - legume - corn as opposed to wheat - legume - legume - corn - corn - corn. Non-sod-based rotations have few of the benefits of a sod-based rotation except improved pest control. Sod-based rotations improve the vegetative cover and soil protection and water infiltration in appropriate years and improve long-term soil structure through replenishing of organic matter. Use of legumes in rotation can inexpensively replenish nitrogen stocks in the soil.

9. Contour and Strip Cropping

This includes cropping operations of working, seeding and harvesting on the contour and/or across the major slope of the land. The effects of these practices are to decrease the slope length and reduce the downhill velocity of runoff water, thus minimizing runoff and soil erosion. Different crops, often a row crop alternated with a sod crop, are grown. The forage strips help control erosion by decreasing the velocity of runoff and trapping and filtering out the sediment from the row crop. Forages also provide organic matter which stabilizes soil particles (structure) and increases the soil's ability to absorb water in a similar manner to crop rotations.

10. Cover Crops

Cover crops are grown to protect the soil surface during periods when it is traditionally bare, i.e. fall, winter and spring. They replace the protective value of crop residue, especially when the residue has been removed as with corn silage. Cover crops include: rye, wheat, barley, hairy vetch, sweet clover and red clover for corn; rye, wheat and barley for soybean stubble; and hairy vetch, alfalfa and sweet clover for small grains. The cover crop intercepts the impact energy of rain and prevents detachment and transport of sediment. Cover crops may be harvested or plowed down as green manure.

Interseeding is closely related to cover cropping in that a grass and/or legume are planted between row crop rows at a suitable time of year; however, there is no seedbed preparation. The most successful time for interseeding with corn appears to be when the crop is 6 inches or taller. Interseeded crops may be one of red clover, ryegrass, fescue, hairy vetch or sweet clover. The interseeded crop may then be plowed under in late fall. If left until spring, it serves as a cover crop, generally in the form of a permanent pasture. Permanent vegetation will protect the soil from rain

and runoff effects and thus minimize detachment and transport of sediment. Certain critical areas that are highly erosive or already eroded should be planted with stabilizing vegetation such as grass, shrubs and trees.

11. Buffer Strip (filter strip)

Field borders and vegetative strips along streambanks and ditchbanks entraps and filter out suspended sediment in transport before it leaves the field. A field border, often two to four planter widths (i.e. >6 m) of a sod or cereal crop may be planted surrounding a field. It may be a temporary vegetative control practice in place for one or two growing seasons.

Open channels should be seeded, fertilized and mulched as soon as possible after soil is disturbed to utilize the surface moisture for seed germination. If a cover is required late in the season, fall rye or oats may be planted as a temporary cover until spring when permanent seeding occurs.

For small applications, a hand-held cyclone seeder may be used. For larger, more rapid applications, on steep slopes, hydroseeding can be used. Hydroseeding places seed, fertilizer, mulch and moisture in one application. Mulch is most often comprised of hay or straw, anchored in place. In agricultural areas, between row crops and an open channel, grass buffer strips have been found to be effective in spreading and slowing runoff water to prevent localized rilling and gullying. If the buffer is wide enough, it can also filter out incoming sediments and nutrients.

On 2% slopes, buffer strips should be at least eight meters wide to have filtering effect and even wider as slopes increase, although size is dependent on the depth and velocity of incoming flow. Often where no buffer strips exist, the upper zone of the bank is critically weakened and may lead to failure. Therefore, even narrow buffers are worthwhile, and width, as a minimum, should allow free access of maintenance equipment. Buffer strips should be as level as possible.

12. Windbreaks

A windbreak may be defined as a vegetative or mechanical barrier designed and constructed to reduce or eliminate the undesirable effects of excessive wind velocities. A windbreak consists of one to five rows of trees planted in open field areas or adjacent to buildings. Shelterbelts are arrangements of trees and shrubs for the same purpose but have six or more rows. Other practices, including conservation tillage techniques, also reduce the effects of wind erosion/transport.

13. Double Cropping Systems

Double cropping is are growing two crops in succession on the same field in the same growing season. Example combinations include peas and soybeans in southern Ontario and winter cereals prior to soybeans in Ohio. The vegetative cover over the entire season helps prevent detachment of sediment by rain.

14. Grassed Waterway

Grassed waterways are broad, shallow and usually parabolic in cross-section. The cross-sectional area is large enough, relative to the design flow, to maintain the velocities below erosive levels depending on the soil type. Cultivation practices may take place across, and not parallel to the waterway which is often between 9 m and 12 m in width. Often the width is dictated by the requirements of crossability by cultivating and harvesting equipment. The channels are lined with sod and may be harvested for hay. If they are to be crossable, they may also be underdrained with a tile drain to prevent rutting by allowing quick drying. Design principles include both stability considerations (when grass is short) and capacity considerations (when grasses are left uncut). Rye or oats may be applied as a quick temporary cover for late fall construction with permanent seeding taking place the following spring. In all cases, a straw mulch cover should be applied and this should be tamped in place using straight-set discs. This assists in retaining moisture and heat for seed germination as well as in providing a temporary protective cover.

15. Terraces

A terrace may be broad based (30 m wide) or narrow based (less than 5 m wide), depending on the slope and whether or not it is to be cropped. A combination of the above two types is termed the "steep-backed terrace" which is gently sloped on the up-slope side but steep on the downslope side.

Terraces are constructed as a level berm and/or channel across a slope, effectively reducing the slope length and grade by intercepting and diverting runoff laterally to an outlet at non-erosive velocities or by storing water.

Soil infiltration capacity is increased, direct runoff decrease and runoff velocity, and soil erosion and transport are thus decreased. Where upland erosion persists, sedimentation may occur immediately upland of the terrace. It is therefore important to combine a conservation tillage and cropping system with terracing.

Parallel tile outlet terracing is a system where runoff water is ponded and slowly drained through an extensive subsurface tile system which finally drains into an open channel. Often, perforated standpipes are used to prevent clogging with sediments, debris and crop residue.

16. Surface Water Diversions

Runoff from above a field may be intercepted by a diversion berm or interceptor channel and diverted laterally to a satisfactory outlet such as a grassed waterway. In fact, the interceptor channel itself may be a grassed waterway built using cut and fill methods (see No. 14, "Grassed Waterway"). If the diversion is to be crossed along its length with agricultural equipment, it should include subsurface drainage to ensure efficient drying to prevent ruts which could potentially lead to the formation of rills.

17. Grade Stabilization Structures

These include various drop inlet measures, such as spillways, rock chutes and other structures of concrete, wood, steel and plastic materials.

A low level berm may be constructed along the buffers and watercourses with negligible land gradient to intercept and prevent surface runoff from flowing over banks. This is often done inadvertently during the course of normal maintenance. The water is thus ponded (which induces sedimentation) and may be allowed to exit slowly through one or more drop inlet spillways consisting of a vertical stand-pipe and a subsurface horizontal conduit into the open channel.

This measure may also be used upland of gullies. The sizing of the structure is determined by available ponding volume and allowable time of ponding based on crop tolerance.

Where water flow encounters an increased gradient, velocities can increase to scouring levels. Such areas may be protected from transport detachment by armoured structures made of rock, concrete, steel, wood and/or heavy plastic. Permeable linings such as rock rip-rap must be underlain with either a natural or synthetic filter while non-permeable materials must be back-drained against uplift and overturning water pressures. All such structures have three common features: a) an inlet; b) an energy dissipation; and c) a stilling basin or apron. Construction geometry of chutes is usually dish-shaped to accommodate the expected flows and not divert water around the structure.

18. Sediment Basin

A watercourse may be over-excavated (increased depth and width) for a short section downstream of the proposed areas of instream sediment disturbances such as reconstruction. The increased cross-sectional area increases retention time and reduces instream velocity to allow suspended sediments to settle according to Stoke's Law. Sediment basins can be designed to remove particles larger than a designated size at varying efficiencies. Obviously to trap smaller particles requires larger basins. The concentration of sediments in the incoming flow and the rate of incoming flow will dictate the frequency of sediment removal. Trap efficiency decreases as sediments accumulate. There may or may not be an outlet structure.

If frequently cleaned, temporary sediment basins constructed of straw bales across the flow path of runoff or instream flow may be suitable for watersheds 5 ha in size or smaller. However, they are generally unreliable during intense storms and are therefore not widely recommended.

19. Stable Ditchbank Construction and Regular Maintenance

The stability of open-channel construction and reconstruction demands that the channel remain intact throughout the period of cover establishment.

This length of time may be up to three years in duration. It is therefore necessary to design

channels for the intermediate conditions despite the fully vegetated condition anticipated. Alternatively, the channel may be immediately lined with established sod or artificial linings or linings providing temporary protection. Regular annual or biannual maintenance, including mowing, is required to prevent degradation necessitating further frequent reconstruction.

20. Armoured Bank Protection

Armoured bank protection may be in the form of broken angular rock, concrete lattice blocks or concrete panels. A porous flexible type of lining is usually preferable due to its "self-healing" properties. The protection is underlain with a granular or synthetic filter to minimize soil movement from behind the lining while allowing water to flow freely through the lining.

Size and subsequent weight of the armoured protection vary with the expected stream velocities to which it will be exposed. When broken angular rock is utilized, there should be a size gradation to minimize the presence of voids. Side slopes should be 2:1 (horizontal:vertical) minimum to prevent slumping. The base of the rock should be (toed-in) to the channel bottom. In some cases, where side slopes are steep, it may be necessary to enclose the rocks with gabion baskets which serve as a retaining wall and avoid slumping of the rock.

21. Tile Drainage

This is a systematic installation of permeable drainage conduit (clay or plastic) in a regular pattern at a depth of 0.6 m to 1.2 m below the soil surface. Normally a system of small (75 mm dia.) tiles is used in upland areas which flow into larger header conduits that ultimately flow into an open channel. Header conduit design size is based on drainage of 12 to 25 mm of runoff water in 24 hours. Hence, fine-textured clay soils which are less permeable have close drain spacing (10-15 m) while more permeable sandy soils are easily drained. Tile drainage lowers the soil's water content allowing increased infiltration capacity, thereby reducing total surface runoff volume which in turn reduces surface sediment transport and detachment. The velocity of flow from a field tile outlet is usually higher (by design) than that tolerable by bare or even vegetated soil. Where this water exits the conduit, a plunge pool can form which could ultimately undermine the conduit structure, itself causing failure. For this reason, a non-permeable corrugated steel pipe outlet of diameter slightly larger than that of the field tile and extending at least 3 m into the bank is installed. The larger diameter ensures against back-pressure and its non-permeability assists against undermining. Further, a protected apron at the outlet is an effective energy dissipation. The apron may be made of rock, concrete, or rock-filled gabion baskets.

22. Livestock Manure Storage

A secure holding facility with the capacity to store all manure and any contaminated dilution water for at least six months is necessary to ensure against overflows and/or emergency disposal requirements. Where significant amounts of dilution water are expected (see No. 23, "Feedlot Runoff Control"), additional storage capacity is required (i.e. internal runoff from feedlot is contained).

Two main types of facilities are reinforced concrete, and excavated earthen storages. Earthen structures are less expensive but may have to be lined with an impermeable material to prevent groundwater contamination. Concrete structures for liquid manure storage demand particular attention to sealed and secure pipe connections. Solid manure systems have similar potential to contaminate waters. When locating solid systems, dilution water such as eavestrough water should be avoided by placing the storage area appropriately, containing it and, in some cases, providing a runoff lagoon.

The containment of runoff from within the feedlot or solid manure storage area can be achieved through a concrete pad and wall system which diverts liquids to a sump from which it is pumped or gravity fed into a holding tank or lagoon. Application rates to land should be based on crop need, residual level of nutrients in soil (soil tests), and the nutrient content of manure. As an alternative to costly structural practices, minimal physical improvements together with careful planning of year-round manure spreading can produce good results as demonstrated in the New York, Upper Delaware River ACP project. (See No. 1 "Fertilizer and Livestock Manure Management").

23. Feedlot Runoff Control

The dilution water runoff from upstream of barnyards or feedlots may be minimized by sloping rooves away from lot, directing eavestroughs away from lot and diverting any upstream runoff (see No. 16, "Surface Water Diversions").

Further, concentrated runoff from the feedlot itself should be contained and directed to a manure storage facility (see No. 22, "Livestock Manure Storage"). This may be done by containing the feedlot using an earthen berm or low concrete wall around the perimeter and diverting the flow to either an inground lagoon or a sump from which it is pumped into an above ground storage. By eliminating the availability of manure for runoff dilution, pollutant transport is significantly reduced or eliminated.

24. Excluded or Limited Livestock Access to Water-courses

A simple fencing of water channels alongside pastured areas prevents cattle from disturbing bottom sediments, trampling streambanks and directly defecating in the watercourse. The magnitude of the problem is very dependent on site-specific conditions such as the soil stability, intensity of livestock usage and the ability of the watercourse to assimilate the contaminants.

Often, provision of concrete or gravel access ramps or crossings in controlled areas is suitable for water supply. However, in some cases, alternate water supply via springs, wells, or pumping from a channel is required.

Where fencing is installed, a buffer should be maintained between the fence and the stream, both for filtering and for accessibility by maintenance equipment (see No. 11, "Buffer Strips").

25. Adequate Control of Milkhouse Wastes

High volumes of disinfectants are used daily to cleanse milkhouses. The runoff from this practice is highly toxic, high in phosphates and should either be stored with manure (including additional storage allowance) or leached into the soil using a sediment tank and tile bed disposal system to prevent direct entry to open channels and/or concentrated seepage into field tile systems. If a tile bed disposal system is used, it should be located well away from field tiles and in medium to fine textured soils.

26. Critical Area Planting

A highly erosive or eroded area (usually unproductive) is planted with stabilizing vegetation such as grass, shrubs and trees. The area is taken out of agricultural production and the resulting vegetation entraps and prevents further detachment and transport of sediments.

Appendix III

URBAN

EROSION AND SEDIMENT CONTROL

Technologies in this area have been quite well developed and demonstrated, and they can be found in many technical guidelines documents from various jurisdictions.

Recently, Ontario Urban Drainage Implementation Committee has produced a draft Guidelines which are intended to control erosion and sediment pollution at all urban construction sites to reduce the loss of valuable topsoil, the sedimentation of off-site drainage works and watercourses, and resulting degradation of water quality and damage to aquatic life. The Guidelines enable a developer of land to evaluate the site erosion potential based on basic information concerning the site such as: soil erodibility, soil structure or textures, slope gradient, and slope length. From a large choice of available methods, the developer can choose the one most suitable and least costly to install. All sites and all areas of each site, even those rated as having a low erosion potential, will require some minimum measures or "good housekeeping" practices.

MANAGERIAL PRACTICES - QUALITY CONTROL

These practices reduce the amount of pollutants available for washoff by storm runoff. They have no effect on either the volume or rate of runoff.

Reduce/Eliminate Chemical Applications

In urban areas, such chemicals include highway de-icing salts, pesticides and fertilizers. These measures are discussed in the 1977 PLUARG Report. Lawn fertilizer and pesticide usage would be controlled through public information programs, the results of which would be quite difficult to assess and document. As a result, there is no basis at present for describing "performance" of this measure.

Reduction in road salt application, and partial substitution with sand, is more amenable to broad scale implementation because local government agencies are responsible for application. A study in Madison, WI examined the feasibility of substituting sand for much of the normally applied salt, and reported on the other social impacts of the program.

Catch Basin Cleaning

This remedial measure has been investigated by two EPA ORD supported studies which have generally concluded that, with adequate maintenance, catch basins can provide appreciable removals of certain pollutants in storm runoff from urban streets. Seven storms monitored on older existing catch basins, which had been cleaned before the initiation of the test program, produced the following results. Although TSS reductions varied widely for individual storms (-10% to +90%),

overall removals were in the order of 60-90% for TSS, 10-50% for COD, and 50-90% for BOD. Tests on an eight mesh inlet strainer for the final three monitored events produced only marginal improvements in performance. Estimating an appropriate cleaning frequency to be several times per year, it was concluded that this process could be economically feasible. There is, however, no evidence of general application of this measure at this time.

Street Cleaning

Vacuum or mechanical broom street sweeping has received considerable emphasis in the past as a control measure having the potential for broad scale reduction in urban stormwater loads. Consideration as a pollution control measure implies the careful operation of street cleaning equipment at frequencies far greater than those normally associated with this practice, as applied for litter control and aesthetic improvement.

Five of the 28 NURP projects had the evaluation of street sweeping as a central element of their work plans. These projects were located in Castro Valley, CA; Milwaukee, WI; Champaign, IL; Winston-Salem, NC; and Bellevue, WA. The experimental designs of these projects varied in detail, but they essentially followed either a paired basin (i.e. parallel or synoptic) or a serial (i.e. longitudinal) approach to gather test and control data, with some projects using both. During a test period, street sweeping would be more intensive (up to daily) and thorough (e.g. with operator training, parking bans, etc.) than during control periods when the streets were to be swept as usual or not at all.

Although analysis of hopper contents shows a removal of street dust and dirt and associated pollutants, examination of concentrations and pollutant loads in runoff from swept and unswept urban catchments has failed to demonstrate a significant effect. Preliminary conclusions are that, as a general, broad-based management practice, street sweeping does not appear to be a universally effective control technique for reducing the mean concentrations or total loads of pollutants in urban stormwater runoff. This conclusion is based on both the analysis of runoff quality data and the fact that none of the NURP projects that investigated street sweeping in depth has as yet reported finding any significant benefit from the practice.

It is not known whether this may be due to the sweeping frequencies employed relative to frequency of storms (in much of the Eastern half of the country, storms occur about every three days on average), or to the relative distribution of pollutants on streets versus areas inaccessible to sweepers (streets are typically about 15% of an urban area).

However, despite the apparent limitations as a universally effective control measure, there will be specific situations where street cleaning can be expected to be useful. In areas which experience long dry periods between rainy seasons, street sweeping can be productive. Intensive cleaning activity in critical seasons (e.g. leaf removal) can also be effective.

Final analysis of NURP results is expected to be completed by the fall of 1983 and may modify the above preliminary results somewhat.

STRUCTURAL RETENTION DEVICES FOR QUALITY AND QUANTITY CONTROL

There are a wide variety of basic designs which comprise this generic category. It is useful to distinguish between several different classes, on the basis of the performance mode by which control of quantity or quality is achieved.

All retention devices attenuate flow rates to a greater or lesser degree, depending on outlet design. Those which cause recharge to occur reduce both the volume and pollutant load discharged to surface waters. Recharge devices which provide volumetric storage, in addition to percolation area, are capable of inherently greater removals than those which do not. Retention basins which have no percolation associated with their design (impervious soils, basin liners) distribute, but do not reduce, runoff volumes. They effect quality improvements through sedimentation, or possibly through biological action (natural coliform die-off, nutrient uptake by rooted plants or phytoplankton). Table A relates this classification scheme to the listing provided in the 1977 report, and identifies the additional breakdown used in this report.

Devices of this general type are among the more significant remedial measures available for control of urban stormwater pollutant discharges. They can be applied either on a local scale or on a broader areawide scale. They can address the control of "residual" pollutant loads which remain in runoff after other preventive measures have been applied. Further, performance can be quantified sufficiently to permit planning activities to relate number and/or size of retention facilities (application density) to overall reductions in pollutant loads.

Retention - Recharge

Control measures of this type may take the form of pit or trenches, percolating catch basins, perforated drain pipes, or larger basins which occupy land set aside for the purpose. The difference is size of the device and of the urban area which can be routed through a particular unit. Given a specific surface area available for percolation, and a unit rate defined by soil characteristics, a "treatment rate" can be defined. When storm runoff is applied to the device at rates equal to or less than this rate, 100% is intercepted. At higher applied rates, the fraction of the runoff flow in excess of the treatment rate overflows to a surface water. If the device provides storage volume, portions of the excess runoff can be retained for subsequent percolation when applied rates subside. Overflow to surface waters occurs only when the available storage is exceeded.

Pollutants associated with the "captured" runoff are either removed by soil filtration, adsorption or biological processes, or percolate to groundwaters. Data secured by the Long Island, NY, and Fresno, CA, NURP project indicate soil processes to be quite effective in reducing particulates, coliform bacteria and heavy metals. Performance of recharge basins as pollution control devices can be considered to be the fraction of total runoff volume (with associated pollutants) which is prevented from discharging directly to surface waters. A procedure has been developed under the NURP program which permits estimates to be made of long-term average removals as a function of basin size, soil percolation rates and rainfall characteristics.

TABLE A. RETENTION/RECHARGE DEVICES

A.	RECHARGE - NO VOLUMETRIC RETENTION	
	Porous Pavements	(4)*
	Precast Concrete Lattice Blocks, Bricks	(5)
B.	RECHARGE - WITH VOLUMETRIC RETENTION	
	Dutch Drain	(3)
	Seepage/Recharge Basins or Pits, Drywells, Gravity Shafts, Trenches, Pressure Injection Wells	(6, 7, 8, 9, 10)
	Percolating Catch Basins, Storm Drains	(-)
C.	RETENTION/TREATMENT - NO RECHARGE	
	Sediment Basin	(81)
	"Wet" Basins	(-)
	Controlled Release Basins	(-)

* Remedial technique catalogue number from 1977 PLUARG Report.

Long-term average removal is defined as the net reduction in overflows over the long-term sequence of storms of different size, and varying intervals between successive storms.

Figure 1 illustrates a relationship between recharge basin size and long-term average removal which should be approximately true for significant portions of the Great Lakes Basin. Storm characteristics used in the computation were estimated on the basis of long-term rainfall records from Chicago, Lansing and Detroit.

Presenting estimated long-term average removals as a function of an area ratio provides useful planning input for determining the application density which would be required to achieve some desired result.

It should be noted that the simple analysis does not address eventual blockage of the soil. The rates assigned should be typical values which can be maintained naturally or by maintenance programs. Neither does the analysis speak to the issue of contamination of the groundwater aquifer. Such considerations must be addressed in any actions or decisions related to implementation of this control approach. In addition, the current analysis assumes a depth to the water table sufficient to prevent the temporary mounding of this surface during storm events, from interacting with the percolation surface and restricting infiltration rates.

Recharge of stormwater runoff has been practiced for many years in Long Island, NY, Fresno, CA, and in the State of Florida. More recent experience includes the use of perforated drain pipes at the Heart Lake development, Brampton, Ontario; the use of percolating catch basins and perforated drains in Bayville, Long Island; and the use of small scale, stone filled pits wrapped with filter cloth for new developments in Adams County (Denver), CO.

Retention/Sedimentation

Retention basins which effect the removal of pollutants by sedimentation have a variety of different forms, ranging from small sediment traps to ponds or small lakes. In one NURP project, the retention device consisted of oversized pipes installed below city streets in a section of the storm drain. Dual purpose stormwater management basins utilize outlet structures which are designed to provide both flood control and quality control. Figure 2 illustrates several of the techniques used to provide slow release of runoff from the bulk of the storms to permit effective quality control by sedimentation or soil filtration. For large storms, peak flows are attenuated; but release rates are higher since discharge takes place via the open top of the riser. Quality performance is sacrificed during such events, though better than what would otherwise occur. Performance of dual purpose basins was monitored extensively by one of the NURP projects, and analysis results will be available at the time final reports are issued late in 1983.

One form of urban stormwater retention basin which is relatively popular is a small or moderate sized pond, located and designed to provide enhanced aesthetic appeal for a development, in addition to stormwater management. Such stormwater ponds are designed to serve moderately large urban catchments

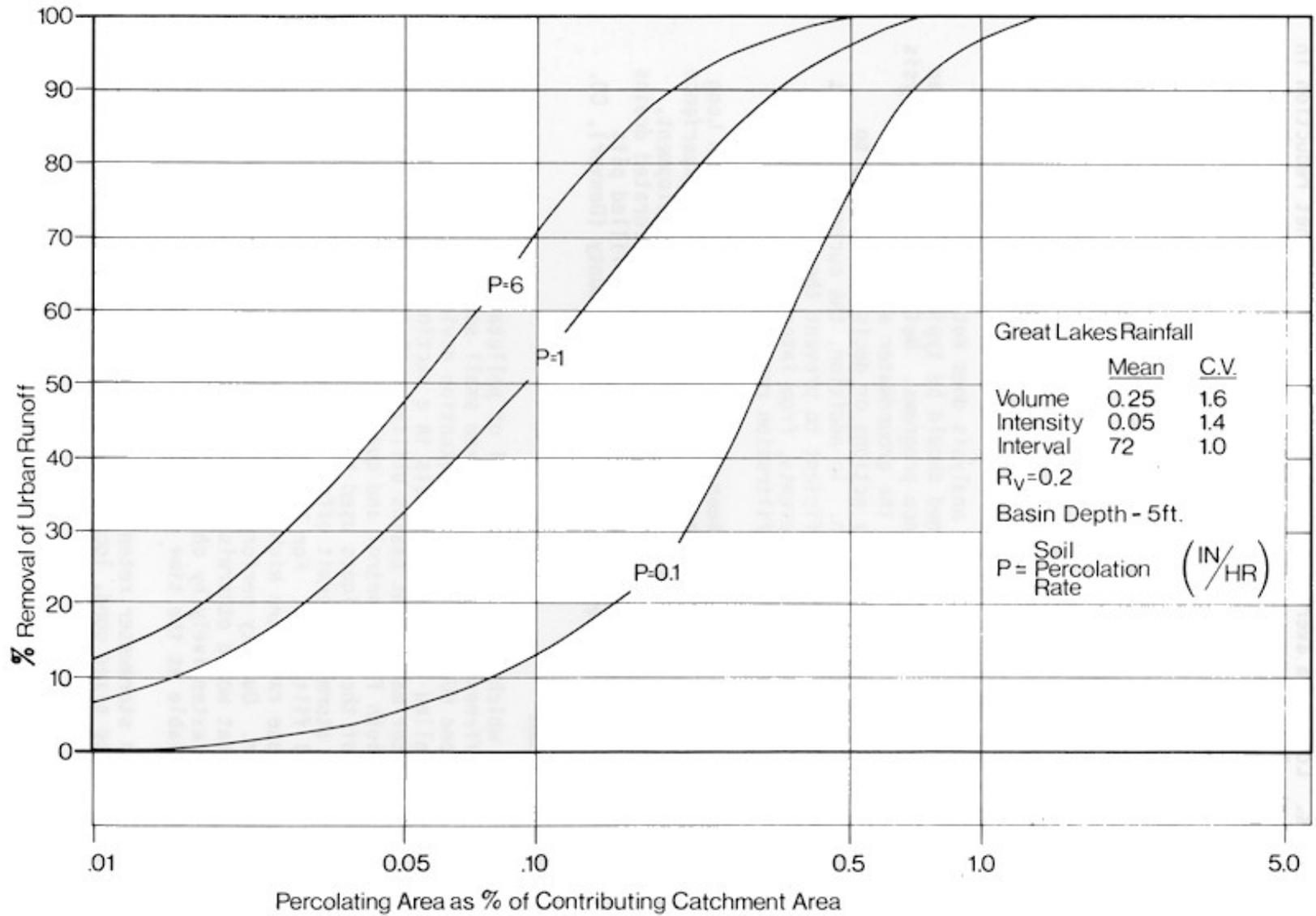


Figure 1. Estimated Performance of Recharge Basins in Parts of the Great Lakes Basin

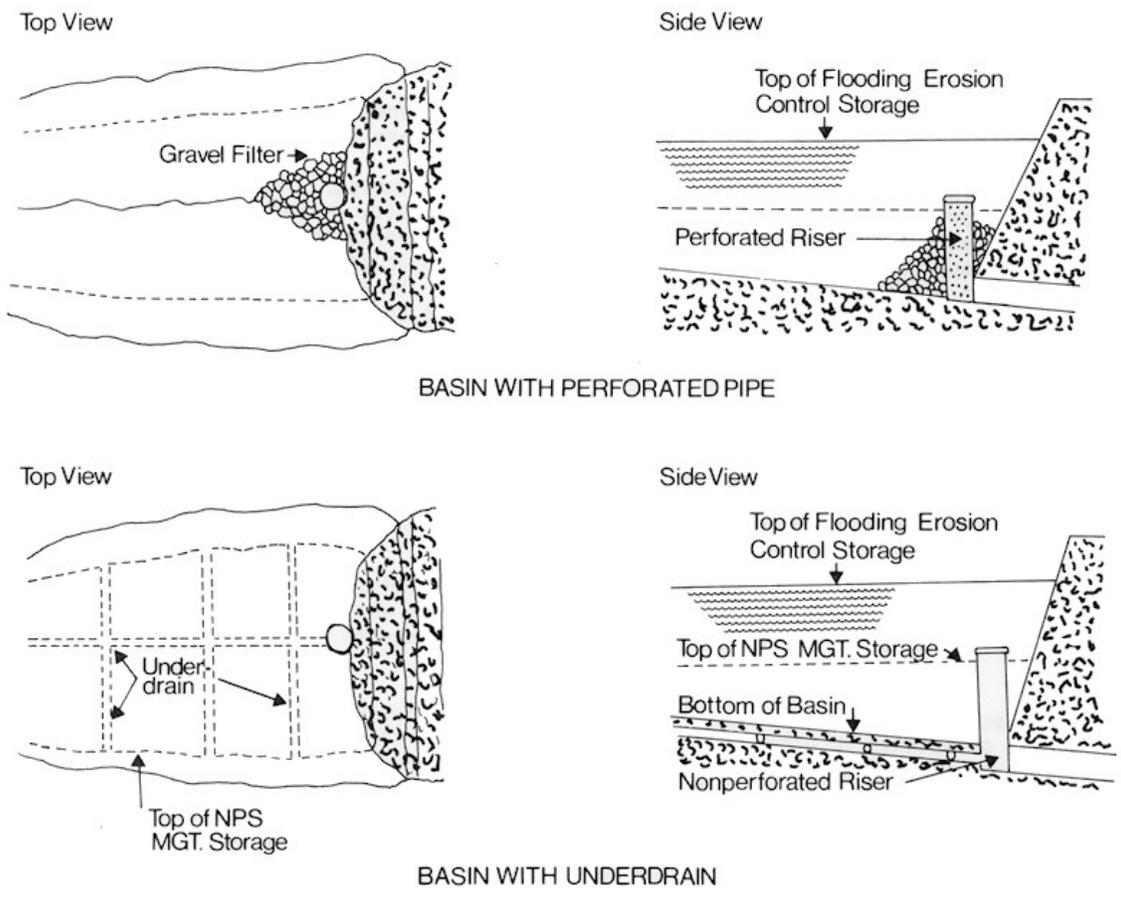


Figure 2. Outlet Designs-Dual Purpose Stormwater Management Basins

-- 100 acres or more -- and provide a pond surface area which is 1% to 2% or more of the catchment area. There are several issues still under general debate with regard to these basins. One deals with responsibility for maintenance and the periodic cleaning which will be necessary to remove accumulations of trapped pollutants. The other relates to safety and the assignment of liability, and whether ponds are fenced in or accessible to residents. While there has been no general resolution of these issues, there appears to be a continuing active interest in this approach to stormwater management.

The principal factors which determine the effectiveness and efficiency of a particular retention basin in removal of pollutants are the following:

- The settling velocity of the material to be removed. This depends principally on particle size and specific gravity -- and to a lesser extent on shape and water temperature. The hydraulic loading rate applied to the basin, which may be expressed as an "overflow rate" -i.e. flow rate per unit surface area (Q/A). In stormwater applications, this is a function of the size and imperviousness of the urban drainage area routed through a basin of particular size, and on the characteristics of local storm patterns.
- The geometry or configuration of the basin, which influences the amount of turbulence introduced and tendency to short circuit. It is assumed in the discussions which follow that, although surface area is the principal design factor, adequate depth is provided for accumulation of settled solids, without interference with normal flow patterns or undue susceptibility to scour.
- The volume of the basin, relative to runoff volumes which are produced. This influences the residence time and the extent to which quiescent settling during intervals between storms will influence overall removals.

A screening method for estimating performance of retention basins, which remove pollutants in urban runoff principally through sedimentation, has been developed in the NURP program. Long-term average performance is related to basin size, relative to the urban catchment it serves, and local rainfall characteristics. Overall performance is computed as the combination of removals which occur under dynamic flow-through conditions (while storms are in progress) and under quiescent conditions (during intervals between storms). The methodology uses probabilistic techniques in recognition that runoff rates, volumes and intervals between storms are variable.

A qualitative measure of the size of a basin, relative to the storms it will process, is provided by the following rate and volume ratios which relate the basin to the characteristics of the mean storm for the area in question.

QR/A = The overflow rate for the mean storm -- cubic feet per hour runoff rate and square feet of basin surface area (= ft/hr). The lower this rate, the better will be expected performance under dynamic conditions.

VB/VR = The volume of the basin relative to the mean storm runoff volume. The larger this ratio, the smaller the volume displaced by the storm and the longer the residence time for quiescent settling. Larger values of this ratio imply greater removals.

Observed performance results from the NURP retention basins, for which analysis results are available at this time, are listed in Table B. Performance levels cover a very wide range, from negligible to quite high in overall average removals. To provide perspective, the rate and volume ratios described earlier are also listed, and projects are listed in order of increasingly effective performance which would be expected on the basis of the ratios. Observed results are in general accord with what appear reasonable to expect, though there are some obvious anomalies. To some degree, these must be assigned to random, unexplained factors, or to poor estimates of influent or effluent averages because of a limited sample size for a highly variable situation.

Rational explanations may be offered in several of the cases, and these are instructive for planning considerations. In several of the cases where observed performance is poor compared with expectations, there is good reason to suspect that scour during larger storms is responsible. In larger basins, where algal activity is known to be present, higher than expected effluent concentrations of TSS and Total P (lower than expected removals) probably reflect not the runoff loads but subsequent internal processes, such as algal growth. For the same reason, reductions in soluble nutrients (not expected from a sedimentation analysis) are observed.

A final observation to provide perspective, for evaluating performance results in Table B, is the following. During monitoring efforts, there is a rather general tendency to bias the storms selected for evaluation toward the larger ones. A comparison of the statistics of monitored storms with those for all storms in each of the study areas shows this to be the case for the results which have been summarized. Therefore, overall long-term performance considering all storms can be expected to be better than the listed results from the monitored storms. Adjusted estimates of performance on this basis, and analysis of results from additional retention basins, are in preparation for the final NURP report but are unavailable at this time.

A very preliminary estimate of expected performance of retention/sedimentation basins in parts of the Great Lakes Basin, as a function of basin size, is presented in Figure 3. The analysis utilizes the methodology developed under the NURP program, calibrated against partial performance observations which were summarized in Table B. Rainfall statistics used in the analysis are based on those derived from long-term records for the Chicago-Lansing-Detroit area, and for simplicity the computation assumes basins to have an average depth of five feet.

An extensive study of a full scale detention pond in Ottawa, Ontario, has demonstrated that with appropriate size and operational mode high levels of removal (95%) can be achieved for TSS, Total P, Fecal Coliform and Fecal Strep. Lower removals of BOD (50%) were indicated. Batch operation was shown to provide improved performance capabilities compared with flow-through

TABLE B. Observed Performance Of Retention Basins (NURP)

Project And Site	No. Of Storms	Size Ratios			Average Mass Removals - All Storms (Percent)								
		QR/A	VB/VR	TSS	BOD	COP	TP	SOL P	TKN	NO3	T.Cu	T.Pb	T.Zn
Lansing													
Grace St. North	18	8.75	0.05	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	9	(-)
Lansing													
Grace St. South	18	2.37	0.17	32	3	(-)	12	23	7	1	(-)	26	(-)
Ann Arbor													
Pitt-AA	6	1.86	0.52	32	21	23	18	(-)	14	7	-	62	13
Ann Arbor													
Swift Run	5	1.92	1.10	85	4	2	3	29	19	80	-	82	(-)
Ann Arbor													
Traver Cr.	5	0.31	0.53	5	(-)	15	34	56	20	27	-	-	5
Long Island													
Urqua	11	0.10	1.74	-	-	-	-	-	-	-	-	77	-
Lansing													
Waverly Hills	29	0.09	7.57	91	69	69	79	70	60	66	57	95	71
NIPC													
Lake Ellyn	23	0.10	10.70	84	-	-	34	-	-	-	71	7P	71

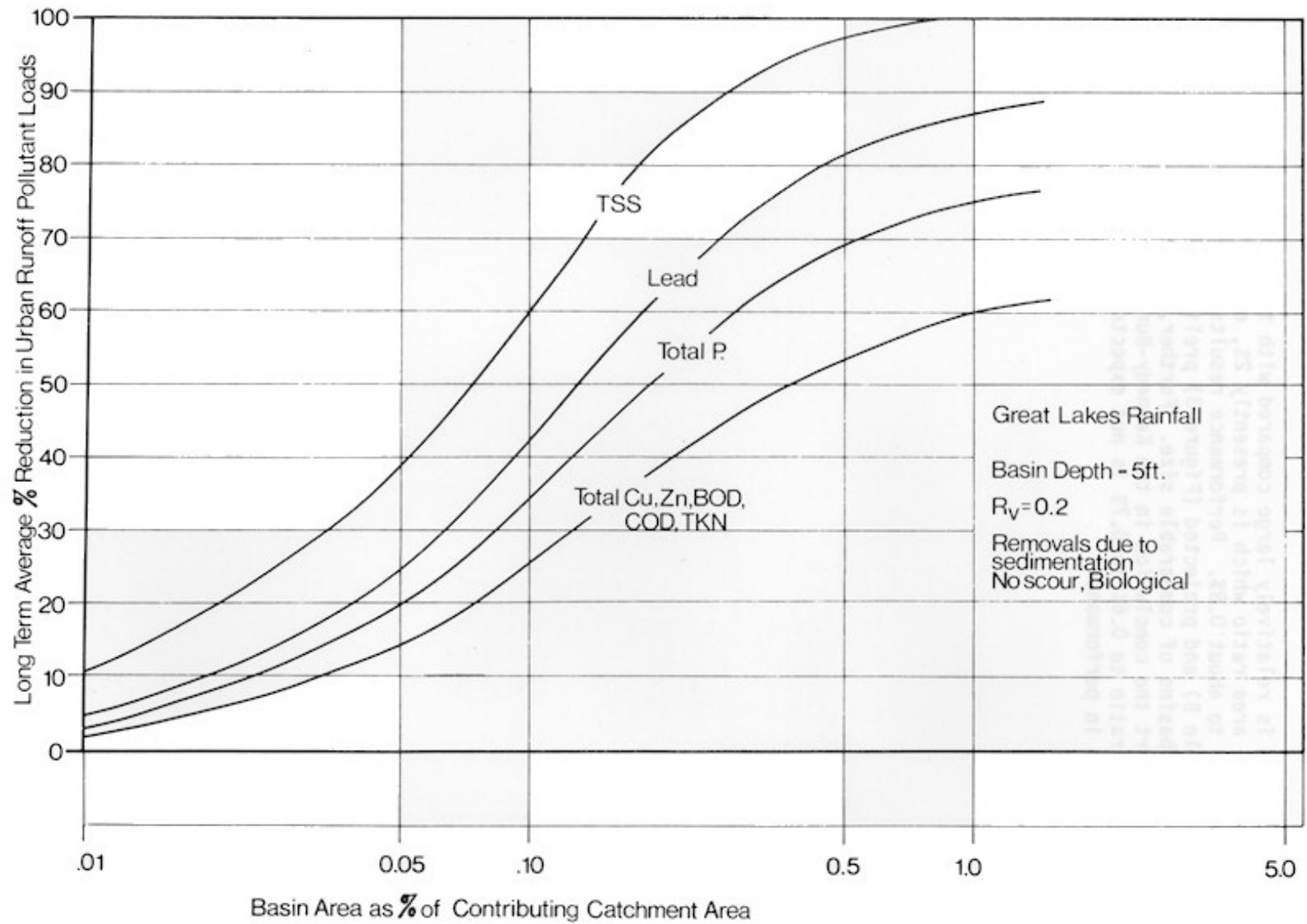


Figure 3. Preliminary Estimate of Performance of Retention/Sedimentation Basins in Parts of the Great Lakes Basin

operations. This basin is relatively large compared with the urban drainage area it serves, with an area ratio which is presently 2%, expected to decrease with future development to about 0.8%. Performance results compare favorably with both observed (Table B) and projected (Figure 3) preliminary results based on NURP data for basins of comparable size. Further, the relationships shown by Figure 3 support the conclusion in, the Kennedy-Burnett study that a reduction in pond area ratio to 0.6% to 0.7% is not expected to result in a significant degradation in performance.

Appendix IV

SUPPORTING DOCUMENTS RECOMMENDED FOR ADDITIONAL READING*

1. EVALUATION OF NONPOINT SOURCE CONTROL REMEDIAL PROGRAMS - ONTARIO by Mr. D. R. Cressman, Ecologistics Limited, Waterloo, Ontario.
2. EVALUATION OF NON-POINT REMEDIAL PROGRAMS - U.S. SIDE by Mr. Lance Marston, Harbridge House, Inc., Washington, D.C.
3. AGRICULTURAL NON-POINT SOURCE TECHNOLOGY by Mr. A. W. Bos, London, Ontario.
4. EVALUATION OF URBAN NON-POINT REMEDIAL MEASURES by Mr. Eugene D. Driscoll, E. D. Driscoll and Associates, Oakland, New Jersey.
5. PRIORITY MANAGEMENT AREAS IDENTIFICATION by Mr. Donald R. Urban, U.S. Department of Agriculture, Washington, D.C. and Dr. Greg J. Wall, Agriculture Canada, Guelph, Ontario.
6. TRANSPORT AND TRANSFORMATIONS OF POINT AND NONPOINT SOURCE PHOSPHORUS by Dr. Mark P. Brown, New York State Department of Environmental Conservation, Albany, New York.
7. PHOSPHORUS BIOAVAILABILITY by Dr. William C. Sonzogni, University of Wisconsin, Madison, Wisconsin.
8. STATUS AND EVALUATION OF PESTICIDE IMPACTS ON THE WATER QUALITY OF THE GREAT LAKES by Mr. Jerry L. Wager, Ohio EPA, Columbus, Ohio.
9. WIND EROSION AS A SOURCE OF WATER POLLUTION by Mr. Bruna Guera, National Oceanic and Atmospheric Administration, Ann Arbor, Michigan, and Dr. William C. Sonzogni, University of Wisconsin, Madison, Wisconsin.
10. TOOLS FOR EVALUATION OF REMEDIAL MEASURES by Mr. J. E. O'Neill, Ontario Ministry of the Environment, Toronto, Ontario and Dr. Stephen M. Yaksich, U.S. Army Corps of Engineers, Buffalo, New York.

* Copies of the above-listed documents are available upon request from the International Joint Commission, Great Lakes Regional Office, 100 Ouellette Avenue, 8th Floor, Windsor, Ontario, N9A 6T3.

Membership List

Mr. G. E. Bangay (Co-Chairman)
Lands Directorate
Ontario Region
Environment Canada
Burlington, Ontario

Dr. P. Seto
Pollution Control Branch
Ontario Ministry of the Environment
Toronto, Ontario

Mr. David Strelchuk (Alternate for
Mr. M. R. Garrett)
Conservation Authorities and
Water Management Branch
Ontario Ministry of Natural Resources
Toronto, Ontario

Mr. G. A. Driver
Plant Industry Branch
Guelph Agriculture Centre Guelph, Ontario

Mr. J.E. O'Neill
Water Resources Branch
Ontario Ministry of the Environment
Toronto, Ontario

Dr. G.J. Wall
Ontario Institute of Pedology
Agriculture Canada
University of Guelph
Guelph, Ontario

Dr. C.S. Baldwin
Soil Section
Ridgetown College of Agricultural
Technology Ridgetown, Ontario

Mr. K. Fuller (Co-Chairman)
Great Lakes National Program Office U.S.
Environmental Protection Agency
Chicago, Illinois

Mr. J. L. Wager
Strategic Planning Section
Ohio Environmental Protection Agency
Columbus, Ohio

Dr. Mark Brown (Alternate for
Mr. I.G. Carcich)
Bureau of Water Research
New York Department of Environmental
Conservation
Albany, New York

Dr. S. M. Yaksich
U.S. Army Corps of Engineers
Buffalo District
Buffalo, New York

Dr. W. C. Sonzogni
State Laboratory of Hygiene
University of Wisconsin
Madison, Wisconsin

Mr. D. R. Urban
Soil Conservation Service
U.S. Department of Agriculture
Washington, D.C.

Mr. D. N. Athayde
Implementation Branch
U.S. Environmental Protection Agency
Washington, D.C.

Secretariat Responsibilities

Dr. M. Husain Sadar
Great Lakes Regional Office
International Joint Commission
Windsor, Ontario