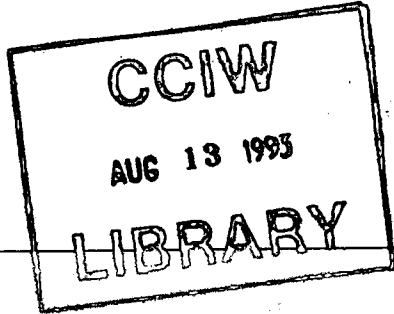




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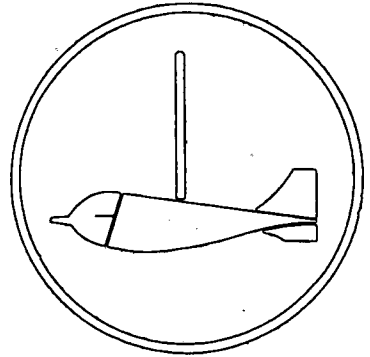
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SEDIMENT ISSUES AND DATA NEEDS IN ONTARIO



CONSERVATION MANAGEMENT SYSTEMS

EXECUTIVE SUMMARY



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WATER RESOURCES BRANCH
INLAND WATERS DIRECTORATE

DIRECTION DES RESSOURCES EN EAU
DIRECTION GENERALE DES EAUX INTERIEURES

Ontario Region

IWD-OR-WRB-SS-86-2

SEDIMENT ISSUES AND DATA NEEDS IN ONTARIO

Executive Summary

March 1986

Submitted by

CMS conservation management systems
CONSULTANTS IN SOIL CONSERVATION AND WATER MANAGEMENT
(A Division of Ecologistics Limited)



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June 1986

This Executive Summary is based on a detailed study of sediment issues and data needs in Ontario conducted by Conservation Management Systems. The Table of Contents of the detailed report has been included in this summary to give the reader an appreciation of the scope of the study and the material presented in the comprehensive report. Copies of the detailed report may be obtained from:

Regional Chief
Water Resources Branch
Inland Waters Directorate
Ontario Region
Conservation and Protection
Environment Canada
75 Farquhar Street
Guelph, Ontario
N1H 3N4

(519) 821-0110

This study on sediment issues and data needs in Ontario is one of several similar consultants' studies undertaken in four other regions of Canada to evaluate the present sediment surveys program and to establish a national perspective on sediment issues. Copies of these reports may be obtained from:

Sediment Surveys Section
Water Resources Branch
Inland Waters Directorate
Conservation and Protection
Environment Canada
Ottawa, Ontario
K1A 0E7

(819) 997-1185

A French translation of the Executive Summary or the comprehensive report entitled "Sediment Issues and Data Needs in Ontario", Report No. IWD-OR-WRB-55-86-1 is available upon request.

L.J. Kamp
Regional Chief
Water Resources Branch
Ontario Region

Canada

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Le présent résumé exécutif a trait à une étude poussée sur des questions relatives aux sédiments et aux besoins de données en Ontario, laquelle a été menée par Conservation Management Systems. La table des matières du rapport détaillé a été annexée au présent résumé afin de donner au lecteur un aperçu de la magnitude de l'étude et du contenu du rapport complet. On peut obtenir un exemplaire de ce rapport en s'adressant au:

Chef régional
Direction des ressources en eau
Direction générale des eaux intérieures
Région de l'Ontario
Conservation et Protection
Environnement Canada
75, rue Farquhar
Guelph (Ontario)
N1H 3N4

(519) 821-0110

Cette étude qui porte sur des questions relatives aux sédiments et aux besoins de données en Ontario est l'une des nombreuses études du genre menées par des experts-conseils dans quatre autres régions du Canada pour évaluer le programme existant d'enquêtes sur les sédiments et pour se doter d'une perspective nationale en ce qui a trait aux questions relatives aux sédiments. On peut obtenir un exemplaire de ces rapports en s'adressant à la:

Section d'études des sédiments
Direction des ressources en eau
Direction générale des eaux intérieures
Conservation et Protection
Environnement Canada
Ottawa (Ontario)
K1A 0E7

(819) 997-1185

On peut obtenir sur demande la version française du résumé exécutif et du rapport complet qui a pour titre "Questions relatives aux sédiments et besoins de données en Ontario", rapport n^o IWD-OR-WRB-55-86-1.

Le chef régional
L.J. Kamp
Direction des ressources en eau
Région de l'Ontario

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EXECUTIVE SUMMARY

In response to a need expressed by Environment Canada, Conservation Management Systems has undertaken a thorough study of sediment issues and programs in Ontario. This study has involved the use of a questionnaire and interviews with a cross section of sediment data users and collectors in the province, a one-day workshop with representatives from many of the sediment data user groups, and an extensive literature review regarding knowledge gleaned from Ontario sediment data. Results from this multifaceted approach to the topic have been combined, organized, and discussed under the headings of: sediment issues, sediment knowledge, and sediment data. The study has led to a clarification of issues relating to sediment, an assessment of knowledge regarding sediment in Ontario, and the identification of needs and recommendations regarding the data base, sampling strategies and methods, and the sediment information system.

Sediment Issues

The exercise of clarifying sediment issues has clearly revealed that sediment data are being used and are required in the province for the exploration of a wide variety of topics, involving both quantitative and qualitative issues. A number of studies relate to the quantity of sediment deposited in channels, ponds, reservoirs, harbours and lakes. However, most sediment data users are more interested in the quality of the suspended materials being transported through the stream and lake systems.

Further, the issues being addressed reveal a focusing of attention on where the sediment is coming from, what it is carrying in the form of potential contaminants, where it is going, and how both the volume and quality of sediments affect downstream water quality and quantity.

Sediment information is required to ascertain the relative quantities of material originating from agricultural, forested, and urban areas; from streambanks and ditches; and from construction and power project sites; and to evaluate the impact of erosion and sediment control measures at such sources. There is considerable interest in the development of a global perspective of the spatial and temporal distributions of sediment yield in the province, including the development of sediment/streamflow models; and the role of suspended sediment as a transport medium for contaminants is clearly an issue of major concern. Virtually all of the issues being addressed have been precipitated by pressing downstream problems brought about by the quantity and/or quality of suspended sediment arising from and transported through the contributing watershed; and although sediment sources and watershed characteristics vary across the province, the main categories of issues identified by persons from various regions have not been noticeably different.

1. It is concluded that there is a strongly expressed need for a sediment data base in Ontario which allows the exploration and resolution of a wide variety of sediment related issues. These issues relate to both sediment quantity and sediment quality; and attention is being and needs to be focussed on sources of sediment, associated contamination, transport and deposition mechanisms, and the manner in and extent to which the volume and quality of sediment moving downstream affect water quantity and quality and can be controlled.

The exercise of clarifying issues has also revealed that a considerable number of people are making use of sediment information, and that a great many and a wide variety of user groups are involved. Most of the user groups are government based (federal, provincial, and municipal), and virtually all users are exploring sediment data on the basis of government funding (i.e. as civil servants, consultants on government contracts, or academics involved in research funded by government grants).

2. **The strong need for a reliable sediment data base in Ontario is confirmed by the large number of data users; and the distribution of user groups reveals the need for an efficient and economical system for collecting, interpreting, and distributing information regarding sediment and sediment issues, in order that costs are minimized for not only the users of the data but also the residents of the province.**

Sediment Knowledge

It is important to note that it is primarily since 1975 (e.g. PLUARG studies) that the need for and the collection of sediment data have been addressed in the province; and it is, therefore, during the last decade that our data and knowledge bases regarding sediment have begun to develop. The study review of literature and data has selectively focussed on sediment issues of particular relevance, dealing principally with suspended sediments and conditions in Southern Ontario, and highlighting knowledge and identifying gaps with regard to stream loadings, seasonal variability, extreme events, spatial variability, sources of sediment, and sediment and water quality.

To begin with suspended sediment loadings in the province are revealed to be only a fraction of those experienced in the mountainous and alluvial regions of Canada, and to be orders of magnitude smaller than loadings observed in many major rivers of the world. It is important to recognize then that the quantity of sediment itself transported in Ontario streams is generally not of major proportions or of major significance.

3. **The development of a provincial sediment program focussed solely on the determination of sediment volumes is not justified.**

The annual suspended sediment loads, although relatively moderate, can nevertheless vary considerably from year to year. However, the skewness of the annual loads appears to be relatively insignificant. These particular characteristics have been shown to be of importance in the estimation of annual sediment loads.

4. **Single year determinations of suspended sediment loads do not provide precise estimates of long-term mean values and should not be considered as such. However, both mean and median values of 10 or more years of data provide good indices of the central tendency of annual suspended sediment loads in the province.**

Daily sediment loads in Ontario streams vary more dramatically than the corresponding annual loads, and vary over a wide range of values. However, the daily loads tend to follow a very distinctive seasonal pattern, the bulk of the annual suspended being transported during the spring period, in concert with the seasonal occurrence of high water flows. Further, in conjunction with the daily suspended sediment loads exhibiting highly skewed frequency distributions, a very large percentage of the annual load is transported downstream in a very small percentage of the time (in many cases, 80 to 90 percent of the annual load is delivered in less than 40 days). Therefore, the movement of suspended sediment in Ontario streams may be considered to be an event-oriented process, and reliable estimates of suspended loads are contingent upon the application of a sampling scheme in time that ensures the obtaining of good sediment samples during the brief periods when most of the load is delivered. A few of the groups collecting sediment data in the province have already adopted such an approach to sampling (e.g. the Water Resources Branch), but a number of others unfortunately have not.

5. **It is strongly recommended that sediment sampling programs in Ontario key on significant runoff events during the season when these events may be expected to occur. Sampling could be greatly reduced or virtually omitted during low flow periods throughout the year. The importance of event and seasonal sampling, acknowledged by the Sediment Survey Program, needs to be strongly advocated to all sediment data collectors in the province.**
6. **It is further recommended that the Water Resources Branch continue to develop more efficient and economical sediment sampling strategies, in light of existing knowledge regarding the highly event-oriented temporal characteristics of Ontario sediment data.**

Further knowledge about the significance of sediment peak events has been revealed in extreme-value analyses. Daily sediment loads with return periods of two years or greater account for approximately 40 percent of the total sediment loads transported by Ontario streams, and annual peak events contribute a similar, or slightly larger, significant portion of the total load. These results regarding extreme values confirm that the reliable estimation of sediment loads requires careful sampling of significant events.

From a temporal point of view, therefore, it can be concluded that the available periods of sediment record of up to 20 years in length have been extremely useful for the ascertaining of temporal and duration characteristics and extremal properties of stream suspended sediment loads. And periods of record in the order of 10 years have been useful and sufficient for the confirmation of seasonal patterns and the estimation of average annual loads. Therefore, much has been learned regarding the temporal variability of Ontario sediment loads, and there is little reason to develop long-term sediment records in the province.

7. Sediment records maintained for long periods of time would now appear to offer very little additional information, with the exception of indications regarding long-term trends and a data base for developing stochastic sediment models. However, there is little need to monitor more than one or two stations for possible long-term trends; and unless trends in other associated variables such as land use were also monitored closely, there may be little point in maintaining a long-term record at any sediment station in Ontario.

Regarding the spatial variability of sediment, it has been noted in the literature that the sediment yield of basins may be related to factors such as climate, basin geomorphology, soil type, and land use. For Ontario conditions, there appears to be no simple relationship between annual suspended sediment load and readily measurable geomorphologic parameters. Annual sediment yields from agricultural watersheds in

Southern Ontario have been linked to land use and surface soil characteristics; and variations in yields have been further attributed to differences in the quantity of sheet and rill erosion, in the sediment transport systems, and in the amount of streambank erosion. The bulk of suspended sediment in rural Southern Ontario streams has been linked to agricultural cropland, with material delivered from sheet and rill erosion from such areas contributing 70 to 100 percent of the annual load. The remaining 0 to 30 percent emanates from the streambanks.

It has also been discovered that the suspended sediment amounts yielded by field-sized areas within agricultural watersheds in the province can be extremely variable, particularly in rolling upland regions. As a result, a great majority of the suspended sediment leaving upland watersheds emanates from a very small percentage of the area. Sediment yield from lowland areas appears to be considerably more uniform in space.

The literature regarding spatial variability and sources of suspended sediment in Ontario reveals that we have been able to develop a preliminary picture of the spatial distribution of sediment loads. However, although significant progress has been made in understanding some of the linkages between watershed sediment yields and source characteristics, it is not yet possible to estimate stream sediment loads with sufficient reliability in terms of readily measurable watershed parameters.

8. There is a need for an improved spatial coverage of sediment data in Ontario, and it is recommended that in the selection of sediment stations more regard be given to factors associated with the determination of sources and transport mechanisms of the sediment and associated variables.
9. Further, it is recommended that there be continued emphasis placed on the development of spatial patterns and cause-and-effect relationships between sediment and other variables, in order to optimize the use of monitored data and minimize the need for additional sediment stations.

Regarding the relationship between sediment and water quality, it has now been clearly determined that many of the Ontario water bodies including the Great Lakes are being polluted from land drainage sources, and that sediment effects the pollution primarily as a carrier of phosphorus, industrial organic compounds, pesticides, and heavy metals. On the one hand, sediment can be a pollutant carrier or source, keeping potential contaminants bound to the surface of sediment particles during transport through some part of the watershed drainage system and releasing the contaminants at a downstream location. On the other hand, sediment can act as a sink or trap, scavenging pollutants from the water column of stream and lake systems and depositing the undesirable materials in bottom sediments.

Much has been learned in recent years about many of the contaminants which are associated with stream and lake sediments in Ontario, and a start has been made in understanding the processes involved in the binding and releasing of contaminants from sediment particles. However, knowledge regarding the spatial and temporal variability of these linkage processes is yet in its infancy.

10. It is vital that carefully conceived data sets involving sediment, various contaminant, and other biochemical variables be assembled for studies to ascertain the nature of linkages among the variables and the manner in which these linkages vary in time and space in stream and lake systems in the province.
11. As the linkages noted in 10 become better understood, it is recommended that combined sediment and water quality sampling strategies be devised for the efficient and accurate estimating of not only sediment concentrations and loads but also various contaminant concentrations and loads.

Sediment Data

A review of available sediment information in Ontario reveals that there are a great many groups, primarily federal and provincial civil servants,

involved in the collection. The information includes a great deal of data involving primarily suspended sediment and stream or lakebed deposits, and much of the data has been collected in relation to specific projects. There has not been a complete inventory of sediment stations available, except for separate mappings of the Water Resources Branch and Ontario Ministry of the Environment stations. Partial combined maps of these and a number of other stations have been prepared as a part of this study, and are included in the report.

At first glance, the maps would indicate that many sediment stations are widely distributed across the province, with obvious concentrations in the southern part, suggesting a reasonable spatial coverage of information. However, a closer look at the periods of record available reveals substantial incompatibility of the data.

12. There is an urgent need for the development of an ongoing coordinated inventory of sediment data for purposes of clarifying both the spatial and the temporal coverage of information.
13. Further, in light of the multitude of groups involved in sediment data collection, there is also a need for a mechanism to coordinate the data made available from the many sources.

Upon further scrutiny, the sediment data in Ontario are found to be collected by many different methods at a wide variety of sampling frequencies, and there is no readily available description of the measurement or analytical techniques used.

14. There is definitely a need for fuller documentation regarding the approaches and methods employed by sediment data collectors in the province.

And it also becomes apparent that the wide variety of sampling, measurement, and analytical techniques employed by the various data collectors is yielding data outputs that are extremely difficult, if not impossible to compare.

15. **Future sediment data must be collected and analyzed in more compatible ways! It is, therefore, recommended that a mechanism be developed to establish standards and/or guidelines for sediment data collection in the province and to offer advisory services regarding the collection and use of sediment data.**

Discussions with both sediment data collectors and users have revealed that the range of accuracy and the possible sources of error for sediment data are not well understood and have not been adequately evaluated. Most collectors have not identified the accuracy of their sediment data base, and sediment data users have generally not specified the accuracy required for their projects. However, an increasing number of users have become interested in ascertaining the accuracy associated with the data, either because they need better data for more critical decision making or because they have become aware of gross errors in existing data.

It is now known that the sampling frequency of sediment concentrations and the method of computation of annual sediment loads can have significant effects on both the accuracy and precision of sediment load estimates. For example, most computational methods used for determining annual loads result in an underestimation of the suspended loads; and infrequent sampling of suspended sediment concentrations can lead to gross underprediction of the loads. Further, the relative level of accuracy for a particular computational method applied to a selected sampling frequency does not necessarily correspond to the relative level of precision for the same combination of method and frequency. Therefore, both accuracy and precision need to be considered when methods and sampling frequencies regarding sediment data are reviewed.

16. **It is imperative that the accuracy and precision of sediment data collected by various groups in Ontario be ascertained in relation to sampling and analytical procedures employed, and in light of the accuracy and precision warranted in user projects. It is also vital that sediment data users be clearly informed about the nature and extent of errors present in sediment data.**

It has also been informative to explore which sediment data are being used in the province. A majority of users have been found to employ Water Resources Branch data as one of their sources of information. However, almost one third of users sampled had not used this source, most of this group collecting their own data. It was further discovered that many sediment data users in the province are unfamiliar with Water Resources Branch and other sediment information; and many of the users who are aware of Water Resources Branch information do not have a very complete picture of the range of data and services available from that source. This is further evidence that the sources of sediment data need to be clarified for users (see Conclusion/Recommendation 14).

It has become clear that a wide variety of sediment data are used. Sediment data users seem generally satisfied with the type of data available; however, it would appear that many data users are somewhat uncertain about their sediment data needs. Where data preferences have been clarified, users have specified more frequent sampling, at more stations, in locations more appropriate to specific problems and issues.

17. **It is recommended that the Water Resources Branch, in conjunction with other sediment data collectors in Ontario, continue to develop their network strategy for sampling sediment information over the extent of the province, in light of spatial information and models already available, apparent gaps in knowledge, and identified needs.**

It has also become apparent that many sediment data users need or would appreciate basic interpretations provided in conjunction with published data. Although there is a diversity of opinion regarding desired interpretations, the more fundamental ones include individual station analysis and descriptions of the temporal variability of the data, regional patterns, linkages to other variables, and linkages to sediment sources.

18. It is recommended that the Water Resources Branch explore more fully the need for basic interpretations regarding collected sediment data, and examine requirements for and implications of including such information as an integral part of an accumulated sediment data base for the province.

A consideration of the program objectives of the various sediment collection groups, in light of the sediment problems and issues clarified earlier, has revealed that the current objectives are in general in tune with the concerns of the user groups. However, it is clear that a number of collection programs and the Sediment Survey Program in particular have been directed principally towards the determination of the quantity of suspended and deposited sediments, with little reference to the quality of such sediments or to other programs involved in monitoring other water quality variables.

19. Sediment data should be collected in Ontario with more regard given to water quality variables of local and temporal interest, and to other data collection programs regarding such variables.
20. The Water Resources Branch Sediment Sampling Program should examine the relevance of their sampling methodology in time and space as well as associated laboratory analyses to not only sediment quantity but also sediment quality and associated water quality issues.

Sediment Information Systems

It is evident from the analysis of sediment issues, knowledge, and data, that there is a substantial need for a much more coordinated approach to the collection and dissemination of sediment information in Ontario. The development of an integrated sediment information system is proposed here, in the context of the following set of recommendations, re-emphasizing some of the previously identified recommendations.

With regard to a more coordinated approach to data collection:

21. It is recommended that sediment and sediment related data continue to be collected in Ontario by a number of agencies, groups, and individuals; and that these various data collectors work together in a coordinated fashion to develop a more integrated sediment data acquisition system.
22. It is recommended that cost-sharing (i.e. among the data collectors) be investigated by the collective group of sediment data collectors in the development of the data acquisition system.
23. It is recommended that guidelines and/or standards be developed by the collective group for the acquisition of sediment and sediment-related data in Ontario.
24. It is recommended that one of the agencies intimately involved with the development of the integrated sediment data acquisition system (i.e. the Water Resources Branch) be responsible for providing advisory services to data collectors and users regarding the collection, analysis, and interpretation of sediment data, continually ascertaining those interpretations deemed to be most useful to user groups.
25. It is recommended that the sediment data acquisition system be established to be more responsive to requests regarding specific project needs.
26. It is recommended that cost-recovery methods (i.e. involving sediment data users) be investigated by the collective group of sediment data collectors in the development of the acquisition system.

And towards the development of a centralized sediment data base for the province:

27. It is recommended that a mechanism be developed by the collective group of sediment data collectors to coordinate the various sediment and sediment-related data bases which have been and are to be assembled. The coordination should address at least information regarding the data sets available, sources of the data, and methods of data collection and analysis.

To encourage enhanced knowledge regarding and intelligent usage of the integrated acquisition system and the centralized data base:

28. It is recommended that information available regarding sediment in Ontario (e.g. data, collection and analysis methods, agencies involved, advisory services) be made more readily available to users.
29. It is recommended that the Water Resources Branch explore more fully ways of publishing and transferring sediment information to user groups (e.g. considering not only data publications, but also workshops, newsletters, etc.).

And finally, to ensure that steps towards the development of a sediment information system will indeed be taken:

30. It is recommended that the Water Resources Branch take the initiative in bringing together the various agencies, groups, and individuals involved in the collection of sediment and sediment-related data to consider the feasibility of and approaches for developing a better coordinated and more integrated sediment acquisition system in Ontario.