Cross Boundary Nonpoint Source Pollution: The Implications

GREAT LAKES POLLUTION FROM LAND USE ACTIVITIES

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In 1972, the Pollution From Land Use Activities Reference Group (PLUARG) of the International Joint Commission (IJC) was established. The purpose was to determine the levels and causes of any pollution of the Great Lakes System from land use activities. The group was also asked to recommend appropriate remedial actions to the Governments of Canada and the United States.

PLUARG reported its findings and recommendations to the IJC in July 1978. In 1980, the IJC forwarded their considerations and conclusions to the parties in the Great Lakes Agreement. Their 18 recommendations basically adopted the comprehensive Environmental Management Strategy for the Great Lakes System PLUARG gave IJC. An Overview of Post-PLUARG Developments by the Nonpoint Source Control Task Force of the Water Quality Board of IJC, was released in 1983. That report stated that:

> PLUARG was a major international cooperative 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 any aspect 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.

In 1982, a report to the Secretary of State by the U.S. General Accounting Office stated: "The U.S. Government has not adequately supported or been sufficiently involved in the water quality activities of the U.S./Canadian International Joint Commission. As a result, the Commission has had difficulty fulfilling its role as the principal advisor for water quality matters on the Great Lakes and other boundary waters." GAO recommended actions to improve U.S. support for the Commission's water quality activities.

In 1984, the IJC Water Quality Board sponsored a Nonpoint Source Pollution Workshop, in Windsor, Ontario, to assess the current status of nonpoint source pollution problems and control in the Great Lakes basin and to obtain comments on and provide an opportunity for technical peer review of the Overview report. Several involved in PLUARG, including the Co-chairman, Dr. Murray B. Johnson, and I participated.

The conclusions of the Overview Task Force were discussed along with programs and practices currently being carried out by Canada and the United States. The Parties to the 1978 Great Lakes Water Quality Agreement had begun to develop management plans in response to the requirements of the Phosphorus Load Reduction Supplement to Annex 3 of the Great Lakes Water Quality Agreement. Knowledge abut phosphorus transport and bioavailability, priority area identification, and pesticide usage were reviewed, and their impact on nonpoint source control programs was assessed. In addition, the workshop was a good international forum for exchange of information and experience regarding nonpoint source pollution control programs and practices: what has and has not worked.

Dr. Johnson and I were reluctant to reinvolve ourselves in that exercise. Murray gave his view of the demanding task of PLUARG, as follows:

> As a research limnologist for the Canadian Government, I was challenged by the terms of reference. The wording implied authority. The Canada–U.S. Agreement on Great Lakes Water Quality signed at Ottawa, April 15, 1972, by the President of the United States and by the Prime Minister of Canada said, "I have the honor to inform you that the Governments—pursuant to Article IX of the Boundary

> Waters Treaty of 1909—have agreed to request the IJC to conduct a study of pollution of the boundary waters of the Great Lakes System from agricultural, forestry and other land use activities, in light of provision of Article IV of the Treaty which provides *that the boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health and property on the other side."* The chance to have my hands on the wheel, have control, steer a course, be a manager, were prerogatives of a Chairman, I thought. However, Norm and I learned much later, to our dismay, that the wheel in our hands could be turned and turned—BUT IT WAS NOT HOOKED TO ANYTHING THAT WOULD CHANGE DIRECTION.

We did hear again at Windsor that cost-effective management practices and implementation programs are available and have been demonstrated in the basin. Sufficient technical knowledge exists to support implementation of programs to reduce nonpoint sources of pollution to the Great Lakes. As a result of extensive review of programs, practices, and issues surrounding the management of nonpoint sources of water pollution, the Task Force concluded that the basic recommendations developed by PLUARG—for IJC—remain valid.

This series of concurrent sessions was to address Making Decisions About NPS Pollution. International aspects of the problem complicate the process. The most recent manifestation involves acid rain, where the decision opts for more study. Cross-boundary groups are prone to take this route and rate high in the conduct of that approach. They were experts at it, and we treasure the experiences of that IJC assignment. Now, what does that research reveal that may be of value for the future? If water quality problems are site-specific, how do local efforts become part of cohesive, coordinated action?

To fully analyze and apply the benefits of that total experience to present day problems would require time and talent beyond my capability. Conditions have changed regarding NPS since 1972. The Water Quality Act in the United States was in the early stages of implementation. The 208 planning process was being implemented. The eight Great Lakes States were represented on a basin commission primarily for data gathering and planning. Lake Erie was dying, if not already dead, and other Lakes would suffer a similar fate, unless the conditions causing pollution were quickly reversed. The rural areas in both Nations were reluctant to admit that land use activities, especially agriculture, could cause pollution many miles from their operations. An early effort of PLUARG was to determine the state-of-the-art. A detailed study plan emphasized four main tasks:

1. Task A: to assess problems, management of programs, and research, and to attempt to set priorities in relation to the best information now available on the effects of land use activities on water quality in the boundary waters
2. Task B: inventory of land use and land use practices, with emphasis on certain trends and projections to 1980 and, if possible, to 2020
3. Task C: intensive studies of several small watersheds, selected and conducted to permit some extrapolation of data to the entire Great Lakes Basin, and to relate contamination to water quality at river mouths of the System to specific land uses and practices
4. Task D: diagnosis of degree of impairment of water quality in the Great Lakes, including assessment of concentrations of contaminants of concern in sediment, fish, and other aquatic resources

The objectives of Task A were to analyze the pollution problems and the potential of various land uses and to document the practicality of alternative remedial, or control measures. To meet these objectives, studies would assess the state-of-the-art for the following categories:

A1: residential areas
A2: commercial and industrial areas
A3: transportation
A4: extractive areas
A5: pesticides and herbicides
A6: nutrients
A7: erosion and sedimentation
A8: animal wastes
A9: intensive animal feedlots
A10: forestry
A11: recreation land
A12: undeveloped land
A13: liquid waste disposal
A14: solid waste disposal
A15: land fills, including dredging activities
A16: deepwell disposal
A17: management and control of land use/water quality problems/institutional and legal arrangements

We published in November 1974 in two volumes our findings of Task A entitled, Management Programs, Effects of Research and Present Land Use Activities on Water Quality of the Great Lakes. This helped PLUARG answer the first question of the Reference: Are boundary waters of the System being polluted by land drainage (including ground and surface runoff and sediments) from agriculture, forestry, urban and industrial land development, recreational and park lands, utility and transportation systems and natural resources? Table 1 lists parameters for which a water quality problem has been identified in the Great Lakes and those for which no problem has been identified, but may be a problem in inland or ground waters.

Although additional work was underway through the other tasks the affirmative answer to the first query was no surprise. PLUARG found that the Great Lakes are being polluted from land drainage sources by phosphorus, sediments, some industrial compounds, some previously used pesticides, and, potentially, some heavy metals. Phosphorus loads in 1976 exceeded the recommended target loads for all lakes. We stated that point source control programs would be sufficient at that time to meet the target loads only in Lake Superior and Lake Michigan, and southern Lake Michigan may need further measures. Toxic substances, such as PCB's, had gained access to the System from diffuse sources, especially through atmospheric deposition.

While in many cases ascribing pollution to any particular land use was difficult, of note was that the cumulative effect of a variety of land use activities ultimately contributes to the pollution of the Great Lakes System. That led to the second question, "If the answer is in the affirmative, to what extent, by what causes, and in what localities is the pollution taking place?"

PLUARG found that the Lakes most affected by phosphorus and toxic substances were Erie and Ontario. Many local problems, including intensive agricultural operations, were identified as the major diffuse source contributors of phosphorus. Erosion from land used for crop production on fine-textured soils and from urbanizing areas were found to be the main sources of sediment. The most important land-related factors affecting the magnitude of pollution were found to be soil type, land use intensity, and materials usage. Northwestern Ohio and southwestern Ontario were sources of high phosphorus loadings.

The third question was and remains the most difficult to answer. We were asked, "If the Group should find that pollution of the character just referred to is taking place, what remedial measures would, in its judgment, be most practicable and what would be the probable cost

Table 1.—Great Lakes water quality pollutants.

Parameters for which a Great Lakes water quality problem has been identified

POLLUTANT	PROBLEM		SOURCES				REMARKS
			DIFFUSE				
	Lake-wide	Nearshore or Localized	Land Runoff	Atmos-phere	In-Lake Sediments	POINT	
Phosphorus[1]	Yes	Yes	Yes	Yes	Yes[a]	Yes	[a]Percentage unknown; not considered significant over annual cycle
Sediment[b,1]	No	Yes	Yes[c]	Negligible	Under some conditions	Negligible	[b]May contribute to problems other than water quality (e.g., harbor dredging) [c]Including streambank erosion
Bacteria of public health concern	No	Yes	Minor[d]	No	No	Yes	[d]Land runoff is a potential, but minor source; combined sewer overflows generally more significant
PCBs[1]	Yes	Yes	Yes	Yes	Yes	Yes	
Pesticides (past)[1]	Yes[e]	Yes[e]	Yes	Yes	Yes	No	[e]Some residual problems exist from past practices
Industrial organics[1]	Yes	Yes	Yes	Yes	Yes	Yes	
Mercury[1]	Yes	Yes	Minor	Yes	Yes	Yes	
Lead[1]	Potential[f]	Potential[f]	Yes	Yes	Yes	Yes	[f]Possible methylation to toxic form

Parameters for which no Great Lakes water quality problem has been identified, but which may be a problem in inland surface waters or ground waters

Nitrogen	No	No[g]	Yes	Yes	Minor	Yes	[g]Some inland groundwater problems
Chloride	No	No[h]	Yes	Negligible	No	Yes	[h]Some local problems exist in nearshore areas due to point source
Pesticides (present)[i]	No	No	Yes	No	No	Yes	[i]New pesticides have been found in the environment; continued monitoring is required
Other heavy metals	Potential[f]	Potential[f]	Yes	Yes	Yes	Yes	
Asbestos[j]	No	Yes	No	?	Yes	Yes	[j]See Upper Lakes Reference Group Report
Viruses[k]	No Data Available					Yes	[k]Better detection methods needed
Acid precipitation	No	No[m]	No	Yes	No	No	[m]Potential problem for smaller, soft water, inland lakes

[1]Sediment *per se* causes local problems; phosphorus and other sediment-associated contaminants have lakewide dispersion.

thereof?" PLUARG found that the remedies for nonpoint source pollution would be neither simple nor inexpensive. NPS are characterized by their wide variety and large numbers of sources, the seemingly insignificant nature of their individual contributions, the intermittent nature of their inputs, the damaging effect of their cumulative impact, the complex set of natural processes acting to modify them, and the variety of social and economic interactions which affect them.

PLUARG did not favor across the board measures for nonpoint source pollution control. We recommended a methodology defining problem areas on a priority basis and then applying the most practicable control means for any particular source. We recommended management plans with four major components:

1. information, education, and technical assistance
2. planning
3. fiscal arrangements
4. regulation

A basic tool for estimating the level and location of management required in potential pollutant contributing areas was to be the identification of the most serious hydrologically active areas (HAA). This was an early concept of targeting and for equity and public and private costs of best management practices (BMP's).

The fact is well documented that monitoring for changes in sediment or nutrient loadings from the implementation of agricultural control practices is extremely difficult. Recent evaluations suggest that loading changes of about 20 percent can be detected, provided good flow and concentration data are collected and that event sampling is included. Expert opinion as to the length of time needed to make definitive judgments range from 5 to 15 years.

To protect the quality of the Great Lakes System the United States and Canada updated the Water Quality Agreement of 1972 in 1978. In October of 1983 the United States and Canada agreed to a supplement to Annex 3 of the Agreement regarding control of excessive loading of phosphorus to the Great Lakes System. The mechanism for preparing the U.S. Load Reduction Plan consists of an interlake State/Federal Great Lakes Phosphorus Task Force (GLPTF) and separate State Task Forces (STF). The STF's are preparing plan elements that will become part of each State's Water Quality Management Plan. The GLPTF will integrate the elements into a total U.S. Load Reduction Plan.

A better definition of pollution in the Great Lakes is still required. PLUARG found that traditional yardsticks, such as water quality objectives or standards insufficiently evaluated the impact of nonpoint sources to the System. Future studies would be of greater value if they were holistic in nature. The pages that follow are from the Overview of Post-PLUARG Developments. Although some progress has been made on a few of our recommendations since this report, it will serve the reader as excellent background to determine whether the Great Lakes ecosystem can, in a timely manner, maintain its desirable characteristics of

- Diversity,
- Resilience, and
- Stability,

when it is changed, as it has been, by man.

APPENDIX

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

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 reveiw 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; and*
- *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 interministerial 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 cooperative 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; and
iii) Proper management and ultimate disposal of toxic substances presently in use.

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 exist. 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 presettlement 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: regulations 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.

PLUARG data were disseminated to conservation authorities and are 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.

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

IRRIGATION RETURN FLOWS AND SALINITY PROBLEMS IN THE COLORADO RIVER BASIN

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Soil and water salinity occur in arid regions wherever irrigation is practiced. In the United States, an estimated 20 percent of all irrigated land, about 4 million ha (10 million acres), suffer from salt-caused yield reductions. Though less serious than pollution from heavy metals or toxic organic compounds, salinity constitutes the most serious water quality problem in the western United States.

In the United States, the Colorado River Basin, including the Imperial and Coachella Valleys of southern California that receive Colorado River water, contains more major salinity problem areas than any other river basin in the western United States. It is closely followed by the Rio Grande Basin and the Central Valley of California.

Land degradation and reduced agricultural productivity are some of the likely downstream effects of high salt content in irrigation water. For example, in the Mexicalli Valley land degradation is more severe than in the adjoining Imperial Valley because: (1) the salinity of the irrigation water is worse where Mexico diverts Colorado River water, and (2) the Mexicalli Valley does not have the intensive drainage network that the Imperial Valley has.

In all affected river basins, salinity has progressively increased as the water resources have been developed and put into use. The water in these rivers becomes increasingly saline from the headwaters to the mouths, mostly from seepage and return flows from irrigated land. In the Colorado River, salinity concentrations increase from less than 50 mg/L in the headwaters to about 900 mg/L at Imperial Dam to about 1,200 mg/L in Mexico. The heavy salt load of 10 million tons is estimated to cost all water users, in the United States alone, more than $133 million a year and is projected to more than double to $267 million annually by 2010 if controls are not instituted.

The general objective of irrigation is to provide a suitable moisture environment in the soil for plant growth. A tendency among farmers in dry regions, however, is to overirrigate. In a typical irrigation field near Grand Junction, Colorado, 38 percent of the water applied was unnecessarily wasted because irrigation was continued for 14 hours after the root zone was filled. The root zone was filled after 23 hours had elapsed. By stopping then, the irrigation efficiency could have been raised from 39 percent to 63 percent. On the average, irrigation efficiencies in the Colorado River Basin are less than 50 percent.

Overirrigation is due to: (1) pricing of water below its scarcity value, which encourages inefficient water use; (2) poor conditions of irrigation infrastructure, that lead to losses through seepage before the water reaches the crops; (3) irrigators' lack of knowledge of water requirements; and (4) inappropriate water policies or provisions in water laws that serve to discourage conservation.

When irrigation water is applied to the soil surface, water is lost in one of three directions: evapotranspiration, surface runoff, and deep percolation. Deep percolation losses add large quantities of salts to ground waters and may add to drainage and downstream salinity problems.

Since all waters used for irrigation contain some dissolved salts, repeated application of water to soils will result in the accumulation of salts (mainly the chlorides, sulfates, and bicarbonates of calcium, magnesium, sodium, and potassium) in the soil profile. To maintain agricultural productivity, these salts must be leached out of the root zone.

Because of the concentrating effect of consumptive use of water by crops, and leaching of soil salts, gradual deterioration of water quality in natural aquifers and receiving streams takes place over a period of time. However, rises in salinity concentrations can often be dramatic. In 1961, salinity concentrations in Colorado River water flowing into Mexico virtually doubled, from 800 mg/L to 1,500 mg/L. The jump was principally a result of pumping of saline ground water (6,000 mg/L) from the Wellton–Mohawk Irrigation District in Arizona, coupled with the closure of Glen Canyon Dam and the reduction in the quantity of water delivered to Mexico.

Negotiations with Mexico resulted in the signing of a treaty, Minute 242, in 1974 and the passage by the U.S. Congress of the Colorado River Salinity Control Act of 1974. The treaty guaranteed that salinity in the water delivered to Mexico would not exceed 115 mg/L ($\pm$30 mg/L) over the annual average at Imperial Dam. This was to be achieved through the construction of a multimillion dollar desalting plant near Yuma, Arizona. Similarly, the Colorado River salinity control program for the American States was to be achieved through the construction of several Federally funded structural control measures, mostly for natural point sources of salinity. Such a program proved acceptable to the States because it interfered little with irrigators' activities and because it would be financed by the Federal government. Gradually, however, the emphasis has been shifting to the cost-effective on-farm control measures.

Many technologies and techniques exist at a variety of costs for water quality management of irrigation return flows. They involve increase in the efficiency of irrigation water application (for example, trickle and sprinkler irrigation), reduction in the amount of irrigation water lost from conveyance systems through seepage (by canal and ditch lining), disposal of saline return flows, or desalinization of saline drainage water.

The U.S. Soil Conservation Service has found these on-farm management practices, including land leveling, crop management, irrigation scheduling, and proper water management, to be the most cost-effective measures for controlling salinity. Yet, only limited enthusiasm exists for changing on-farm water use practices because of water management policies and laws, water pricing, and especially the perception that the actor is not generally the beneficiary.

Water laws in most States in the West discourage water conservation, and in many areas irrigators have little incentive to conserve because they cannot apply the saved water to new land. In addition, most water resources in the United States have been developed and managed by the public sector and are heavily subsidized. Prices for water are often based on distribution system operating costs

rather than on scarcity value or true costs. Water pricing should be considered as a means to effect efficient water use. Rate structures can be adjusted to make water quantities exceeding efficient irrigation needs more costly. Such rate structures can use existing or other appropriate base rates for efficient irrigation, and excess funds can be invested in on-farm management measures on a project or a district scale.

Finally, on-farm salinity control measures for water quality improvement will not be undertaken by the private farmer at his own expense in the absence of economic incentives and disincentives by the Federal and State governments. As in the case of many soil and water conservation issues, the question of who benefits from and who pays for improved conservation practices is also a valid one for salinity control.

AGRICULTURAL NONPOINT SOURCE POLLUTION IN THE MIDWEST

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The area often referred to as the North Central States and Northern Great Plains includes Ohio, Indiana, Illinois, Missouri, Iowa, Minnesota, Wisconsin, and Michigan, the North Central States, and Kansas, Nebraska, South Dakota, and North Dakota, the Northern Great Plains. These areas generally have the highest percent of land devoted to agricultural crops in the United States. Over 60 percent of the total land is used to grow agricultural crops. The major crops are corn, soybeans, sorghum grains, and wheat; corn and soybeans are grown in the North Central States and wheat and sorghum grains in the Northern Great Plains States.

Concentrations of orchards on the east side of Lake Michigan and commercial vegetable production are found throughout the area with heavy concentrations in Wisconsin, southern Minnesota, and northern Illinois for canning.

Along with concentrated feed grain production, animals are farmed. Dairy cattle are found throughout the area with very heavy concentrations in Wisconsin and Minnesota. Cattle are fed grain and sold for slaughter throughout the region, with heavy concentration in western Iowa and eastern Nebraska. Hogs and poultry are also raised throughout the area.

Changes in agriculture have been occurring that cause higher levels of nonpoint pollution. The acres of row crops have nearly doubled over the past 40 years. This shift occurred because low-cost nitrogen fertilizer became available after World War II. It was no longer necessary to grow legume crops to provide nitrogen for corn. The result was a shift from grasses and legumes to soybeans on a large portion of the Corn Belt land.

A change in soil erosion occurred as a result of the shift. On a typical central Illinois soil with 4 percent slope, we had annual soil erosion losses of approximately 5–6 tons per acre with a typical corn-corn-oat-hay rotation in 1940. In the 1980's, we have annual soil erosion losses of approximately 15 tons per acre with a typical corn-soybean rotation using conventional tillage on the same field. Crop yield increases (3 to 4 times) during this same time period have helped to reduce soil erosion, but not enough to make up for the increased erosion resulting from the shift to more row crops.

The soil erosion problem changes as we go from west to east in the area. Wind erosion is the dominant problem in the Western Great Plains, changing to water erosion as we move eastward into the North Central States. Water erosion is affected mainly by rainfall amounts, but also by soil types. Sandy and high organic matter soils are affected more by wind erosion than other soils. Wind erosion reduces air quality, but the blowing soils can also affect water quality. Both types of erosion degrade environmental quality.

Sediment is a major water pollutant, especially through the central Corn Belt of Indiana, Illinois, and Iowa. Sediment delivered to streams and lakes is also affected by the soil type and rainfall. The deep loess soils found along the Missouri, Mississippi, and Illinois Rivers are highly erosive, resulting in high sedimentation rates in lakes and rivers. Rainfall intensities also increase as we go from north to south and west to east. This is reflected in the R values used in the Universal Soil Loss Equation (USLE) with R-50 being used in the western edge of North Dakota to R-250 used in southern Missouri.

Until recently, soil erosion was generally thought to be associated with reduced crop yields. With the addition of fertilizers and improved agricultural technology, yields increased. In fact, we have had a three- to fourfold increase in most of our feed grain crop yields from 1930 to the present. Since yields were increasing, many landowners reasoned that soil erosion could not be a problem. It wasn't until the Section 208 studies that we began to get a clearer picture of the real impact of soil erosion as a water pollutant.

Sediment is a pollutant when suspended and carried by water. In addition, sediment reduces water storage capacity in lakes and streams as it settles to the bottom. Sediment may also carry plant nutrients, pesticides, and organic matter. The amount of plant nutrients reaching streams can be greatly reduced simply by reducing soil erosion. Phosphorous is held tightly by the soil clay particles, and a large portion of the nitrogen is in the soil organic matter. A soil erosion control program reduces the loss of both of these nutrients.

A major soil erosion control practice that is now promoted to reduce soil erosion is conservation tillage. Conservation tillage systems include those reduced tillage systems that leave 20- to 30-percent crop residue soil cover after planting. The systems range from changing from a moldboard plow to a chisel plow, till-plant or ridge planting, strip tillage, and no-till planting. The shift to conservation tillage has been increasing in the Corn Belt. Conservation tillage is now used on 34 percent of the cropland in the North Central and northern Great Plains States.

The major environmental problem with these systems has been the increased dependence on pesticides, particularly herbicides to control weeds as tillage is reduced. While the systems are effective in reducing soil erosion by 50 to perhaps 80 percent, we do not know the long-term consequences of using the pesticides. Since the major increase in pesticides use has been with herbicides, we have assumed that the tradeoffs have been in favor of using conservation tillage. Conservation tillage permits us to continue to grow most crops competitively, while substantially reducing soil erosion.

Many studies are attempting to find ways of reducing the amount of pesticides used on our row crops. Other studies are examining the long-term impacts pesticides may have on the environment.

I believe that we are beginning to make progress in reducing soil erosion in the Corn Belt. Iowa provided leadership in starting a State soil erosion control program, but Minnesota, Wisconsin, Illinois, Missouri, Ohio, and other States have recently developed programs and are providing State cost-share money to get soil conservation practices applied.

The large amount of publicity given to soil erosion has convinced most landowners that soil erosion is a problem. The State program has gone far enough to set specific soil erosion goals as a target for farmers. Generally, this long-term goal is to reduce soil erosion to the established soil loss tolerance.

Changes have also occurred with livestock farms affecting nonpoint pollution from livestock waste. We now have fewer, but larger, livestock farms. Livestock waste washing into streams adds substantially to the nutrient load of streams from these large units. In addition, the organic matter decomposition process uses up oxygen in water, killing fish and other aquatic life, as well as causing odors and decreasing esthetic values.

I see only one logical answer to handling livestock waste: to store the waste until it can be properly applied on cropland at rates usable by crops. This practice will become more economical as the price of fertilizers continues to increase. Federal and State livestock waste handling programs are bringing the livestock waste problem under control.

Nitrate levels in ground water and streams have increased in some areas as a result of agricultural operation over the past few years. I am not sure how serious the problem is or how to reduce the nitrate levels and maintain a viable agriculture, but in several areas we have large acreages of corn nitrogen fertilized. Nitrate levels that exceed public health standards at times during the year are found in several of the streams used for public water supply. Also, I understand that nitrate levels in ground water under irrigation in sections of Nebraska and other areas have increased above the public health standards.

There is much concern regarding nonpoint sources of pollution in the northern Lake States and Missouri because of the recreational uses of lakes and streams. Recreation brings in many dollars in northern Minnesota, Michigan, Wisconsin, and southern Missouri. These States are working on the problems.

In summary, the major nonpoint sources of water pollution from agriculture that I see in the Midwest are: sediment, livestock waste, plant nutrients, and pesticides. These materials are impacting water quality in specific areas. However, the impacts are different for different areas requiring different programs.