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Canada Centre For Inland Waters

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SUMMARY OF SEDIMENT RELATED STUDIES WITHIN CCIW FOR THE PERIOD 1967-77

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PREFACE

The enclosed report is intended to be no more than an initial attempt to summarize sediment-related activities and productivities within the Canada Centre for Inland Waters Branch between 1967 and 1977. It should be realized that this report is incomplete in that the "areas of research" may appear to be artificial by some, may appear to be too broad or too narrow by some, or to be completely inadequate by others. It is a first attempt and, as such, provides much room for improvement. The listing of publications in appendix III is by "areas of research" and, consequently, some entries may appear more than once. Hopefully, this will not be construed by some as padding. Clearly, some authors may wish to see their publications listed under different headings.

It is hoped that some of our colleagues will update or augment the information and ideas contained herein and thereby provide a focus for sediment-related activities within the CCIW Branch for the future.

This is a working report used to assist in preparing a document on the "Rationale for sediment-related activities within the Inland Waters Directorate" requested of the senior author by the Director's office, CCIW.

L. D. Delorme

SUMMARY OF SEDIMENT RELATED STUDIES WITHIN CCIW FOR THE PERIOD 1967-77

RATIONALE

Definition of Terms and Reponsibilities

The fundamental reasons for the involvement of the Inland Waters Directorate in sediment-related activities is based on questions or problems raised by the management of water resources. The IWD Director's Committee, at its meeting held on June 17 and 18, 1975, adopted the following:

> "The IWD research objective is to provide the necessary information on and understanding of water systems for short and long-term management problems and opportunities in Canada."

The term "sediment" is defined as follows: 1. "Solid material settled from suspension in a liquid." 2. "Solid material, both mineral and organic, that is in suspension, is being transported or has been removed from its site of origin by air, water or ice and has come to rest on the earth's surface either above or below sea level." (Weller, 1960, p. 59.)

Sediment related research should be an essential part of the IWD research effort by the very nature of the constraints on water quantity and quality imposed by sediment in its dual role as the water "container" (the lake basin or drainage basin) and as a component of the water column in the form of suspended material. There are two aspects to sediment-related activities which should be clarified. These are

1) the study of present-day processes associated with erosion and deposition of sediments and post-depositional physical

and chemical changes (hydraulics, geochemistry, geomorphology and sedimentology);

2) the identification and application of the imprint of these processes in the sediment to the problems of interpreting the evolution of the basin and determining the rates and forms of basin modification needed to predict future change (paleolimnology, sedimentology and geomorphology), and also the use of sediments as containing baseline information of events as they have occurred in the past.

Based on the EMS "Green Paper", broad categories for sediment-related activities can be identified as follows:

Water Planning and Management

- the effect of sediments on the release of nutrients and the rate of eutrophication;
- the effect of sediments on the presence and release of toxic substances;
- the use of historical and prehistorical sedimentological and paleolimnological records for determining successional development and eutrophication indices for use in pollution abatement;
- the effect of landfill and tailing sites in close proximity to shorelines;
- the use of sediments to define mixing zones;
- the effect on the ecosystem of using wetland sediments as filters for sewage effluents.

Food Production

Fisheries:

- the effect of toxic substances, released from sediments, on fish and other aquatic organisms which form part of the food chain for fish and man;
- the harmful effects of sediment deposition on fish spawning grounds;
- knowledge of sediments as an input into the identification of suitable fish spawning sites.

Industry

Forestry:

- the effect of waste cellulose fibre (such as bark, wood chips and sawdust, etc.) on sediments and fish spawning grounds;
- the effect of pulp and paper sewage effluents on sediments and release of toxicants from sediments.

Mining:

- the effect of tailings on the geochemistry of sediments and release of toxicants from sediments;
- to determine the distribution of selected mineral fibres (such as asbestos) which could be detrimental to the well being of organisms (including man) and the repository of such fibers;
- the effect of removal of economic sand and gravel deposits from the basin.

Transportation

- the effect of shoreline erosion on pier construction;
- the effect of bars and spits on shipping and recreation;
- the effect of accelerated sedimentation rates on access to harbours;

- the effect of infilling a basin on large ship movement;
- the effect of ship movement on bottom sediments and shorelines;
- the effect of dredging spoils on the ecosystem.

Energy

Hydroelectric power:

- the effect of accelerated sedimentation rates on infilling of reservoirs;
- the effect of soil and plant degradation on oxygen content of a new reservoir;
- the effect of flooding extensive peatlands in a new impoundment.

Others:

- oil spills -- effect on shorelines and sediments;
- implications of peat use as an energy source.

Recreation

Lake use:

- the effects of sediment turbidity;
- the effects of shoreline erosion and redeposition of sediments as bars or spits;
- the effect of recreational use on shoreline degradation;
- the effects of organic-rich sediments on eutrophication and the resultant esthetic appeal.

Wildlife:

- the effect on the ecosystem of destroying or modifying wetlands by high or low water levels or infilling of local basin(s) by sediments.

INVOLVEMENT

There are many ways in which a scientific institution, such as CCIW, can reply to such broad categories for sediment related studies. The "Centre" has chosen initially to familiarize itself, relative to sediment studies, with the problems and deficiencies within the environmental earth sciences, and subsequently to fill in the large gaps in its knowledge about lake sediments and erosion processes. This has gradually led to a better understanding of sediment related problems, the resolution of some of these problems and the schema for resolving the other problems (a listing of some problems or questions is given in Appendix I). In general, the areas of research are as follows:

1) Degradation and transport of sediments
2) Aggradation of sediments within lake basins
3) Effects of physical processes on redistribution of sediments
4) Effects of biological processes on sediments
5) Effects of geochemical processes on sediments
6) The use of sediments from the lacustrine sedimentary column as a record or imprint of conditions and events as they occurred during the history of the basin
7) Development of instrumentation and methodology.

Subdivision of these areas can be found in Appendix II.

An examination of the publications within these seven areas shows that the following have received the most attention:

Sediment composition, distribution, budgets and rates of sedimentation.

Form, distribution and residency time of heavy metals, other toxic substances and nutrients from the sediment-water interface.

Development of instrumentation and methodology.

However, many subareas have barely been touched upon, while others appear to have received attention only because the geographical area of study is large and therefore labour intensive. There remain a number of important problems which have received insufficient attention to date. These can be stated under three broad categories:

Environmental Geology

- Baseline studies of shoreline geology and geomorphology.
- Effects of physical processes on the redistribution of sediments.
- Coastal and basin evolution.
- Coastal wetlands.

Geochemistry Research

- Degradation of organic substances at the sediment-water interface.
- Cycling of trace metals with sediments as a primary source.
- The exchange mechanism(s) of metals, toxicants and nutrients across the sediment-water interface.

Paleoenvironmental Research

- Development of suitable paleo-interpretive models.
- Development of trophic state indices based on proxy data for use in successional development.
- Development of a suitable chronology for use with the models.

Another area of sediment-related activity which has been alluded to in the references of the appendix (II) are activities outside of the Ontario Region. These are:

a) CCIW Detachment, Freshwater Institute, Winnipeg, where joint studies are being carried out on the Qu'Appelle chain lakes, and proposed for the Lake Winnipeg basin;

b) CCIW Detachment, Pacific and Yukon Region, Vancouver, where joint studies have been undertaken on the Okanagan and Kootenay systems;

c) National Hydrological Research Institute (NHRI). A report has been prepared by the chairman (Dr. T.M. Dick) of the "ad hoc Committee on Research Responsibilities of CCIW and NHRI", dated 9 May 1977. Responsibilities are given under "section 3 - Erosion and Sedimentation" for both institutes.

The Canada Centre for Inland Waters has also been involved in a joint Canada-USA study to assess Great Lakes pollution from land use activities. This has been referred to as Task D of PLUARG, and deals primarily with land derived toxicants with sediment load, the distribution of these sediments through streams and rivers into lakes and the impact of these released toxicants on the aquatic ecosystem.

APPENDIX I

Problems or questions arising from the management of water resources

- How stable are the shoreline bluffs?
- Is the stability of shoreline bluffs affected by composition and/or the rate of erosion?
- What is the rate of erosion of a bluff for a given material?
- How much will the morphology of the shoreline change?
- Where is the eroded sediment being transported to?
- What is the mineralogical and chemical composition of the bluff and does it contain harmful substances such as that from exposed land fill or mine tailing sites?
- What type of sedimentary structure is being created by the eroded sediments and will it be a detriment to navigation?
- Will the redeposition of sediments foul sewage outfalls and water intakes?
- Do the shoreline processes severely limit the aquatic ecosystem(s)?

- What are the sources of sediment for the basin(s)?
- What is the textural and mineralogical composition of the sediments in the basin(s)?
- Does the textural composition at anyone locality within the basin change with time? If so, why?
- What heavy metals accumulate with the sediments?

- What other inorganic substances accumulate with the sediments?
- What organic substance accumulate with the sediments?
- Which of these substances are potentially harmful to aquatic organisms?
- What is the residency time of these substances in the sediments?
- What changes could take place in the composition of these substances while in the sediments?
- What is the release rate of these substances from the sediments?
- What is the rate of sedimentation in the basin(s)?
- What is the sediment budget for the basin(s)?
- Are there any anthropogenic minerals formed in the sediment?
- Are there any harmful authigenic minerals brought into the basin?
- Where are these deposited?
- What is or are the relationship(s) between the nature of bottom sediments (substrate) and the biota?
- How do toxic substances released from sediments affect the biota?
- What is the organic composition of the sediment?
- What effect does the organic composition of sediment have
    - . on the release rate of nutrients?
    - . on oxygen demand?
    - . on the development of a hypolimnion?
    - . on the benthic faunal composition?

- What is the benthic faunal composition and what is its relationship to the habitat?
- What is the fossil composition at the mud-water interface and its relationship to the present habitat?
- What is the fossil composition of the lacustrine sediment profile beneath the mud-water interface and its relationship to the succesional development of the lake?

Areas of Research

1. Degradation and transport of sediments:
   a) degradability of materials being transported;
   b) degradation and morphology of the shoreline and basin being degraded;
   c) morphological and sedimentological evolution of the shorelines and basins;
   d) rates of degradation.

2. Aggradation of sediments within lake basins:
   a) morphology of old and new structures (bays, spits, beaches) and basin areas being aggraded;
   b) sediment composition (mineralogy, texture, structure), distribution, budgets and rates of sedimentation;
   c) incorporation of organic remains into sediments;
   d) source, form and distribution of undesirable products from mine tailings and landfill sites;
   e) sedimentalogical and geochemical effects of the removal of sediments and the relocation of dredged spoils.

3. Effects of physical processes on redistribution of sediments:
   a) depth of disturbance below the sediment-water interface relative to the magnitude of the physical process and depth of water;
   b) transport of suspended or resuspended sediments (vertical and horizontal).

4. Effects of biological processes on sediments:
   a) effects of burrowing organisms on disturbance of primary sedimentary structures, increase or decrease of sediment porosity, changes in geochemical activity, and changes in oxygen depletion rate;
   b) decomposition and degradation products of organic matter on and below the sediment-water interface.

5. Effects of geochemical processes on sediments:
   a) cementation or leaching of sediments at the time of deposition;
   b) formation of anthropogenic minerals;
   c) diagenesis;
   d) form, distribution and residency time of heavy metals and other elements in sediments, and their release rate from the sediment-water interface;
   e) source, form and residency time of toxic substances (excluding heavy metals) in sediments, and their release rate from the sediment-water interface;
   f) source, form and residency time of nutrients in sediments, and their release rate from the sediment-water interface;
   g) the effect on the ecosystem of using wetland sediments as filters for sewage effluents.

6. The use of sediments from the lacustrine sedimentary column as a record or imprint of conditions and events as they occurred during the history of the lake basin:
   a) to use organic (fossil) remains for obtaining proxy data on chemical and physical conditions during the lake basin's history;

b) to identify specific events, such as prolonged droughts, abrupt changes in the chemical, physical and biological regime, advent of eutrophication by means of changes and rates of change within the time framework of the quantitative proxy data obtained from the sediments of the lake basin;

c) the delimitation of eutrophication indices during the successional development of a lake basin, using proxy data, for use in pollution abatement programs;

d) the use of proxy data as baseline information when present day data is inadequate because of cultural disturbance;

e) the use of modern sediment data as baseline information in areas where there is little cultural disturbance.

7. Development of instrumentation and methodology:

a) instrumentation;

b) methodology.

APPENDIX III

This appendix is sediment-related research that has been done by scientists at the Canada Centre for Inland Waters. The identification of the subject by number and letter corresponds to appendix II.

1. Degradation and transport of sediments

1a. Zeman, A., 1976. Failure mechanisms in rapidly eroding Lake Erie bluffs near Port Burwell, Ontario. Abstract, 19th Annual Meeting Assoc. Engineering Geologists.

1b. Anderson*, T.W. and C.F.M. Lewis*, 1975. Acoustic profiling and sediment coring in Lake Ontario, Lake Erie and Georgian Bay. Geol. Surv. Can. Paper 75-1, pt. A: 373-376.

1b. Canada Centre for Inland Waters, Environment Canada Staff, Burlington, 1973. Great Lakes shore erosion studies, a progress report. Canada Centre for Inland Waters, Paper No. 11: 10 p.

1b. Coakley, J.P., 1974. Shore erosion in the Great Lakes: a serious problem. S.I.L. Pre-symposium Congress, Hamilton.

1b. Coakley, J.P. and H.K. Cho, 1972. Shore erosion in western Lake Erie. Proc. 15th Conf. Great Lakes Res.: 344-360.

1b. Coakley, J.P., R.W. Durham, D.E. Nelson and R. Goble, 1974. Determination of nearshore sediment movement in the Great Lakes, using neutron-activable glass sand. Mém. Inst. Géol. Bassin Aquitaine, No. 7: 363-368.

1b. Coakley, J.P., W.S. Haras and N. Freeman, 1973. The effect of storm surge on beach erosion, Point Pelee. Proc. 16th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res.: 377-389.

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* Scientist from the Geological Survey of Canada housed at CCIW for better access to the study area based on inter-Branch and later inter-departmental cooperation.

1b. Coakley, J.P. and P.F. Hamblin, 1969. Preliminary investigations of bank erosion and nearshore sedimentation in Lake Diefenbaker. CCIW Tech. Publication: 18 p.

1b. Coakley, J.P., A.J. Zeman and M.G. Skafel, 1976. Review of University of Waterloo study of shore erosion, shoreline geotechnics, hydrodynamic processes and shore protection along the shore of western Lake Ontario. 4 reports.

1c. Coakley, J.P., 1976. The formation and evolution of Point Pelee, western Lake Erie. Can. Jour. Earth Sciences, Vol. 13(1): 136-144.

1c. Coakley, J.P., 1976. A study of processes in sediment deposition and shoreline changes in the Point Pelee area, Ontario.

1c. Coakley, J.P. and H.K. Cho, 1973. Beach stability investigations at Van Wagner's Beach, western Lake Ontario. Proc. 16th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res.: 357-376.

1c. Coakley, J.P. and H.K. Cho, 1974. The effect of various lake parameters on the geometry of beach and inner nearshore deposits at the western end of Lake Ontario. 17th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res.

1c. Rukavina, N.A., 1974. Seasonal and progressive changes in the nearshore sediments of western Lake Ontario. Proc. Int. Symposium interrelationships of estuarine and continental shelf sedimentation, Bordeaux, France: 119-123.

2. Aggradation of sediments within lake basins

2a. Anderson*, T.W. and C.F.M. Lewis*, 1975. Acoustic profiling and sediment coring in Lake Ontario, Lake Erie and Georgian Bay. Geol. Surv. Can. Paper 75-1, pt. A: 373-376.

2a. Hobson*, G.D., C.E. Herdendorf and C.F.M. Lewis*, 1969. High resolution reflection seismic survey in western Lake Erie. Proc. 12th Conf. Great Lakes Res., Ann Arbor, Int. Assoc. Great Lakes Res.: 210-224.

2a. Lewis, C.F.M., 1968. Late quaternary events on Manitoulin Island. The Geology of Manitoulin Island by B.A. Liberty & F.D. Sheldon. Michigan Basin Geol. Soc., Annual Field Excursion: 60-67.

2a. Lewis, C.F.M., 1970. Recent uplift of Manitoulin Island, Ontario. Can. Jour. Earth Sciences, Vol. 7(2): 665-675.

2a. Lewis*, C.F.M. and L.A. Jaskula, 1971. Uplift studies of the Lake Huron basin. Geol. Surv. Can. Paper 71-1A: 172 p.

2a. Lewis*, C.F.M. and P.G. Sly, 1971. Seismic profiling and geology of the Toronto waterfront area of Lake Ontario. Proc. 19th Conf. Great Lakes Res., Ann Arbor, Int. Assoc. Great Lakes Res.: 303-354.

2b. Burns, N.M., J.-M. Jaquet, A.L.W. Kemp, D.C.L. Lam, J.H. Leach, M. Munawar, T.J. Simons, P.G. Sly, R.L. Thomas, N.H.F. Watson and J.D.H. Williams, 1976. Process within Lake Erie. Jour. Fish. Res. Board Can., Vol. 33: 639-643.

2b. Coakley, J.P., 1972. Nearshore sediment studies in western Lake Erie. Proc. 15th Conf. Great Lakes Res., Ann Arbor, Int. Assoc. Great Lakes Res.: 330-343.

2b. Coakley, R.P. Bukata, W.S. Haras and J.E. Burton, 1974. Satellite airborne, and ground-based observations of suspended sediment transport off Point Pelee in Lake Erie. Proc. Conf. on Human Environment, Warsaw, Poland.

2b. Cronan, D.S., and R.L. Thomas, 1970. Ferromanganese concretions in Lake Ontario. Can. Jour. Earth Sciences, Vol. 7: 1346-1349.

2b. Damiani, V., T.W. Morton and R.L. Thomas, 1973. Freshwater ferromanganese nodules from the Big Bay Section of the Bay of Quinte. 16th Proc. Int. Assoc. Great Lakes Res.: 397-403.

2b. Damiani, V., and R.L. Thomas, 1974. The surficial sediments of the Big Bay Section of the Bay of Quinte, Lake Ontario. Can. Jour. Earth Sciences, Vol. 11: 1562-1576.

2b. Dell, C.I., 1972. A preliminary assessment of geological research to be carried out in Lake Superior. CCIW Unpublished Manuscript.

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2b. Dell, C.I., 1973. A quantitative mineralogical examination of the clay-size fraction of Lake Superior sediments. Proc. 16th Conf. Great Lakes Res.: 413-420.

2b. Dell, C.I., 1975. Pyrite concretions in sediment from South Bay, Lake Huron. Can. Jour. Earth Sci., Vol. 12(6): 1077-1083.

2b. Kemp, A.L.W., T.W. Anderson*, R.L. Thomas and A. Mudrochova, 1974. Sedimentation rates and recent sediment history of Lakes Ontario, Erie and Huron. Jour. Sedimentary Petrol., Vol. 44: 207-218.

2b. Kemp, A.L.W., C.I. Dell and N.S. Harper, 1977. Sedimentation rates and a sediment budget for Lake Superior. Jour. Great Lakes Res.

2b. Kemp, A.L.W., C.B.J. Gray, A. Mudroch, H.K.T. Wong and G. Duncan, 1976. The distribution and the geochemistry of the sediments of South Bay, Lake Huron. CCIW Unpublished Report.

2b. Kemp, A.L.W. and N.S. Harper, 1977. Sedimentation rates in Lake Huron. Jour. Great Lakes Res.

2b. Kemp, A.L.W., G.A. MacInnis and N.S. Harper, 1977. Sedimentation rates and a revised sediment budget for Lake Erie. Jour. Great Lakes Res.

2b. Lewis*, C.F.M., 1968. Quaternary geology of the Great Lakes. Geol. Surv. Can., Paper No. 69-1A: 63-64.

2b. Lewis*, C.F.M. and T.W. Anderson*, 1971. Quaternary geology of the Great Lakes (Project No. 680055). Geol. Surv. Can., Paper No. 72-1A: 167 p.

2b. Prior, W. and P.G. Sly, 1977. Geological studies in the Kingston Basin, Lake Ontario. CCIW Technical File, 20 p.

2b. Rukavina, N.A., 1969. Nearshore sediment survey of western Lake Ontario, methods and preliminary results. Proc. 12th Conf. Great Lakes Res.: 317-324.

2b. Rukavina, N.A., 1970. Lake Ontario nearshore sediments, Whitby to Wellington, Ontario. Proc. 13th Conf. Great Lakes Res.: 266-273.

2b. Rukavina, N.A., 1973. Dispersion of shore and stream-derived sediments by nearshore processes in the Great Lakes. Proc. Workship on "Water Quality and Land Use Activities", International Reference Group on Great Lakes Pollution from Land Use Activities, Guelph, Ontario.

2b. Rukavina, N.A., 1975. Nearshore sediments of Lakes Ontario and Erie. Proc. Great Lakes Basin Symposium May 1975, Geoscience Canada, Vol. 3: 185-190.

2b. Rukavina, N.A., and D.A. St. Jacques, 1971. Lake Erie nearshore sediments, Fort Erie to Mohawk Point, Ontario. Proc. 14th Conf. Great Lakes Res.: 387-393.

2b. Rukavina, N.A. and G.G. LaHaie, 1977. Measurement of thickness of nearshore sands by hydraulic jetting.

2b. Rukavina, N.A. and D.A. St. Jacques, 1976. Lake Erie nearshore sediments, Port Burwell to Point Pelee, Ontario. CCIW Unpublished Report.

2b. Sandilands, P.G. and P.G. Sly, 1977. Data listings of surficial sediment samples from grid sampling studies on the Great Lakes. CCIW Tech. File Series.

2b. Sly, P.G., 1969. Sedimentological studies in the Niagara area of Lake Ontario and in the area immediately north of the Bruce Peninsula and Georgian Bay. Proc. 12th Conf. Great Lakes Res., Ann Arbor, Int. Assoc. Great Lakes Res.: 341-346.

2b. Sly, P.G., 1973. Sediment process in Great Lakes. Proc. Hydrology Symposium Fluvial Processes and Sedimentation: 464-492.

2b. Sly, P.G., 1973. The significance of sediment deposits in large lakes and their energy relationships. In Hydrology of Lakes Symposium, Int. Assoc. Hydrological Sci. Publ., No. 109: 383-396.

2b. Sly, P.G., 1974. Sedimentation - a general report. Hydrol. Sci. Bull. 19(1): 115-117.

2b. Sly, P.G., 1977. Sedimentation and sediment transport. In Lakes: their physics and chemistry, Ed. A. Lerman. Springer-Verlag (N.Y.).

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2b. St. Jacques and N.A. Rukavina, 1972. Lake Ontario nearshore sediments - Wellington to Main Duck Island, Ontario. Proc. 15th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res.: 394-400.

2b. St. Jacques and N.A. Rukavina, 1973. Lake Erie nearshore sediments - Mohawk Point to Port Burwell, Ontario. Proc. 16th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res.: 454-467.

2b. St. John, B.E., P.G. Sly and R.L. Thomas, 1973. The importance of sediment studies in western lakes as a key to basin management. Proc. Symposium Lakes of Western Canada. University of Alberta. Water Resources Centre Publ. No. 2: 145-174.

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2b. Thomas, R.L., A.L.W. Kemp and C.F.M. Lewis*, 1972. Distribution, composition and characteristics of the surficial sediments of Lake Ontario. Jour. Sedimentary Petrol., Vol. 42: 66-84.

2b. Thomas, R.L., A.L.W. Kemp and C.F.M. Lewis*, 1972. The surficial sediments of Lake Huron. Can. Jour. Earth Sciences, Vol. 10: 226-271.

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2c. Delorme, L.D., 1976b. Freshwater Ostracoda from Northwestern Ontario. CCIW Unpublished Manuscript: 53 p.

2c. Delorme, L.D., 1977a. Freshwater Ostracoda from Alberta. CCIW Unpublished Manuscript: 165 p.

2c. Delorme, L.D., 1977b. Freshwater Ostracoda from Saskatchewan: CCIW Unpublished Manuscript: 210 p.

2c. Delorme, L.D., 1977c. Freshwater Ostracoda from Manitoba. CCIW Unpublished Manuscript: 121 p.

2c. Delorme, L.D., 1977d. Freshwater Ostracoda from the Okanagan Valley, British Columbia. CCIW Unpublished Manuscript: 33 p.

2c. Delorme, L.D., 1977e. Freshwater Ostracoda from the Northwest Territories. CCIW Unpublished Manuscript, 45 p.

2c. Delorme, L.D., 1977f. Freshwater Ostracoda from the Yukon Territory: CCIW Unpublished Manuscript: 33 P.

2c. Delorme, L.D., 1977g. Freshwater Ostracoda from the Bay of Quinte, Ontario. CCIW Unpublished Manuscript: 53 p.

2c. Delorme, L.D., 1977h, Freshwater Ostracoda from east of Point Pelee, Lake Erie, Ontario. CCIW Unpublished Manuscript: 23 p.

2c. Delorme, L.D., 1977i, Freshwater Ostracoda from the east end of Lake Superior, Ontario. CCIW Unpublished Manuscript: 19 p.

2c. Delorme, L.D., 1977j, Benthic organisms (Ostracoda) of Lake Erie: Jour. Great Lakes Res.

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