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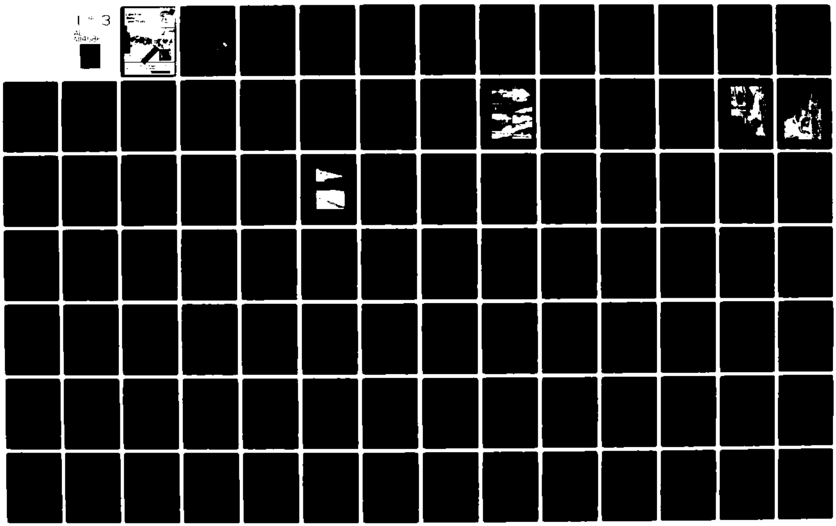

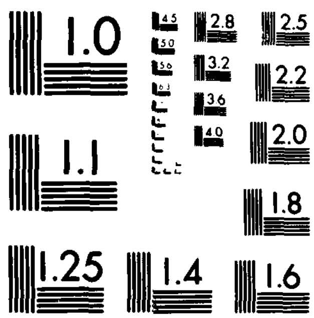

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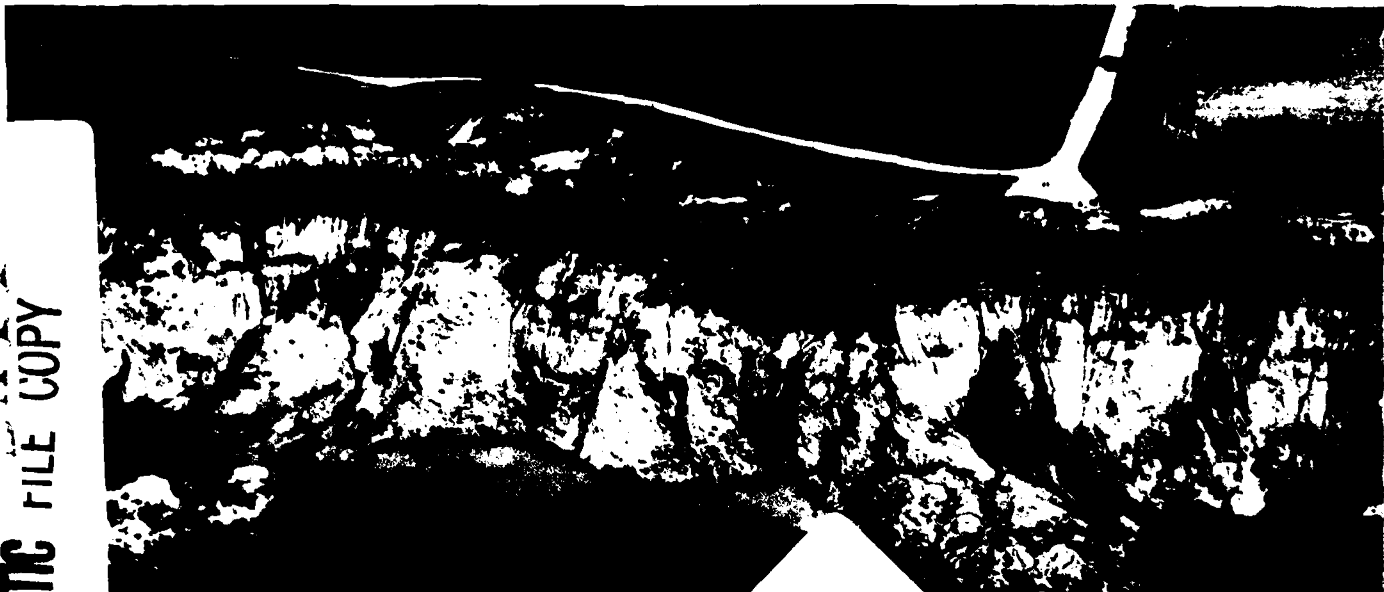

Appendix C
Coastal Zone

International Lake Erie Regulation Study Board

International Joint Commission

July 1981

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This appendix presents the results of studies completed by the Coastal Zone Subcommittee of the International Lake Erie Regulation Study Board, which was established by the International Joint Commission in May 1977.

The purpose of the studies was to determine the economic effects of changes in levels and flows on the coastal zone. The methodologies used for
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20. evaluating alternative regulation plans for flood and erosion damage indicate by lake, interest and country, the amount and distribution of benefits or losses. Results of the evaluation of selected regulation plans are presented.

During the coastal zone evaluations a number of assumptions were necessary regarding physical processes, future levels and socio-economic conditions. Sensitivity analyses were conducted to evaluate the effect of altering some of these assumptions. Descriptions of these assumptions and the sensitivity analyses are contained in this appendix.

LAKE ERIE REGULATION STUDY

APPENDIX C

COASTAL ZONE

REPORT TO THE

INTERNATIONAL JOINT COMMISSION

BY THE

INTERNATIONAL LAKE ERIE REGULATION STUDY BOARD

(UNDER THE REFERENCE OF 21 FEBRUARY 1977)

July 1981

SYNOPSIS

This appendix presents the results of studies completed by the Coastal Zone Subcommittee of the International Lake Erie Regulation Study Board, which was established by the International Joint Commission in May 1977.

The purpose of the studies was to determine the economic effects of changes in levels and flows on the coastal zone. The methodologies used for evaluating alternative regulation plans for flood and erosion damage indicate by lake, interest and country, the amount and distribution of benefits or losses. Results of the evaluation of selected regulation plans are presented.

It was necessary to make a number of assumptions regarding physical processes, future levels and socio-economic conditions. Sensitivity analyses were conducted to evaluate the effect of altering some of these assumptions. Descriptions of these assumptions and the sensitivity analyses are contained in this appendix.

Water intakes were evaluated for effects of fluctuating lake levels by comparing pumping costs for basis-of-comparison and regulated lake level conditions.

Certain regulation plans were selected by the International Lake Erie Regulation Study Board to be evaluated both qualitatively and quantitatively for the effects of lake levels provided by a specific plan as compared with the bases-of-comparison levels. The evaluations carried out for erosion, inundation and water intakes were completed for selected plans 25N, 15S, and 6L.

The results of the entire study, as well as findings and conclusions, are provided in the International Lake Erie Regulation Study Board's Report, "Lake Erie Regulation Study".

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APPENDIX A - LAKE REGULATION

A detailed description of the various factors which govern the water supply to the Great Lakes-St. Lawrence River System and affect the response of the system to this supply along with documentation of the development and hydrologic evaluation of plans for limited regulation of Lake Erie.

APPENDIX B - REGULATORY WORKS

A description of design criteria and methods used and design and cost estimates of the regulatory and remedial works required in the Niagara and St. Lawrence Rivers to facilitate limited regulation of Lake Erie.

APPENDIX C - COASTAL ZONE

A documentation of the methodology developed to estimate in economic terms the effects of changes in water level regimes on erosion and inundation of the shoreline and water intakes and of the detailed economic evaluations of plans for limited regulation of Lake Erie.

APPENDIX D - COMMERCIAL NAVIGATION

A documentation of the methodology applied in the assessment of the effects on shipping using the Great Lakes-St. Lawrence navigation system as a consequence of changes in lake level regimes and the evaluation of the economic effects on navigation of regime changes that would take place under plans for limited regulation of Lake Erie.

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APPENDIX E - POWER

A documentation of the methodology applied in the assessment of the effects of hydro-electric power production at installations on the outlet rivers of the Great Lakes and of the detailed economic evaluation of the effects of plans for limited regulation of Lake Erie on the capacity and energy output of these installations.

APPENDIX F - ENVIRONMENTAL EFFECTS

A documentation of the qualitative assessment of the effects of plans for limited regulation of Lake Erie on fish, wildlife, and water quality within the lower Great Lakes and the St. Lawrence River.

APPENDIX G - RECREATIONAL BEACHES AND BOATING

A documentation of the methodology applied in the assessment of the effects of plans for limited regulation of Lake Erie on beaches and recreational boating activities, along with a detailed economic evaluation, within the lower Great Lakes and the St. Lawrence River.

APPENDIX H - PUBLIC INFORMATION PROGRAM

A documentation of the public information program utilized throughout the study to inform the public of study activities and findings and provide a vehicle for public comment on the study.

Section 1

INTRODUCTION

1.1 General

The Governments of Canada and the United States jointly requested on February 21, 1977 that the International Joint Commission (IJC) undertake a study to determine the feasibility of limited regulation of Lake Erie. In particular, this study was to "... examine and report on the effects of such limited regulation with respect to:

(a) Domestic water supply and sanitation;
(b) Navigation;
(c) Water supply for power generation and industrial purposes;
(d) Agriculture;
(e) Shore property, both public and private;
(f) Flood control;
(g) Fish and wildlife, and other environmental aspects;
(h) Public recreation; and,
(i) Such other effects and implications which the Commission may deem appropriate and relevant."

The Governments requested that the Commission, upon availability of adequate funding, proceed with the study as expeditiously as practicable and report to the Governments. This Appendix forms part of the Final Report of the International Lake Erie Regulation Study Board to the International Joint Commission.

1.2 Organization

In order to carry out the study, the Commission established the International Lake Erie Regulation Study Board which consisted of four Canadian and four United States members. The Study Board then appointed a Working Committee to expedite the study. Under the Working Committee, six Subcommittees were designated, each containing equal representation from both countries. In addition, the Working Committee established two work groups - the Ad-Hoc Economics Working Group and the Ad-Hoc Public Information Group. The six Subcommittees were:

1. Regulation Subcommittee;
2. Coastal Zone Subcommittee;
3. Power Subcommittee;
4. Environmental Effects Subcommittee;
5. Navigation Subcommittee; and,
6. Regulatory Works Subcommittee.

It was the purpose of each Subcommittee to review all pertinent past studies to determine what data are available for use in the evaluations. The International Great Lakes Levels Board (IGLLB) Study, "Regulation of Great Lakes Water Levels," December 1973, was used as a starting point for updating and modifying previously developed methodologies. The 1977 Reference is outlined in the Study Plan for the International Lake Erie Regulation Study Board, approved September 14, 1977.

1.3 Coastal Zone Study Process

In accordance with the February 21, 1977 letter to the International Joint Commission from the Governments and the Directive of the International Joint Commission to the International Lake Erie Regulation Study Board, dated May 10, 1977, the Coastal Zone Subcommittee evaluated the economic effects of regulation plans on certain coastal zone interests on the Great Lakes, their connecting channels and St. Lawrence River. Factors to be evaluated included physical damage and property loss due to erosion and inundation, effects of varying water levels on marine structures, and, domestic and industrial water supply facilities.[1] In carrying out its assigned work the Subcommittee accomplished the following tasks:

1. Compiled and updated existing physical and economic data on the coastal zone;

2. Prepared loss functions for erosion and inundation damages and water intakes pumping;

3. Developed detailed methodologies for evaluating shoreline damages due to erosion and inundation and effects on water intakes pumping due to pressure head alteration from lake level changes;

4. Evaluated erosion and inundation damages in the coastal zone and determined effects of regulation plans on water intakes pumping costs using methodologies developed in "3" above.

5. Conducted sensitivity analyses on some of the major assumptions used in the development of the detailed methodologies;

6. Prepared coastal zone study reports;

7. Prepared information for the public participation program; and,

8. Compiled a detailed Appendix for the International Lake Erie Regulation Study Board's final report.

The above tasks were performed in accordance with a schedule determined by the Working Committee.

---

1. Although marine structures were listed in the Directive for evaluation, they were eliminated after preliminary evaluation for reasons discussed in Section 3.4.

1.4 Land Use

The total length of the Great Lakes-St. Lawrence River system shoreline, including islands, is approximately 12,100 miles. See Table C-1. In the United States there are about 5,300 miles of shoreline, which includes all the shoreline in eight states: Minnesota, Wisconsin, Michigan, Illinois, Indiana, Ohio, Pennsylvania, and New York. In Canada, there are about 6,800 miles of shoreline made up from the Provinces of Ontario and Quebec. The shoreline characteristics range from extremely flat lowland areas, highly susceptible to flooding (such as the St. Clair Flats), to high bluff areas, some of which are highly erodible till, (such as in southern Lake Michigan along the Michigan shore and the north central shore of Lake Erie) to impregnable rock bluffs (as are typical along most of the north shore of Lake Superior). See Figure C-1.

The Great Lakes basin economy is predominantly industrial, utilizing the transportation, power and water supply advantages offered by the Great Lakes - St. Lawrence River system. In addition, there is significant agricultural, mining and forestry production. Commercial fishing, historically one of the oldest activities, has declined in economic importance relative to increased tourism. Programs to rehabilitate fisheries are presently underway. While the entire basin is affected by the levels of the Great Lakes, the coastal zone is most directly impacted by fluctuating lake levels. The coastal zone contains valuable land which has been developed by many diverse and sometimes conflicting interests.

A major use of coastal land is for residential purposes, both permanent and seasonal. Residential uses incur most of the damage from storms due to either the absence or ineffectiveness of protective works constructed along shoreline that is susceptible to flooding and/or erosion. Another major use of the coastline is for public and private recreation. Parks, beaches, boating facilities, forest preserves, and other types of recreational developments abound along the shoreline. Recreational boating facilities are sensitive to fluctuations in lake levels in that their docks and ancillary structures may be inundated or left high and dry, preventing normal usage. Other users of coastal land include marine transportation facilities, industries and electric power plants.

Much of the basin land can accommodate each and every use. Availability for any particular use is determined by the characteristics of the shore type, land cover, accessibility, and the current uses of the specific area and adjacent land.

Table C-1 - Length of Great Lakes Shoreline

(Miles)

Shoreline	In Canada		In United States	
	Mainland	Islands	Mainland	Islands
Lake Superior	866	615	863	382
St. Marys River	66	63	29	89
Lake Michigan	0	0	1400	238
Lake Huron	1270	1720	580	257
St. Clair River	30	5	28	0
Lake St. Clair	71	43	59	84
Detroit River	30	33	30	39
Lake Erie	368	29	431	43
Niagara River	33	3	36	34
Lake Ontario	334	50	300	28
St. Lawrence River -				
Above Power Dam	150	188	151	164
Below Power Dam	445	435	9	0

TYPICAL SHORE TYPES

FIGURE C-1

In the International Joint Commission report to the Governments of Canada and the United States, "Further Regulation of the Great Lakes," 1976 (IJC, 1976) one of the conclusions was that future damages can best be controlled by the enactment of land use controls. The Commission recommended that appropriate authorities act to institute land use zoning and structural setback requirements so as to reduce future Great Lakes shoreline damage. The Canadian and Ontario governments have completed flood and erosion susceptibility mapping which shows a 100-year erosion limit based on long-term erosion rates and the 1% flood contour. These maps and a guide for their use have been distributed to municipalities and conservation authorities to aid them in developing land use regulations. Under the October 1976 Canada-Quebec Flood Risk Agreement, flood zones in the Montreal region were designated in May 1978. Future development in the flood prone areas has thereby been regulated by government policies and development in the susceptible areas will be restricted through land use zoning regulations. The United States has instituted a federal Coastal Zone Management Program which is administered on a voluntary basis by the individual States through the National Oceanic and Atmospheric Administration (NOAA). Even with these programs, however, there is concern that some development may continue in many of the inundation and erosion susceptible areas of the coastal zone.

Presented in the following sections is a summary of existing shoreline use and the problem areas which would likely be most affected by further regulation of Great Lakes water levels. A more complete description of the damage data is contained in Section 2 of this Appendix.

1.4.1 United States Shoreline

The Great Lakes Basin Commission (GLBC) was contracted, in 1977, by the U.S. Environmental Protection Agency to compile land cover information for the entire U.S. Great Lakes drainage basin utilizing LANDSAT satellite data collected during the Springs of 1976 and 1977.

The U.S. Army Corps of Engineers requested and funded the GLBC staff to reformat the data to cover all Great Lakes shoreline counties and approximately a 1,000-foot strip along the shoreline, corresponding roughly to the coastal zone. The work was completed in 1978 and is summarized by lake in Table C-2.

As part of the contract, the GLBC compiled projected land-use by county based upon the best available information. The land-use data projections for the Great Lakes coastal counties were compiled essentially from the publications issued by water quality management agencies in the Great Lakes basin. At the time of the study not all of the twenty-nine agencies had completed their data collection. As a result, the projections were not of a consistent quality for the entire basin. However, the general trend along the coastal zone appears to be a slow increase in population with a gradually decreasing rate of development. Based on U.S. Great Lakes States data, coastal zone development during the next 20 to 50 years could increase from 10% to 30% in many areas throughout the Great Lakes, depending upon the effectiveness of coastal zone management programs.

Table C-2 - United States Land Use By Lake

LAKE	Shoreline Length (mile)	Inland Water	Wetland	Forest	Brushland	Grassland	Barren	Plowed	PERCENT Total Urban* Residential	High Density Residential	Low Density Residential	Commercial
SUPERIOR[a]	892	2.7	6.0	62.1	4.5	1.1	5.6	0.5	15.6	1.4	14.0	0.2
MICHIGAN	1400	0.9	5.9	35.8	8.0	5.6	1.3	5.6	36.9	7.1	25.3	4.5
HURON	580	3.7	7.5	31.6	9.6	4.1	0.0	7.4	36.1	9.0	27.0	0.0
ST. CLAIR[b]	117	1.0	9.8	4.2	4.4	1.2	0.0	5.8	73.6	24.4	22.5	26.7
ERIE	431	0.4	6.7	10.6	9.0	4.8	1.0	9.7	57.8	23.4	21.7	12.7
ONTARIO[c]	336	3.3	2.8	24.4	14.0	7.8	0.1	5.2	42.4	5.7	36.3	0.4
GREAT LAKES SYSTEM	3756	2.0	6.8	28.1	8.2	4.2	1.3	5.8	43.6	11.8	24.5	7.3

a - Includes St. Marys River
b - Includes St. Clair River, Lake St. Clair, and Detroit River
c - Includes Niagara River
* - Total Urban Residential is the total of High Density Residential, Low Density Residential, and Commercial classes.

Source: Great Lakes Basin Commission, Summary of Existing and Projected Lake Use Information for the Great Lakes Coastal Counties, Contract # W74 RDV 78290 005 for U.S. Army Engineers, November 1978.

1.4.2 Canadian Shoreline

As part of the Canada-Ontario Great Lakes Shore Damage Survey, the land use of the shoreline was tabulated from Port Seve... on Lake Huron to Cornwall on the St. Lawrence River. For the shore of Lake Superior and the remainder of Lake Huron, land use data from the International Great Lakes Levels Board study were used. The federal-provincial St. Lawrence River Study Committee collected land use information for the Canadian Reach of the St. Lawrence River. This information is presented in Tables C-3 and C-4.

It is not anticipated that there will be a major increase in property development along the Canadian shoreline. Land use regulations and construction setback requirements currently being implemented are expected to prevent large scale development in areas susceptible to flooding and erosion.

1.4.3 Problem Areas

United States: For the period 1972-1976, about 60% of the total damages were incurred on Lakes Erie and Michigan, with about $119 million and $91 million, respectively, including costs of protective measures. The Lake Erie shoreline is essentially all low lying erodible bluff with extensive development along the entire shoreline. It is this development, together with the shore type and elevation, which makes the Lake Erie shore so prone to damages. While Lake Michigan has a much greater variety of shore types with a higher level of undeveloped and forested land, the large damages incurred were primarily the result of its shoreline length.

In the United States, with the more intensive use of the coastal zone, the potential damages from erosion and inundation will increase both in developed areas that are currently experiencing problems as well as those areas which are presently being developed or will be developed in the future.

Figure C-2 shows the major areas which are affected by flooding and Figure C-3 shows the areas most affected by erosion and the degree of erosion severity along the Great Lakes shoreline.

Canada: Areas of the Canadian shoreline that are affected by erosion are shown in Figure C-3. The most severe problems are on western Lake Ontario, much of Lake Erie, and southern Lake Huron. These areas are mainly erodible bluff, with much of the erodible portion of the Lakes Ontario and Huron coastal zone heavily developed.

BUILDING THREATENED BY EROSION ON LAKE MICHIGAN (MARCH 1976)

(B. MILLS, MICHIGAN DNR)

BUILDING DESTROYED BY FLOODING AT RENO BEACH, OHIO ON LAKE ERIE (APRIL 1973)

(B. MILLS, MICHIGAN DNR)

Table C-3 - Land Use Along Province of Ontario Shore

(Miles)

	Superior[a]	Huron[a]	St. Clair	Erie	Ontario[b]
Residential	12	244	35	164	269
Commercial & Industrial	106	169	5	8	34
Agricultural & Forest	1,250	2,169	33	145	422
Recreational	131	525	43	62	307

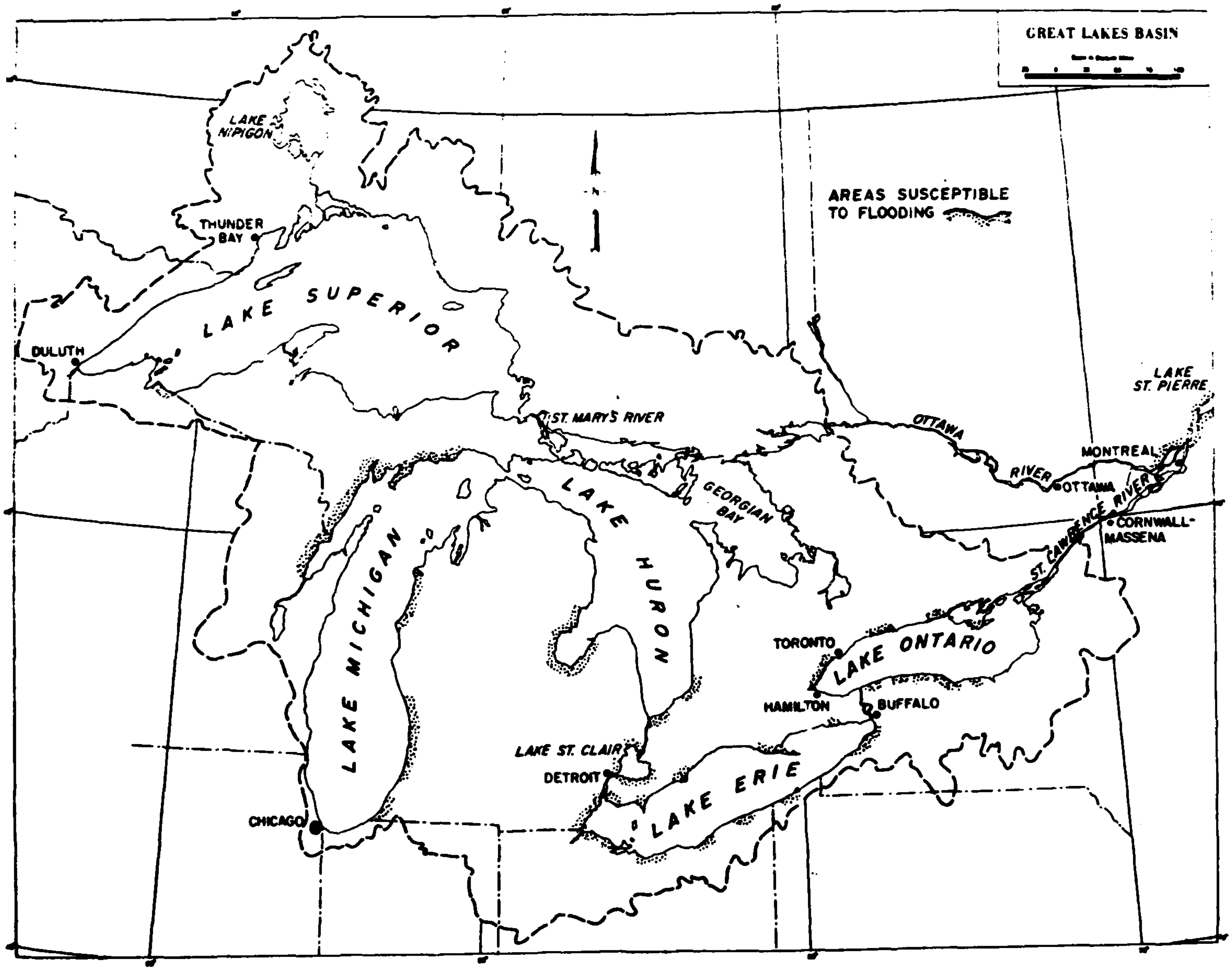
a - Approximate

b - Includes St. Lawrence River to Cornwall

Table C-4 - Land Use, St. Lawrence River, Cornwall-Trois-Rivières Shore

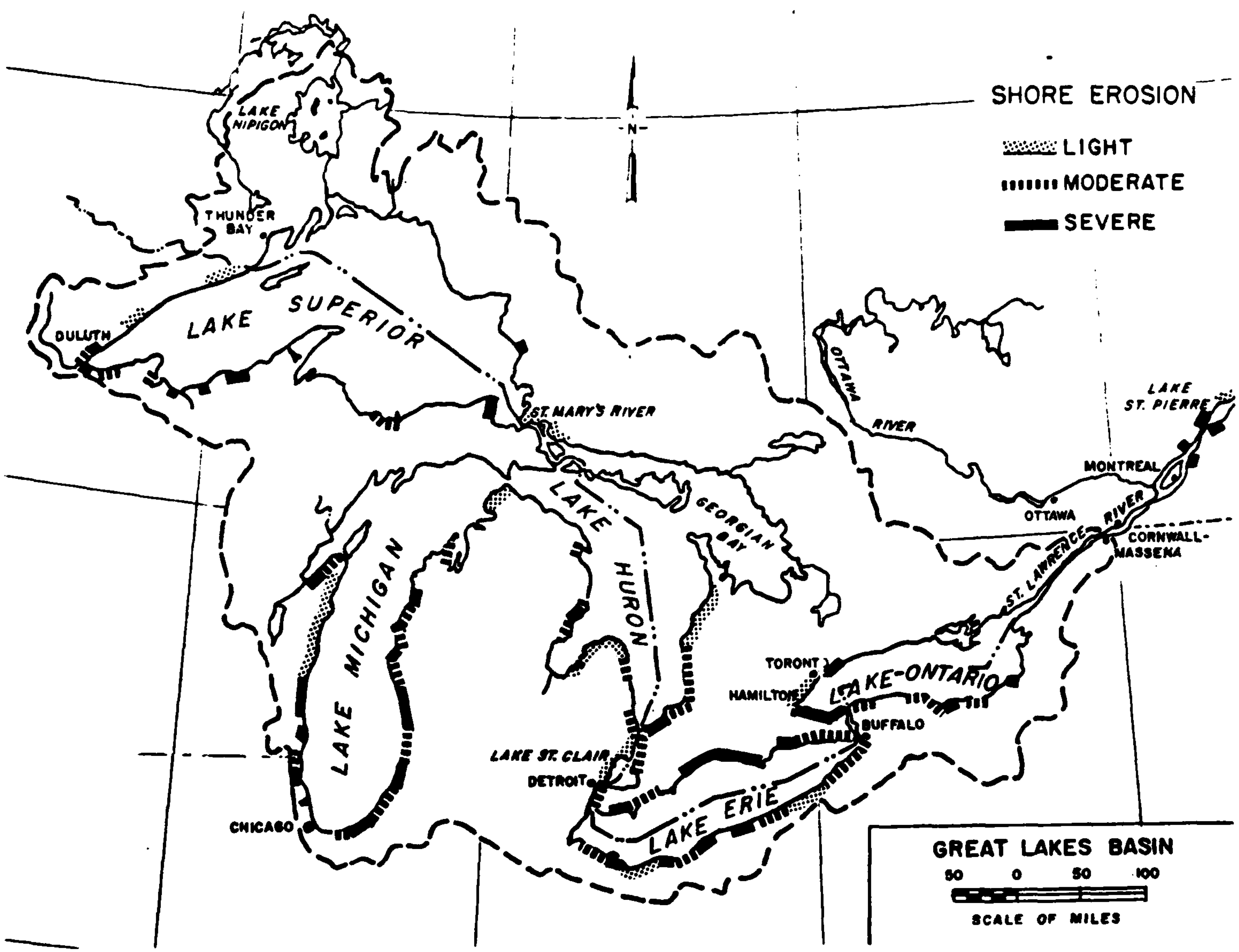
(Miles)

Urban	320
Industrial	30
Roads	70
Agricultural	210
Forest	250



GREAT LAKES-ST. LAWRENCE RIVER SHORELINE SUBJECT TO FLOODING

Figure C2



GREAT LAKES-ST. LAWRENCE RIVER SHORELINE SUBJECT TO EROSION

Areas that had moderate to severe flooding problems are shown in Figure C-2. The Montreal area and the south shore of Lake St. Clair suffer the most severe damages. Both of these areas have extensive shoreline developments.

In Canada, land use controls and setback requirements are currently being implemented in many areas and will increase in the future as coastal zone management programs become more effective. It is anticipated that shoreline usage will not continue to shift from undeveloped to developed in susceptible areas.

Summary: Regulation of the Lake Erie levels can impact positively with respect to reducing the amount of damage caused by erosion and inundation. However, should adequate land use regulations be effectively implemented in both countries, lake level regulation would have a lesser impact in reducing future damages. While lake regulation can effect some change in the overall regime of levels and flows, it should be noted that this regime is primarily the result of the water supplies to the Great Lakes basin. Thus, flooding and erosion will continue to be permanently associated with the Great Lakes system. Restricting development on exposed bluffs, flood plains and similarly susceptible areas will play the largest role in minimizing future problems. This can best be accomplished through effective coastal zone management programs.

1.5 Basis-of-Comparison Conditions

The major goal of this Study was to determine the feasibility of limited regulation of Lake Erie. At the present time, Lakes Superior and Ontario are regulated. Moreover, there are a number of diversions into, within and out of the Great Lakes system, all of which impact on the levels and flows of the Great Lakes and St. Lawrence River system.

Over the years, man has changed some of the physical conditions on the Great Lakes and its connecting channels. In order to provide a uniform set of physical characteristics, certain conditions were assumed to be extant throughout the period of historic levels and flows considered (1900-1976). This set of physical characteristics, the basis-of-comparison (BOC), was also used to measure the relative costs and benefits of regulation plans. The basis-of-comparison conditions are:

1. Lake Superior regulated in accordance with Plan 1977;

2. Lake Ontario regulated during the period 1900-1959 in accordance with Plan 1958-D and during the period from 1960 to 1976 with Plan 1958-D with the discretionary deviations that occurred in actual practice;

3. A constant diversion of 5,000 cubic feet per second (cfs), into Lake Superior from the Albany River Basin via the Long Lake and Ogoki Diversions;

4. A constant diversion of 3,200 cfs out of Lake Michigan at Chicago into the Mississippi River Basin;

5. A constant diversion of 7,000 cfs from Lake Erie into Lake Ontario through the Welland Canal;

6. 1962 conditions for Lake Huron's outlet channel;

7. 1953 conditions for Lake Erie's outlet channel; and,

8. Recorded conditions for the Ottawa River and local inflow through the St. Lawrence River.

The historical water supplies were routed through the Great Lakes system, using the above conditions. The effects of changes in channels, diversions and lake regulation were thus removed. These basis-of-comparison conditions are described further, below.

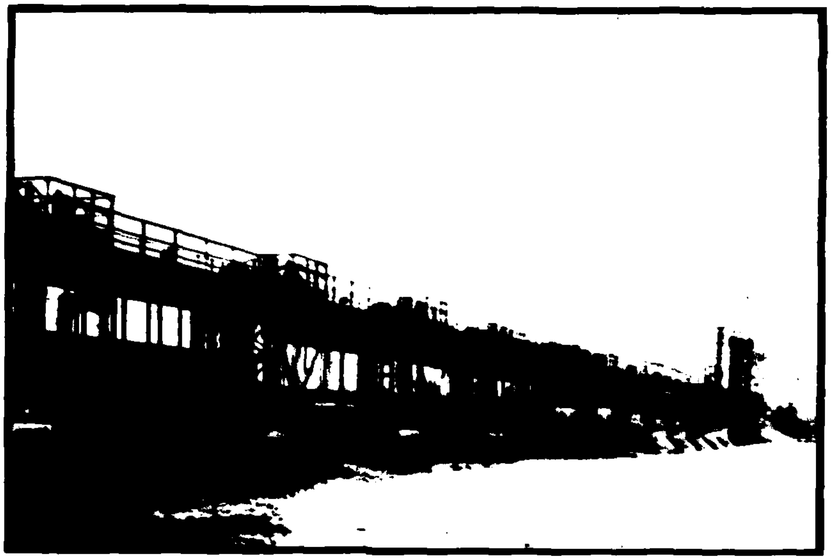
1.5.1 Lake Superior Regulation

By Orders of Approval dated 26 and 27 May, 1914, the International Joint Commission established the International Lake Superior Board of Control to oversee the regulation of Lake Superior on behalf of the Commission. Since the completion of the Compensating Works in the St. Marys River in 1921, the outflow of Lake Superior has been fully regulated. The Compensating Works, consisting of 16 gates, along with three hydropower diversions, allow outflows from the lake to be greater or less than those that would occur naturally.

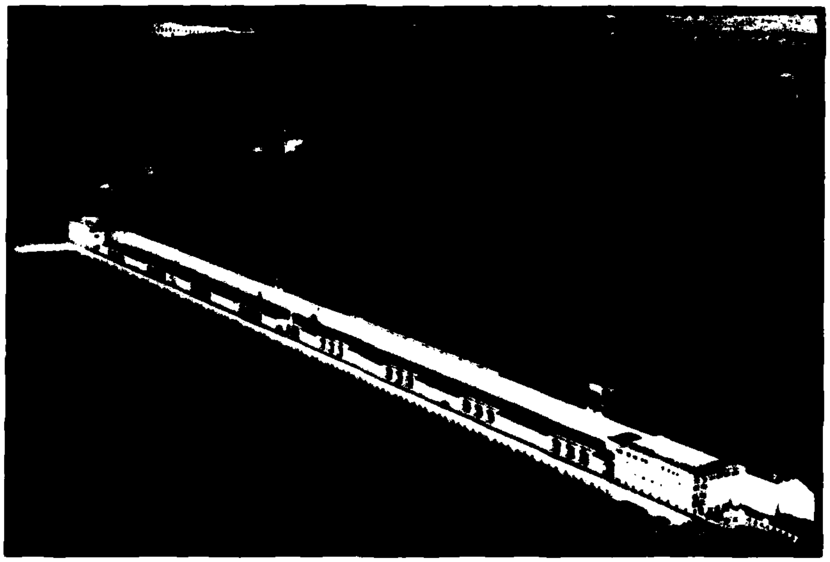
On October 4, 1979, the Commission amended its 1914 Orders of Approval and changed the objective for regulating Lake Superior to take into consideration the downstream conditions on Lakes Michigan - Huron. To accomplish this, the Commission adopted Regulation Plan 1977. Although Plan 1977 was implemented in October 1979, the historic supply conditions from 1900 through 1976 were used to compute outflows and levels. These computed outflows and levels under Plan 1977, modified by dredging in the connecting channels in 1933 and 1962, constitute the basis-of-comparison condition for the upper Great Lakes.

1.5.2 Lake Ontario Regulation

The International Joint Commission, by Orders of Approval dated October 29, 1952, and a Supplementary Order, dated July 2, 1956, authorized the construction of certain works for power development in the International Rapids Section of the St. Lawrence River (the International Rapids Section is just downstream of Lake Ontario). As a result of these Orders of Approval, Lake Ontario's outflow has been controlled since July 1958 and the lake has been regulated since 1960. Regulation has been in accordance with criteria set forth in the October 29, 1952 Orders of Approval and subsequent directives. The current approved regulation plan is Plan 1958-D, and levels and flows associated with this plan are used as the basis-of-comparison for Lake Ontario and the St. Lawrence River.



Control Works on the St. Marys River at Sault Ste. Marie.



Aerial view of St. Lawrence River Control Works at Cornwall, Ontario and Massena, N.Y.

Successive man-made changes over the past have affected the recorded Lake Ontario levels and the St. Lawrence River flows. The two principal changes are diversions into and out of the Great Lakes basin and the alterations in the configuration of the channels of the St. Lawrence River. The basis-of-comparison was adjusted to account for this. These "recorded adjusted" levels take into account present diversion rates and use the March 1955 configuration of the Lake Ontario outflow channels. It should be noted that regulation of Lake Ontario has no effect on Lake Erie outflows due to the discontinuity between the two lakes, about 175 feet of which occurs at Niagara Falls.

1.5.3 Diversions

A number of diversions affect the levels of the Great Lakes. On Lake Superior, about 5,000 cfs are diverted into the Great Lakes system through the Ogoki and Long Lake projects. This water would normally flow north to Hudson Bay. At Chicago, about 3,200 cfs are diverted out of the Great Lakes basin into the Mississippi River basin. These diversions cause a net average inflow of 1,800 cfs into the Great Lakes.

Another diversion is into the New York State Barge Canal system. The Canal diverts about 700 cfs from the Niagara River to Tonawanda Creek. Also, between Lakes Erie and Ontario there is a diversion through the Welland Canal. This canal, which has a series of locks, allows ships to proceed between Lakes Erie and Ontario and provides water to the DeCew Falls hydroelectric stations. It runs from Port Colborne, Ontario on Lake Erie to Port Weller, Ontario, on Lake Ontario, thereby passing west of Niagara Falls. The International Great Lakes Diversions and Consumptive Uses Study Board has reported that since 1977 the usage has been about 9,400 cfs.

For the basis-of-comparison conditions, it was considered that all of the diversions were in operation for the period of record. The outflows and levels were adjusted accordingly. Appendix A - Lake Regulation -gives further details relating to diversions and basis-of-comparison conditions.

The effects of varying the rates of these diversions were studied by the International Joint Commission's International Great Lakes Diversions and Consumptive Uses Study Board. A report detailing its methodology, findings and conclusions is available.

1.6 Development of Regulation Plans

Limited regulation of Lake Erie would result in extra water from the lake being released during high water level conditions. A number of plans were developed to accomplish this end. The plans would release extra water during periods of high levels, but would not hold back water during low level periods. Therefore, the structural alternatives considered do not allow complete control of Lake Erie's outflow, such as a dam would provide. Three of the most promising plans were chosen for detailed analyses.

1.6.1 Regulation Plan 25N

This plan would involve placing a gated structure in the Niagara River near the Peace Bridge. The structure would extend part way across the river. Some dredging would be required in the Niagara River to allow an increased flow of up to about 25,000 cfs.

As in all of the regulation plans, the lakes which would be either partially or fully regulated are Superior, Erie and Ontario. The N for this plan denotes a Niagara River structure and the 25 refers to an increased outflow maximum of 25,000 cfs.

1.6.2 Regulation Plan 15S

This plan would involve utilizing a diversion canal across Squaw Island, as denoted by the S, controlled by a single gated structure. The structure would be designed to increase Lake Erie outflows by 15,000 cfs during periods of extreme supply conditions. However, due to backwater effects in the main channel of the Niagara River, and operation of the Black Rock Canal for commercial and recreational boating, the design discharge is effectively limited to a 9,600 cfs increase. No dredging would be required. Some bank protection at critical areas of the Black Rock Canal would be needed.

1.6.3 Regulation Plan 6L

This plan would modify the existing Black Rock Lock to permit diversion flow through the lock chamber. As with Plan 15S, some bank protection would be necessary. The Black Rock Lock is currently being used by both recreational and commercial vessels during the navigation season. Periodic (daylight) lockages, plus a slight backwater effect, would reduce the effective maximum Lake Erie outflow increase from the 6,000 cfs design discharge to about 3,700 cfs.

Appendix B, Regulatory Works, gives more details about the structures for these three plans.

1.6.4 Lake Ontario Regulation Categories

Limited regulation of Lake Erie would result in a higher supply of water to Lake Ontario when the levels of Lake Erie are high. This could result in supplies that are in excess of the supplies that Plan 1958-D was designed for. To account for the increased supplies, and to satisfy the criteria established for the regulation of Lake Ontario, a number of alternatives were considered. These were reduced to four categories.

Category 1: Category 1 considered no change in the regulation of Lake Ontario. It is the basis-of-comparison condition. The increased supply to Lake Ontario would be handled by using the discretionary authority in Plan 1958-D.

Category 2: Category 2 would change the regulation of Lake Ontario by modification of Plan 1958-D to accommodate Lake Erie regulation so that the Lake Ontario criteria are satisfied to the same degree that occurred under the historic test and under operation since 1960 as represented by the basis-of-comparison.

Category 3: Under Category 3 the St. Lawrence River channels would be altered (i.e., dredged) as necessary to accommodate combined regulation of Lakes Erie and Ontario. A new regulation plan for Lake Ontario is also considered which would satisfy all the Commission's criteria over the entire period (1900-1976).

Category 4: Category 4 would regulate Lake Ontario without regard to downstream conditions, as required in the present Orders of Approval. The St. Lawrence River channels and the Orders of Approval would be modified, if necessary. Since the project proved economically infeasible prior to Category 4 study initiation, a detailed evaluation of Category 4 was not attempted.

1.7 Adjusted Basis-of-Comparison

In order to meet the requirements for combined regulation of Lakes Erie and Ontario, channel excavations would be required in the St. Lawrence River. In Category 3 study, an adjusted basis-of-comparison was developed for the purpose of defining such excavations.

The adjusted basis-of-comparison was developed with the same conditions as for the basis-of-comparison, except that the regulation plan for Lake Ontario was modified so that the resulting water levels and outflows satisfy the IJC's criteria and other requirements. Channel enlargements were assumed to exist throughout the historic period (1900-1976) to facilitate the modified Lake Ontario regulation plan.

A detailed description of the adjusted basis-of-comparison is contained in Appendix A, Lake Regulation.

Section 2

DATA UTILIZED

2.1 Reach Data

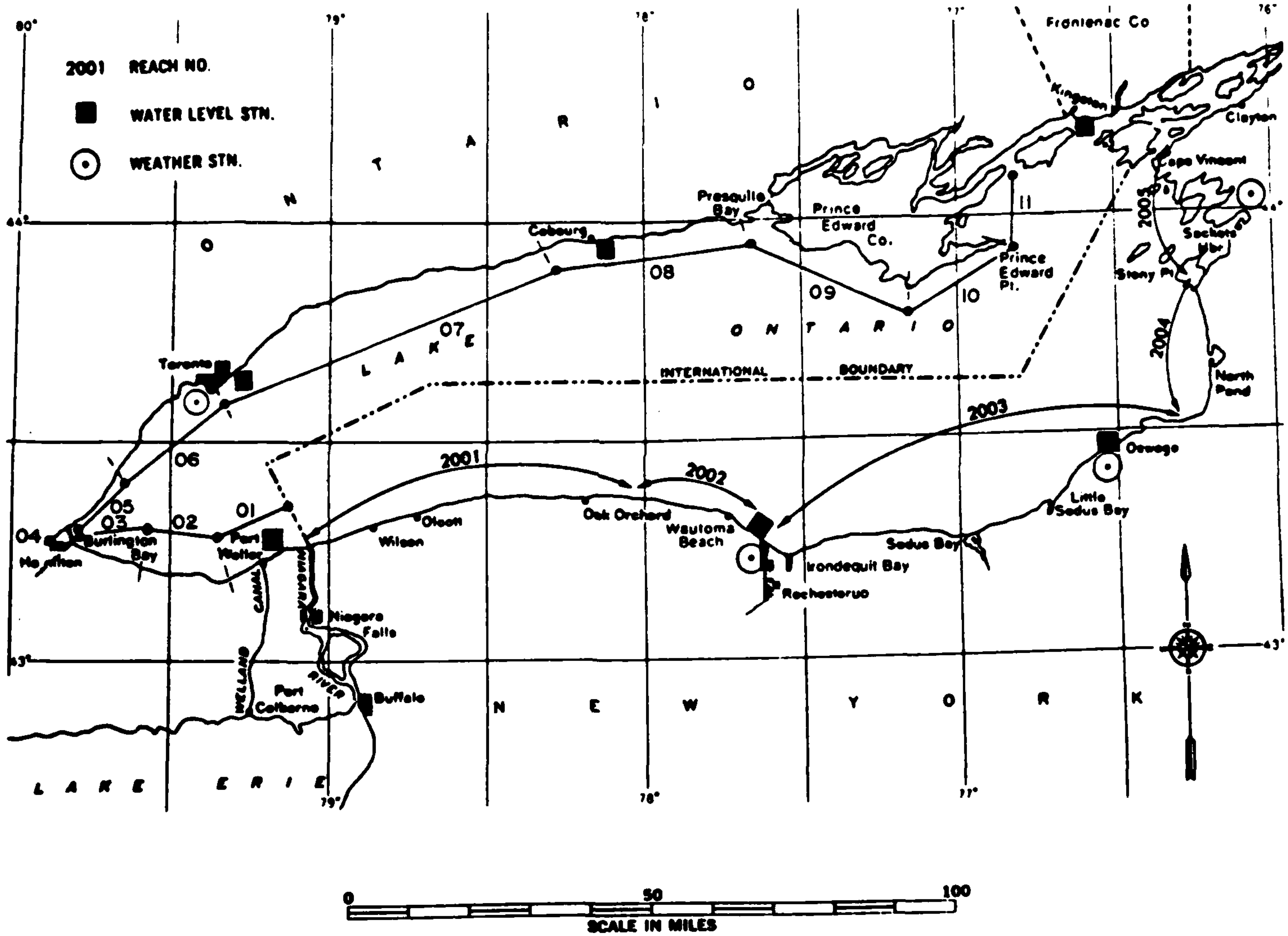
The United States and Canadian shores of the Great Lakes and their connecting channels were divided into 37 and 45 reaches, respectively. Reaches were identified by numerical designations. The U.S. reaches are those used in the International Great Lakes Levels Board Study Report, 1973. The Canadian reaches were the same as those used for Canada-Ontario Great Lakes Flood and Erosion Prone Area maps. Reaches were chosen so as to have similar onshore and offshore physiographic characteristics, orientation and fetch length. The reaches are shown on location maps for each of the Great Lakes (Figures C-4 to C-8).

2.2 Damage Data

The data used for the estimation of inundation and erosion damages differed greatly as different data bases were available. In the United States, estimates of shoreline flooding and erosion damages for the 1972-76 high water period were obtained from the U.S. Army Corps of Engineers' Great Lakes Shoreline Damage Survey. In Ontario, flood damages were obtained from the 1972-73 Canada-Ontario Great Lakes Shore Damage Survey (GLSDS). Future erosion damage was estimated based on property data figures available from the GLSDS, obtained from Regional Assessment Offices, and on recent erosion rates. In Quebec, flood damage estimates were based on government compensation payments for the 1974 and 1976 floods. Table C-5 briefly compares the three data sources.

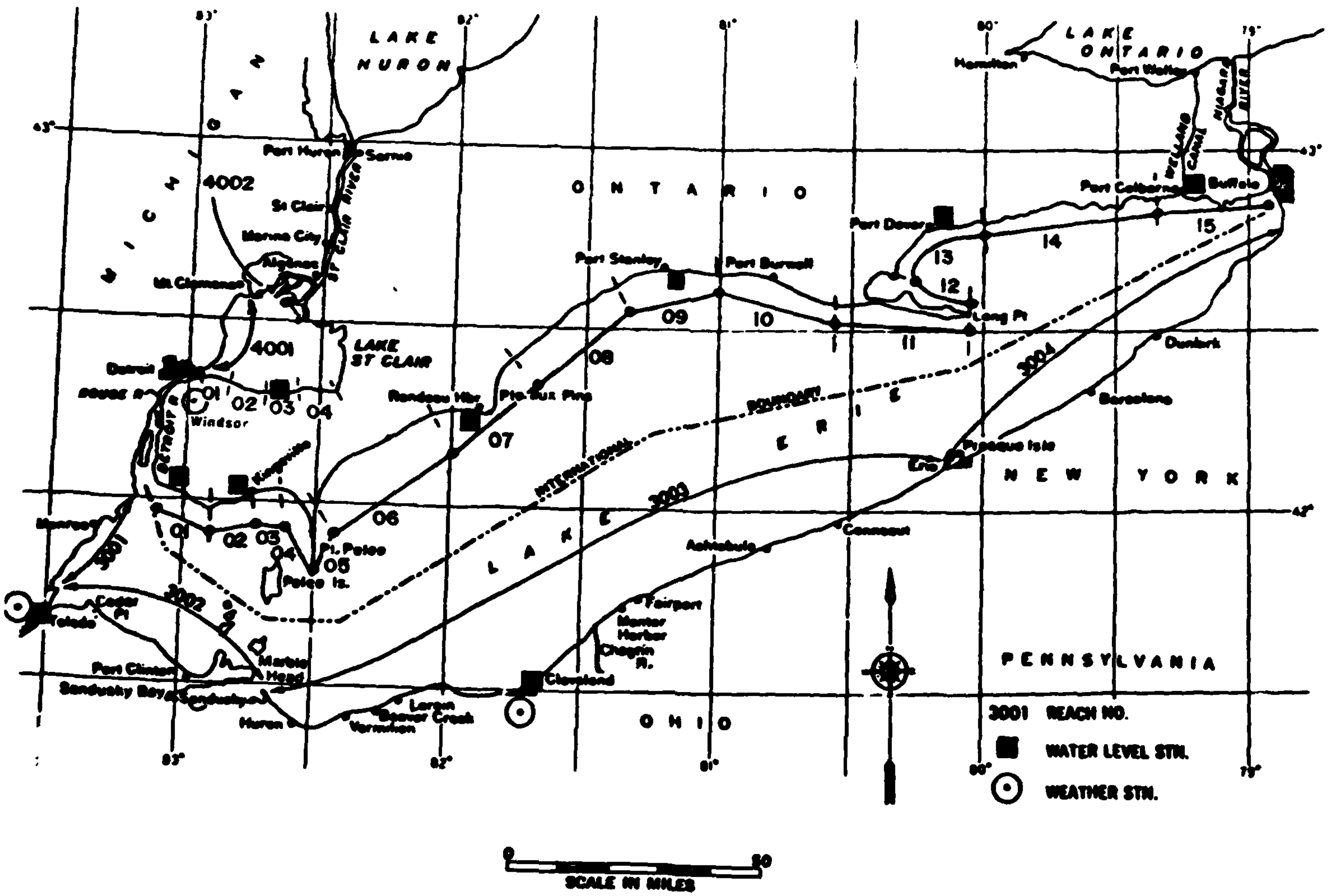
2.2.1 United States

Shore property owners in the Great Lake States became concerned that damage estimates from the early 1950's did not adequately reflect the increased shoreline development that has occurred since 1952. As a result, the Corps of Engineers was asked to conduct a study that would determine the extent of damages due to the more recent high water levels. In the period of time between Labor Day 1972 and Labor Day 1976 some lakes reached historic high water levels. In an effort to determine the economic impact of water levels on damage to the shoreline, the U.S. Army Corps of Engineers initiated and implemented an extensive damage survey covering the entire U.S. shoreline. The results showed that during that 4-year period of time there were in excess of $375 million in damages and costs of protection attributable to the combined effects of erosion and inundation along the coastal zone. During the period of high water, the U.S. Army Corps of Engineers spent some $27 million in advanced temporary flood protection measures which prevented an additional estimated $132 million in damages. The study, completed in 1978, was conducted under the continuing authority of 1952 legislation that has provided for a series of studies on Great Lakes water levels.



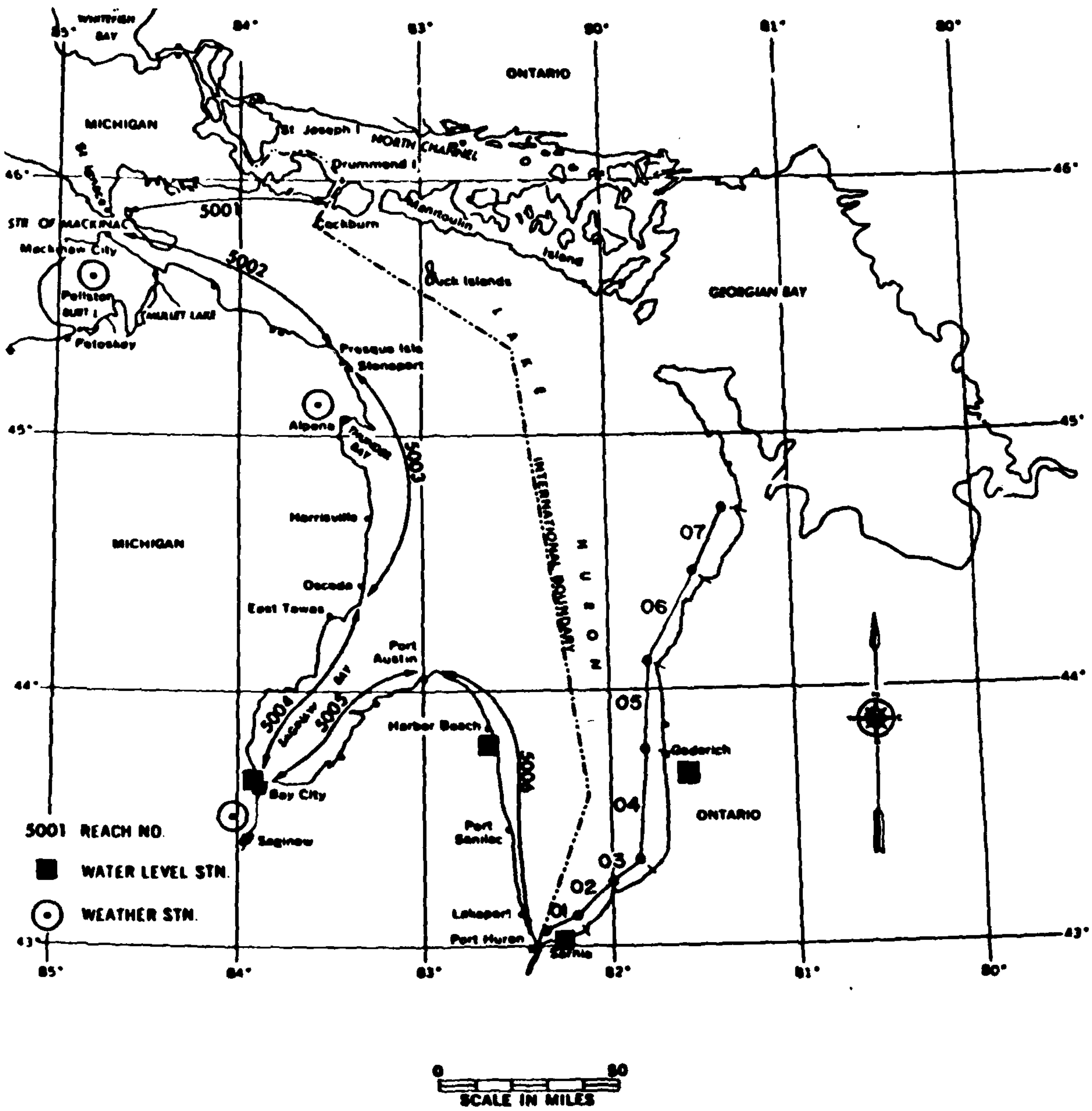
LAKE ONTARIO LOCATION MAP

Figure C4



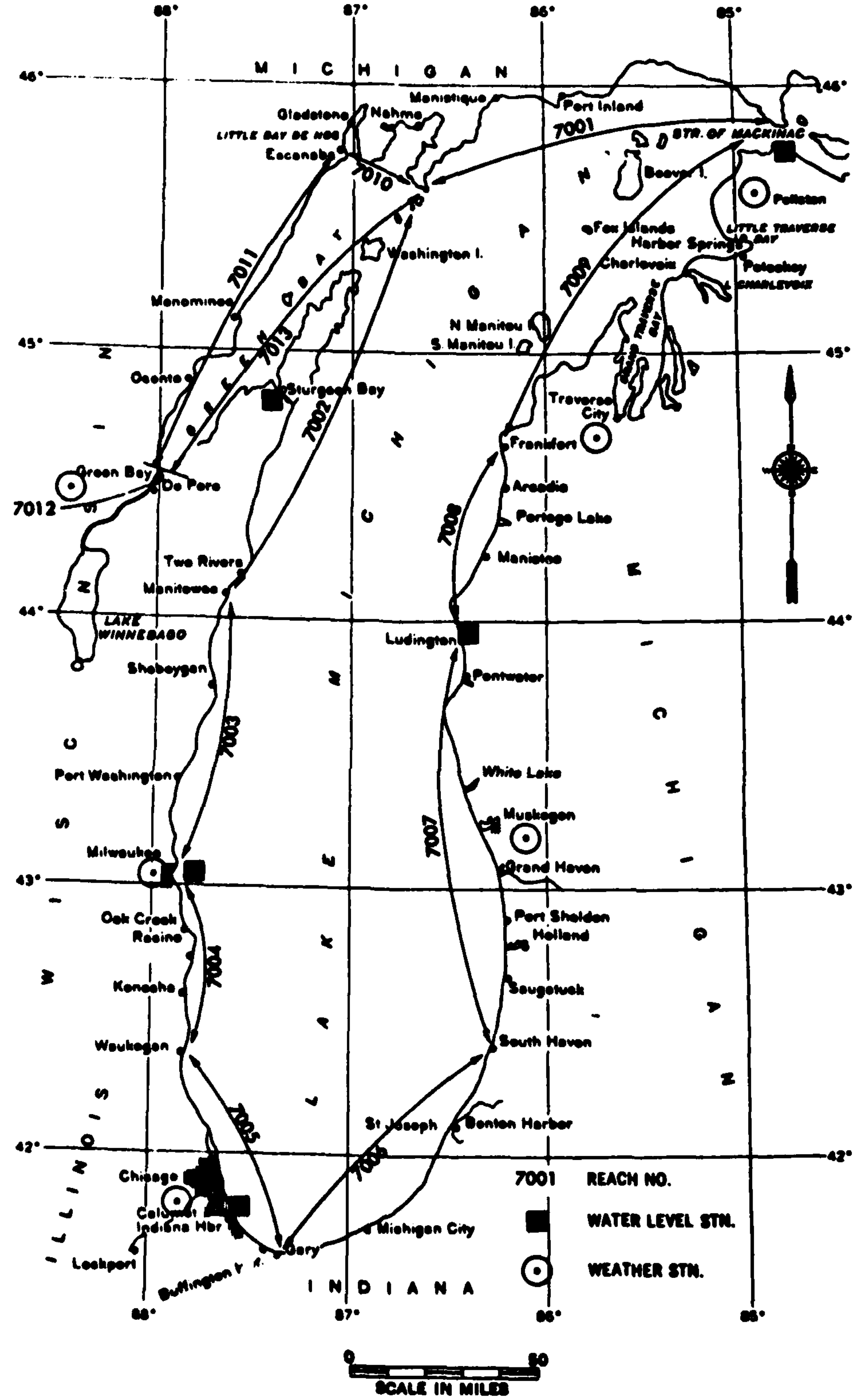
LAKE ERIE LOCATION MAP

Figure C5



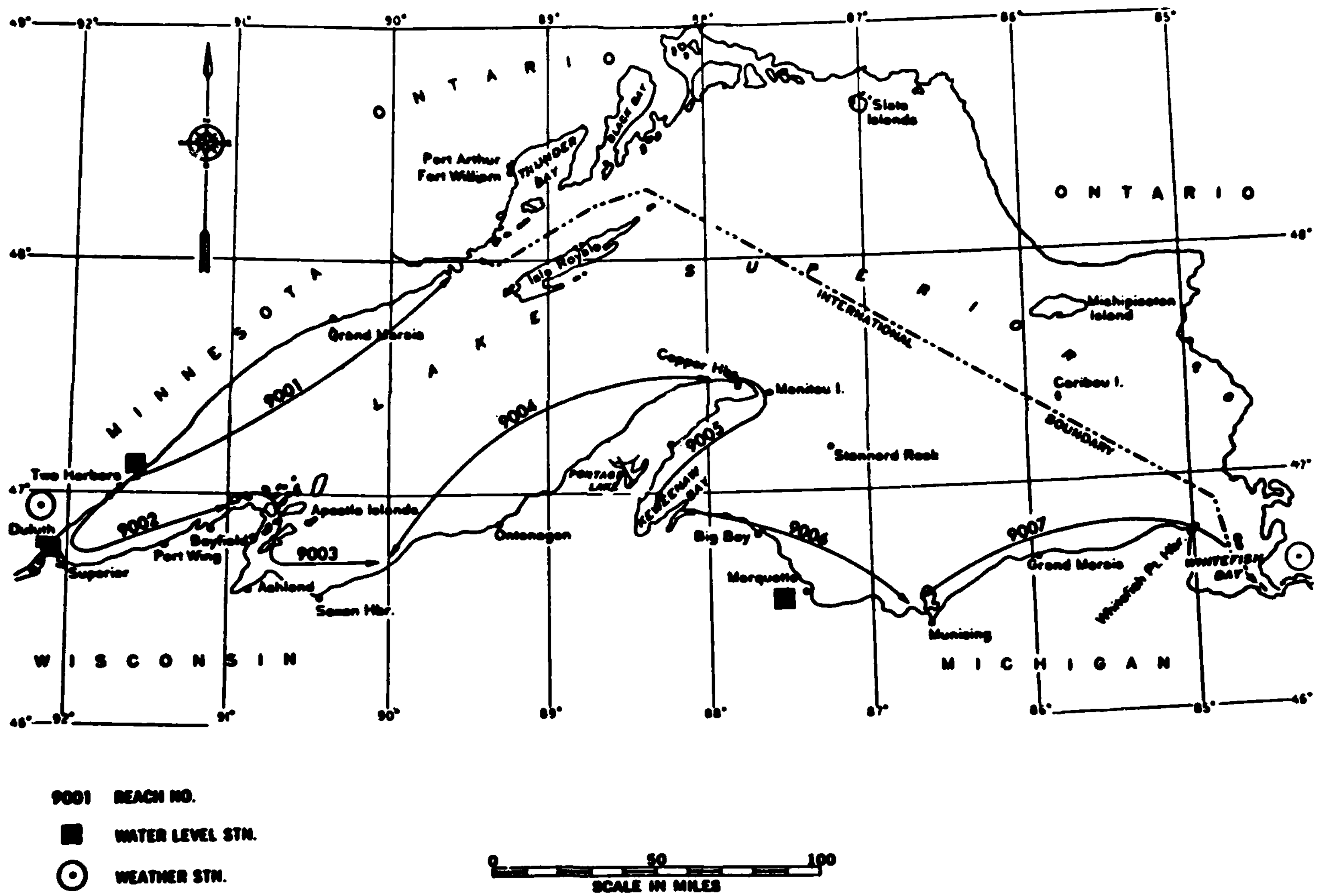
LAKE HURON LOCATION MAP

Figure C6



LAKE MICHIGAN LOCATION MAP

Figure C7



LAKE SUPERIOR LOCATION MAP

Figure C8

Table C-5 - Flood and Erosion Damages Data

Sector	U.S. Shores - Great Lakes, Connecting Channels, and St. Lawrence River	Ontario Shores - Great Lakes and Connecting Channels	Quebec Shores - St. Lawrence River
Data Source	- Self-administered questionnaire distributed to sample of residential properties. - Complete census with follow-up interviews for commercial and industrial properties. - Comparison done of interview and self-administered responses and respondents and non-respondents and results adjusted accordingly. - 1972-76 damages.	- Comprehensive field inventory of flood damages for 1972-73, adjusted. - Property values obtained from regional assessment offices for erosion losses. Assessed values were adjusted to current market conditions using recent sales data. - Erosion rates for 1973-76 obtained from erosion monitoring program.	- Flood Compensation payments. - Claims filed by residents and reviewed by insurance assessors. - 1974 and 1976 flood events.
Flood Damage	- Damage to buildings and contents. - Damage to grounds and improvements. - Clean-up costs. - Costs of emergency evacuation. - Lost income. - Other damage. - Costs of relocation. - Damage to protective structures.	- Structural damage to protective works. - Structural damage to marine structures. - Structural damage to buildings. - Loss-of-use for buildings. - Damage to building contents. - Landscaping damage.	- Damage to permanent residence ($5,000 max). - Damage to contents ($3,000 max.). - Damage to farm structures, equipment, livestock, and crops ($5,000 max. in '74 and $40,000 max. in '76). - Damage to business structures and contents (75% of '74 damages, $1,000 deductible from '76 damages, $40,000 max., $20,000 max. for recreational properties, $10,000 maximum for rental losses) - Institutional costs for buildings and contents and emergency measures. - Estimates for seasonal residences in Montreal area estimated from compensation payments for permanent residences. - Some damages were not eligible for government compensation, i.e.: (a) covered by private insurance or other assistance programs; (b) greater than maximum allowable payments; (c) less than minimum allowable claim; (d) seasonal residences; and, (e) Costs of landscaping, fences, access roads, and outbuildings. An estimate of these damages was derived by comparing compensation payments against total damage estimates for the Montreal area obtained during the study of Flooding in the Montreal Region.
Erosion Damage	- Structures and contents. - Grounds and improvements. - Clean-up. - Other damage. - Includes residential property, commercial-industrial, transportation, utilities, institutions/government, and parks. - Costs of new protective structures were not included.	- Value of land and buildings in erosion-prone area calculated on a reach basis per foot of erosion. - Assessed values adjusted to 1979 market conditions. - Costs of new protective structures were not included.	- Although erosion losses are significant, there is insufficient data to evaluate them.

Damage Survey Organization and Participants: This survey was a cooperative effort between the Corps of Engineers and the involved States. To assure that the damage estimates would be acceptable to all parties, the States were fully involved in the survey process. The States' approval, through the Great Lakes Basin Commission's Standing Committee on Coastal Zone Management, was obtained for the survey methods used.

Damage Survey Methods: Information about damages to residential properties was obtained by sending property owners an 8-page questionnaire. This questionnaire was designed to determine flooding and erosion damages, the costs of measures to prevent potential damage, and the nature of possible future damages.

When the damage survey began, questionnaires were sent to every shore property owner in an 11-county pilot area for survey. Subsequently, a 20% random sample of the owners in the remaining study area was surveyed.

Information about nonresidential properties was gathered through specialized interview forms. Because nonresidential properties are more diverse and less numerous than residential, the survey for nonresidential locations aimed at 100% coverage for the entire survey. Initially, personal interviews were used to collect the data about nonresidential properties. Later, the information was obtained through telephone and mail procedures.

County property-tax records were the main source of addresses for the survey mailing lists. Those properties included on the master list are either on the shore front, or at elevations where flooding is estimated to have a 1% chance of occurring annually.

In accordance with the Federal Privacy Act, those surveyed were informed of the voluntary nature of their responses and also that the names and addresses compiled for the study would not be disclosed.

The information was collected over the period from 1972 (when the high water levels began) to 1974, 1975, or 1976. Most of the data collected covered the period 1972 to 1976. Table C-6 shows the damages, by reach, for the survey period and Table C-7 shows the Agencies that participated in the Damage Survey.

2.2.2 Canada

Ontario: The high water levels of the early 1970's and the resulting shore property damage led the Federal and Provincial Governments to carry out an inventory of the damages. Known as the "Canada-Ontario Great Lakes Shore Damage Survey", the survey covered the 13-month period from November 1972 to November 1973. Since shore damages were not significant on Lake Superior and Georgian Bay, the survey extended from Port Severn, Simcoe County, on Georgian Bay to Gananoque, Leeds County, on Lake Ontario. The Damage Survey included the St. Clair and Detroit Rivers, but not the Niagara River. Only properties that had direct contact with the shore were considered. The estimated total damages, costs of new protective structures and flood related expenditures for the 13-month period totalled in excess of $28.4

Table C-6 - United States Shoreline Damage Survey Results

Reach	Survey Period	Erosion Damage[a]	Inundation Damage[a]	Total Damage
2001	1972-75	4,229,000	28,600	4,257,600
2002	1972-75	4,725,300	2,756,000	7,481,300
2003	1972-75	3,928,900	547,200	4,476,100
2004	1972-76	311,000	0	311,000
2005	1972-76	5,009,900	729,600	5,739,500
Subtotal		18,204,100	4,061,400	22,265,500
3001	1972-76	18,644,500	6,783,400	25,427,900
3002	1972-76	10,710,600	21,382,000	32,092,600
3003	1972-76	7,826,800	1,589,600	9,416,400
3004	1972-76	4,292,700	1,782,000	6,074,700
Subtotal		41,474,600	31,537,000	73,011,600
4001	1972-76	1,730,500	7,046,000	8,776,500
4002	1972-76	1,372,300	2,537,400	3,909,700
Subtotal		3,102,800	9,583,400	12,686,200
5001	1972-76	812,700	2,990,100	3,802,800
5002	1972-76	355,300	60,200	415,500
5003	1972-76	2,690,000	372,400	3,062,400
5004	1972-76	953,000	4,899,200	5,852,200
5005	1972-76	155,000	708,600	863,600
5006	1972-76	7,190,200	557,700	7,747,900
Subtotal		12,156,200	9,588,200	21,744,400
7001	1972-76	159,500	133,700	293,200
7002	1972-76	1,573,200	81,200	1,654,400
7003	1972-76	1,853,500	2,260,700	4,114,200
7004	1972-76	951,100	7,300	958,400
7005	1972-75	6,193,600	0	6,193,600
7006	1972-75	4,863,500	2,614,800	7,478,300
7007	1972-76	4,439,800	72,600	4,512,400
7008	1972-76	766,000	24,800	790,800
7009	1972-76	4,959,300	305,600	5,264,900
7010	1972-76	113,700	82,100	195,800
7011	1972-75	996,900	354,300	1,351,200
7012	1972-74	134,200	343,800	478,000
7013	1972-75	1,262,500	359,700	1,622,200
Subtotal		28,266,800	6,640,600	34,907,400
9001	1972-75	333,300	23,600	356,900
9002	1972-75	462,500	1,355,200	1,817,700
9003	1972-75	474,800	261,700	736,500
9004	1972-76	358,000	85,000	443,000
9005	1972-76	188,000	73,100	261,100
9006	1972-76	1,465,800	16,900	1,482,700
9007	1972-76	800,300	254,300	1,054,600
Subtotal		4,082,700	2,069,800	6,152,500
Grand Total		107,287,200	63,480,400	170,767,600

a 1975 Dollars

Table C-7 - U.S. Shoreline Survey Agencies

Area of Study	Responsible Agency
Minnesota	Minnesota Department of Natural Resources; subcontracted to Arrowhead Regional Development Commission
Wisconsin	Wisconsin Department of Natural Resources; subcontracted to University of Wisconsin at Milwaukee, Department of Geological Studies
Michigan	Coastal Zone Laboratory, The University of Michigan
Illinois	Division of Water Resources, Illinois Department of Transportation
Indiana	Indiana State Planning Services Agency
Ohio	Ohio State University
Pennsylvania	Edinboro State College
New York	St. Lawrence-Eastern Ontario Commission and the State University of New York at Buffalo

Note: Initial development of survey forms and procedures by the University of Michigan's Institute for Social Research and Department of Statistics.

million, consisting of $8.9 million erosion, $8.0 million flooding and $11.5 million for construction of new shore protection.

Data collected in the inventory included property size, value, location and flood-induced damages. In compiling information on shoreline property for evaluation and analysis, specific data were required. The data required were as follows:

1. amount of shore property damage;

2. shore property information (land and building values, lot dimensions, exact location, etc.);

3. erosion-prone and flood-prone areas; and,

4. reach limits (defined by geographic considerations).

Flood damage estimates, as well as property characteristics, such as size and location of property, and length of frontage along the shoreline, were obtained for the shore properties from the inventory previously mentioned.

Erosion damage estimates were based on the determination of the damages to each reach that would result from the loss of one foot of land along the entire erodible portion of the reach. From the Flood and Erosion Prone Area Maps the property that is likely to erode over the next 50 years was delineated. The value, area and frontage of these properties were determined from the data inventory, from which the average value per foot of depth was calculated for the reach. This was combined with the amount of erosion that actually occurred during all or part of the period 1972 to 1976, resulting in the estimation of the damages that occurred for that period for each reach.

The values obtained from the inventory were in 1973 dollars which were adjusted to 1979 market conditions. Updating required different procedures for erosion and flood damages.

The evaluation of erosion damages were based on property assessment data. Adjustment to real market value and updating was accomplished by using data from the Ministry of Revenue Assessment Offices for shoreline properties sold between 1973 and 1978. The sales data for each year were totalled, and adjusted to the year 1978. This adjustment to 1978 values was done by using average housing sale values, compiled by the Canadian Real Estate Association. The total sales value, adjusted to 1978 price levels, was then compared to the total 1973 assessment of these properties to derive an adjustment factor, which was:

$$\text{Adjustment Factor} = \frac{\text{Total sales value (1978)}}{\text{Total assessed value (1973)}}$$

The adjustment factor, which was developed for each reach, was used to adjust the erosion damages from 1973 to 1978 values. Since there was minimal change in the sales value of residential properties between 1978 and July 1979, no adjustment was made to the 1978 values to bring them to July 1979 values.

For flood damages the adjustment factor was calculated by using the residential building construction price index from the Canadian Statistical Review, 1975 and 1979. This was calculated as:

$$\frac{\text{residential building construction index, July 1979}}{\text{residential building construction index, 1973}}$$

Flood damages in each reach were multiplied by this factor to provide a July 1979 damage value. The flood damages by reach are shown in Table C-8, and erosion damages by reach are shown in Table C-9.

Quebec: The Quebec portion of the St. Lawrence River suffered severe flood damages in both 1974 and 1976. Following these flood events the Government of Quebec established the "Bureau d'aide financière-inondation 1974", and the "Bureau d'aide financière-inondation 1976". These bureaus were responsible for establishing procedures and criteria to be used in the compensation program, to receive requests for financial assistance, to assess these claims and to compensate the flood victims. This compensation program was carried out within the framework of a Federal-Provincial disaster assistance program. Table C-10 briefly highlights the procedures and flood damage criteria used in the compensation for damages to permanent residences, small enterprises, farms, equipment and for emergency measures.

Total assistance and flood fighting costs were $3,728,000 (Dec 1974) and $9,335,000 (Dec 1976) for these two flood events. However, these figures only represent a portion of the actual damages, since the assistance programs involved the exclusion of some damages, upper limits for other damages, and deductible adjustments. Tables C-11 and C-12 include a summary by sector and by category of damages for 1974 and 1976, respectively, in July 1979 dollars. These figures are extracted (with required adjustments) from data compiled by the two "Bureaux d'aide financière".

2.3 Physical Data

The data base used was common for both the United States and Canada.

2.3.1 Water Level Data

Three types of water level data were required: 1. Monthly mean water level data for each lake and each regulation plan (these data were provided by the Regulation Subcommittee); 2. Hourly water level data (supplied by the responsible Federal agencies in Canada and the United States); and, 3. Monthly maximum storm rise (calculated from gage records of the closest stations to the reaches being evaluated).

Table C-8 - Canada-Ontario Shoreline Flood Damages

(Dollars)

	Values based on 1973 G L S D Survey	Adjustment Factor	Losses adjusted to July 1979 Market Conditions
LAKE HURON			
Reach 1	$ 223,931	1.69	$ 377,500
Reach 2	9,894	1.69	16,700
Reach 3	93,322	1.69	157,700
Reach 4	66,052	1.69	111,600
Reach 5	76,863	1.69	129,800
Reach 6	17,269	1.69	29,200
Reach 7	35,468	1.69	59,900
Subtotal	522,799		882,400
ST. CLAIR RIVER			
Reaches 1-6	None	-	0
LAKE ST. CLAIR			
Reach 1	$ 289,741	1.69	$ 489,700
Reach 2	653,451	1.69	1,104,300
Reach 3	529,166	1.69	894,300
Reach 4	501,119	1.69	846,900
Reach 5&6	None	-	0
Subtotal	1,973,477		3,335,200
DETROIT RIVER			
Reach 1	$ 103,266	1.69	$ 174,500
Reach 2	143,726	1.69	242,900
Reach 3	None	-	0
Reach 4	295,379	1.69	499,200
Subtotal	542,371		916,600

	Values based on 1973 G L S D Survey	Adjustment Factor	Losses adjusted to July 1979 Market Conditions
LAKE ERIE			
Reach 1	$ 415,823	1.69	$ 702,700
Reach 2	367,207	1.69	620,600
Reach 3	22,499	1.69	38,000
Reach 4	102,893	1.69	173,900
Reach 5	234,206	1.69	395,800
Reach 6	83,672	1.69	141,400
Reach 7	166,974	1.69	282,200
Reach 8	None	-	0
Reach 9	6,751	1.69	11,400
Reach 10	None	-	0
Reach 11	54,229	1.69	91,600
Reach 12	23,464	1.69	39,700
Reach 13	114,442	1.69	193,400
Reach 14	90,609	1.69	153,000
Reach 15	36,633	1.69	61,900
Pelee Island	$ 193,623	1.69	327,200
Subtotal	1,913,025		3,232,800
LAKE ONTARIO			
Reach 1	57,618	1.69	97,400
Reach 2	60,578	1.69	102,400
Reach 3	51,116	1.69	86,400
Reach 4	None	-	0
Reach 5	149,885	1.69	253,300
Reach 6	547,514	1.69	925,300
Reach 7	106,497	1.69	180,000
Reach 8	41,698	1.69	70,500
Reach 9	61,725	1.69	104,300
Reaches 10&11	None	-	0
Reach 12	149,169	1.69	252,100
Subtotal	1,225,800		2,071,700
TOTAL	6,177,472		10,438,700

Table C-9 - Canada-Ontario Erosion Damages

(Dollars)

Reach	Damages/foot eroded (July 1979 Dollars)	Estimated 1973 Damages (July 1979 Dollars)[1]
LAKE HURON		
Reach 1	$ 71,300	$418,800
Reach 2	13,200	29,000
Reach 3	0	0
Reach 4	19,600	48,400
Reach 5	29,100	86,500
Reaches 6&7	0	0
Subtotal		582,700
LAKE ST. CLAIR		
Reaches 1&2	$ 0	$ 0[2]
Reach 3	26,900	118,300[2]
Reach 4	15,800	133,400[2]
Subtotal		251,700
LAKE ERIE		
Reach 1	$ 13,400	$ 7,200
Reach 2	24,400	108,300
Reach 3	20,7[illegible]	13,100
Reach 4	0	0[2]
Reach 5	15,200	202,600[3]
Reach 6	24,300	35,100[3]
Reach 7	18,700	35,800[3]
Reach 8	3,400	13,100
Reach 9	6,100	62,900
Reach 10	1,500	19,100
Reach 11	500	10,000[4]
Reach 12	300	-
Reach 13	28,500	156,000
Reach 14	22,500	39,200
Reach 15 & Pelee	0	0
Subtotal		702,400
LAKE ONTARIO		
Reach 1	67,600	500,000
Reach 2	40,800	72,400
Reach 3	38,600	374,900
Reach 4	0	0
Reach 5	330,000	223,000
Reach 6	239,200	312,200
Reach 7	201,400	377,400
Reach 8	14,600	12,300
Reaches 9-12	0	0
Subtotal		1,872,200
TOTAL		3,409,000

(1) The values represent estimated damages based on average wave energies that would occur with basis-of-comparison waster levels for 1973.

(2) These estimatus are for beach areas, for which the determination of short term erosion rates are subject to considerable inaccuracy.

(3) Estimated 1971 damages. (4) Included in Reach 13.

Table C-10 - Financial Assistance to Quebec Flood Victims in 1974 and 1976

1. Procedures: Flood victims had to fill a questionnaire listing flood damages; -each application was evaluated by a professional reclamation agent (assessors) according to techniques and schedules used by insurance companies in case of damages caused by a fire. Also, maximum payments were set for category of goods; -no compensation given if damages are covered by a private insurance or another governmental program.

2. Flood damage compensation

2.1 Permanent residences: -Damages to structure including foundations, walls, heating systems, water intakes, interior finishing (maximum $5,000); -no compensation given if it is a seasonal residence or for loss of land, damages to landscape, fences, access road, out-buildings; -damage to contents (total maximum: $3,000): kitchen and dining room (chairs and table, stove, refrigeration, freezer, small electric appliances as toaster, kettle, vacuum cleaner, etc.) (maximum $1,000); -living room (furniture, T.V., lamp, table) (maximum $600); bathroom and laundry room (washing machine, dryer) (maximum $400) bedroom (furniture, lamp, alarm-clock) (maximum per bedroom $100); miscellaneous (carpets, floor-covering, drapes, etc.) (maximum $500): -no compensation given for: cars; toys and sport articles; tools and motorized tools; furs; jewels, art collections, antiques, etc.; -in 1974, minimum payment of $500 and maximum for structure and contents; $10,000. In 1976, a deductible of $200, and a maximum payment of $10,000.

2.2 Farms: - Damages to permanent residence as above, plus: -maximum of $5000 for damages to ($40,000 in 1976): agricultural equipment; agricultural structures; live-stock and loss of cultures; stock and produces stored on the farm; -not covered: loss of land, loss of revenue due to late seeding or insufficient growth, (loss of culture, in 1976).

2.3 Small enterprises: -Definition: 30 employees or less; gross annual income not exceeding $1,000,000; main source of revenue of the owner; -structure including foundations, walls, floors, heating system, etc; -contents: furniture office equipment and accessories; machinery and equipment; stock or inventory (including raw material and final products); -compensation (in 1974, 75% of damages; in 1976. $1,000 deductible): A) manufacturing, commercial and transport industries, hotel, restaurants, services stations: Maximum of $40,000; B) recreation enterprises: maximum of $20,000; C) building rented to one or more enterprise: maximum of $10,000.

2.4 Government and Institutional: Structure and contents of properties owned by: -municipal government (including infra-structures); -provincial government (including infra-structures); -school boards; -religious, cultural or educational organizations: Deductibles fixed on individual basis.

2.5 Emergency measures: Flood fighting expenditures including sand-bagging, temporary evacuation, temporary lodging, etc.

2.6 Required adjustments to residential damages: During the study carried out by the Committee on Flow Regulation, Montreal Region (CFRMR) the firms Dupuis Morin, Routhiér et Ass., Estimateurs Associes Inc., and Société technique d'Aménagement régional were contracted to evaluate flood damages and relocation alternatives. These contractors used two methodologies to evaluate flood damages for the 1974 flood event:

Method 1: Criteria as described above.
Method 2: Criteria used by Ministere des Richesses naturelles for the 1973 flood event as applied to the 1974 flood event. All damages were considered in this survey, e.g., seasonal residences, all contents, loss of use, landscaping damages, etc., in addition to damages of Method 1.

Results for the 1974 flood event ($ Dec., 1974):	Total damages using Method 2 = $4,708,000.
	Total damages using Method 1 = $1,890,000.
	Factor = $ Method 2/$ Method 1 = 2.49

This 2.49 factor was applied to the permanent residential damages and Tables C-11 and C-12 reflect this change, by sector, for the 1974 and 1976 damages.

Table C-11 - Canada-Quebec 1974 Shoreline Flood Damages
($1,000)*

	Residences	Farms	Small enterprises	Government & Institutional Equipment	Emergency Measures	Total
1) Lac des Deux Montagnes	2,797	37	305	182	339	3,660
2) des Mille Iles River	2,890	82	174	491	519	4,156
3) des Prairies River	1,710	8	85	204	218	2,225
4) Lake St. Louis	1,154	6	116	501	726	2,503
5) St. Lawrence River between Repentigny and Trois-Rivieres	436	723	126	375	11	1,671
TOTAL	8,987	856	806	1,753	1,813	14,215

* July 1979 Dollars

Table C-12 - Canada-Quebec 1976 Shoreline Flood Damages
($1,000)*

	Residences	Farms	Small enterprises	Government & Institutional Equipment	Emergency Measures	Total
1) Lac des Deux Montagnes	3,456	38	387	232	353	4,466
2) des Mille Iles River	4,973	82	264	540	577	6,436
3) des Prairies River	2,165	13	126	228	336	2,868
4) Lake St. Louis	1,363	26	149	557	808	2,903
5) St. Lawrence River between Repentigny and Trois-Rivières	3,727	781	572	559	114	5,753
TOTAL	15,684	940	1,498	2,116	2,188	22,426

* July 1979 Dollars

2.3.2 Meteorological Data

Hourly wind speed and direction were acquired for twenty locations for the period 1966-1976 from the responsible Federal agencies in Canada and the U.S. The data were required for utilization in the erosion evaluation.

2.3.3 Physiographic Data

Overlake fetch length and lake depths for each reach were determined using appropriate maps. Average bluff toe elevations for each reach were determined by the Coastal Engineering Branch of the U.S. Army Corps of Engineers, North Central Division, in Chicago and by the Canadian Department of Public Works in Ottawa. Beach slopes were determined from survey reports on specific projects in the various reaches. Historic erosion data for the Canadian shore were obtained from the Department of Fisheries and Oceans.

Section 3

EVALUATION PROCEDURES

The evaluation procedures developed were designed with the aim of having identical procedures in both the United States and Canada, to the degree possible. The procedures were developed, for the most part, for use on high-speed computers; the software for the computer programs used in the evaluations is included in Annex B to this Appendix.

3.1 Inundation Evaluation Procedure

The procedure developed to evaluate inundation along the Great Lakes shoreline was based upon damage data, water level data, and the physical characteristics of the shore.

3.1.1 Data Utilized

Damage Data: The source of damage data varied for each of the three portions of the Great Lakes - St. Lawrence River system. See Table C-5 for a description of the damage data.

Water Level Data: Two types of water level data were used in this procedure: the monthly mean levels and the peak hourly level for each month. Storm rise was calculated by subtracting the monthly mean level from the peak hourly level for each month. The difference was the peak storm rise for that month.

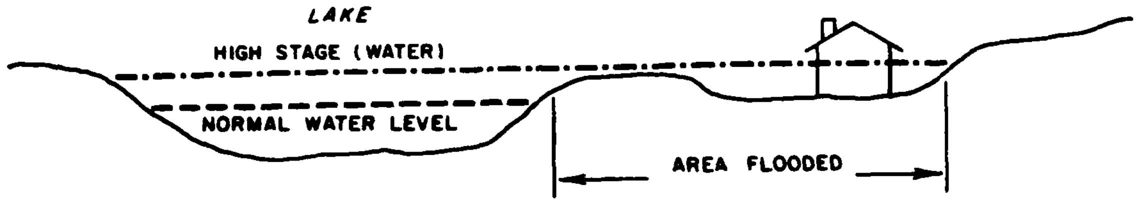
Physiographic Data: Physical characteristics for the reaches were determined using the best available data. Topographic maps, flood studies, project reports, and measured profiles were among the major sources for this information.

Figure C-9 illustrates the types of flooding which are associated with the Great Lakes. Inundation is an event process. It occurs occasionally and without regularity. The evaluation procedure assumed that in any one month the mean water level could be combined with recorded short-term rises to generate a population of stormwater levels. This population was generated, by reach, for use in deriving the stage-damage relationship.

3.1.2 Derivation of Stage-Damage Curve

The most important aspect of the procedure was the determination of a stage-damage curve for each reach of shoreline. Guidelines to develop the stage-damage curves on a consistent basis include:

A. FLOODING DUE TO HIGH CALM WATER STAGES (MEAN MONTHLY)



NORMAL CALM WATER LEVEL BELOW LAND CREST. HIGH WATER EXCEEDS LAND HEIGHT.

B. STORM STAGE FLOODING

CALM WATER LEVEL BELOW LAND CREST. STORM WATER LEVEL EXCEEDS LAND HEIGHT.

THE PRINCIPAL DIFFERENCE BETWEEN A & B IS THE DURATION IN A. THE DURATION MAY BE ONE TO SEVERAL MONTHS IN B. THE DURATION IS USUALLY ONLY SEVERAL HOURS, ALTHOUGH IT MAY REMAIN LONGER, DEPENDING ON DRAINAGE BACK INTO LAKE.

TYPES OF FLOODING

1. The shape of the stage-damage curves was based on the physical and land use characteristics of the shore;

2. For the St. Lawrence River Canadian Reaches, stage-damage curves were derived from 3 points: 1974 and 1976 damage events and a zero point which is the elevation at which significant damage will begin to occur;

3. For the Great Lakes reaches, stage-damage curves were developed based on one or more of the following information sources:

   a. Operation Foresight (U.S. Army Corps of Engineers) stage-damage curves;

   b. Canada/Ontario Great Lakes Shore Damage Survey results;

   c. Elevation of structures on the shore;

   d. Shore topography;

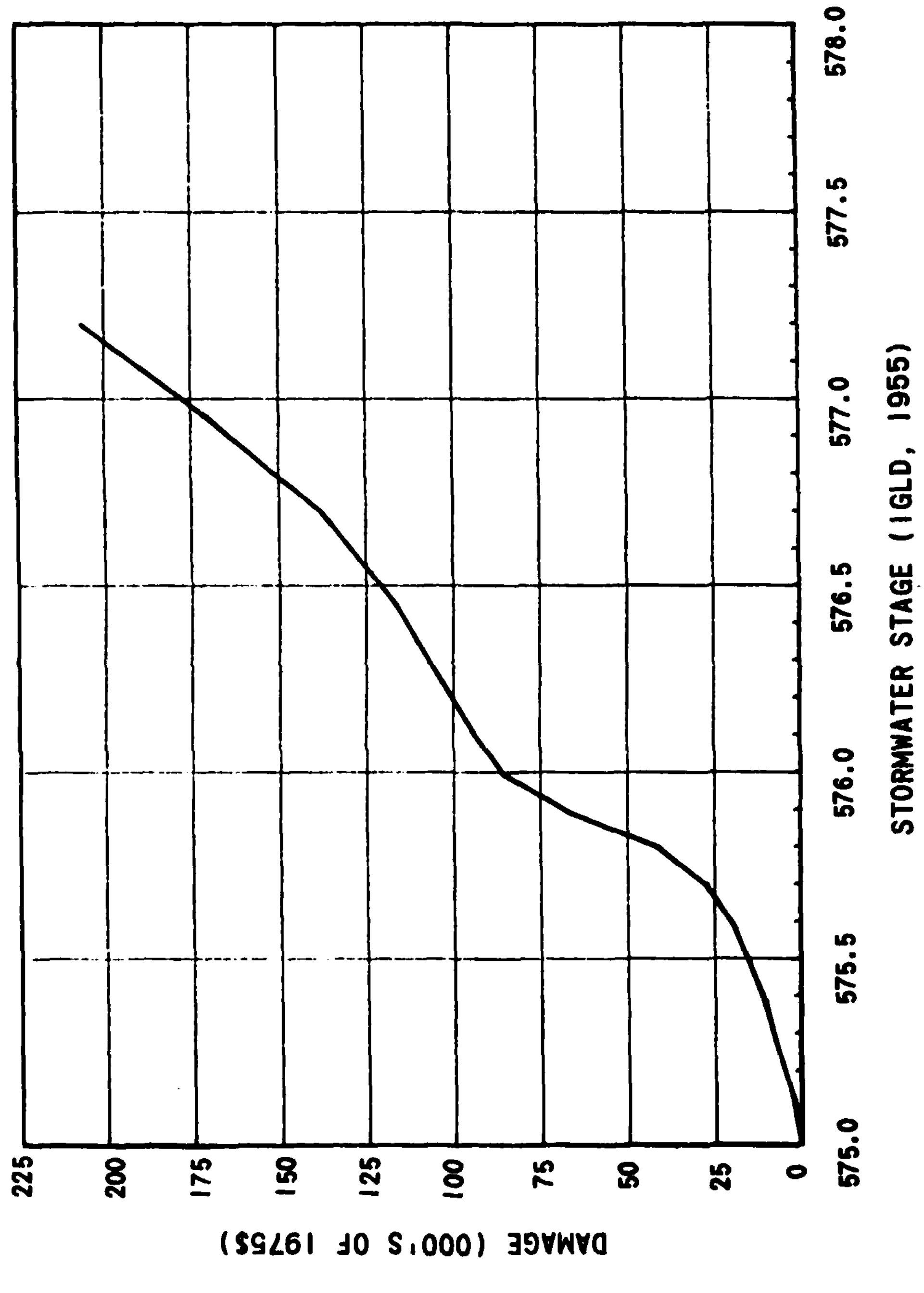
   e. Other available flood studies; and,

   f. Engineering judgment of the relative damages for levels below and above the 1973-74 high water levels;

4. The stage-damage curves cover the entire range of possible levels (i.e, they extend beyond the 1973-74 record or near-record levels).

Figure C-10 is the stage-damage curve for the U.S. Reach 4002 on Lake St. Clair. It was developed using the Operation Foresight data as the physical basis and was calibrated to represent the actual damage during the damage survey period.

The inundation stage-damage curve for each reach was calibrated using recorded monthly peak stormwater levels, one per month, for the period of time corresponding to the Damage Survey. The shape of the stage-damage curve was established using the guidelines noted above. This curve was then calibrated to yield total recorded damages based on recorded monthly stormwater levels. To accomplish this, for each stormwater level for the Survey period, the damage corresponding to that stormwater level was obtained from the stage-damage curve and summed. By dividing the total of the damage units into the total recorded inundation damage for the reach, the damage scale was adjusted. The original damage scale was then replaced by the calibrated damage scale to give a calibrated inundation stage-damage curve which was used with monthly water level data.



U. S. REACH 4002 STAGE DAMAGE CURVE

Figure 10

3.1.3 Determination of Stormwater Levels

An assumption made in this evaluation was that the different regulation plans would affect only the mean water level and not the rise. This was considered reasonable due to the general acceptance of the independence of these two factors. The combined mean water level and rise is referred to as the stormwater level.

In order to determine the stormwater level for each month by reach, historic rise data were combined with the mean water level for corresponding months. If, for example, there were 77 years of monthly mean water levels and 20 years of monthly rise data, then each of the 20 rises was added to each of the 77 mean water levels for the corresponding month to generate a population of stormwater levels consisting of 77 x 20, or 1,540 points for each month. It should be noted that several combinations of monthly mean levels and rises may give the same stormwater level. A tabulation of the frequency of each stormwater level being equalled or exceeded was completed, by month, for the points generated.

3.1.4 Calculation of Average Annual Damage

A computer program was written for the coastal zone inundation evaluation which utilized several files containing the following information:

1. Monthly rise data;

2. Monthly mean lake level data from the regulation plans;

3. Stage-damage curve for each reach; and,

4. A population of stormwater levels, generated from files 1 and 2, and their corresponding frequencies, as described above.

The program used the inundation stage-damage curve and the generated monthly stormwater levels population to calculate the damage corresponding with every monthly stormwater level. The calculated damage was multiplied by the frequency of exceedence (percentage) of the associated stormwater level. The process was repeated for each monthly stormwater level population to give an average monthly damage. The average monthly damages were summed to give the average annual damage.

It should be noted that monthly damages may be caused not only by a once-a-month stormwater level, but also by other lower levels during the month. Thus, the stormwater levels are an index of damage capacity. The average annual damages, determined as described above, are a good indication of the relative benefits or losses between the regulation plans.

3.2 St. Lawrence River (Canadian Reach) Inundation Procedure

3.2.1 Introduction

Flood damages associated with high St. Lawrence River flows have been broken down into five sectors. Damages in each sector can be related to a water level or discharge. The five sectors and the required hydraulic indicator in each sector are as follows:

I- Lac des Deux Montagnes - damages are a function of the level on Lac des Deux Montagnes at Sainte-Anne-de-Bellevue.

II- Des Prairies River - damages are a function of the des Prairies River flow at Rapides-du-Cheval-Blanc.

III- Des Mille Iles River - damages are a function of des Mille Iles River flow at Bois-des-Filion.

IV- Lac Saint-Louis - damages are a function of the Lac Saint-Louis elevation at Pointe-Claire.

V- St. Lawrence River between Repentigny and Trois-Rivières - damages are a function of the addition of flows on the St. Lawrence at Lachine and des Mille Iles and des Prairies Rivers.

The required hydraulic parameters are:

E(DM)- Elevation of Lac des Deux Montagnes;

Q(P)- Des Prairies River flow;

Q(MI)- Des Mille Iles River flow;

E(SL)- Elevation of Lac Saint-Louis;

Q(R)- Addition of the flow at Lachine, Bois-des-Filion and Rapides-du-Cheval-Blanc; and,

Q(Local)- Local inflow to Lac Saint-Francois and Lac Saint-Louis.

The above parameters are a function of the following input parameters:

Q(Ont)- Lake Ontario outflow as measured at Cornwall;

Q(Ott)- Ottawa River flow measured at Carillon; and,

Q(Local)- Local inflows to Lac Saint-Francois and Lac Saint-Louis were estimated at 4 times the flow of the Chateauguay River.

The required parameters F(DM), Q(P), Q(MI), E(SL) and Q(R) were calculated from the input parameters Q(Ont), Q(Ott), and Q(Local) using an existing one-dimensional hydrodynamic model for the Montreal region.

3.2.2 Determination of Montreal Region Levels and Flows

Several procedures can be used to evaluate the effects of Great Lakes regulation on flooding on the Canadian Reach. A procedure was used which determined the effects of Lake Ontario outflows at Cornwall on water levels and flows in the Montreal region based on the probability of occurrence of Ottawa River flows and local inflows.

In order to calculate the probabilities of levels and flows resulting from various combinations of the input parameters, some assumptions were made regarding the relationship between the input data. It was assumed that the Lake Ontario outflows, the Ottawa River flows and local inflows are independent. This assumption is thought to be generally valid as the three flows result from very different hydrologic and unrelated hydraulic regimes. The Lake Ontario outflow depends on various response times (1-4 years) to meteorologic events. The Ottawa River is also a large basin, but with very much less storage capacity than the Great Lakes. Therefore, it has a much shorter response time. The local inflow results from the much smaller basins south of the St. Lawrence River.

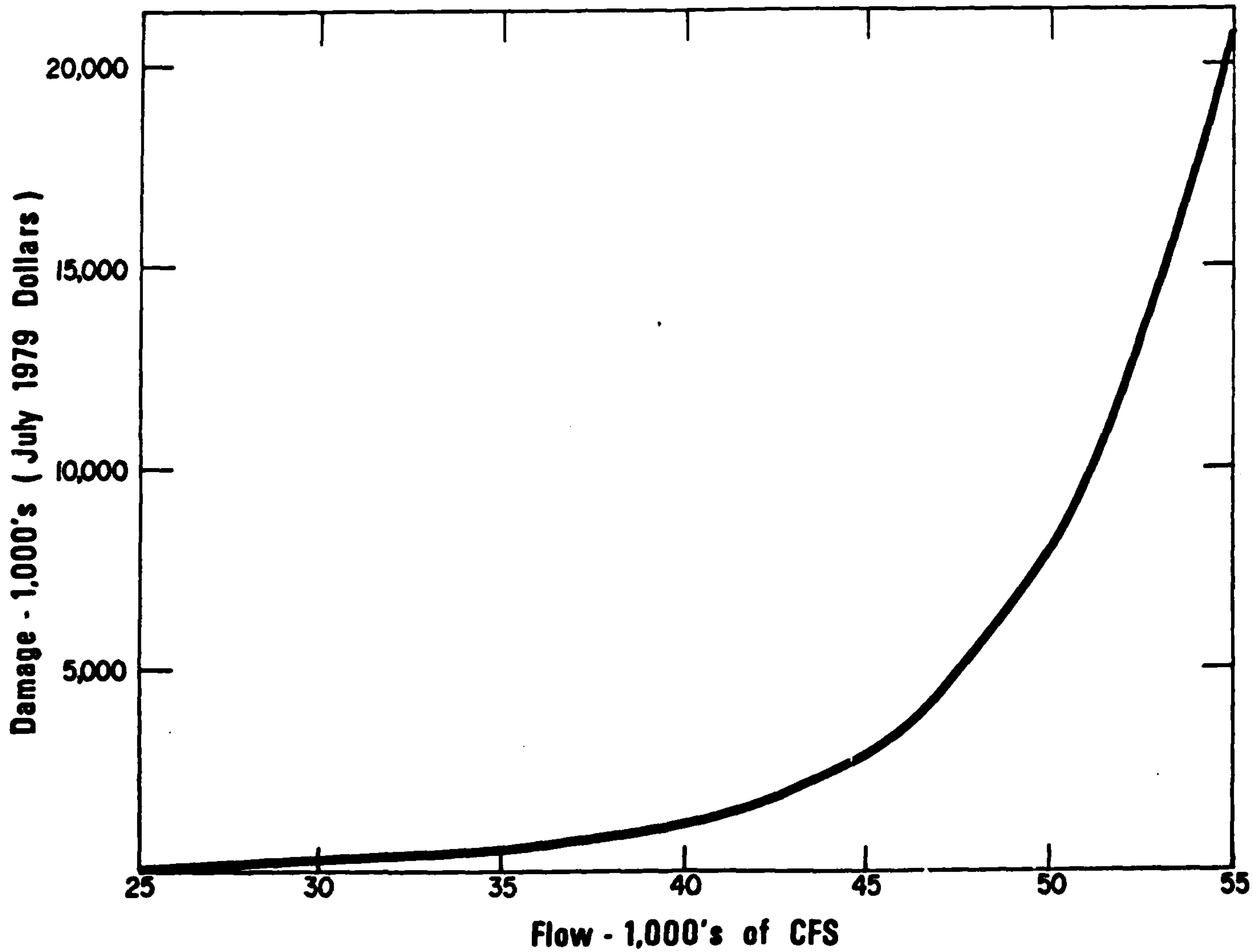
3.2.3 Collection of Input Data

Hydrologic Data: Probability distributions of annual maximum peak flows for the Ottawa River and the local inflows were used. For the Lake Ontario outflows, the maximum flows at Cornwall, occurring during April through May, were used to establish probability distributions.

Economic Data: Stage-damage curves were derived for Sectors I and IV; for Sectors II, III and V flow-damage curves were used. These curves represent annual damage for peak annual level or flow. Figure C-11 shows the flow-damage curve for Sector III.

3.2.4 Determination of Flow-Damage Curves

Since only the effects of Great Lakes regulation are being evaluated, the outflows from Cornwall were fixed at a number of values throughout the range of expected flows. Since flooding seldom occurs below St. Lawrence River flows of 250,000 cfs, this was the lowest value used by the hydro-dynamic model. The maximum flow at Cornwall is 350,000 cfs and this was the highest value used. Intermediate flows were also used. The same approach was applied to the Ottawa River and the local inflows, the values ranging from 100,000 to 350,000 cfs, and from 0 to 120,000 cfs respectively.



QUEBEC, SECTOR III RIVIERE DES MILLE ILES INUNDATION FLOW DAMAGE CURVE

Figure CI

The hydrodynamic model was used to calculate the output parameters in the five sectors for the different combinations of input parameters. Stage-damage or flow-damage curves were used to associate these different combinations of hydraulic conditions and their expected level of damages. Applying the probability distribution of maximum annual peaks of the Ottawa River and of the local inflow to these expected levels of damages, the Cornwall outflow-damage curve was derived. (See Annex A-3)

3.2.5 Evaluation of Regulation Plans

The Cornwall outflow-damage curves developed from the above procedure were used to evaluate Great Lakes regulation plans. Since the original stage-damage and flow-damage curves represented damage for the peak annual flood event, which usually occurs in either April or May, the damages were estimated by using a probability distribution of the maximum Lake Ontario outflows at Cornwall which occurred during these two months.

For the Canadian Reach of the St. Lawrence River, no methodology was developed to determine the effect of the regulation plans on erosion. This decision was made in recognition of the unavailability of data needed to develop such a methodology. Since most of the damages in the Montreal region are due to flooding, this decision will not impact significantly on the results of this study. However, any future studies should develop such methodology and data.

3.3 Erosion Evaluation Procedure

The erosion evaluation procedure was developed using a wave hindcasting procedure which was applied to each reach of Great Lakes shoreline. The hindcasting procedure represents the state-of-the-art with regards to using hourly recorded water levels and wind speed and direction data to determine wave climates at the breaker zone. The basic components of the procedure are damage data, water level data, wind speed and direction data, and physiographic data. Although the hindcasting was done on a year-round basis, only the months of March through December were utilized in the evaluations. The months of January and February were not used since the near-shore area of the Great Lakes are generally ice-covered during this period, which minimizes wave attack on the shore.

3.3.1 Data Utilized

The erosion data utilized in this evaluation were obtained from the sources described earlier in the Appendix. These damage data were collected and compiled separately for erosion and inundation.

Water Level Data: Hourly water data for the period January 1967 thru December 1976 were acquired on computer tapes from the responsible Federal agencies for a number of stations throughout the Great Lakes system. A 10-year period of data was determined to be statistically representative for the purposes of this evaluation. Table C-13 lists the wind and water level stations used and the reaches associated with them.

Wind Data: The wind data were recorded at various stations during 1966-1976 for the periods shown in Table C-13. These data consisted of either hourly or 3-hourly values of wind speed and direction. Any gaps in the wind data of between 2 to 12 hours duration were filled by linear interpolation between values on either side of the gap. If the gap was larger than 12 hours, no analysis was undertaken during the periods of missing records.

Modification of Data: The values of wind speed, which were recorded at on-land stations, were modified to represent values of over-water wind speed by applying the curve shown in Figure C-12. The part of the curve representing higher values of wind speed is based on the work of Resio (Resio, 1976). For the lower values of wind speed, the curve was obtained as a result of a comparison of over-water and over-land wind speeds under-taken for this study. The curve shown in Figure C-12 was adopted by the Coastal Zone Subcommittee.

The water level data used were edited in a fashion similar to the wind data; however, gaps longer than 12 hours were filled by linear interpolation from values adjacent to the gap. If the gap in the water level data was greater than 30 days, a mean monthly level was substituted from the nearest available water level recording station.

Wind to Wave Hindcast: The edited and modified hourly values of wind speed and direction were input to a hindcast procedure developed by Public Works Canada. The procedure was based on equations presented by Bretschneider (CERC, 1973). This hindcast procedure makes allowance for the history of wind speed prior to the hour under consideration. Wave decay resulting from changes in wind direction were considered. The results of the analysis were hourly values of significant wave height, peak period, and wave direction, corresponding to the wind direction.

3.3.2 Rationale of Use of Wave Hindcast

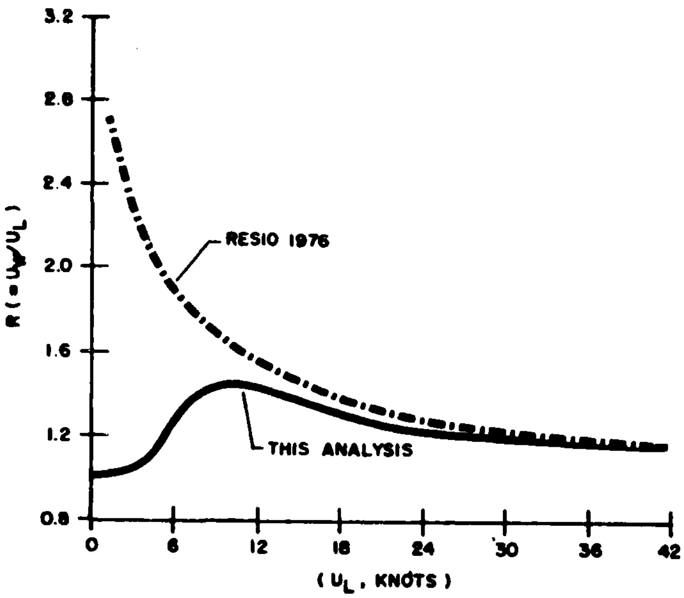
It is well recognized that wave attack is the primary cause of bluff erosion. This procedure assumes that the energy of the wave is the actual causative factor for erosion and that the rate of recession of the bluff is directly proportional to the amount of wave-energy which reaches the bluff toe. (See Figure C-13)

It is recognized that erosion is dependent on a number of factors, including wind, surface runoff, groundwater flow and the shore composition. However, there is no model currently available that takes into consideration all these factors and generates results suitable for this economic evaluation. Nevertheless, wave energy is the dominant factor in causing erosion and it was assumed to be the sole factor for the purpose of this study. In order to evaluate long reaches of shoreline, average values of several parameters (beach slope, toe-of-bluff elevation, center point of reach) were determined and applied to the whole reach.

Table C-13 - Wind and Water Level Stations

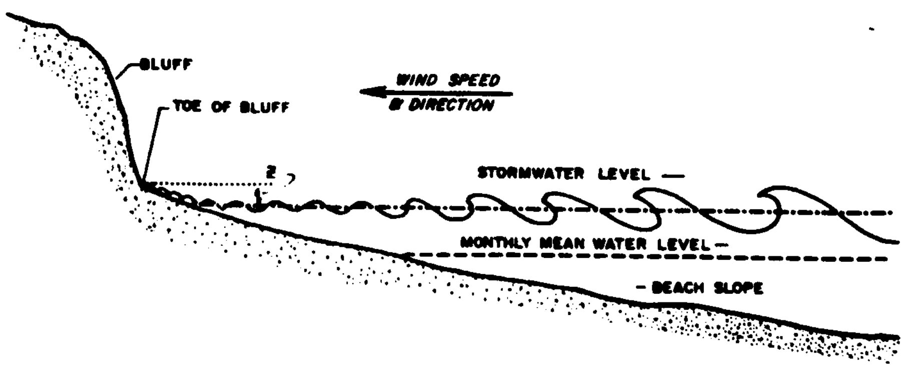
Wind Station	Reach	Water Level Station	Years of Interest
Lake Ontario			
Rochester, NY	U.S. 2002	Rochester, NY	1967-76
	U.S. 2003	Oswego, NY	1967-76
	U.S. 2004		1967-76
	U.S. 2005	Kingston, ONT	1967-76
	U.S. 2001	Port Weller, ONT	1967-76
Toronto Island, ONT	CAN. 2001		1967-76
	CAN. 2002		1967-76
	CAN. 2003		1967-76
	CAN. 2005	Toronto, ONT	1967-76
	CAN. 2006		1967-76
	CAN. 2007		1967-76
Trenton, ONT	CAN. 2008	Cobourg, ONT	1967-76
Lake Erie			
Toledo, OH	U.S. 3001	Toledo, OH	1967-76
	U.S. 3002		1967-76
Cleveland, OH	U.S. 3003	Cleveland, OH	1967-76
	CAN. 3006	Erieau, ONT	1967-76
	CAN. 3007		1967-71
	CAN. 3008	Port Stanley, ONT	1967-71
	CAN. 3009		1967-76
	CAN. 3010		1967-76
	CAN. 3011		1967-76
Buffalo, NY	CAN. 3013	Port Dover, ONT	1967-76
	CAN. 3014		1967-76
	CAN. 3015	Port Colborne, ONT	1967-76
	U.S. 3004	Erie, PA	1967-76
Windsor, ONT	CAN. 3001	Bar Point, ONT	1967-76
	CAN. 3002	Kingsville, ONT	1967-76
	CAN. 3003		1967-76
	CAN. 3004		1967-76
	CAN. 3005		1967-76
Lake St. Clair			
Windsor, ONT	U.S. 4001	Grosse Point & St. Clair	1967-76
	U.S. 4002	Shores, MI	1967-76
	CAN. 4003	Belle River, ONT	1967-76
	CAN. 4004		1967-76

Wind Station	Reach	Water Level Station	Years of Interest
Lake Huron			
Alpena, MI	U.S. 5001	Mackinaw, MI	1967-76
	U.S. 5002		1967-76
	U.S. 5003		1967-76
	U.S. 5004	Essexville, MI	1967-76
	U.S. 5005		1967-76
Windsor, ONT	U.S. 5006	Harbour Beach, MI	1967-76
	CAN. 5001	Point Edward, ONT	1966-75
	CAN. 5002		1966-75
	CAN. 5003	Goderich, ONT	1966-75
	CAN. 5004		1966-75
	CAN. 5005		1967-76
Lake Michigan			
Milwaukee, WI	U.S. 7003	Milwaukee, WI	1967-76
	U.S. 7004		1967-76
Chicago, IL	U.S. 7005	Calumet, IL	1967-76
	U.S. 7006		1967-76
Green Bay, WI	U.S. 7010	Mackinaw, MI	1967-76
	U.S. 7011	Sturgeon Falls, WI	1967-76
	U.S. 7012		1967-76
	U.S. 7013		1967-76
Traverse City, MI	U.S. 7002		1967-76
	U.S. 7001	Mackinaw, MI	1967-76
	U.S. 7009		1967-76
	U.S. 7008	Ludington, MI	1967-76
Muskegon, MI	U.S. 7007		1967-76
Lake Superior			
Duluth, MN	U.S. 9002	Duluth, MN	1967-74
	U.S. 9001	Two Harbors, MN	1967-74
	U.S. 9003		1967-74
	U.S. 9004	Marquette, MI	1967-74
Sault Ste. Marie, ONT	U.S. 9005		1967-76
	U.S. 9006		1967-76
	U.S. 9007		1967-76



RATIO OF OVER WATER TO OVER LAND WIND SPEED

Figure C12



AVERAGE BEACH PROFILE

Figure C13

3.3.3 Offshore Wave Energy

The total wave energy (E_o), per foot of wave crest, approaching the shore in 1 hour is equal to $38000 H_s^2 T$, where H_s is the significant wave height and T the wave period. This value was calculated for each hourly value of H_s and T. The resulting values were then added to provide estimates of total wave energy available by month, year and ice free season (March to December inclusive), regardless of wave direction.

Wave Refraction: As waves move into relatively shallower depths, their velocity and wave length are reduced. As a consequence, the direction of wave travel may be changed and wave energy may be concentrated or reduced at any selected point. For the study, it was assumed that the offshore contours are parallel to a straight shoreline. With that assumption, the following may be written:

$$\sin(\beta) = \frac{C}{C_o} \sin(\alpha) \qquad \text{(See Fig. C-14)}$$

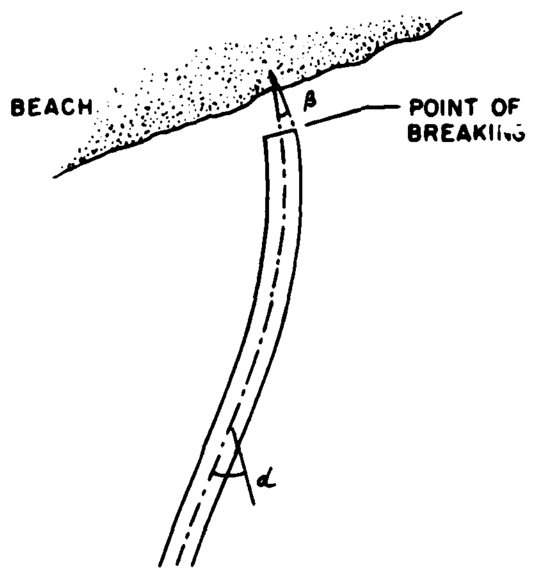
where α is the angle of the offshore waves to the perpendicular of the beach, β is the angle of the waves at the point of breaking, C_o is the deep water wave velocity and C is the wave velocity at the depth at which breaking occurs. Now,

$$C = \frac{gT}{2} \tanh\left(\frac{2\pi d}{L}\right),$$

where d is the depth at breaking, T is the wave period and L the wave length (g is the gravitational constant of 32.2 feet/sec/sec). If the ratio of H_s to L_o (the deep-water wave length) is constant then it can be shown that tanh $(2\pi d/L)$ is also constant for a given beach slope. A review of wave hindcast data showed that for storm waves on the Great Lakes, the ratio of H_s to L_o is relatively constant and approximately equal to 0.04. Therefore, this value was used for the analysis.

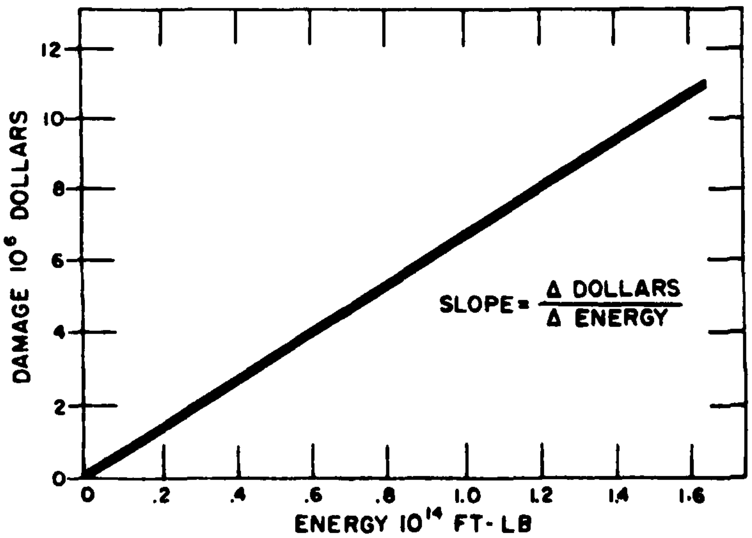
Hence, it follows that the direction of the wave, relative to the shore, at the point of breaking does not vary with wave period and is only dependent on the offshore wave direction. With the straight and parallel offshore contours, the wave height at the point of breaking (H_b) can be written as follows:

$$\frac{H_b}{H_o} = 0.303 \quad \frac{L_o}{H_o} \; 1/3$$



WAVE REFRACTION

Figure C14



U. S. REACH 3002 WAVE ENERGY VS. DAMAGE CURVE

Figure C15

The energy at point of breaking (E_b) may be written:

$$E_b = \frac{(\cos \beta)}{(\cos \alpha)} E_o$$

with angle α known, angle β was obtained from $\sin \beta = \tanh (\sin \alpha)$.

Wave Energy at Point of Breaking: The wave energy at the point of breaking was calculated as described and was then resolved into components perpendicular and parallel to the beach as follows:

Perpendicular component = $E_b \cos \beta$

Parallel component = $E_b \sin \beta$

3.3.4 Toe-of-Bluff Wave Energy

From the point the wave breaks, it was assumed that the energy was dissippated exponentially after breaking according to the following:

$$\frac{E}{E_b} = e^{-3 \frac{1.28H + Z}{1.28H + 2.3 \sqrt{H}\, T \tan \alpha}}$$

where E is the energy at a point with elevation Z above the storm water level and E_b is the component of energy at the point of breaking perpendicular to the beach. H is the refracted wave height, T the wave period, and $\tan \alpha$, the beach slope. This equation was solved for all hourly values of wave data using the corresponding water level.

Wave Energy vs. Water Level Curves: By holding monthly mean water levels constant at one-half foot intervals, the breaker energies, wave data, and storm rises were used to derive 10 toe-of-bluff wave energies for each month. These 10 values were averaged to give curves of monthly mean water levels versus average toe-of-bluff wave energy.

3.3.5 Calibration Procedures

In order to be useful in the analysis of erosion damages, the toe-of-bluff energy values were related to dollar damages. For U.S reaches, toe-of-bluff wave energy was calculated for the period of damage data collection using historic water level data. Total accumulated toe-of-bluff energy for this period was equated to the dollar damages for the damage survey period. This, along with the assumption that dollar damages are a linear function of toe-of-bluff wave energies, i.e., a straight line through 2 points (zero energy-zero damage and total accumulated energy-total accumulated damage) permitted the replacement of the toe-of-bluff wave energy axis on the wave energy vs. water level curve with a dollar damage axis. Figure C-15 illustrates this assumption and calculation of the total energy at toe of bluff vs. total damages for a given damage period. The slope of the line is in dollars per unit of energy (\$/E).

For Canadian reaches, stage-energy curves were calibrated using erosion data and toe-of-bluff wave energy from the high water period (1972-1976). The toe-of-bluff wave energy which occurred during that period was equated to erosion damages which could occur in the future, based on property values and erosion rates from the high water calibration period. This resulted in a dollar damage per unit energy which was used to calibrate actual toe-of-bluff wave energy.

Figure C-16 is the stage-damage curve for U.S. Reach 3002 for the month of March as derived using the steps described above for the U.S. shoreline.

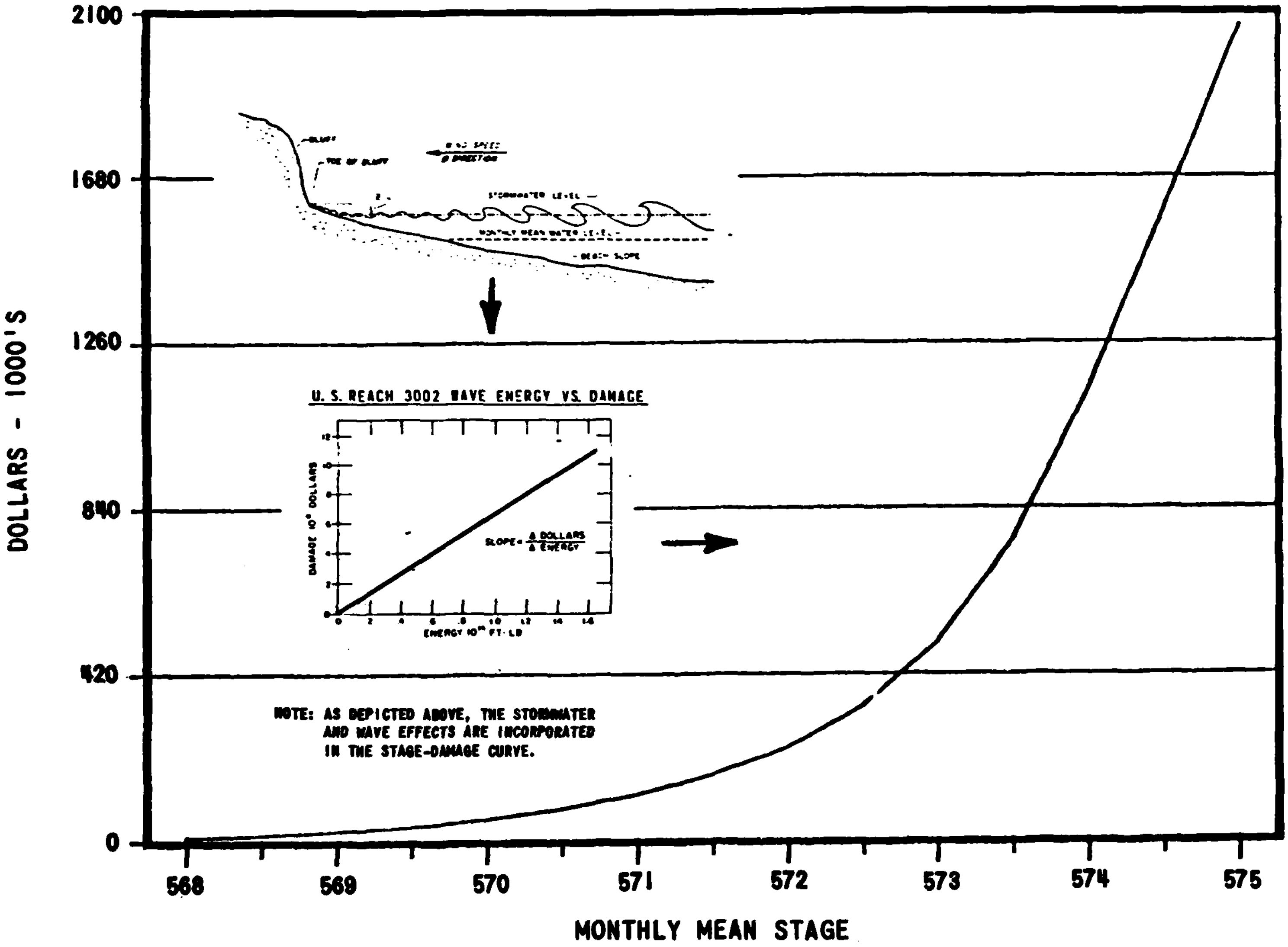
3.3.6 Evaluation of Regulation Plans

Erosion damage vs. water level curves were programmed for computer use and regulation plans were evaluated. Monthly mean water level data were inputs to the program and average erosion damages for each month were calculated. Summing the average monthly damages produced an average annual erosion damage value for each regulation plan.

Wearoff of the Effect of Regulation: It was assumed that the shore will, over a period of time, adjust to a change in mean water level, which will result in a reduction and eventual elimination of the effects of changing the mean lake levels. Due to a lack of research data, there is no consensus as to the period of time required for this "wearoff" to occur. Some evidence suggests it could occur as rapidly as 5 years; other evidence suggests it might take 50 years or more. In the absence of any conclusive data upon which to base a judgement, it was decided to assume a uniform rate of wearoff, as was done in the IGLLB Study. Further, this process, for most areas of the Great Lakes shoreline, was assumed to be complete in 50 years. The benefits or losses due to a change in mean water level are then reduced to zero after 50 years. Any benefits or losses due to a compression of the range of stages are not subject to this effect.

A procedure, similar to that utilized in the IGLLB Study, mentioned above, was employed in determining wearoff. If the long-term mean is changed by a regulation plan, wearoff is defined quantitatively as the change in long-term mean from the basis-of-comparison. If the regulation plan decreases the long-term mean, that difference was added to all the monthly mean levels for the period of record. The regulation plan was then reevaluated to calculate average monthly and average annual damages.

The new average annual damage represented the damage at the end of wearoff period (generally, year 50). Using the values of damage for years 1 and 50, and the assumption that wearoff is a straight line function, the average annual damages in the other years were calculated.



U. S. REACH 3002 EROSION STAGE DAMAGE CURVE

Figure C16

The average annual damages for the 50 years were discounted, using an 8.5% interest rate, to obtain a present worth value. From this present worth value an average annual damage was determined. For a reduction in the long-term mean water level, average annual damages after wearoff would be greater than the average annual damages before wearoff. The average annual damage reported for the regulation plan would be between the two calculated averages, due to discounting.

For the U.S. reaches, it was assumed that wearoff occurs at varying rates, dependent upon the shoreline composition. The wearoff was therefore broken down into three main categories: hard, semi-soft and soft. The first category is composed of hard rock bluffs which recede very slowly. For this category the wearoff was assumed to be zero. For the soft category, which included such shore types as sand dunes and glacial moraines, the wearoff was assumed to occur completely within the 50-year project period. Thus, all of the wearoff (due to a change in mean level) was added to the monthly mean levels when reevaluating the plans. For the semi-soft category, one-half of the wearoff was added to the mean levels when reevaluating to determine average annual damages after wearoff. In other words, the shoreline was assumed to adjust half-way in the 50-year project life, with complete adjustment after 100 years. In Canada, all erodible shorelines were assumed to be soft. Table C-14 lists the wearoff categories for U.S. reaches.

Table C-14 - Wearoff Categories For U.S. Reaches

Lake	Reach	Category	Wearoff Period (years)
Ontario	2001-2005	soft	50
Erie	3001-3003	soft	50
	3004	semi-soft	100
St. Clair	4001-4002	soft	50
Huron	5001-5005	soft	50
	5006	semi-soft	100
Michigan	7001	hard	-
	7002-7013	soft	50
Superior	9001, 9006	hard	-
	9002, 9007	soft	50
	9003-9005	semi-soft	100

3.4 Marine Structures Evaluation Procedure

3.4.1 Introduction

The analysis of effects of regulation plans on coastal marine facilities was based on techniques developed by the Shore Property Subcommittee for the International Great Lakes Levels Board (IGLLB) Study. The evaluation developed at that time consisted of two major categories - recreational boating facilities (marinas) and the deterioration of timber substructures.

3.4.2 Marinas

As noted in Section 1.3, Coastal Zone Study Process, the Coastal Zone Subcommittee was given the task to evaluate effects of regulation on marinas. However, since the Environmental Effects Subcommittee (EES) undertook an inventory and comprehensive analysis of recreational boating facilities (marinas) and developed techniques to evaluate the effects of lake levels on these facilities, this evaluation was eliminated as a Coastal Zone Subcommittee responsibility to avoid double-counting this effect.

3.4.3 Timber Substructure Deterioration

The second major category of the marine structures evaluation was to determine the effect of fluctuating water levels on timber substructures. In reconsidering the data and techniques used in the IGLLB Study, it was determined that dry-rot is no longer a major problem, as in previous years. Dry-rot deterioration occurs when untreated timbers are exposed to dry and wet cycles, which occurs due to lake level fluctuations. Most timber substructures (pilings) presently being installed are treated with creosote to prevent this problem. Those timber substructures that have already deteriorated are, in many cases, being cut off below the low water line and are capped with concrete, precluding a re-occurrence of the problem.

For these reasons this portion of the marine structures evaluation was eliminated as a Coastal Zone Subcommittee responsibility.

3.5 Water Pumping Evaluation Procedure

3.5.1 Introduction

Benefits to water pumping facilities in the form of reduced pumping costs derived from higher lake levels obtained through regulation can be calculated. Conversely, increased pumping costs due to lower lake levels can also be calculated. A pumping benefit will accrue from regulation when the average regulation plan levels are greater than the average levels occurring under basis-of-comparison conditions. Increased pumping costs accrue when the average regulation plan levels are lower than the average basis-of-comparison.

Several assumptions were necessary in order to provide an economic evaluation of the effects of the regulation plans on water pumping. First, it was assumed that extreme low levels do not affect the water treatment costs of the water being pumped. Also, it was assumed that there will be no significant changes in pumping technology during the evaluation period. Electrical power costs (1977) for pumping on the United States side were estimated to average $0.10 per million foot-gallons. The Canadian evaluations used a rate of $0.0527 per million foot-gallons, that is, about 5.27 cents to pump one million gallons of water a vertical distance of one foot. Finally, it was assumed that communities and industries would protect pumping and outfall facilities against flooding.

3.5.2 Calculation of Pumping Costs

The change in cost of pumping due to regulation, C, equals the change in average regulated lake stage, S, multiplied by the unit pumping cost per million gallons per foot of head, r, times the volume of water pumped, v. Expressed as a formula, $C = rvS$, where C is in dollars/year, r is in dollars/million gallons/foot, v is in millions of gallons/year, and S is in feet.

The following is a sample calculation:

Find the total pumping benefit C at Chicago for 1976 for Plan 25N.

Average pumping rate for 1977...991 Million Gallons Per Day (MGD).

Electric power cost per million gallons per foot..$0.10/MG feet.

Average 1976 Michigan-Huron Plan 25N stage..579.39 feet.

Average 1976 Michigan-Huron Basis-of-Comparison stage..579.77 feet.

$S = 579.39 - 579.77 = -0.38$ foot.

$V = 991$ MGD x 365 days/year = 361,715MG/year.

$C = \$0.10$/MG-feet x 361,715 MG/year x -0.38 foot = -$13,700/year.

Since the average annual regulation plan stage is less than the basis-of-comparison stage, S is negative and C represents an increased pumping cost.

The methodology for water pumping was programmed to calculate average annual level comparisons and derive a cost difference between the regulation plan and the basis-of-comparison conditions for each lake.

Pumping volume data from the International Great Lakes Diversions and Consumptive Uses Study Board were utilized in this analysis. Future pumping costs, due to increased consumption, were not developed.

3.6 Sensitivity Analyses

In order to conduct the economic evaluations, it was necessary to make a number of general and specific assumptions regarding physical processes and future development. Sensitivity analyses were conducted to evaluate the effect of altering some of these assumptions. The assumptions used are summarized below.

3.6.1 Assumptions

General: Stormwater level data and wave-energy relationships can represent large reaches of the shore having similar physiographic characteristics and subject to similar storm set-up and wave conditions.

Flooding:

1. Flooding damage is a function of peak storm water level.

2. Storm rises and monthly mean levels on the Great Lakes are independent.

3. The recorded storm rises (generally numbering 20 years for most gages, but as few as 13 years for some gages) provide an adequate representation of the storm climate and occurrence of stormwater levels for the period of record, 1900-1976.

4. Lake Ontario outflows, Ottawa River flows, and local St. Lawrence River inflows are independent.

5. Stage-damage curves are a function of shore topography and level of development.

Erosion:

1. Amount of erosion or damage is directly proportional to the amount of wave energy striking the toe-of-bluff.

2. Wind climate over each fetch can be considered similar to the wind climate of the closest inland weather station adjusted to over water conditions.

3. Wave climate can be estimated accurately from wind climate using wave hindcasting techniques based on Bretschneider's equations.

4. Wind and storm set-up climates for a 10-year period can be used to adequately represent average annual wave-energy for the period of record, 1900-1976.

5. Wave energy reaching the toe-of-bluff at a specific representative point of the reach and a representative shore profile is a good indicator of the wave energy reaching the toe-of-bluff over the entire reach.

6. Changes in erosion damage resulting from a change in mean lake level will eventually wear off. This is due to the adjustment of the beach profile to the new water level regime.

7. Erosion evaluations were not made for the Canadian Reach of the St. Lawrence River since insufficient data were available.

3.6.2 Wearoff Period Sensitivity

Wearoff is the process by which a shore profile will adjust to changes in long-term water levels. If, for instance, the long-term water level decreases, more of the beach and toe-of-bluff area would be uncovered, resulting in less erosion in these areas, but increasing erosion in the nearshore waters. Wearoff is then the process by which the shore profile, over a period of time, builds back to its original configuration. It is not known at this time, due to lack of research in this area, how long it would take the shore profile to revert back to its original shape. To determine the effect of different periods, a sensitivity analysis was conducted which varied the wearoff period.

A sensitivity analysis procedure of varying the wearoff period, showing its effect on regulation benefits was undertaken. The calculations for one reach is presented in Table C-15. Regulation Plan 25N (increasing the Lake Erie outflow by a maximum of 25,000 cfs), which would decrease the long-term average level by 0.59 foot on Lake Erie, was chosen for this example as was U.S. Reach 3002, which has suffered high erosion damages.

The basis-of-comparison average annual erosion damages are about $1,033,000. The average annual damages for Plan 25N are about $601,000, before giving any consideration to wearoff. This gives an average annual benefit of $432,000. The plan was then reevaluated with 0.59 foot added to all the levels and new erosion damages calculated. This gave an average annual damage of $924,000, or a benefit of $109,000. This shows that average annual benefits of $432,000 at the start of the project life can be expected to decrease to $109,000 after 50 years. It must be noted that these damages are the averages calculated before any discounting.

The wearoff period sensitivity was analyzed by varying the period in which the wearoff was assumed to occur in. That is, if the wearoff process is completed in 25 years, instead of 50, the benefits would be reduced to $109,000/year after 25 years and the benefits remain at this level for the remainder of the project life. Similarly, if the wearoff process is completed in 5 years, the benefits remain at $109,000 for the last 45 years of the project life. The benefits were assumed to decrease linearly from year 1 to the point in time when the wearoff process is complete, i.e., decrease from $432,000 per year to $109,000 per year in a straight line. It can be shown that this is equivalent to increasing damages in a linear manner.

If this wearoff process occurred instantaneously, there is, in effect, no decrease in erosion attributable to lower lake levels. The only benefits are those that accrue to decreasing the fluctuations of high levels. On the other hand, if the wearoff process takes an infinite amount of time, i.e., never occurs, then benefits due to decreased levels are permanent. The benefits are thus greater than with wearoff occurring.

As noted previously, the average annual benefits (before discounting over the project life) for U.S. Reach 3002 under Plan 25N are $432,000 and $109,000 before and after wearoff, respectively. The average annual benefits over the project life, when discounted to present worth, would be somewhere between these two and would vary with the interest rate and the length of the assumed wearoff period used. The average annual benefits which accrue when assuming various wearoff periods were calculated. These average annual benefits over the project life were compared to the discounted average annual regulation plan benefits that would accrue when assuming the wearoff process takes 50 years. The results are displayed in Table C-15.

From Table C-15, the discounted average annual benefits for a 50-year wearoff period are about $355,000. If wearoff occurs instantaneously, erosion benefits would be reduced to $109,000 per year, or, would be about 31% of the benefits for a 50-year wearoff period. Total benefits, inundation plus erosion, would be about 83% of those for a 50-year wearoff period. If the wearoff is assumed to occur in 25 years (twice as fast) the benefits to erosion for Plan 25N would be about $290,000 (about 82% of those for a 50-year wearoff period) and the total benefits for erosion and inundation would be reduced by about 4%.

To account for uncertainty in estimating the wearoff period, the Coastal Zone Subcommittee determined that the use of a 5-year wearoff period for a sensitivity analysis was adequate. The results of this analysis were extrapolated to all the other Great Lakes reaches. As shown in Table C-15, erosion benefits would be reduced by 52% and total average annual benefits would be reduced by 13%.

A similar analysis of the effect of varying the wearoff period was done for the Canadian evaluations. It was found that reducing the wearoff period to 5 years would lower erosion benefits by 57% and total benefits by 10% for the Canadian portion of the Great Lakes.

3.6.3 Coastal Zone Development and Affluence Sensitivity Analyses

The International Lake Erie Regulation Study Board made a decision not to include future coastal zone development or increasing affluence in deriving average annual costs and benefits in the coastal zone economic analyses of various regulation plans. However, sensitivity analyses of the effect of future coastal zone development and affluence were done by the U.S. Section of the Coastal Zone Subcommittee at the direction of the Board.

Table C-15 - Effect of Wearoff Period Variation on Benefits Under Regulation Plan 25N U.S. Reach 3002

Wearoff Period (Years)	Benefits[1] ($1,000) Erosion	Inundation	Ratio of Erosion Benefits	Ratio of Total Benefits
0	109	1,113	0.31	0.83
5	170	1,113	0.48	0,87
10	215	1,113	0.61	0.90
15	245	1,113	0.69	0.92
20	270	1,113	0.76	0.94
25	290	1,113	0.82	0.96
30	306	1,113	0.86	0.97
35	321	1,113	0.90	0.96
40	333	1,113	0.94	0.98
45	345	1,113	0.97	0.99
50	355	1,113	1.00	1.00

1) discounted over 50-year project life, using 8.5% interest rate.

The U.S. Section of the Coastal Zone Subcommittee determined average and maximum growth rates by lake basin specifically for use in a sensitivity analysis. Maximum growth rates for the basins took into account the remaining non-urban and residential land in the 1,000 foot wide coastal strip. Maximum development assumed the remaining space would be developed in 50 years and is then limited by the amount of open space available. Average growth rates took into account both available land and projected population growth.

The results of this analysis showed that the U.S. portion of Lakes Michigan, Huron, and Ontario could have maximum annual growth rates of about 2% per year over the next 50 years. Lake Superior's maximum annual growth rate was determined to be about 4% per year, while Lake Erie's is about 1% per year. The average annual growth rate for Lakes Superior, Michigan and Ontario was determined to be about 0.6%. Lake Erie and Lake Huron have corresponding rates of 0.9% and 1%, respectively. Lake St. Clair was included with Lake Erie for the purposes of these sensitivity analyses.

Using this information, the effect of average and maximum growth rates on regulation benefits was determined. The assumption was made that average annual damages would increase as the shoreline develops. The average annual damages for each basin and regulation plan were increased by the average and maximum annual growth rates for that basin. This was done for a period of 50 years and discounted. For the U.S. Reaches, average basin-wide growth would increase regulation benefits by a factor of about 1.11 (an 11% increase). If the maximum growth rates were obtained, benefits to the U.S. Reach would increase by a factor of about 1.15 (a 15% increase). It was assumed that there will be no future development in damage-susceptible areas along the Canadian shore. In other words, any future development will occur outside the damage-susceptible areas.

According to OBERS[1] studies, the average real income in the U.S. portion of the Great Lakes Region is expected to increase at a rate of 1.5% per year. This increasing affluence was assumed to be applicable in the Coastal Zone in the value of properties and their contents. The sensitivity analysis used a 1.5% per year increase in shore property value over a 50-year period, which was then discounted to present dollar values. This analysis showed benefits can increase by a factor of about 1.21 (21% increase) over the U.S. portion of the Great Lakes. It has been assumed that there will be no significant increase in property or content values in damage-susceptible areas in the Canadian portion of the Great Lakes-St. Lawrence system.

1. An acronym derived from the Office of Business Economics (OBE), U.S. Department of Commerce and the Economic Research Service (ERS), U.S. Department of Agriculture.

3.6.4 Meteorological Sensitivity

The inundation evaluation procedures (see Section 3.1) used both monthly mean levels and stormwater rises. As wind set-up (stormwater rise) reflects meteorological conditions, two sensitivity analyses were conducted on the stormwater rises (rises). U.S. Reach 3002, on the western portion of Lake Erie, was chosen as a test reach.

The first sensitivity analysis varied the period of rise data. For most of the Great Lakes reaches, both U.S. and Canadian, 20 years of rise data were used. However, due to lack of a complete data base, as few as 13 years of data were used on some reaches. To see if a shorter or longer data base would affect the results, the data base was varied from 10 to 40 years.

The sensitivity analysis showed that by increasing the data base from 20 to 40 years the basis-of-comparison damages would decrease by about 0.5 to 1% and the benefits due to regulation would decrease by about 2.0%. When the 40 years of data were broken down into four 10-year data bases, the benefits for each data base showed similar decreases.

The second sensitivity analysis for meteorological data, in relation to inundation, utilized various frequency distributions for the rise and monthly mean lake level data in order to incorporate data extremes reflected in probability distributions which may not show up in a limited period of recorded data.

The combined rises and monthly mean lake levels, i.e., stormwater levels, (see Section 3.1.3) were represented individually by five frequency distributions. The Chi-square goodness of fit test was used to find the distribution which best represented the stormwater levels. Using that distribution and the stage-damage curve for Reach 3002, average basis-of-comparison damages were determined. It was found that these damages varied about plus or minus 8% from those determined using actual recorded data instead of probability distributions for storm rise and monthly mean water levels.

Based on these sensitivity analyses, it was determined that the use of as few as 10 years of meteorological data (rises), as applied in the inundation model, appears to adequately represent wind set-up conditions. It has been noted, however, that the fewest number of years of data used was 13. Further, based on the two sensitivity analyses described above, it was determined that the record of storm rises used provided an adequate representation of the storm climate and no adjustment was needed to the inundation damages/benefits.

With regard to the meteorological data used in the erosion evaluation, the wave hindcasting for the evaluation of erosion damages used 10 years of recorded wind data. A 10-year record has been stated as "generally accepted to be of sufficient length for wind frequency distribution analysis" in a publication of the Meteorological Branch of the Canadian Department of Transport. The wind data were used directly in wave hindcasting rather than for the calculation of a frequency analysis. This may have resulted in a slight underestimation of wave energies, but it was considered that this approach was satisfactory in light of the degree of accuracy of other data used as input to the wave hindcasting.

3.6.5 Damage Data Sensitivity - U.S. Reaches

In response to concerns raised by the Board's Ad Hoc Economics Working Group, and to clarify procedures utilized by the States in the 1972-1976 Shoreline Damage Surveys, a detailed and comprehensive review of the Damage Surveys of the States of New York, Ohio, and Michigan was carried out. The combined total damages of these three States represented over 80% of the total damages for the survey period between 1972 and 1976. Results of the review were applied to the remainder of the data for the other five States.

State of New York: There are nine counties in the State of New York which have Great Lakes shoreline. These counties were surveyed in three groups: Monroe County by the Buffalo District of the Corps of Engineers; Wayne, Cayuga, Jefferson and St. Lawrence Counties as a group by the St. Lawrence-Eastern Ontario Commission; and, Chautauqua, Erie, Niagara, and Orleans Counties as a group by the St. Lawrence-Eastern Ontario Commission.

The eight counties surveyed by the St. Lawrence-Eastern Ontario Commission were reviewed with respect to two major concerns. The first concern was with the extrapolation of the census data for the "non-normal" residential properties. The non-normal group represented the extreme (high) values of assessed property values, or 5% of all residential properties in a given reach. The remaining 95% of the residential properties were grouped as "normal" and were subjected to a random sampling process where a 20% random sample was determined and questionnaires were mailed. For obtaining damages of the non-residential properties a census was conducted in all cases.

In conducting the census for the non-normal properties all properties selected were sent questionnaires. When the census results were totalled, they were extrapolated to a response rate of 100%, regardless of the actual response rate. If, for example, half of the mailed questionnaires for a region were completed, the total damages reported were then doubled to account for the remaining one-half who did not respond - assuming non-respondents had damages/property values comparable to respondents. This extrapolation of the actual reported non-normal damages added about 4.6% to the total damages (including residential and non-residential).

An adjustment to the total damages was applied to correct for (take out) this extrapolation of the non-normal census data as it is recognized that census data are not extrapolated. The stage-damage curves used reflect this adjustment.

The second area of concern regarding the U.S. damage data related to the handling of non-respondents in the extrapolation of the normal residential property damages. Response rates for completed questionnaires were calculated and the respective damages were linearly projected using the average damage per reported property applied to all properties in the reach. This assumed that the non-respondents to the survey had damages equal to the average damage of the respondents. This assumption was neither confirmed nor rejected through field testing. In order to determine the possible range of upward bias which may have been introduced by applying this assumption in the calculation of extrapolated damages an analysis using the assumption that all non-respondents had zero damages was carried out. The result of this analysis was that an amount equal to 15% of the total compiled damages in each State could be attributed to the use of the original assumption.

State of Ohio: The State of Ohio damage data were entirely for Lake Erie. In reviewing the survey conducted by Ohio State University for the Corps of Engineers, an error in programming was located in the projection procedure used for the handling of non-respondents to the residential normal survey. This error was corrected and the program rerun to calculate an accurate extrapolation using the standard procedure. The difference between the original and recalculated extrapolated normal residential damages was 32% of the original total State compiled damages. That is, damages had previously been overestimated by 32%. The totals employed in the evaluations were adjusted to reflect the new totals. After making this correction, and in light of the concerns noted for the State of New York, two determinations were reached. First, the amount of damages attributable to the extrapolation of the non-normal residential survey damages was about 5.0% of the total State compiled damages. The damages used in the evaluation programs were adjusted to correct for this amount. Secondly, if all normal population non-respondents had zero damage, the maximum over-estimation of total damages would be about 36%.

State of Michigan: The State of Michigan has shoreline on five of the six Great Lakes. It accounts for more than 50% of U.S. shoreline damages. The same two areas of analysis were investigated in Michigan as in the two states described above. The extrapolation of censused non-normal residential damages was 4.6% of the total damages. The damage curves were adjusted to account for this amount.

The maximum range of possible overestimation of total damages for the State of Michigan is 33%, if all normal population non-respondents to the survey had zero damage.

Upper Limit Analysis: In order to estimate an upper range of the damage data, Operation Foresight data were utilized. While the damages reported by each State from its surveys represent the best available information on damages which actually occurred, there is uncertainty inherent in any survey. As an indicator of the amount of damages which were not included in the damage surveys, the costs of Operation Foresight actions on a lake by lake basis were determined.

A total of almost $27 million was spent on temporary shore protection for the high water period, which was the same period included in the damage surveys. An estimated additional $132 million in damages were prevented by this temporary protection.

In other words, if it were not for the temporary protection provided by Operation Foresight, the total damages incurred would have been at least 50% more than that estimated by the damage survey. It was determined that, at a minimum, the $27 million actually spent on temporary protective works could be used as an additional increment of damages (on the premise that the temporary projects prevented at least as much damage as the cost of the works) to indicate a possible upper limit to be applied to the damage estimates.

Based upon the Operation Foresight costs spent per lake, and the proportion of damages from the surveys, a weighted average upper limit damage estimate for the whole Great Lakes system was determined to be a 16% increase over the surveyed damage estimate.

It should be noted that costs of protection are not included in the stage-damage curves utilized in the evaluations. The reported costs of protection exceeded $150 million during the four-year survey period and the $27 million is being used here only as a conservative estimate of additional damages, not accounted for by the damage survey data, in order to estimate the possible upper limit uncertainty of the damage data estimates.

Summary: Detailed investigations into three State damage surveys were carried out within the constraints of the projects being conducted several years ago and each state being handled by a separate surveying agency. Many of the personnel involved with the survey were no longer available for comment and the Coastal Zone Laboratory of the University of Michigan (which handled the Michigan survey) has closed completely. The two areas of analysis gave similar results for all three states. The result of extrapolation of the non-normal censused residential population damages was about a 5% over-estimation. All stage-damage curves were adjusted accordingly. The range of possible over-estimation of damages due to the handling of nonrespondents in the normal residential survey was 15% to 36%. A weighted average for the total range of the three states damages was 30%. In other words, the maximum lower range of damages is 30% less than that used in the U.S. evaluations.

Based on the Operation Foresight cost and damage analysis, a weighted average upper limit damage estimate would be an approximate 16% increase in damages. Therefore, the range of U.S. shore Great Lakes damage data can be expected to fall within the upper and lower range of +16% and -30%, respectively.

In each case, for the three states evaluated, the damage data were reanalyzed, corrected where necessary, and determined to be the best estimate of Great Lakes damages for the U.S. shoreline. Because these data analyses represent 80% of the damages of the U.S. Great Lakes shoreline, the review results were considered applicable to the remainder of the damage data for the other five states surveyed.

3.6.6 Damage Data Sensitivity - Canadian Reaches

Great Lakes Flood Damages: The primary source of data for the evaluation of Great Lakes flood damages was the Canada-Ontario Great Lakes Shore Damage Survey conducted in 1973 which calculated flood damages of $8.0 million for the period November 1972 to November 1973. A review of the basic data indicated that some damage items were open to interpretation as to whether a reduction in future high levels would create benefits due to prevention of a reoccurrence of these damages. The complete elimination of these items reduced the damages to $4.4 million. It was felt that the best estimate of damages applicable to the evaluation of Lake Erie regulation lies between the two extremes. As a compromise, the midpoint of $6.2 million was chosen, while the two extremes were chosen as the upper and lower limits of the sensitivity analysis. This gave a possible range of ± 29% for the benefits from reduction of flood damages, which is equivalent to a range of ± 26% on the total benefits for the Canadian reaches of the Great Lakes. The inundation stage-damage curves were calibrated using the $6.2 million damage total.

Quebec Flood Damages: The primary source of data for the evaluation of the Canadian reach of the St. Lawrence River were payments made under the governmental financial assistance program following the 1974 and 1976 flood events. Since these compensation programs excluded some damages, attached upper limits to others and had deductible amounts, payments were adjusted to determine total damage figures (see Table C-10). For the residential sector, a factor of 2.49 was used to evaluate total damage estimates; factors of 2.25 and 2.75 were used to determine the sensitivity of the adjustment factor. As a result of this analysis, it was determined that the average annual damages calculated for each regulation plan were only slightly affected by the damage adjustment factor.

Erosion Damages: Three major data items formed the basis of the erosion stage-damage curves - wave hindcast data, recorded erosion rates, and assessed property values. No easily-applicable, accurate method was available to estimate the effect of varying the assumptions inherent in the calculation and application of these data items. For this reason, no sensitivity analysis was performed for the evaluation of erosion damages.

3.6.7 Shore Profile Parameters

Section 3.6.4 discussed the effect of meteorological data on the inundation evaluation methodology. No similar analysis was done on meteorological data as they relate to the erosion evaluation methodology. However, some of the parameters inherent in the erosion evaluation methodology could impact on the determination of toe-of-bluff energies and are discussed below.

A number of assumptions were needed to define an erosion evaluation procedure. Among these were a simplified shore profile - single beach slope and toe-of-bluff elevation per reach. These were addressed in qualitative terms.

If the beach slope used on a particular reach were to be decreased (made more horizontal), this would cause incoming waves to break farther from the toe of the bluff. This would have the effect of decreasing the energy reaching the bluff, the energy being dissipated in turbulence and friction. Regulation plans that decrease the water levels would then cause the waves to break even further from the bluff toe with subsequent decreased energy reaching the bluff toe. This would cause a greater difference between the basis-of-comparison and the regulation plan, effectively increasing benefits. On the other hand, if the beach slope was increased, the opposite effect could be expected, with a subsequent decrease in benefits.

In a similar manner, the elevation of the toe of the bluff could affect erosion. The basic premise of the erosion methodology is that erosion is caused by wave energy striking the toe of the bluff. If the elevation of the toe is increased this makes it more inaccessible to wave energy. Those plans which decrease the water levels would, consequently, have even less energy striking the bluff toe. This would cause an increase in benefits. Conversely, if the toe of bluff elevation were lowered the relative difference between plans (the benefits) would be decreased. Note that with a single beach slope, raising the toe of bluff elevation has the same effect as decreasing the beach slope. Although these two parameters could have a significant impact on the determination of energy in the wave hindcasting, sensitivity analyses that varied these parameters were not carried out due to the time constraints.

3.6.8 Summary of Sensitivity Analyses

U.S. Reaches: The sensitivity analyses as discussed previously can be applied to the evaluation results as multiplicative factors. Two sets of factors are considered -- those that either increase or decrease the reported benefits/losses. The factors are:

	Lower Range	Upper Range
Wearoff Period	0.81	1.00
Development	1.00	1.15
Affluence	1.00	1.21
Damage Data	0.70	1.16
Cumulative Effect	0.57	1.61

These factors represent basin-wide effects, so that the total average annual benefits or losses for the U.S. portion for a regulation plan could be multiplied by a single factor. The factors would vary for individual lakes.

Canadian Reaches: The sensitivity analyses developed for Canadian reaches benefits/losses can similarily be summarized. The factors are:

	Lower Range	Upper Range
Damage Data - Great Lakes[1]	0.74	1.26
Wearoff Period	0.90[2]	1.00
Cumulative Effect	0.67	1.26
Total (Canada and U.S.)	0.62	1.57

1) Sensitivity analyses carried out for damage data in the Canadian Reach determined these to have no significant impact.

2) Varies slightly with lake and regulation plan.

Section 4

EVALUATION OF REGULATION PLANS

4.1 Regulation Plan 25N

Regulation Plan 25N was discussed in Section 1.6.1. As discussed in Section 1.6.4, Lake Ontario regulation was considered in four Categories. Of these, three were analyzed by the Coastal Zone Subcommittee. Tables C-16 and C-17 show the economic evaluations for Categories 1, 2, and 3 using average annual and present worth dollars, respectively, to show benefits and losses against the basis-of-comparison and Category 3 evaluations against the adjusted basis-of-comparison, described in Section 1.7. It can be seen from Table C-16 that Plan 25N would accrue net average annual benefits system-wide of about \$5 million. Sensitivity analyses show these net benefits can range from about \$3 million to \$8 million. Table C-17 presents the results of Table C-16 in present value dollars to the system. Section 5.5 presents a detailed discussion of the benefit or loss to the various interests for Plan 25N.

4.2 Regulation Plan 15S

Regulation Plan 15S was discussed in Section 1.6.2. Tables C-18 and C-19 show the economic evaluations for Categories 1, 2 and 3 using average annual and present worth dollars, respectively, to also show benefits and losses against the bases-of-comparison. It can be seen from Table C-18 that Plan 15S would accrue about \$2½ million net average annual benefits system-wide. Sensitivity analyses put a range on the net average annual benefits of about \$1½ million to \$3½ million. Table C-19 shows what the net average annual benefits over a 50-year project life would be worth at present. Section 5.6 presents a detailed discussion of the benefit or loss to the various coastal zone interests for Plan 15S.

4.3 Regulation Plan 6L

Section 1.6.3 of this Appendix discussed Regulation Plan 6L. Tables C-20 and C-21 show the economic evaluations for Categories 1, 2 and 3 using average annual and present worth dollars, respectively, to show benefits and losses against the bases-of-comparison. Table C-20 shows that about \$1 million net average annual benefits can be expected to accrue to coastal zone interests per year under Plan 6L. Sensitivity analyses place a range on the net average annual benefits of about \$½ million to \$1½ million. Table C-21 shows these net average annual benefits when expressed in present worth. Section 5.7 presents a detailed discussion of the benefit or loss to coastal zone interests under Plan 6L.

Table C-16 - Summary of Average Annual Economic Effects by Lake and Country - Regulation Plan 25N ($000)

Lake/River		Damages Basis-of-Comparison	Damages Plan 25N	Calculated Benefit (+) or Loss (-)	Sensitivity Range Lower	Sensitivity Range Upper
Superior	U.S.	2,005	1,942	: + 63 :	+ 36	+ 101
	Can.	0	2	: - 2 :	- 2	- 2
Michigan	U.S.	10,285	9,718	: + 565 :	+ 322	+ 910
Huron	U.S.	2,920	2,515	: + 405 :	+ 231	+ 652
	Can.	492	459	: + 33 :	+ 5	+ 44
St. Clair	U.S.	858	366	: + 492 :	+ 262	+ 795
	Can.	442	101	: + 341 :	+ 238	+ 434
Erie	U.S.	11,689	8,516	: +3,173 :	+1,809	+5,109
	Can.	658	399	: + 259 :	+ 144	+ 326
Ontario	U.S.	4,420	4,551	: - 131 :	- 75	- 211
(Cat. 1)	Can.	780	796	: - 16 :	- 12	- 20
St. Law. (Cat. 1)	Can.	1,873	1,884	: - 11 :	- 11	- 11
Total (Cat. 1)		36,420	31,249	: +5,171 :	+2,967	+8,127
Ontario	U.S.	4,420	4,682	: - 262 :	- 149	- 422
(Cat. 2)	Can.	780	778	: + 2 :	+ 19	- 2
St. Law.	Can.	1,873	1,959	: - 86 :	- 86	- 86
Total (Cat. 2)		36,420	31,437	: +4,983 :	+2,849	+7,859
Ontario	U.S.	4,420	4,451	: - 32 :	- 18	- 52
(Cat. 3)	Can.	780	751	: + 29 :	+ 34	+ 32
St. Law.	Can.	1,873	2,152	: - 279 :	- 279	- 279
Total (Cat. 3)		36,420	31,373	: +5,047 :	+2,802	+8,070
Adjusted Basis-of-Comparison						
Ontario	U.S.	4,349	4,452	: - 103 :	- 58	- 166
(Cat. 3)	Can.	754	759	: - 5 :	+ 3	- 9
St. Law.	Can.	2,026	2,152	: - 126 :	- 126	- 126
Total (Cat. 3)		36,476	31,381	: +5,095 :	+2,884	+8,068

Table C-17 - Summary of Present Value of Economic Effects by Lake and Country - Regulation Plan 25N ($000,000)

Lake/River		Damages Basis-of-Comparison	Damages Plan 25N	Calcaulated Benefit (+) or Loss (-)	Sensitivity Range Lower	Sensitivity Range Upper
Superior	U.S.	23.19	22.46	:+ 0.73:	+ 0.42	+ 1.18
	Can.	0	0.02	:- 0.02:	- 0.02	- 0.02
Michigan	U.S.	118.93	112.39	:+ 6.54:	+ 3.73	+10.53
Huron	U.S.	33.77	29.09	:+ 4.68:	+ 2.67	+ 7.53
	Can.	5.69	5.31	:+ 0.38:	+ 0.06	+ 0.51
St. Clair	U.S.	9.92	4.21	:+ 5.71:	+ 3.25	+ 9.19
	Can.	5.11	1.17	:+ 3.94:	+ 2.75	+ 5.02
Erie	U.S.	135.19	98.49	:+36.70:	+20.92	+59.09
	Can.	7.61	4.61	:+ 3.00:	+ 1.67	+ 3.77
Ontario	U.S.	51.12	52.63	:- 1.51:	- 0.87	- 2.44
(Cat. 1)	Can.	9.02	9.21	:- 0.19:	- 0.14	- 0.23
St. Law.	Can.	21.66	21.79	:- 0.13:	- 0.13	- 0.13
Total (Cat. 1)		421.21	361.39	:+59.83:	+34.31	+94.00
Ontario	U.S.	51.12	54.15	:- 3.03:	- 1.73	- 4.88
(Cat. 2)	Can.	9.02	9.00	:+ 0.02:	+ 0.22	- 0.02
St. Law.	Can.	21.66	22.66	:- 1.00:	- 1.00	- 1.00
Total (Cat. 2)		421.21	363.56	:+57.65:	+32.94	+90.90
Ontario	U.S.	51.12	51.49	:- 0.37:	- 0.21	- 0.60
(Cat. 3)	Can.	9.02	8.68	:+ 0.34:	+ 0.39	+ 0.37
St. Law.	Can.	21.66	24.89	:- 3.23:	- 3.23	- 3.23
Total (Cat. 3)		421.21	362.81	:+58.40:	+32.40	+93.34
Adjusted Basis-of-Comparison						
Ontario	U.S.	50.30	51.49	:- 1.19:	- 0.67	- 1.92
(Cat. 3)	Can.	8.72	8.78	:- 0.06:	+ 0.03	- 0.10
St. Law.	Can.	23.43	24.89	:- 1.46:	- 1.46	- 1.46
Total (Cat. 3)		421.86	362.94	:+58.92:	+33.35	+93.32

Table C-18 - Summary of Average Annual Economic Effects by Lake and Country - Regulation Plan 15S ($000)

Lake/River		Damages Basis-of-Comparison	Damages Plan 15S	Calculated Benefit (+) or Loss (-)	Sensitivity Range Lower	Sensitivity Range Upper
Superior	U.S.	2,005	1,981	:+ 24:	+ 14	+ 39
	Can.	0	1	:- 1:	- 1	- 1
Michigan	U.S.	10,283	10,052	:+ 231:	+ 132	+ 372
Huron	U.S.	2,920	2,749	:+ 171:	+ 97	+ 275
	Can.	492	475	:+ 17:	+ 5	+ 23
St. Clair	U.S.	858	610	:+ 248:	+ 141	+ 399
	Can.	442	245	:+ 197:	+ 138	+ 252
Erie	U.S.	11,689	10,171	:+1,518:	+ 865	+2,444
	Can.	658	515	:+ 143:	+ 85	+ 179
Ontario	U.S.	4,420	4,534	:- 114:	- 65	- 184
(Cat. 1)	Can.	780	786	:- 6:	- 1	- 8
St. Law.	Can.	1,873	1,917	:- 44:	- 44	- 44
Total (Cat. 1)		36,420	34,036	:+2,384:	+1,366	+3,746
Ontario	U.S.	4,420	4,600	:- 180:	- 103	- 290
(Cat. 2)	Can.	780	770	:+ 10:	+ 21	+ 8
St. Law.	Can.	1,873	1,953	:- 80:	- 80	- 80
Total (Cat. 2)		36,420	34,122	:+2,298:	+1,314	+3,620
Ontario	U.S.	4,420	4,406	:+ 14:	+ 8	+ 22
(Cat. 3)	Can.	780	750	:+ 30:	+ 31	+ 35
St. Law.	Can.	1,873	2,164	:- 291:	- 291	- 291
Total (Cat. 3)		36,420	34,119	:+2,301:	+1,224	+3,748
		Adjusted Basis-of-Comparison				
Ontario	U.S.	4,349	4,406	:- 57:	- 32	- 92
(Cat. 3)	Can.	754	758	:- 4:	0	- 5
St. Law.	Can.	2,026	2,164	:- 138:	- 138	- 138
Total (Cat. 3)		36,476	34,127	:+2,349:	+1,306	+3,747

Table C-19 - Summary of Present Value of Economic Effects by Lake and Country - Regulation Plan 15S ($000,000)

Lake/River		Damages Basis-of-Comparison	Damages Plan 15S	Calculated Benefit (+) or Loss (-)	Sensitivity Range Lower	Sensitivity Range Upper
Superior	U.S.	23.19	22.91	:+ 0.28:	+ 0.16	+ 0.45
	Can.	0	0.01	:- 0.01:	- 0.01	- 0.01
Michigan	U.S.	118.93	116.26	:+ 2.67:	+ 1.53	+ 4.30
Huron	U.S.	33.77	31.79	:+ 1.98:	+ 1.12	+ 3.18
	Can.	5.69	5.49	:+ 0.20:	+ 0.06	+ 0.27
St. Clair	U.S.	9.92	7.05	:+ 2.87:	+ 1.63	+ 4.61
	Can.	5.11	2.83	:+ 2.28:	+ 1.60	+ 2.91
Erie	U.S.	135.19	117.63	:+17.56:	+10.00	+28.27
	Can.	7.61	5.96	:+ 1.65:	+ 0.98	+ 2.07
Ontario	U.S.	51.12	52.44	:- 1.32:	- 0.75	- 2.13
(Cat. 1)	Can.	9.02	9.09	:- 0.07:	- 0.01	- 0.09
St. Law.	Can.	21.66	22.17	:- 0.51:	- 0.51	- 0.51
Total (Cat. 1)		421.21	393.65	:+27.57:	+15.80	+43.32
Ontario	U.S.	51.12	53.20	:- 2.08:	- 1.19	- 3.35
(Cat. 2)	Can.	9.02	8.90	:+ 0.12:	+ 0.24	+ 0.09
St. Law.	Can.	21.66	22.59	:- 0.93:	- 0.93	- 0.93
Total (Cat. 2)		421.21	394.62	:+26.59:	+15.19	+41.86
Ontario	U.S.	51.12	50.96	:+ 0.16:	+ 0.09	+ 0.25
(Cat. 3)	Can.	9.02	8.67	:+ 0.35:	+ 0.36	+ 0.41
St. Law.	Can.	21.66	25.03	:- 3.37:	- 3.37	- 3.37
Total (Cat. 3)		421.21	394.59	:+26.62:	+14.15	+43.34
Adjusted Basis-of-Comparison						
Ontario	U.S.	50.30	50.96	:- 0.66:	- 0.37	- 1.06
(Cat. 3)	Can.	8.72	8.77	:- 0.05:	0	- 0.06
St. Law.	Can.	23.43	25.03	:- 1.60:	- 1.60	- 1.60
Total (Cat. 3)		421.86	394.69	:+27.17:	+15.10	+43.33

Table C-20 - Summary of Average Annual Economic Effects by Lake and Country - Regulation Plan 6L ($000)

Lake/River		Damages Basis-of-Comparison	Plan 6L	Calculated Benefit (+) or Loss (-)	Sensitivity Range Lower	Sensitivity Range Upper
Superior	U.S.	2,005	1,998	+ 7	+ 4	+ 11
	Can.	0	0	0	0	0
Michigan	U.S.	10,283	10,194	+ 89	+ 51	+ 143
Huron	U.S.	2,920	2,853	+ 67	+ 38	+ 108
	Can.	492	484	+ 8	+ 3	+ 10
St. Clair	U.S.	858	758	+ 100	+ 57	+ 161
	Can.	442	356	+ 86	+ 60	+ 110
Erie	U.S.	11,689	11,085	+ 604	+ 344	+ 972
	Can.	658	595	+ 63	+ 38	+ 78
Ontario	U.S.	4,420	4,449	- 29	- 17	- 47
	Can.	780	771	+ 9	+ 10	+ 10
St. Law.	Can.	1,873	1,855	+ 18	+ 18	+ 18
Total (Cat. 1)		36,420	35,398	+1,022	+ 606	+1,574
Ontario	U.S.	4,420	4,510	- 90	- 51	- 145
(Cat. 2)	Can.	780	760	+ 20	+ 26	+ 21
St. Law.	Can.	1,873	1,870	+ 3	+ 3	+ 3
Total (Cat. 2)		36,420	35,463	+ 957	+ 573	+1,472
Ontario	U.S.	4,420	4,366	+ 54	+ 31	+ 87
(Cat. 3)	Can.	780	44	+ 36	+ 35	+ 42
St. Law.	Can.	1,873	2,035	- 162	- 162	- 162
Total (Cat. 3)		36,420	35,468	+ 952	+ 499	+1,560
Adjusted Basis-of-Comparison						
Ontario	U.S.	4,349	4,366	- 17	- 10	- 27
(Cat. 3)	Can.	754	751	+ 3	+ 5	+ 3
St. Law.	Can.	2,026	2,035	- 9	- 9	- 9
Total (Cat. 3)		36,476	35,475	+1,001	+ 581	+1,560

Table C-21 - Summary of Present Value of Economic Effects by Lake and Country - Regulation Plan 6L ($000,000)

Lake/River		Damages Basis-of-Comparison	Damages Plan 6L	Calculated Benefit (+) or Loss (-)	Sensitivity Range Lower	Sensitivity Range Upper
Superior	U.S.	23.19	23.11	:+ 0.08:	+ 0.05	+ 0.13
	Can.	0	0	:+ 0:	+ 0	+ 0
Michigan	U.S.	118.93	117.90	:+ 1.03:	+ 0.59	+ 1.65
Huron	U.S.	33.77	33.00	:+ 0.77:	+ 0.44	+ 1.25
	Can.	5.69	5.60	:+ 0.09:	+ 0.03	+ 0.12
St. Clair	U.S.	9.92	8.77	:+ 1.15:	+ 0.66	+ 1.86
	Can.	5.11	4.12	:+ 0.99:	+ 0.69	+ 1.27
Erie	U.S.	135.19	128.20	:+ 6.99:	+ 3.98	+11.24
	Can.	7.61	6.88	:+ 0.73:	+ 0.44	+ 0.90
Ontario	U.S.	51.12	51.46	:- 0.34:	- 0.20	- 0.54
	Can.	9.02	8.92	:+ 0.10:	+ 0.12	+ 0.12
St. Law.	Can.	21.66	21.45	:+ 0.21:	+ 0.21	+ 0.21
Total (Cat. 1)		421.21	409.41	:+11.80:	+ 7.01	+18.21
Ontario	U.S.	51.12	52.16	:- 1.04:	- 0.59	- 1.68
(Cat. 2)	Can.	9.02	8.79	:+ 0.23:	+ 0.30	+ 0.24
St. Law.	Can.	21.66	21.63	:+ 0.03:	+ 0.03	+ 0.03
Total (Cat. 2)		421.21	410.16	:+11.05:	+ 6.62	+17.01
Ontario	U.S.	51.12	50.49	:+ 0.63:	+ 0.36	+ 1.01
(Cat. 3)	Can.	9.02	8.60	:+ 0.42:	+ 0.40	+ 0.48
St. Law.	Can.	21.66	23.53	:- 1.87:	- 1.87	- 1.87
Total (Cat. 3)		421.21	410.20	:+11.01:	+ 5.77	+18.04
Adusted Basis-of-Comparison						
Ontario	U.S.	50.30	50.50	:- 0.20:	- 0.12	- 0.31
(Cat. 3)	Can.	8.72	8.70	:+ 0.02:	+ 0.05	0
St. Law.	Can.	23.43	23.53	:- 0.10:	- 0.10	- 0.10
Total (Cat. 3)		421.86	410.31	:+11.55:	+ 6.71	+18.01

Section 5

SUMMARY

5.1 General

The purpose of this appendix has been to identify and analyze the processes causing damage to the coastal zone of the Great Lakes and their connecting channels. Having identified and analyzed these processes, the benefits and losses of limited control of lake level fluctuations through limited regulation of Lake Erie were analyzed.

In identifying the processes that cause inundation, it was determined that the coastal zone inundation damages vary with the still-water (mean) level and the wind-generated temporary increase in water level at a specific location. The total elevation of these two levels has been termed the stormwater level. In identifying the processes that cause erosion in the coastal zone, it was assumed that erosion varies directly with the amount of the wave energy reaching the toe of the shore bluff.

Water pumping facilities are also affected by lower water levels, resulting in increased pumping costs.

Three regulation plans were selected to be evaluated and the results of these evaluations on inundation, erosion and water pumping are summarized in this section. The economic evaluations are average annual losses or benefits, rounded to the nearest one thousand dollars. Table C-22 presents the total net benefits for the Great Lakes-St. Lawrence system under the three regulation plans.

5.2 Inundation

The methodology used to evaluate inundation differs from previous studies in that stormwater levels were used as an index of inundation damages. For the United States coastal zone, damage data were based on the four-year damage survey of Labor Day, 1972 to Labor Day, 1976. For the Canadian portion of the Great Lakes, the Canada-Ontario Great Lakes Shore Damage Survey, covering the period of November, 1972 to November, 1973, provided the inundation damage data. The Canadian Reach of the St. Lawrence River used the 1974 and 1976 inundation damage events as the basis for damages. No money spent on construction of new protective works to prevent or alleviate inundation and/or erosion damages were included in the data utilized.

Table C-22 - Summary of Coastal Zone Net Benefits[1]

	Average Annual Benefits ($000)			Present Value of Benefits ($000,000)		
Category 1						
	6L	15S	25N	6L	15S	25N
U.S.	838	2,073	4,567	9.70	24.03	52.83
Can.	184	306	604	2.12	3.54	6.98
Total	1,022	2,384	5,171	11.82	27.57	59.81
Category 2						
U.S.	777	2,012	4,436	9.00	23.28	51.31
Can.	180	286	547	2.07	3.31	5.32
Total	957	2,298	4,983	11.07	26.59	57.63
Category 3						
U.S.	921	2,206	4,666	10.65	25.51	53.97
Can.	31	95	381	0.36	1.10	4.40
Total	952	2,301	5,047	11.01	26.61	58.37
Category 3 (Adjusted Basis-of-Comparison)						
U.S.	850	2,135	4,595	9.83	24.69	53.14
Can.	151	214	500	1.75	2.48	5.78
Total	1,001	2,349	5,095	11.58	27.17	58.92
Sensitivity Analyses - Upper Limit						
Cat. 1	1,574	3,746	8,127	18.21	43.32	94.00
Cat. 2	1,472	3,620	7,859	17.02	41.86	90.09
Cat. 3	1,560	3,748	8,070	18.04	43.35	93.33
Cat. 3[2]	1,560	3,747	8,068	18.04	43.34	93.31
Sensitivity Analyses - Lower Limit						
Cat. 1	605	1,366	2,967	7.01	15.80	34.31
Cat. 2	573	1,314	2,849	6.63	15.20	32.94
Cat. 3	499	1,224	2,802	5.77	14.16	32.41
Cat. 3[2]	581	1,306	2,884	6.72	15.10	33.36

(1) Comprising reduced erosion, inundation and pumping costs.
(2) Using the adjusted basis-of-comparison.

For the Great Lakes, stormwater stage-damage curves were developed from a number of information sources. These curves were calibrated to the survey period damages by using the recorded stormwater levels of the damage survey periods. Development of a relationship between stormwater levels and damages assumes that the two elements of a damaging event, acting independently or in combination, are capable of producing damage to the coastal zone real estate. In other words, even at low or average mean lake levels, severe storms can cause inundation damage; conversely, at high mean lake levels a small storm can damage the coastal zone. Monthly damages may be caused not only by a once-a-month peak stormwater level, but also by other lower levels during the month. Thus, the stormwater levels are only an index of damage capacity. Estimated average inundation damages were determined for each month and added to obtain an average annual damage. The average annual damages developed by this methodology are thus an indication of the relative benefits or losses between regulation plans.

For the evaluation of the effects of the regulation plans to the Canadian Reach of the St. Lawrence River, a slightly different inundation methodology was developed. For this methodology the effect of local inflow and Ottawa River inflow to the Montreal region were taken into account. It was assumed that the outflow from Lake Ontario under the regulation plans, the local inflow to the Cornwall-Montreal section of the St. Lawrence River and the Ottawa River flow are independent. Average damages were determined based on the combined probability of these events. Table C-23 summarizes the effect of the regulation plans on inundation.

In determining average annual damages, neither the effect of future development of presently undeveloped land, nor the effect of increasing value of presently developed land were taken into account. It was assumed that for the Canadian reaches of the Great Lakes-St. Lawrence system there would be no future development or increasing affluence (value) of property. For the United States reaches, sensitivity analyses of the effect of these two factors on average annual damages or benefits were conducted.

Sensitivity analyses were conducted on the damage data utilized by both the United States and Canada. The effect on average annual damages and benefits were determined.

5.3 Erosion

The erosion damages evaluation methodology utilized a "wave energy" approach in the development of stage-damage curves. Wave energy was considered to be the main source of coastal erosion damage, based on average monthly wave energy reaching the shore. Using hindcast wave climates, mean beach slopes and toe of bluff elevations above a reference level, an index of damage was determined. This index computed, for each reach, was used to convert stage-energy curves to stage-damage curves.

Table C-23 - Summary of Inundation Benefits

		Average Annual Benefits ($000)			Present Value of Benefits ($000,000)		
Lake/River		6L	15S	25N	6L	15S	25N
Superior	U.S.	+ 4	+ 14	+ 39	+0.05	+ 0.16	+ 0.45
	Can.	NE	NE	NE	NE	NE	NE
Michigan	U.S.	+ 29	+ 74	+ 177	+0.34	+ 0.86	+ 2.05
Huron	U.S.	+ 40	+ 100	+ 235	+0.46	+ 1.16	+ 2.72
	Can.	+ 8	+ 20	+ 41	+0.09	+ 0.23	+ 0.47
St. Clair	U.S.	+ 85	+ 208	+ 406	+0.98	+ 2.41	+ 4.70
	Can.	+ 82	+ 187	+ 319	+0.95	+ 2.16	+ 3.69
Erie	U.S.	+332	+ 815	+1,761	+3.84	+ 9.43	+20.37
	Can.	+ 56	+ 127	+ 231	+0.65	+ 1.47	+ 2.67
Ontario	U.S.	- 7	- 29	- 50	-0.08	- 0.34	- 0.58
(Cat. 1)	Can.	+ 3	- 7	- 13	+0.03	- 0.08	- 0.15
St. Law.	Can.	+ 18	- 44	- 11	+0.21	- 0.51	- 0.13
Total (Cat. 1)		+650	+1,465	+3,135	+7.52	+16.94	+36.26
Ontario	U.S.	- 9	- 28	- 58	-0.10	- 0.32	- 0.67
(Cat. 2)	Can.	+ 3	- 4	- 14	+0.03	- 0.05	- 0.16
St. Law.	Can.	+ 3	- 80	- 86	+0.03	- 0.93	- 0.99
Total (Cat. 2)		+633	+1,433	+3,051	+7.32	+16.57	+35.29
Ontario	U.S.	+ 42	+ 37	+ 15	+0.49	+ 0.42	+ 0.17
(Cat. 3)	Can.	+ 21	+ 17	+ 11	+0.24	+ 0.20	+ 0.13
St. Law.	Can.	-162	- 291	- 279	-1.87	- 3.37	- 3.23
Total (Cat. 3)		+537	+1,308	+2,956	+6.21	+15.13	+34.19
Adjusted Basis-of-Comparison							
Ontario	U.S.	- 4	- 9	- 31	-0.05	- 0.10	- 0.36
(Cat. 3)	Can.	+ 1	- 3	- 9	+0.01	- 0.04	- 0.10
St. Law.	Can.	- 9	- 138	- 126	-0.10	- 1.60	- 1.46
Total (Cat. 3)		+624	+1,395	+3,043	+7.22	+16.14	+35.20

(NE) Not evaluated. The inclusion of these evaluations would not significantly affect the results.

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LAKE ERIE WATER LEVEL STUDY. APPENDIX C. COASTAL ZONE.(U)
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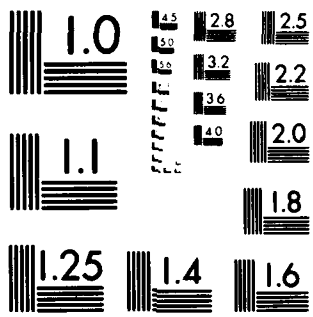
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For the United States, the erosion damages utilized were based on the same damage survey as the inundation damages. For the Canadian portion of the Great Lakes, potential future damages were determined based upon long-term erosion rates. These potential damages, along with wave energies for the 1972-1976 period were used to calculate damage indices. Stage-energy curves were then converted to stage-damage curves.

While it is known that significant erosion damages occur along the Canadian Reach of the St. Lawrence River, there were insufficient data to quantitatively evaluate the impact of the regulation plans on these damages. It is likely, however, that increased extreme flows, as would occur under the regulation plans, would cause increased erosion damages along the Canadian Reach of the St. Lawrence River. The omission of these damages does not have a major impact on the overall results of this Study. Table C-24 summarizes the effect of the regulation plans on erosion.

Sensitivity analyses on the effect of assuming a shorter wearoff period and varying interest rates were conducted and applied to both the United States and Canadian reaches. Other sensitivity analyses, similar to those for inundation, were conducted only for the United States reaches.

5.4 Water Pumping

Many communities near the shoreline of the Great Lakes and their connecting rivers have water pumping facilities to serve the needs of both industry and population centers. These facilities were surveyed for the 1973 International Great Lakes Levels Board Study Report to determine the effects on them of extreme variations in lake levels. The same methodology was adopted for this study.

The methodology for water pumping compares pumping costs between the basis-of-comparison and the regulation plans. The difference in pumping costs between the two conditions represents a benefit or loss attributable to the regulation plan. No increase in water use was projected in the economic evaluations of the plans.

The results of the evaluation, displayed in Table C-25, show relatively small economic effects on water pumping.

5.5 Regulation Plan 25N

The evaluations of average annual benefits/losses on inundation, erosion and water pumping are summarized in Table C-26.

Table C-24 Summary of Erosion Benefits

Lake/River		Average Annual Benefits ($000) 6L	15S	25N	Present Value of Benefits ($000,000) 6L	15S	25N
Superior	U.S.	+ 3	+ 10	+ 25	+0.03	+ 0.12	+ 0.29
	Can.	NE	NE	NE	NE	NE	NE
Michigan	U.S.	+ 69	+ 183	+ 453	+0.80	+ 2.12	+ 5.24
Huron	U.S.	+ 27	+ 71	+ 170	+0.31	+ 0.82	+ 1.97
	Can.	+ 4	+ 9	+ 23	+0.05	+ 0.10	+ 0.27
St. Clair	U.S.	+ 15	+ 40	+ 86	+0.17	+ 0.46	+ 0.99
	Can.	+ 4	+ 10	+ 22	+0.05	+ 0.12	+ 0.25
Erie	U.S.	+295	+ 763	+1,571	+3.41	+ 8.82	+18.17
	Can.	+ 14	+ 35	+ 76	+0.16	+ 0.40	+ 0.88
Ontario	U.S.	- 23	- 85	- 81	-0.27	- 0.98	- 0.94
(Cat. 1)	Can.	+ 3	- 5	- 3	+0.03	- 0.06	- 0.03
St. Law.	Can.	NE	NE	NE	NE	NE	NE
Total (Cat. 1)		+411	+1,031	+2,342	+4.75	+11.92	+27.09
Ontario	U.S.	- 82	- 154	- 206	-0.95	- 1.78	- 2.38
(Cat. 2)	Can.	+ 1	- 8	- 12	+0.01	- 0.09	- 0.14
St. Law.	Can.	NE	NE	NE	NE	NE	NE
Total (Cat. 2)		+350	+ 959	+2,208	+4.05	+11.09	+25.54
Ontario	U.S.	+ 12	- 24	- 48	+0.14	- 0.27	- 0.56
(Cat. 3)	Can.	+ 6	0	- 1	+0.07	0	- 0.01
St. Law.	Can.	NE	NE	NE	NE	NE	NE
Total (Cat. 3)		+449	+1,097	+2,377	+5.19	+12.69	+27.49
Adjusted Basis-of-Comparison							
Ontario	U.S.	- 13	- 49	- 73	-0.15	- 0.57	- 0.85
(Cat. 3)	Can.	- 1	- 7	- 8	-0.01	- 0.08	- 0.09
St. Law.	Can.	NE	NE	NE	NE	NE	NE
Total (Cat. 3)		+417	+1,065	+2,345	+4.82	+12.31	+27.12

(NE) Not evaluated. The inclusion of these evaluations would not significantly affect the results.

Table C-25 - Summary of Pumping Economic Effects

Lake/River		Average Annual Benefits ($000) 6L	15S	25N	Present Value of Benefits ($000,000) 6L	15S	25N
Superior	U.S.	0	0	- 1	0	0	- 0.01
	Can.	0	- 1	- 2	0	- 0.01	- 0.02
Michigan	U.S.	- 9	- 26	- 65	- 0.10	- 0.30	- 0.75
Huron	U.S.	A	A	A	A	A	A
	Can.	- 4	- 12	- 31	- 0.04	- 0.14	- 0.36
St. Clair	U.S.	0	0	0	0	0	0
	Can.	0	0	0	0	0	0
Erie	U.S.	- 23	- 60	-159	- 0.27	- 0.69	- 1.84
	Can.	- 7	- 19	- 48	- 0.08	- 0.22	- 0.56
Ontario	U.S.	+ 1	0	0	+ 0.01	0	0
(Cat. 1)	Can.	+ 3	+ 6	0	+ 0.03	+ 0.07	0
St. Law.	Can.	NE	NE	NE	NE	NE	NE
Total (Cat. 1)		- 39	-112	-306	- 0.45	- 1.30	- 3.54
Ontario	U.S.	+ 1	+ 2	+ 2	+ 0.01	+ 0.02	+ 0.02
(Cat. 2)	Can.	+ 16	+ 22	+ 28	+ 0.19	+ 0.26	+ 0.32
St. Law.	Can.	NE	NE	NE	NE	NE	NE
Total (Cat. 2)		- 26	- 94	-276	- 0.30	- 1.09	- 3.19
Ontario	U.S.	0	+ 1	+ 1	0.00	+ 0.01	+ 0.01
(Cat. 3)	Can.	+ 9	+ 13	+ 19	+ 0.10	+ 0.15	+ 0.22
St. Law.	Can.	NE	NE	NE	NE	NE	NE
Total (Cat. 3)		- 34	-104	-286	- 0.39	- 1.20	- 3.31

Adjusted Basis-of-Comparison

		6L	15S	25N	6L	15S	25N
Ontario	U.S.	0	+ 1	+ 1	0.00	+ [illegible]	+ 0.01
(Cat. 3)	Can.	+ 3	+ 6	+ 13	+ 0.03	+ 0.0[illegible]	+ 0.15
St. Law.	Can.	NE	NE	NE	NE	NE	NE
Total (Cat. 3)		- 40	-111	-292	- 0.46	- 1.28	- 3.38

(A) Included in Lake Michigan.
(NE) Not Evaluated. The inclusion of these evaluations would not significantly affect the results.

Table C-26 - Summary of Economic Evaluations For Coastal Zone Interests - Plan 25N

		Average Annual Benefits ($000)			Present Value of Benefits ($ 000,000)	
Lake/River		Erosion	Inundation	Pumping	Total	Total
Superior	U.S.	+ 25	+ 39	- 1	:+ 63:	+ 0.73
	Can.	NE	NE	- 2	:- 2:	- 0.02
Michigan	U.S.	+ 453	+ 177	- 65	:+ 565:	+ 6.54
Huron	U.S.	+ 170	+ 235	A	:+ 405:	+ 4.68
	Can.	+ 23	+ 41	- 31	:+ 33:	+ 0.38
St. Clair	U.S.	+ 86	+ 406	0	:+ 492:	+ 5.69
	Can.	+ 22	+ 319	0	:+ 341:	+ 3.94
Erie	U.S.	+1,571	+1,761	-159	:+3,173:	+36.70
	Can.	+ 76	+ 231	- 48	:+ 259:	+ 3.00
Ontario	U.S.	- 81	- 50	0	:- 131:	- 1.51
(Cat. 1)	Can.	- 3	- 13	0	:- 16:	- 0.19
St. Law.	Can.	NE	- 11	NE	:- 11:	- 0.13
Total (Cat. 1)		+2,342	+3,135	-306	:+5,171:	+59.81
Ontario	U.S.	- 206	- 58	+ 2	:- 262:	- 3.03
(Cat. 2)	Can.	- 12	- 14	+ 28	:+ 2:	+ 0.02
St. Law.	Can.	NE	- 86	NE	:- 86:	- 1.00
Total (Cat. 2)		+2,208	3,051	-276	:+4,983:	+57.63
Ontario	U.S.	- 48	+ 15	+ 1	:- 32:	- 0.37
(Cat. 3)	Can.	- 1	+ 11	+ 19	:+ 29:	+ 0.33
St. Law.	Can.	NE	- 279	NE	:- 279:	- 3.23
Total (Cat. 3)		+2,377	+2,956	-286	:+5,047:	+58.37
Adjusted Basis-of-Comparison						
Ontario	U.S.	- 73	- 31	+ 1	:- 103:	- 1.19
(Cat. 3)	Can.	- 9	- 9	+ 13	:- 5:	- 0.06
St. Law.	Can.	NE	- 126	NE	:- 126:	- 1.46
Total (Cat. 3)		+2,344	3,043	-292	:+5,095:	+58.93

(A) Included in Lake Michigan.
(NE) Not Evaluated; the inclusion of these would not significantly affect the results.

5.5.1 Erosion

The evaluation of the effects of regulation plans on unprotected coastal zone property is based on erosion damage to structures and loss of land through erosion. All lakes upstream of Lake Ontario show net benefits being accrued to Plan 25N. That is, average annual erosion damages would be decreased if Plan 25N were implemented. Further, erosion damages would not be eliminated but would be decreased. The benefits are then due to decreased, not eliminated, damages. Lake Erie, which is most affected by the limited regulation plans, would show net average annual benefits to the United States coastal zone of about $1,571,000 and to the Canadian coastal zone of about $76,000. Lake Ontario under Category 1 regulation would show average annual losses of about $81,000 and $3,000 to the United States and Canadian coastal zones, respectively. Total system-wide net annual benefits for Category 1 erosion would amount to about $2,342,000.

For Category 2 regulation, Lake Ontario would show increased erosion damages relative to both Category 1 and the basis-of-comparison. The average annual losses to the United States portion of Lake Ontario would be about $206,000. The Canadian portion of Lake Ontario would show erosion losses of about $12,000, for a total of $218,000.

For Plan 25N, under Category 3 regulation, total erosion losses on Lake Ontario would be about $81,000 when compared to the adjusted basis-of-comparison, with the U.S. coastal zone showing losses of $73,000. Category 3 would cut erosion losses on Lake Ontario by a factor of three, when compared to Category 2, and is also somewhat lesser than Category 1. In all three categories, erosion on the Canadian Reach of the St. Lawrence River was not calculated, but could be expected to reduce system-wide benefits.

5.5.2 Inundation

Inundation damages for the Great Lakes system would be reduced by Plan 25N. For the United States, Lake Erie would show the greatest reduction in average annual inundation damages, with an average annual benefit of about $1,761,000. For the Canadian portion of the system, Lake St. Clair would produce the greatest benefits, averaging about $319,000 per year. All lakes upstream of Lake Ontario would show reduced inundation damages. The total system-wide net average annual benefits would be about $3,135,000.

As regulated under Category 1, Lake Ontario would show a loss of about $63,000 per year; downstream, the St. Lawrence River losses would be about $11,000 per year. Under Category 2, Lake Ontario inundation losses would increase slightly to about $72,000 per year, while downstream losses in the Canadian Reach of the St. Lawrence River would be about

$86,000 per year. Under Category 3, Lake Ontario's annual losses would be reduced to $40,000 while St. Lawrence River losses increase to $126,000, relative to the adjusted basis-of-comparison. When compared to the basis-of-comparison for Categories 1 and 2, Lake Ontario's inundation changes from losses to a small average annual benefit of $26,000. This is more than offset, however, by average annual losses downstream of $279,000.

The regulatory works for Category 3 would include the dredging of material from the Lachine Rapids at Montreal to permit greater releases of water from Lake Ontario without increasing flood damages on Lac Saint-Louis. While such dredging would reduce flood damages on Lac Saint-Louis for a given flow, it would be at the expense of increased flood damages downstream on the St. Lawrence River and on Lac Saint-Pierre. The hydrodynamic model used in the evaluation of flood damages could not practically be modified to accommodate dredging in the Lachine Rapids, but it was estimated that, for any given Lake Ontario outflow, total flood damages in the Canadian Reach would not be significantly altered by the proposed dredging. Since one stage-damage curve was used to represent all five sectors (see Section 3.2), the reduction in damages in the Lac Saint-Louis area along with an increase in damages in the downstream (Repentigny to Trois-Rivieres) area would result in no change in the overall stage-damage curve. Therefore, Canadian Reach damages under Category 3 plans were determined in the same manner as damages under Category 1 and 2 plans.

5.5.3 Water Pumping

All of the Great Lakes except Ontario would show minor losses in average annual pumping costs. System-wide, the average annual losses for Category 1 would be about $306,000, with Lake Erie showing the greatest loss, about $207,000. Under Category 2, Lake Ontario would show a benefit of about $30,000 per year and under Category 3, about $20,000 and $14,000 in benefits for the basis-of-comparison and adjusted basis-of-comparison, respectively.

5.5.4 Total Benefits

For Category 1, Plan 25N would show an average annual benefit to the coastal zone of about $5,171,000. Of this, Lake Erie would derive the greatest benefit of about $3,432,000 per year. About 60% of the system-wide benefits would be due to reduced inundation damages. The rest of the benefits would be due to decreased erosion, with water pumping showing a loss. The only Lake to show net losses would be Ontario with $147,000 in average annual losses.

Category 2, which differs from Category 1 only in how it affects Lake Ontario and the St. Lawrence River, would decrease the system-wide benefits to about $4,983,000. Lake Ontario and downstream show increased losses of about $188,000 over Category 1.

Under Category 3 regulation, the system-wide net annual benefits would be about $5,047,000. This is $124,000 less than Category 1, but $64,000 greater than Category 2. Lake Ontario would show average annual losses of about $3,000 under Category 3, while downstream the St. Lawrence River would show $279,000 in losses. When comparing Category 3 to the adjusted basis-of-comparison, Lake Ontario average annual losses are about $108,000, for a net system-wide benefit of about $5,095,000.

5.5.5 Sensitivity Analyses

By applying the sensitivity analyses discussed in Section 3, upper and lower limits were determined for these benefits. By using the sensitivity analyses for Category 1 regulation, annual benefits derived from Plan 25N could decrease to $2,967,000 or increase to $8,127,000. This represents a range of -43% and +57%. Similar ranges occur for Categories 2 and 3 and are shown in Table C-16.

5.6 Regulation Plan 15S

The evaluation of average annual benefits/losses to inundation, erosion and water pumping for Plan 15S is summarized in Table C-27.

5.6.1 Erosion

Plan 15S would reduce the system-wide erosion relative to the basis-of-comparison. In general, those lakes which show erosion benefits under Plan 25N would show erosion benefits under Plan 15S, but to a lesser degree.

For Category 1 regulation, the system-wide average annual benefits would be about $1,031,000. Again, Lake Erie would derive the greatest benefit, with erosion being reduced an average of $798,000 per year, of which $763,000 accrues to the United States shoreline. Lake Ontario erosion damages would increase by about $90,000 per year. The greatest benefits to the Canadian shoreline would occur on Lake Erie, with erosion being reduced by an average of $35,000 annually.

Under Category 2, erosion on Lake Ontario would increase over both Category 1 and the basis-of-comparison, with a subsequent lowering of system-wide benefits. System-wide annual erosion benefits would be about $959,000. Category 3 would show an improvement over Categories 1 and 2. Lake Ontario erosion would show losses of about $24,000 and $56,000 relative to the basis-of-comparison and adjusted basis-of-comparison, respectively. System-wide average annual erosion benefits would be about $1,097,000 and $1,065,000, respectively, for the two Category 3 bases-of-comparison.

Table C-27 - Summary of Economic Evaluations For Coastal Zone Interests - Plan 15S

Lake/River		Average Annual Benefits ($000) Erosion	Inundation	Pumping	Total	Present Value of Benefits ($ 000,000) Total
Superior	U.S.	+ 10	+ 14	0	:+ 24:	+ 0.28
	Can.	NE	NE	- 1	:- 1:	- 0.01
Michigan	U.S.	+ 183	+ 74	- 26	:+ 231:	+ 2.67
Huron	U.S.	+ 71	+ 100	A	:+ 171:	+ 1.98
	Can.	+ 9	+ 20	- 12	:+ 17:	+ 0.20
St. Clair	U.S.	+ 40	+ 208	0	:+ 248:	+ 2.87
	Can.	+ 10	+ 187	0	:+ 197:	+ 2.27
Erie	U.S.	+ 763	+ 815	- 60	:+1,518:	+17.56
	Can.	+ 35	+ 127	- 19	:+ 143:	+ 1.65
Ontario	U.S.	- 85	- 29	0	:- 114:	- 1.32
(Cat. 1)	Can.	- 5	- 7	+ 6	:- 6:	- 0.07
St. Law.	Can.	NE	- 44	NE	:- 44:	- 0.51
Total (Cat. 1)		+1,031	+1,465	-112	:+2,384:	+27.57
Ontario	U.S.	- 154	- 28	+ 2	:- 180:	- 2.08
(Cat. 2)	Can.	- 8	- 4	+ 22	:+ 10:	+ 0.12
St. Law.	Can.	NE	- 80	NE	:- 80:	- 0.93
Total (Cat. 2)		+ 959	+1,433	- 94	:+2,298:	+26.59
Ontario	U.S.	- 24	+ 37	+ 1	:+ 14:	+ 0.16
(Cat. 3)	Can.	0	+ 17	+ 13	:+ 30:	+ 0.34
St. Law.	Can.	NE	- 291	NE	:- 291:	- 3.36
Total (Cat. 3)		+1,097	+1,308	-104	:+2,301:	+26.61
Adjusted Basis-of-Comparison						
Ontario	U.S.	- 49	- 9	+ 1	:- 57:	- 0.66
(Cat. 3)	Can.	- 7	- 3	+ 6	:- 4:	- 0.05
St. Law.	Can.	NE	- 138	NE	:- 138:	- 1.60
Total (Cat.3)		+1,065	+1,395	-111	:+2,349:	+27.16

(A) Included in Lake Michigan.
(NE) Not evaluated; the inclusion of these would not significantly affect the results.

5.6.2 Inundation

All lakes upstream of Lake Ontario would show decreased inundation damages for Plan 15S. On Lake Erie, annual inundation damages would be lowered about $942,000, relative to the basis-of-comparison. Lake St. Clair would show inundation benefits of about $395,000 per year, which consists of $208,000 and $187,000 for the United States and Canada, respectively. Lake Ontario's annual loss would be about $36,000 and downstream, on the St. Lawrence River, annual losses would be about $44,000 for Category 1 regulation. System-wide, the inundation benefits that would accrue to Plan 15S, Category 1, are about $1,465,000.

Category 2 would not show as great a loss on Lake Ontario as Category 1, but downstream the losses would increase. System-wide, Category 2 inundation benefits would be reduced by $32,000, to about $1,433,000. As with erosion, Lake Ontario would show improvement under Category 3; however, downstream on the St. Lawrence River the losses increase. System-wide, Category 3 benefits of reduced inundation would be about $1,308,000 and $1,395,000 for the basis-of-comparison and adjusted basis-of-comparison, respectively.

5.6.3 Water Pumping

Water pumping would be relatively unaffected by Plan 15S. Minor losses would be shown on Lakes Michigan-Huron and Erie. Total Category 1 losses would be about $112,000 per year.

Category 2 would show a benefit to water pumping on Lake Ontario, due to somewhat higher levels. Consequently, the system-wide losses under Category 2 would be reduced to about $94,000 per year. Under Category 3 the system-wide benefits would be about $104,000 and $111,000 per year, respectively, for the basis-of-comparison and adjusted basis-of-comparison.

5.6.4 Total Benefits

Plan 15S would show an average annual benefit to the coastal zone of the Great Lakes-St. Lawrence system of about $2,384,000 for Category 1. Lake Erie would derive the greatest benefit with about $1,661,000 in reduced damages annually. Lake St. Clair would show average annual benefits of about $445,000. Benefits to the United States coastal zone would be about $2,078,000 and to the Canadian coastal zone would be about $306,000. Lake Ontario would have an average annual loss of about $120,000. The Canadian Reach of the St. Lawrence River would have an average annual loss of about $44,000, due to increased flooding.

Category 2 would increase the average annual losses on Lake Ontario and downstream by about $86,000, relative to Category 1. This is due to increased erosion on Lake Ontario and increased inundation on the St. Lawrence River. The system-wide benefits for Category 2 regulation of Plan 15S are about $2,298,000 per year.

Under Category 3, the coastal zone interests on Lake Ontario would show benefits that total $44,000. However, with losses downstream of $291,000 the system-wide average annual benefits would be about $2,301,000. With the adjusted basis-of-comparison, system-wide benefits for Category 3 would be about $2,349,000 annually.

5.6.5 Sensitivity Analyses

By applying sensitivity analyses to the results, a range of possible benefits were obtained. As a result, Category 1 benefits could be as low as $1,366,000 and as high as $3,746,000, system-wide. This is a variation of -$1,018,000 and +$1,362,000, or -43% and +57%, respectively. Lake Erie would show the greatest effect, where benefits could decrease to $950,000 or increase to $2,623,000. Categories 2 and 3 show similar ranges. The ranges by Lake and Category are shown in Table C-18.

5.7 Regulation Plan 6L

The evaluation of average annual benefits/losses to inundation, erosion and water pumping for Plan 6L is summarized in Table C-28.

5.7.1 Erosion

Plan 6L is expected to reduce Great Lakes average annual erosion damages by about $411,000 with a loss of about $20,000 per year using Category 1 regulation on Lake Ontario. Lake Erie would account for about 75% of the erosion benefits, with $309,000 in reduced damages. Under Category 2, Lake Ontario erosion damages would increase by another $61,000 to show an annual loss of about $81,000. System-wide erosion benefits under Category 2 would be about $350,000 per year. Under Category 3, system-wide benefits due to reduced erosion would be about $449,000 and $417,000 annually for the basis-of-comparison and adjusted basis-of-comparison, respectively.

5.7.2 Inundation

Inundation is affected to a greater degree than erosion under Plan 6L. System-wide, the average annual benefits for Category 1 would be about $650,000. Lake St. Clair would show benefits of about $167,000 annually and Lake Erie about $388,000 annually. Lake Ontario would have slight annual losses amounting to about $4,000 while downstream, the annual benefits would be about $18,000.

Under Category 2, inundation benefits would be reduced in relation to Category 1. Lake Ontario would show losses of about $6,000 while downstream a net annual benefit of $3,000 is accrued. This would result in total system-wide Plan 6L benefits to inundation of about $633,000, which is $17,000 less than Category 1.

Table C-28 - Summary of Economic Evaluations For Coastal Zone Interests - Plan 6L

		Average Annual Benefits ($000)				Present Value of Benefits ($ 000,000)
Lake/River		Erosion	Inundation	Pumping	Total	Total
Superior	U.S.	+ 3	+ 4	0	:+ 7:	+ 0.08
	Can.	NE	NE	0	: 0:	0.00
Michigan	U.S.	+ 69	+ 29	- 9	:+ 89:	+ 1.03
Huron	U.S.	+ 27	+ 40	A	:+ 67:	+ 0.77
	Can.	+ 4	+ 8	- 4	:+ 8:	+ 0.09
St. Clair	U.S.	+ 15	+ 85	0	:+100:	+ 1.16
	Can.	+ 4	+ 82	0	:+ 86:	+ 0.99
Erie	U.S.	+ 295	+332	-23	:+604:	+ 6.99
	Can.	+ 14	+ 56	- 7	:+ 63:	+ 0.73
Ontario	U.S.	- 23	- 7	+ 1	:- 29:	- 0.33
(Cat. 1)	Can.	+ 3	+ 3	+ 3	:+ 9:	+ 0.10
St. Law.	Can.	NE	+ 18	NE	:+ 18:	+ 0.21
Total (Cat. 1)		+411	+650	-39	:+1,022:	+11.82
Ontario	U.S.	- 82	- 9	+ 1	:- 90:	- 1.04
(Cat. 2)	Can.	+ 1	+ 3	+16	:+ 20:	+ 0.23
St. Law.	Can.	NE	+ 3	NE	:+ 3:	+ 0.04
Total (Cat. 2)		+350	+633	-26	:+957:	+11.07
Ontario	U.S.	+ 12	+ 42	0	:+ 54:	+ 0.62
(Cat. 3)	Can.	+ 6	+ 21	+ 9	:+ 36:	+ 0.42
St. Law.	Can.	NE	-162	NE	:-162:	- 1.87
Total (Cat. 3)		+449	+537	-34	:+952:	+11.01
Adjusted Basis-of-Comparison						
Ontario	U.S.	- 13	- 4	0	:- 17:	- 0.20
(Cat. 3)	Can.	- 1	+ 1	+ 3	:+ 3:	+ 0.04
St. Law.	Can.	NE	- 9	NE	:- 9:	- 0.10
Total (Cat. 3)		+417	+624	-40	:+1,001:	+ 11.58

(A) Included in Lake Michigan
(NE) Not evaluated; the inclusion of these would not significantly affect the results.

Under Category 3, Lake Ontario shows a net benefit of $63,000 while losses downstream would be about $162,000. Total system-wide Plan 6L benefits due to reduced inundation would be $537,000 annually. When comparing Category 3 to the adjusted basis-of-comparison, the system-wide inundation benefit would be about $624,00.

5.7.3 Water Pumping

Water pumping would be virtually unaffected by Plan 6L. The total losses system-wide for Categories 1 and 2 would be about $39,000 and $26,000, respectively, and for Category 3 about $34,000 and $40,000 for the basis-of-comparison and adjusted basis-of-comparison.

5.7.4 Total Benefits

Plan 6L would show a net average annual benefit to coastal zone interests of about $1,022,000 under Category 1 regulation of Lake Ontario. Over 60% of these benefits would be due to decreased inundation damages. Water pumping would show a very small loss with the remainder of the net benefits being accrued to reduced erosion damages. About 82% of all benefits would accrue to the United States coastal zone.

Under Category 2 regulation of Lake Ontario, the system-wide benefits would decrease slightly, to about $957,000. As with Category 1, Lake Erie would accrue the greatest net benefits - about $667,000 annually, of which $604,000 would accrue to the United States coastal zone interests. The decrease in benefits, relative to Category 1, would be due mainly to increased erosion damages on Lake Ontario.

For the United States reaches of Lake Ontario, Category 3 regulation would show marked improvement over Categories 1 and 2. Relative to the basis-of-comparison, the U.S. reaches would show average annual benefits of about $54,000. Relative to the adjusted basis-of-comparison, the U.S. reaches would sustain average annual losses of about $17,000. The Canadian reaches of Lake Ontario would show average annual benefits of $36,000 and $3,000 relative to the basis-of-comparison and the adjusted basis-of-comparison, respectively. The Canadian Reach of the St. Lawrence River would show average annual Category 3 losses of $162,000 and $9,000 when compared to the two bases-of-comparison. Total system-wide average annual benefits for Category 3 would be about $952,000 for the basis-of-comparison and $1,001,000 for the adjusted basis-of-comparison.

5.7.5 Sensitivity Analyses

By applying sensitivity analyses to the evaluation results, a range of possible results were obtained. Table C-20 details these analyses by Lake and regulation category. For Category 1, total system-wide benefits could be expected to range from $606,000 to $1,574,000. This is a range of -$416,000 and +$552,000 from the calculated benefits of $1,022,000. This is a range of -41% and +54%, respectively. Similar results were obtained for Categories 2 and 3.

ANNEX A1
COMPUTER SOFTWARE

COMPUTER SOFTWARE

In the course of executing its assigned tasks, the Coastal Zone Subcommittee developed and used a number of computer programs. These programs made it possible to accomplish detailed evaluations of the proposed regulation plans.

The Coastal Zone Subcommittee evaluations fell into three categories: erosion, inundation and water intakes pumping. Each evaluation has its own computer program, written in Fortran. The U.S. Section has combined the three programs into one package to more efficiently evaluate the proposed regulation plans. This annex will address the evaluation programs as they are contained in that package.

The evaluation package (CZSEVAL - for Coastal Zone Evaluations) consists of a short main program and eight subroutines. Figure A1-1 shows the flow chart for CZSEVAL and Figure A1-2 is a listing of the program. The main program inputs the regulation plan name and levels and calls for the execution of the desired evaluations. All three evaluations can be executed in one run. The main program calls an evaluation if a flagging variable is set to a value greater than zero; otherwise the evaluation is skipped (see Figure A1-1).

Some data are common to all of the evaluations - such as regulation plan name, levels, and years in the period-of-record. These data are contained in a COMMON block. Other needed data are input from the individual subroutines (evaluations).

The first evaluation called by the main program is erosion. The erosion subroutine (EDE2-Erosion Damage Evaluation) calls for the input of erosion stage-damage curves and wearoff values. The stage-damage curves are read in from their assigned tape, TAPE7, and the wearoff is input from the same tape as the regulation plan levels, TAPE10. (The erosion stage-damage curves for the U.S. Section are listed in Figure A2-1, and for the Great Lakes portions of the Canadian Section in Figure A2-2).

The first line of data in each erosion stage-damage curve contains the Reach number, number of levels and the lake number. The lakes are numbered one through five, going upstream from Lake Ontario to Lake Superior. Lakes Michigan and Huron, with common monthly mean levels, are assigned the same lake number. The monthly mean levels for the period of record for the regulation plan are printed out before the first reach of each lake. Each year has ten damage values associated with it - one each for the months of March through December. The monthly mean levels and damage values are read in from alternating lines - the level from lines two, four, etc and the damages from lines three, five, etc; as many pairs of lines as indicated from line one. The stage-damage curve and the wearoff are then output.

After the erosion program calculates the damage for a month it calls another subroutine, DAW (Damage After Wearoff). This subroutine increments the monthly mean level by an amount equal to the wearoff. The damages for that month are then calculated. Subroutine AMD (Average Monthly Damage) calculates the monthly mean damages for the period-of-record for the wearoff-incremented mean water levels.

After calculating all of the monthly and average annual damages for the period-of-record, the average annual damages before and after the wearoff increments are input to subroutine EC (Economic Calculations). The difference between the two average annual damages is uniformly distributed over fifty years and the present worth calculated. From the present worth an average annual damage is calculated. The present worth and average annual damages over the fifty years are output.

The second evaluation called by the main program is inundation. The inundation program (INUNDAT) inputs the inundation stage-damage curves and the historic storm rises. The storm rise data are input from TAPE8 and the stage-damage curves from TAPE5, the normal input tape. The historic storm rises are input as integers (in hundredths of a foot), 20 for each month. The stage-damage curve lists stormwater and damage. (Figure A2-3 and A2-4 list the inundation stage-damage curves for the U.S. and Canadian Sections, respectively. Figures A2-5 and A2-6 list the historic storm rises for the U.S. and Canadian Sections, respectively).

Subroutine INUNDAT calls subroutine FREQ (Frequency) to derive a stormwater-frequency curve. Each historic rise is added to each monthly mean level to obtain stormwater levels. These are then ordered and an empirical frequency determined. The damage for each stormwater level is multiplied by the frequency of occurence of that level. This is done for all the combinations of stormwater levels for the month and summed to give average monthly damages. This process is repeated for each month and summed to give average annual damages.

The inundation subroutine also calls subroutine STATS (Statistics) to compute intermediate damages between the points on the stage-damage curve. The stage-damage curve is output, along with the average monthly damages and average annual damage.

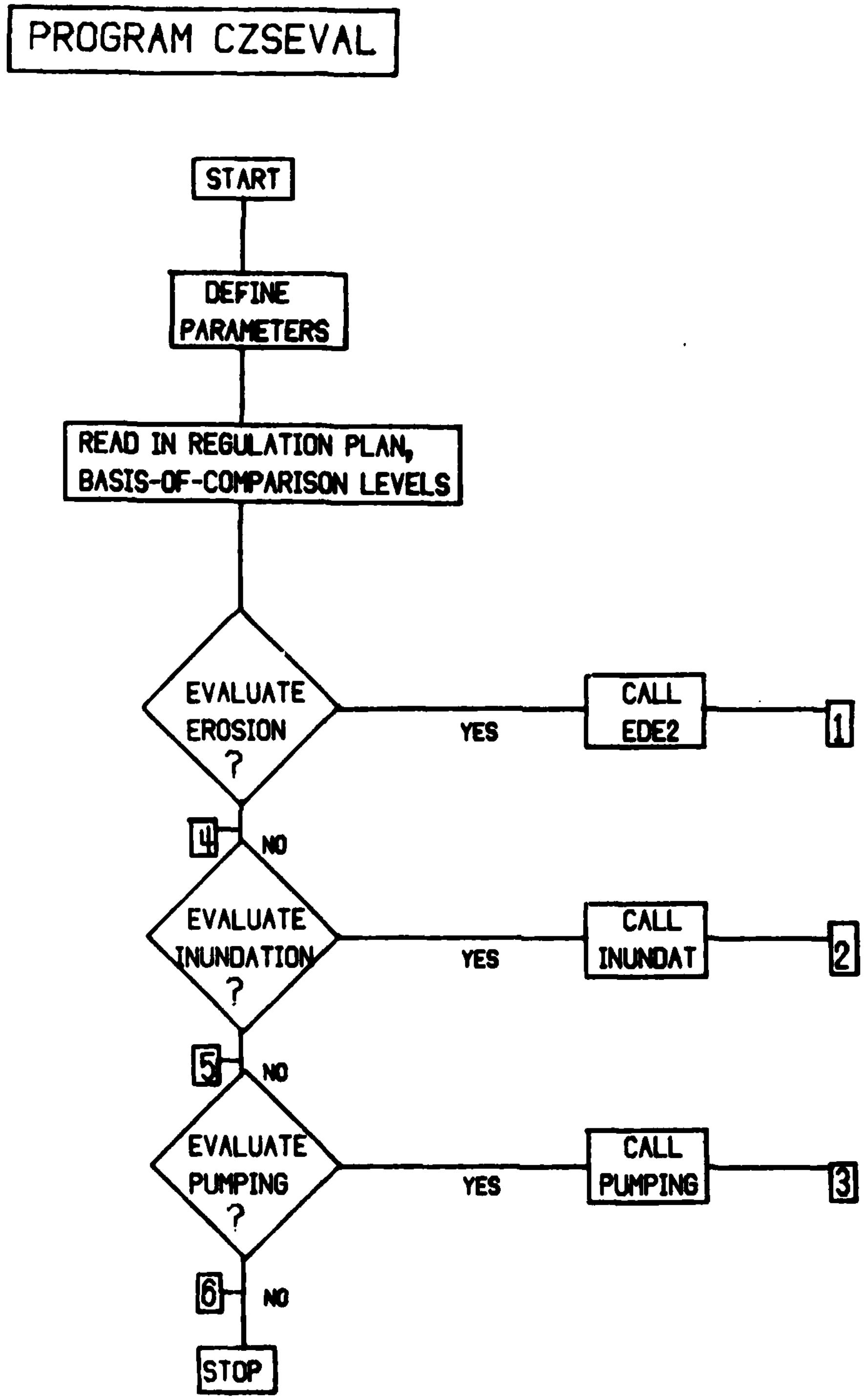
The erosion and inundation evaluations are done on a Reach basis. The total damage for each lake is obtained by adding the damages for the Reaches on that lake. The erosion and inundation evaluations execute until there are no more stage-damage curves to input.

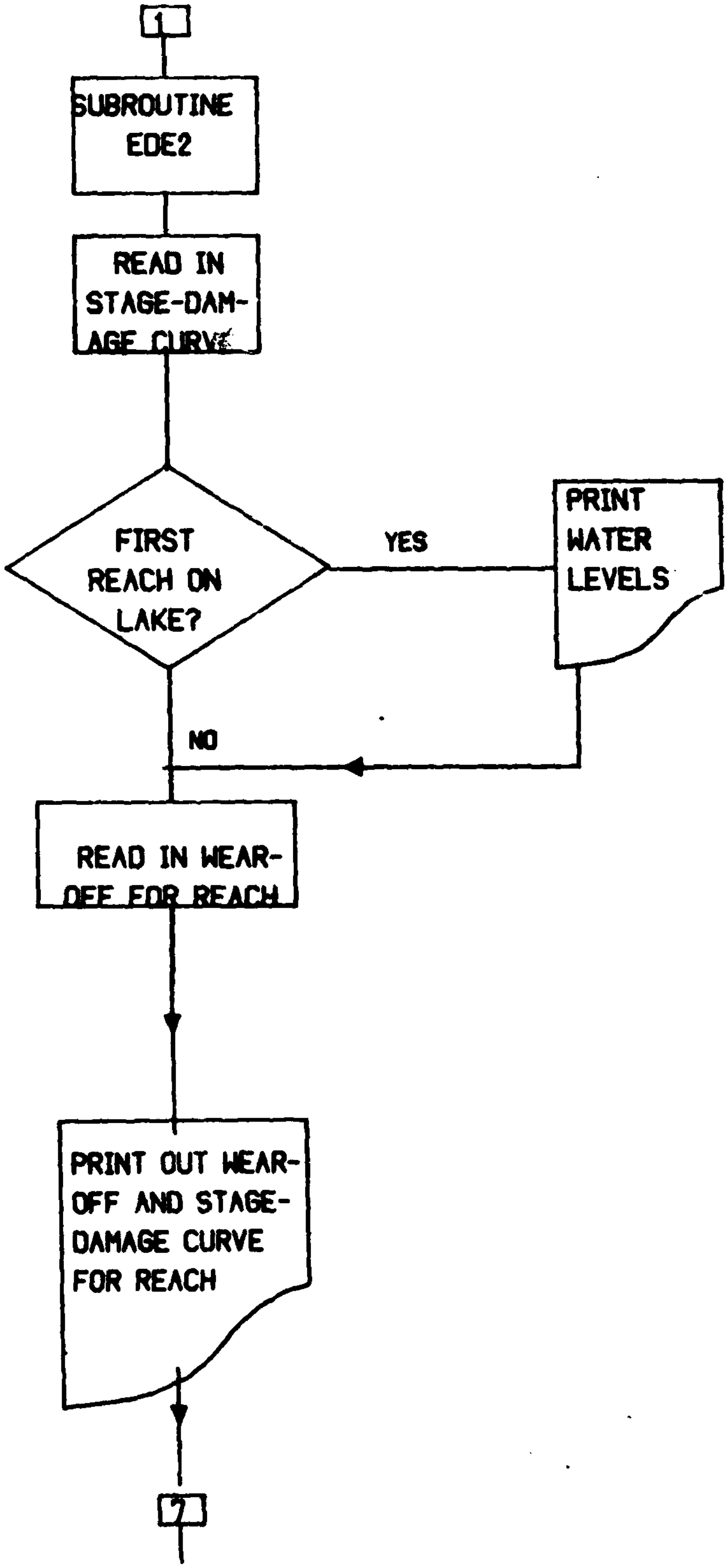
The third, and final, evaluation called by the main program is the effect of the regulation plans on pumping water out of the lakes (Subroutine PUMPING). The subroutine PUMPING calculates the annual mean level for the regulation plan for each year. The annual mean level for the Basis-of-Comparison is also calculated, with the values input from TAPE9.

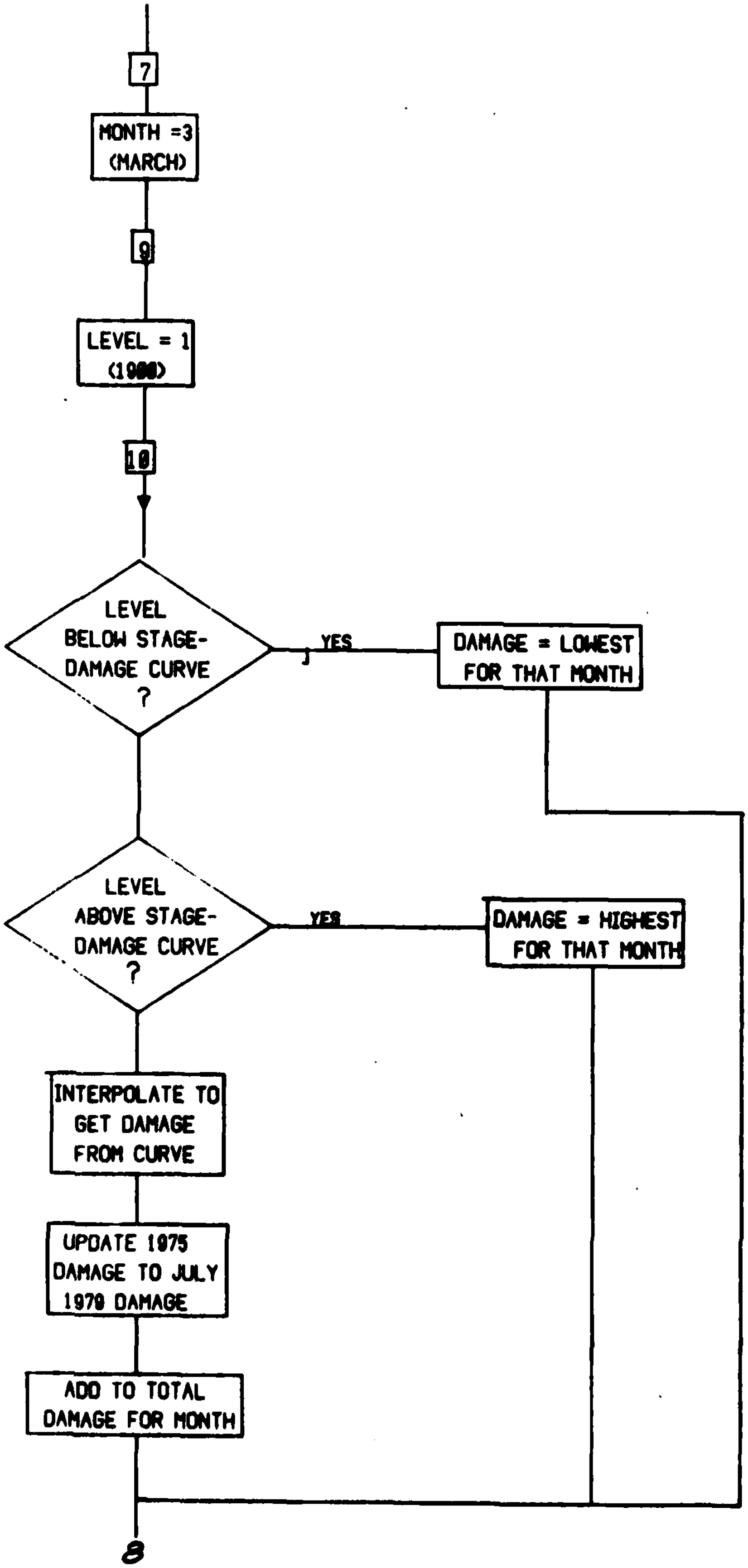
This evaluation requires no additonal data input. The cost of pumping water per foot of lift to a point ten feet above datum is already in the subroutine, as is the amount of water pumped per lake. It was determined in the IGLLB Study that, generally, on the Great Lakes most treatment plants require the water to be pumped about ten feet above Low Water Datum. The subroutine calculates and prints out the cost of pumping the water for the Basis-of-Comparison and the regulation plan for each year of the period-of-record. The total costs and average annual costs are determined and output.

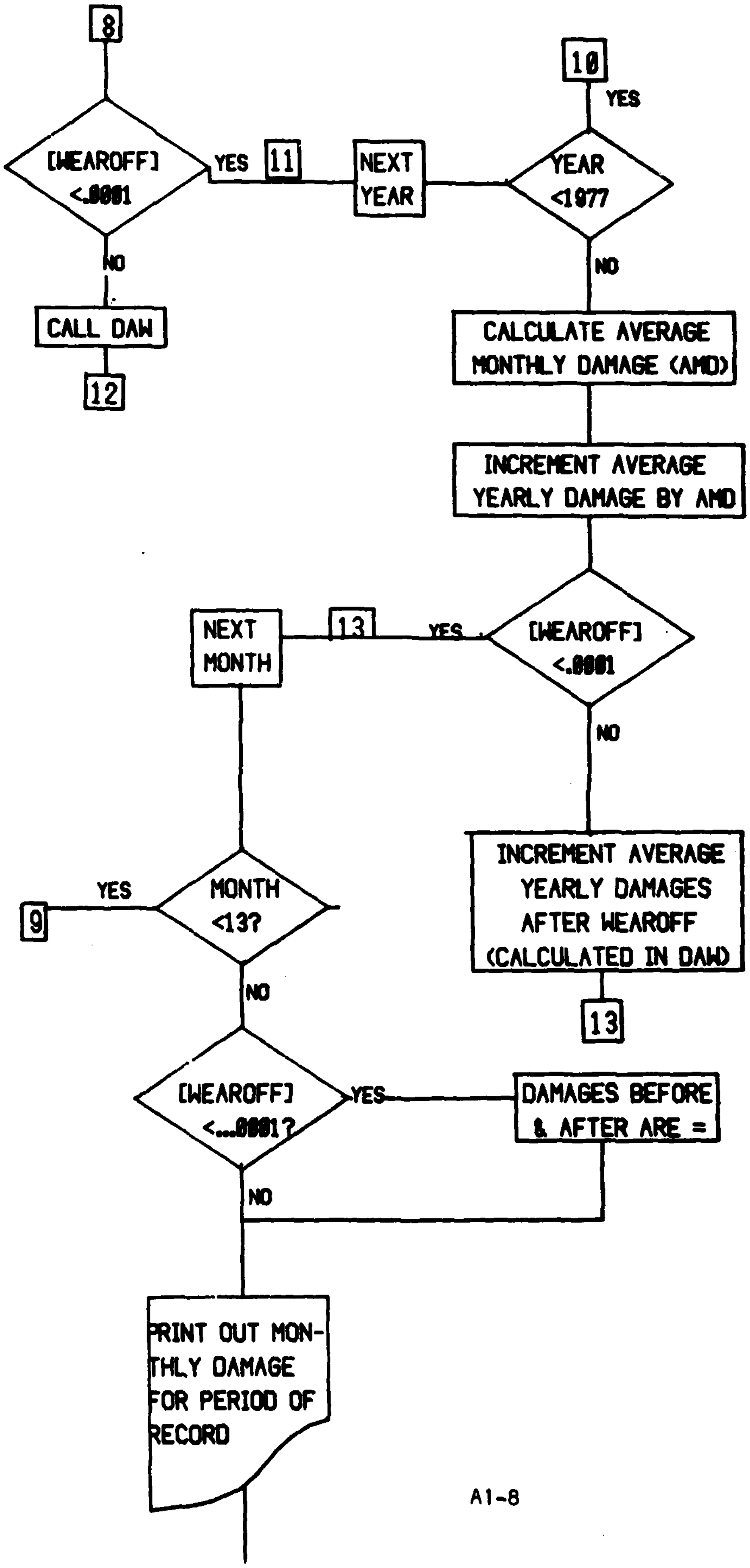
The Canadian Section did not use subroutine PUMPING for the evaluation of regulation plans. Instead, this was performed with the aid of a calculator using the method outlined above.

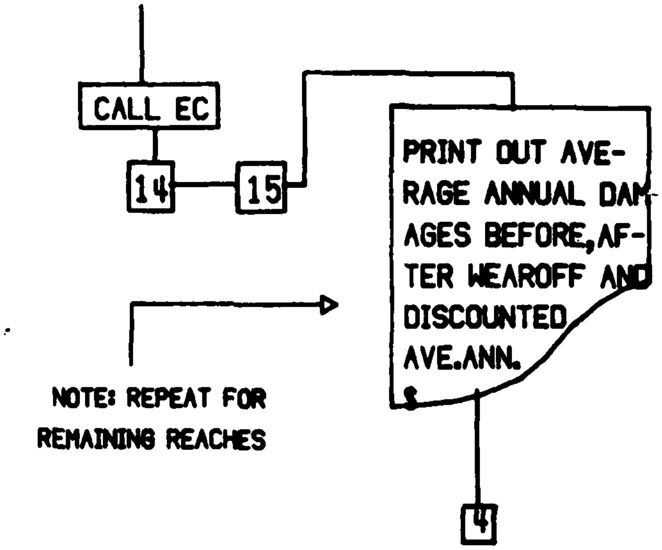
FIGURE A1-1

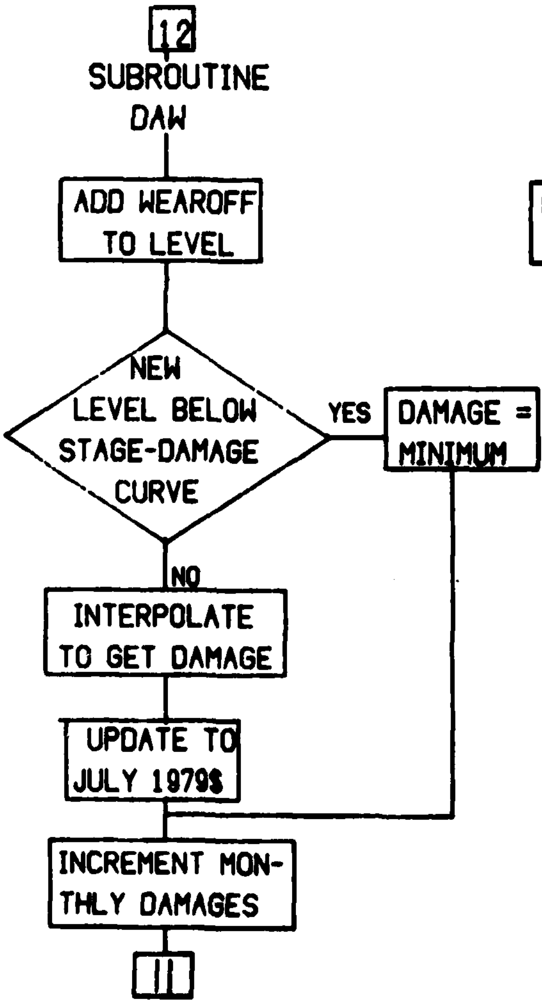

PROGRAM CZSEVAL
START
DEFINE PARAMETERS
READ IN REGULATION PLAN, BASIS-OF-COMPARISON LEVELS
EVALUATE EROSION ?
YES
CALL EDE2
1
4
NO
EVALUATE INUNDATION ?
YES
CALL INUNDAT
2
5
NO
EVALUATE PUMPING ?
YES
CALL PUMPING
3
6
NO
STOP

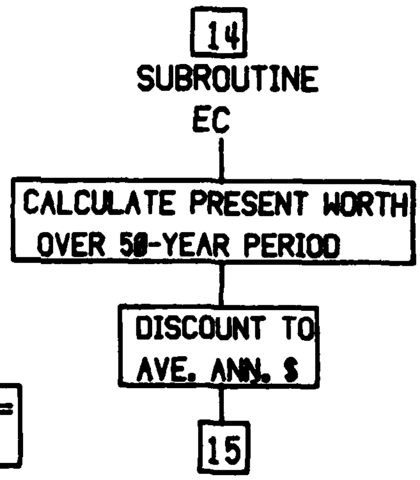

1
SUBROUTINE EDE2
READ IN STAGE-DAMAGE CURVE
FIRST REACH ON LAKE?
YES
PRINT WATER LEVELS
NO
READ IN WEAR-OFF FOR REACH
PRINT OUT WEAR-OFF AND STAGE-DAMAGE CURVE FOR REACH
7

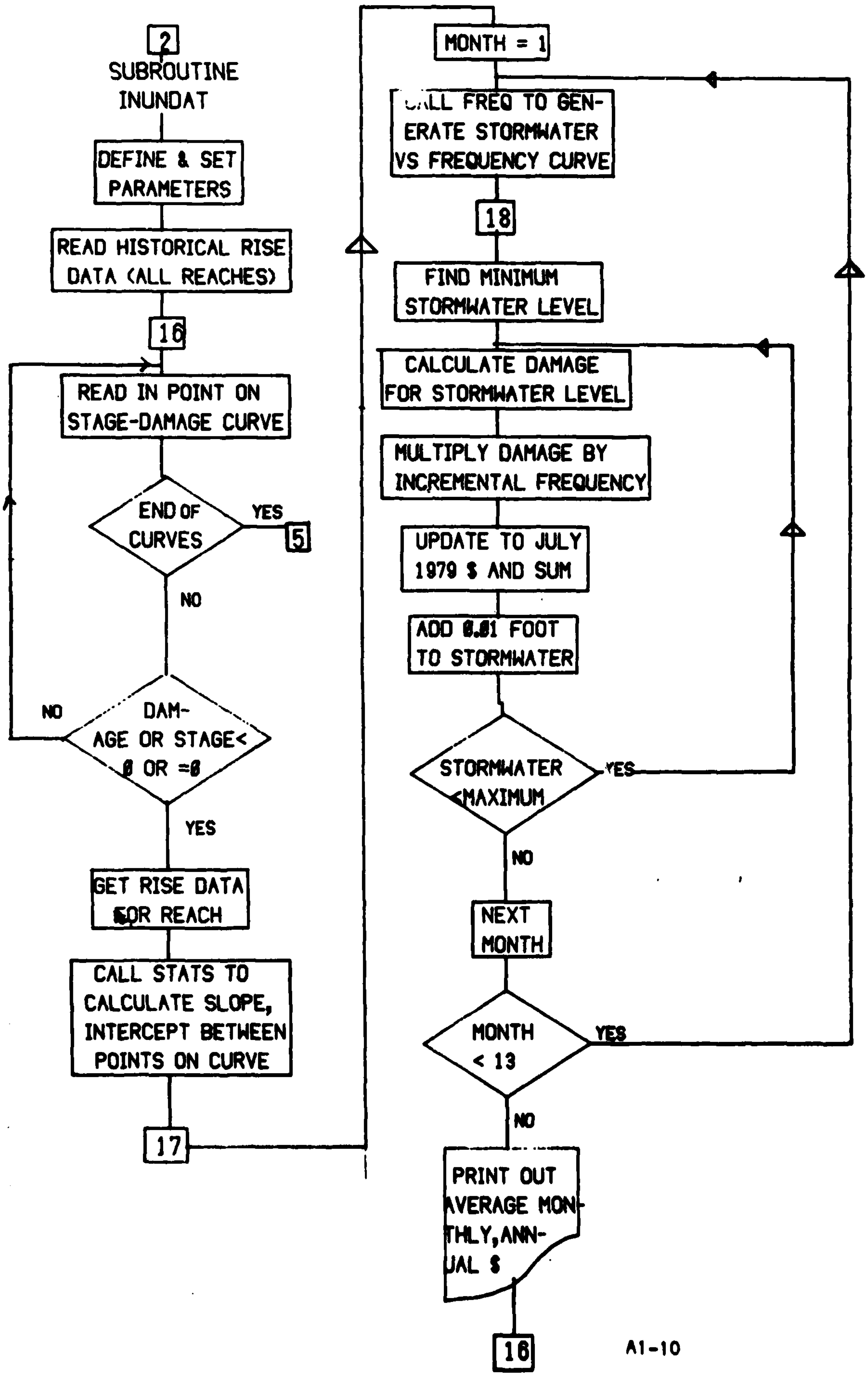

7
MONTH =3 (MARCH)
9
LEVEL = 1 (1900)
10
LEVEL BELOW STAGE-DAMAGE CURVE ?
YES
DAMAGE = LOWEST FOR THAT MONTH
LEVEL ABOVE STAGE-DAMAGE CURVE ?
YES
DAMAGE = HIGHEST FOR THAT MONTH
INTERPOLATE TO GET DAMAGE FROM CURVE
UPDATE 1975 DAMAGE TO JULY 1979 DAMAGE
ADD TO TOTAL DAMAGE FOR MONTH
8


8
[WEAROFF]
<.0001
YES
11
NEXT
YEAR
10
YES
YEAR
<1977
NO
NO
CALL DAW
12
CALCULATE AVERAGE
MONTHLY DAMAGE (AMD)
INCREMENT AVERAGE
YEARLY DAMAGE BY AMD
NEXT
MONTH
13
YES
[WEAROFF]
<.0001
NO
INCREMENT AVERAGE
YEARLY DAMAGES
AFTER WEAROFF
(CALCULATED IN DAW)
13
YES
9
MONTH
<13?
NO
[WEAROFF]
<...0001?
YES
DAMAGES BEFORE
& AFTER ARE =
NO
PRINT OUT MON-
THLY DAMAGE
FOR PERIOD OF
RECORD

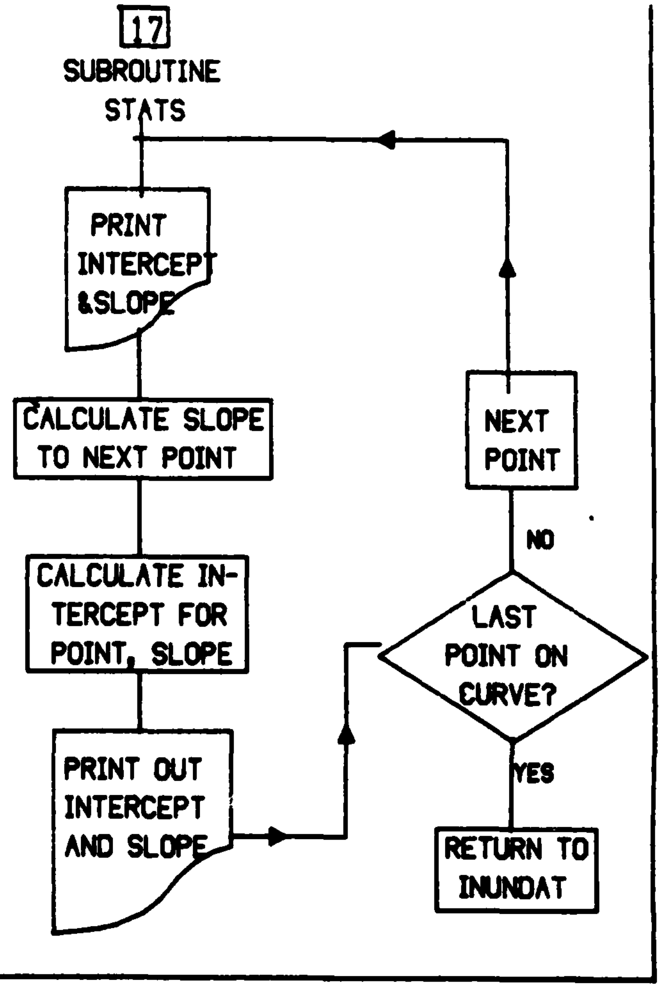

CALL EC
14
15
PRINT OUT AVERAGE ANNUAL DAMAGES BEFORE, AFTER WEAROFF AND DISCOUNTED AVE.ANN. $
NOTE: REPEAT FOR REMAINING REACHES
4


12
SUBROUTINE DAW
ADD WEAROFF TO LEVEL
NEW LEVEL BELOW STAGE-DAMAGE CURVE
YES
DAMAGE = MINIMUM
NO
INTERPOLATE TO GET DAMAGE
UPDATE TO JULY 1979$
INCREMENT MONTHLY DAMAGES
11

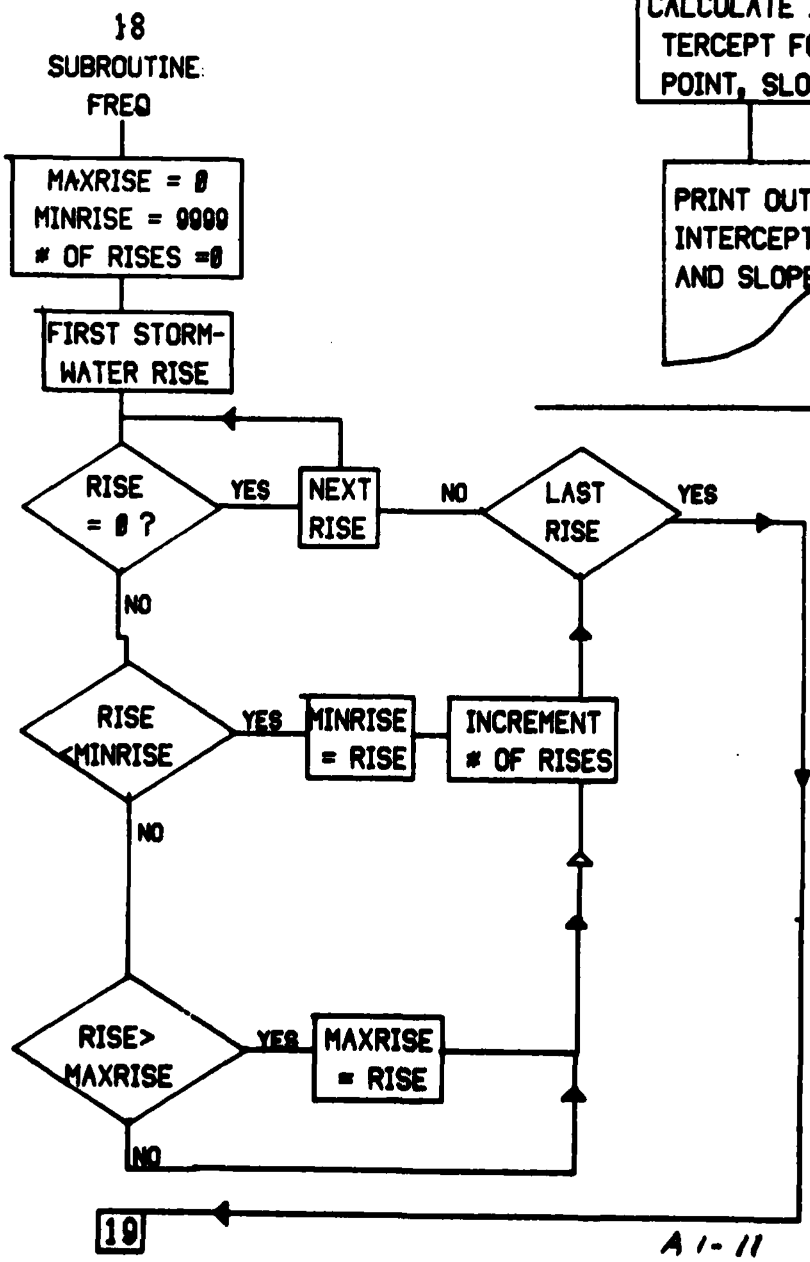

14
SUBROUTINE EC
CALCULATE PRESENT WORTH OVER 50-YEAR PERIOD
DISCOUNT TO AVE. ANN. $
15



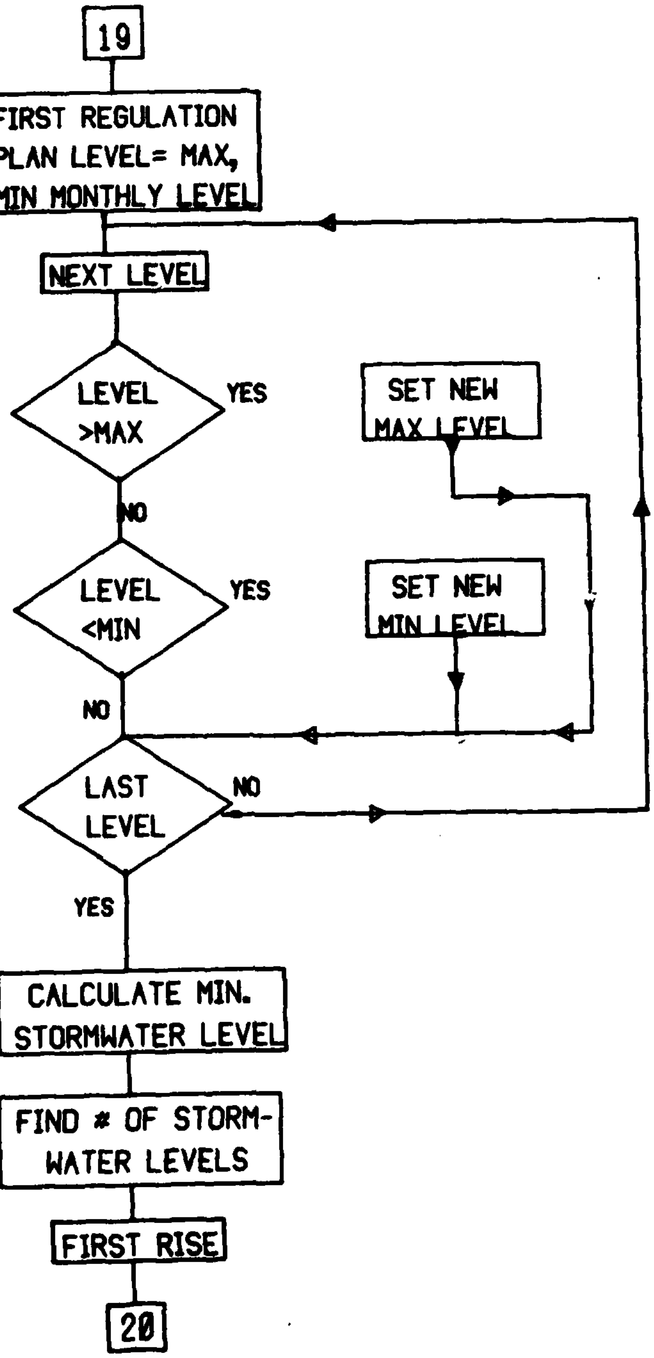
2
SUBROUTINE INUNDAT
DEFINE & SET PARAMETERS
READ HISTORICAL RISE DATA (ALL REACHES)
16
READ IN POINT ON STAGE-DAMAGE CURVE
END OF CURVES
YES
5
NO
DAMAGE OR STAGE< Ø OR =Ø
NO
YES
GET RISE DATA FOR REACH
CALL STATS TO CALCULATE SLOPE, INTERCEPT BETWEEN POINTS ON CURVE
17
MONTH = 1
CALL FREQ TO GENERATE STORMWATER VS FREQUENCY CURVE
18
FIND MINIMUM STORMWATER LEVEL
CALCULATE DAMAGE FOR STORMWATER LEVEL
MULTIPLY DAMAGE BY INCREMENTAL FREQUENCY
UPDATE TO JULY 1979 $ AND SUM
ADD Ø.Ø1 FOOT TO STORMWATER
STORMWATER <MAXIMUM
YES
NO
NEXT MONTH
MONTH < 13
YES
NO
PRINT OUT AVERAGE MONTHLY, ANNUAL $
16

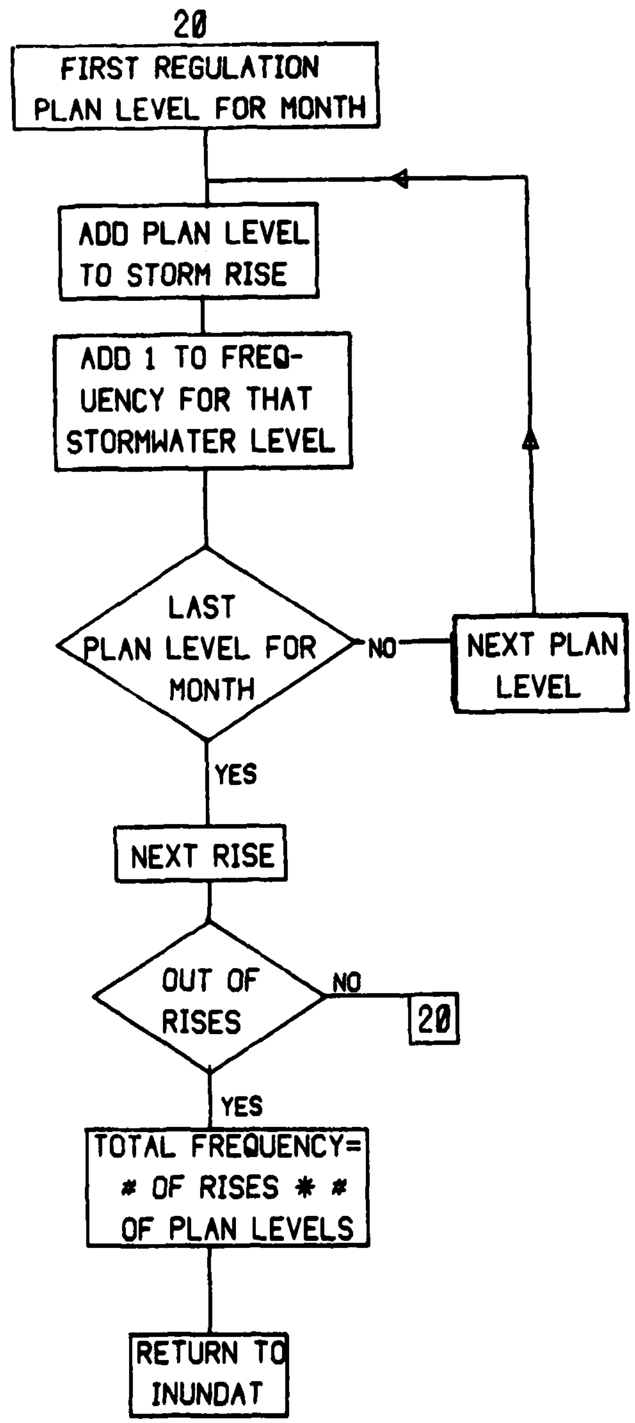


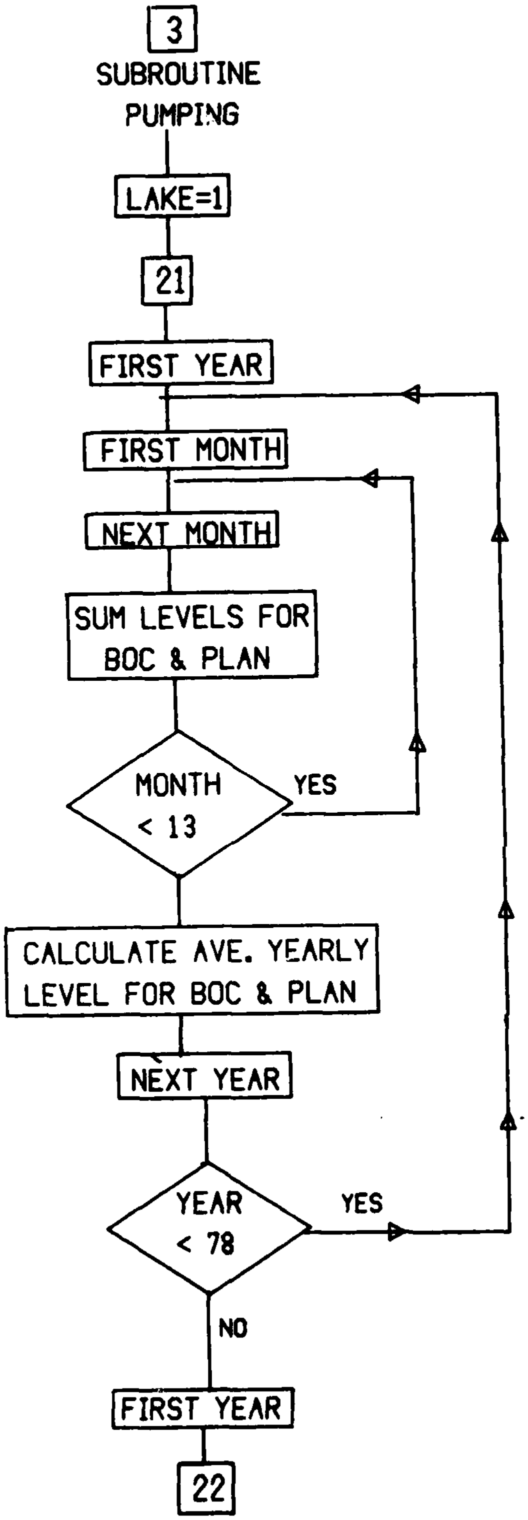
17
SUBROUTINE STATS
PRINT INTERCEPT &SLOPE
CALCULATE SLOPE TO NEXT POINT
CALCULATE INTERCEPT FOR POINT, SLOPE
PRINT OUT INTERCEPT AND SLOPE
LAST POINT ON CURVE?
NO
NEXT POINT
YES
RETURN TO INUNDAT



18
SUBROUTINE FREQ
MAXRISE = 0
MINRISE = 9999
# OF RISES =0
FIRST STORM-WATER RISE
RISE = 0 ?
YES
NEXT RISE
NO
LAST RISE
YES
NO
RISE <MINRISE
YES
MINRISE = RISE
INCREMENT # OF RISES
NO
RISE> MAXRISE
YES
MAXRISE = RISE
NO
19


19
FIRST REGULATION PLAN LEVEL= MAX, MIN MONTHLY LEVEL
NEXT LEVEL
LEVEL >MAX
YES
NO
SET NEW MAX LEVEL
LEVEL <MIN
YES
NO
SET NEW MIN LEVEL
LAST LEVEL
NO
YES
CALCULATE MIN. STORMWATER LEVEL
FIND # OF STORM-WATER LEVELS
FIRST RISE
20


20
FIRST REGULATION PLAN LEVEL FOR MONTH
ADD PLAN LEVEL TO STORM RISE
ADD 1 TO FREQ-UENCY FOR THAT STORMWATER LEVEL
LAST PLAN LEVEL FOR MONTH
NO
NEXT PLAN LEVEL
YES
NEXT RISE
OUT OF RISES
NO
20
YES
TOTAL FREQUENCY= # OF RISES * # OF PLAN LEVELS
RETURN TO INUNDAT


3
SUBROUTINE
PUMPING
LAKE=1
21
FIRST YEAR
FIRST MONTH
NEXT MONTH
SUM LEVELS FOR
BOC & PLAN
MONTH
< 13
YES
CALCULATE AVE. YEARLY
LEVEL FOR BOC & PLAN
NEXT YEAR
YEAR
< 78
YES
NO
FIRST YEAR
22

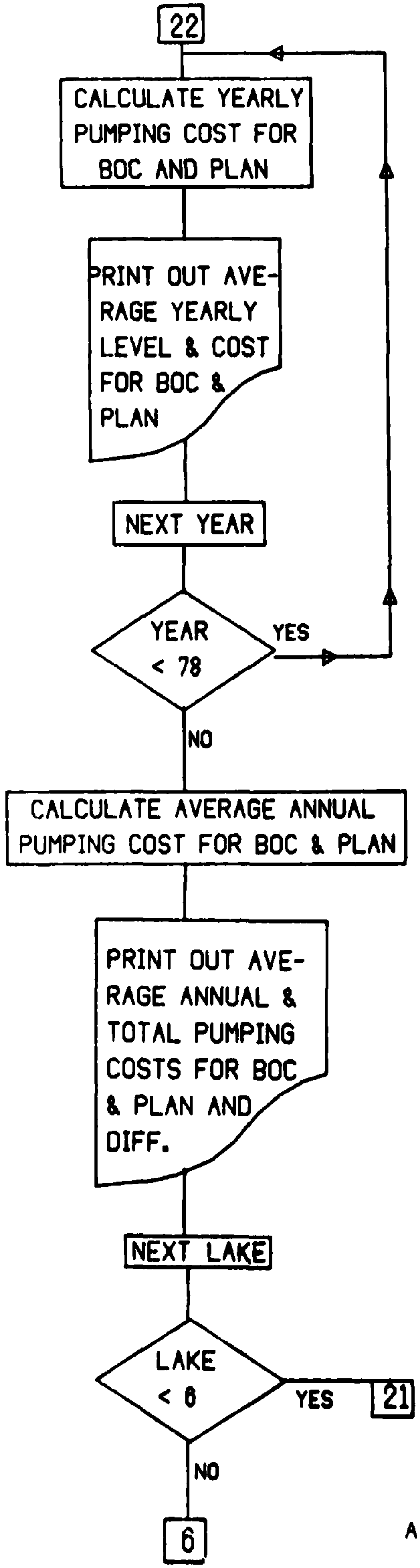

22
CALCULATE YEARLY PUMPING COST FOR BOC AND PLAN
PRINT OUT AVERAGE YEARLY LEVEL & COST FOR BOC & PLAN
NEXT YEAR
YEAR < 78
YES
NO
CALCULATE AVERAGE ANNUAL PUMPING COST FOR BOC & PLAN
PRINT OUT AVERAGE ANNUAL & TOTAL PUMPING COSTS FOR BOC & PLAN AND DIFF.
NEXT LAKE
LAKE < 6
YES
21
NO
6

FIGURE A1-2
PROGRAM LISTING

```
      PROGRAM CZSEVAL(INPUT,OUTPUT,TAPE5=INPUT,
     .            TAPE6=OUTPUT,TAPE7,TAPE8,TAPE9,TAPE10 )
C
C
C        THIS PROGRAM WILL TIE TOGETHER THE VARIOUS EVALUA-
C     TIONS USED IN THE ECONOMIC ANALYSES OF THE COASTAL ZONE
C     SUBCOMMITTEE.  THE ANALYSES ARE:
C        1. INUNDATION - USING FREQUENCY ANALYSIS OF RISE DATA
C        2. EROSION    - USING WAVE ENERGY HIND-CASTING
C        3. WATER  PUMPING
C
C     THE TAPE INPUTS ARE:
C        TAPE5: INPUT OF INUNDATION STAGE-DAMAGE CURVES
C        TAPE6: OUTPUT OF RESULTS
C        TAPE7: INPUT OF EROSION STAGE-DAMAGE CURVES
C        TAPE8: INPUT OF RISE DATA, USED IN EVALUATION 1
C        TAPE9: INPUT BASE CASE LEVELS FOR EVALUATION 3
C        TAPE10: INPUT REGULATION LEVELS FOR EVALUATIONS 1,2&3,
C              AND INPUT OF WEAROFF FOR THE EROSION EVALUATION
C
C
C
C        THE DAMAGES GENERATED WILL BE IN JULY 1979 DOLLARS. FOR
C     THE UNITED STATES SECTION, INUNDATION AND EROSION STAGE-
C     DAMAGE CURVES ARE IN AVERAGE 1975 DOLLARS.  AN ENR INDEX
C     WAS USED TO UPDATE INUNDATION AND EROSION CURVES ---
C       1975 AVERAGE ENR INDEX: 1306.
C       JULY 1979    ENR INDEX: 1826.5
C     FACTOR TO UPDATE TO JULY 1979 = 1826.5/1306. = 1.39855
C
C     PUMPING IS IN AVERAGE 1977 DOLLARS.
C       1977 ENR INDEX    :1515.
C     FACTOR TO UPDATE TO JULY 1979 = 1826.5/1515. = 1.2056
C
C        FOR THE CANADIAN SECTION, INPUT DATA ARE IN JULY
C     1979 DOLLARS AND NO UPDATING WAS NECESSARY.
C
C
      COMMON/A/NCASES
      COMMON/B/REGNAM(8),LEV,ALEV,BPWL(79,12,5),RPWL(79,12,5)
      DIMENSION REGNBAS(8), AFLG(3)
C
C        USE THE ARRAY AFLG ( A FLAG ) TO CALL THE ANALYSES.
C
      DATA AFLG/11.,12.,13./
C
C     READ IN REGULATION PLAN NAME AND LEVELS
C     READ IN BASE CASE NAME AND LEVELS
C
         READ ( 9,1000 ) LEV, (REGNBAS(II),II=1,8)
```

FIGURE A1-2(CONT'D)

```
      READ ( 10,1000 ) LEV,  (REGNAM(I),I=1,8)
 1000 FORMAT ( I2,8A7 )
      LAK = 0
      ALEV = FLOAT(LEV)
  100 LAK = LAK + 1
      IF ( LAK .GT. 5 ) GO TO 140
      DO 120 I = 1,LEV
             READ (  9,1010 ) ( BPWL(I,K,LAK),K=1,12 )
             READ ( 10,1010 ) ( RPWL(I,J,LAK),J=1,12 )
 1010        FORMAT ( 12F6.2 )
  120 CONTINUE
      GO TO 100
  140 CONTINUE
C
C
C        CALL THE EROSION EVALUATION
      IF ( AFLG(1) .GT. 0.0 )   CALL EDE2
C
C
C        CALL THE INUNDATION EVALUATION
      IF ( AFLG(2) .GT. 0.00 )   CALL INUNDAT
C
C
C        CALL THE PUMPING EVALUATION
      IF ( AFLG(3) .GT. 0.00 )  CALL PUMPING
C
C
C
      STOP
      END
      SUBROUTINE PUMPING
C
C     THIS SUBROUTINE CALCULATES THE RELATIVE EFFECT OF THE
C    REGULATION PLANS ON PUMPING WATER OUT OF THE LAKES.  THE
C    PREMISE OF THE EVALUATION IS THAT THE HIGHER THE LAKE
C    LEVELS, THE LESS DISTANCE THAT THE WATER WILL HAVE TO BE
C    PUMPED VERTICALLY TO THE TREATMENT PLANTS.
C
C      THE AMOUNT OF WATER PUMPED OUT OF EACH LAKE IS LISTED
C    IN THE ARRAY PUMP.  THE SUBROUTINE CALCULATES THE AVERAGE
C    ANNUAL LEVEL FOR THE REGULATION PLAN (ARRAY RPWL) AND FOR
C    THE BASE CASE (ARRAY BPWL).  IT THEN CALCULATES THE AVER-
C    AGE COST OF PUMPING THE WATER FOR BOTH THE REGULATION PLAN
C    AND THE BASE CASE. THE EVALUATION THEN OUTPUTS THE YEAR,
C    AVERAGE LEVELS, COSTS AND BENEFITS (DIFFERENCE IN COSTS)
C    EACH YEAR OF THE PLANS.  THE TOTAL COSTS AND PERIOD-OF-
C    RECORD AVERAGES ARE PRINTED OUT AT THE END, ALONG WITH
C    THE AVERAGE DIFFERENCE (BENEFIT OR LOSS).
C
C      THE CANADIAN SECTION OF THE COASTAL ZONE SUBCOMMITTEE
```

```
C     DID NOT USE THIS SUBROUTINE.  INSTEAD, A CALCULATOR WAS
C     USED AND COSTS AND BENEFITS DETERMINED BY HAND.
C
C
        DIMENSION AVER(100,2), DUMMY(100,5)
        COMMON/B/REGNAM(8),LEV,ALEV,BPWL(79,12,5),RPWL(79,12,5)
        DIMENSION PUMP(5,2),ALAKE(5)
        DATA ALAKE/8HONTARIO ,8HERIE    ,8HST CLAIR,8HMICH HUR,
       . 8HSUPERIOR /
        DATA PUMP/150970.,2238590.,0.,2511040.,151555.,
       1242.8,568.6,0.,576.8,600.0/
        DO 111   ILAK=1,5
        WARD1=0.
        WARD2=0.
C
C     CALCULATE YEARLY AVERAGE LEVEL AND PUT IN ARRAY AVER(N,2)
C       AVER(N,1)= BASIS-OF COMPARISON AVERAGE LEVEL FOR YEAR N
C       AVER(N,2) = REGULATION PLAN AVERAGE LEVEL FOR YEAR N
C
        DO 2  I=1,LEV
        SUM=0.
        DO 3  J=1,12
      3 SUM=SUM+ BPWL (I,J,ILAK )
        AVER(I,1)=SUM/12.00
        SUM=0
        DO 4    J=1,12
      4 SUM=SUM+RPWL (I,J,ILAK )
      2 AVER(I,2) = SUM/12.00
        SUMB=0.
        DO 42  I=1,LEV
        A=AVER(I,2)
        B=AVER(I,1)
C
C     CALCULATE PUMPING COST FOR YEAR I TO A DATUM 10 FEET
C     ABOVE LWD.
        C= (PUMP(ILAK,1))*.10*(PUMP(ILAK,2)+10.-B)
        DD=(PUMP(ILAK,1))*.10*(PUMP(ILAK,2)+10.-A)
C
C     ADJUST PUMPING COSTS TO JULY 1979 $.
C
        C = C * 1.20561
        DD=DD * 1.20561
        EE=C-DD
        WARD1=WARD1+C
        WARD2=WARD2+DD
        SUMB=SUMB+EE
        DUMMY(I,1)=A
        DUMMY(I,2)=B
        DUMMY(I,3)=DD
        DUMMY(I,4)=C
```

```
      DUMMY(I,5)=EE
   42 CONTINUE
      SUMB=SUMB/ALEV
      PRINT  900,  REGNAM, ALAKE(ILAK), PUMP(ILAK,2),
     1 PUMP(ILAK,2)+10. ,PUMP(ILAK,1)
  900 FORMAT  (1H1 34X 'COASTAL ZONE SUBCOMMITTEE ' // 32X,
     1 'PUMPING BENEFITS TO WATER INTAKE FACILITIES',//,30X,
     2 8A7,//,43X,'LAKE ',A8,//,43X,'LWD',F10.2,//,'PUMPING',
     3 ' ELEVATION',F10.2,//32X,'WATER PUMPED 1977 CONDI',
     4 'TIONS',F10.2,//, 2('        REGULATED',
     5 '    R/A   REGULATED    R/A    BENEFIT'),
     6 /,2('  YEAR    STAGE     STAGE     COST',
     7 '     COST     DOLLARS'),/ )
      KHALF=LEV/2
      DO 977  I=1,KHALF
      K=1899+KHALF+I
      M=KHALF+I
  977 PRINT 901,I+1899,(DUMMY(I,J),J=1,5),K,(DUMMY(M,L),L=1,5)
  901 FORMAT(2(I6,2F9.3,3F9.0))
      IF(LEV  .EQ. 2*KHALF)  GO TO 904
      M=LEV
      PRINT 902, M+1899,(DUMMY(M,L),L=1,5)
  902 FORMAT(51X,I6,2F9.3,3F9.0)
  904 A=WARD1/ALEV
      B=WARD2/ALEV
      C=SUMB/ALEV
      PRINT 905,WARD1,WARD2,A,B,SUMB
  905 FORMAT(//,21X,'TOTAL COSTS   ',F15.0,' (R/A)',F14.0,
     1 ' (REGL)',/,22X,'AVERAGE ANNUAL',F14.0,' (R/A)',
     2 F14.0,'  (REGL)',F12.0,'  (DIFF JULY 1979 DOLLARS)' )
  111 CONTINUE
      .RETURN
      END
       SUBROUTINE INUNDAT
C
C       THIS SUBROUTINE EVALUATES THE EFFECT OF THE REGULATION
C     PLANS ON INUNDATION.  THE PREMISE OF THE EVALUATION IS
C     THAT THE SHORT-TERM RISES WILL NOT BE AFFECTED BY LAKE
C     REGULATION.  THEN, THE HISTORIC RISES CAN BE USED TO DE-
C     TERMINE STORM-WATER LEVELS FOR EACH REGULATION PLAN.
C     THIS IS ACCOMPLISHED BY ADDING EACH HISTORIC RISE FOR A
C     PARTICULAR MONTH TO THE MONTHLY MEAN LEVELS FOR THE COR-
C     RESPONDING MONTH.  THIS GIVES THE STORM-WATER LEVELS.  FOR
C     20 YEARS OF RISES AND 77 YEARS OF LEVELS, THERE IS A POS-
C     SIBILITY OF 20 TIMES 77, OR 1540, STORMWATER LEVELS.  THIS
C     PROCESS IS DONE IN THE SUBROUTINE FREQ.
C
C       THE STAGE-DAMAGE CURVES ARE READ IN ON TAPES. THE SUB-
C     ROUTINE STATS CALCULATES THE SLOPE BETWEEN THE POINTS ON
```

```
C     THE CURVE AND CALCULATES THE INTERCEPT OF THE LINE BETWEEN
C     EACH PAIR OF ADJACENT POINTS.  THE SUBRINE STATS ALSO OUT-
C     PUTS THE STAGE-DAMAGE CURVES, SLOPES AND INTERCEPTS.
C
C       THE HISTORIC SHORT-TERM RISES ARE READ IN ON TAPE8 AND
C     ARE USED IN SUBROUTINE FREQ.  ONCE THE STORMWATER LEVELS
C     ARE DETERMINED, THE NUMBER OF OCCURENCES OF EACH STORMWA-
C     TER LEVEL ARE COUNTED AND THE FREQUENCY OF THAT LEVEL DE-
C     TERMINED BY DIVIDING THE OCCURENCES BY THE TOTAL NUMBER OF
C     STORMWATER LEVELS.
C
C       THE DAMAGES ARE DETERMINED BY FINDING THE DAMAGES ASSO-
C     CIATED WITH EACH STORMWATER LEVEL, USING THE STAGE-DAMAGE
C     CURVE.  THE DAMAGE FOR THAT STORMWATER LEVEL IS MULTIPLIED
C     BY THE FREQUENCY ASSOCIATED WITH THAT LEVEL.  THIS IS DONE
C     FOR EACH STORMWATER LEVEL AND SUMMED.  THE PROCESS IS RE-
C     PEATED FOR EACH MONTH.  FOR THE UNITED STATES EVALUATIONS,
C     THE TOTAL DAMAGES FOR EACH MONTH ARE MULTIPLIED BY ABOUT
C     1.4 TO UPDATE THE DOLLAR VALUE FROM 1975 TO JULY 1979.
C
C
      COMMON/A/NCASES
      COMMON/B/REGNAM(8),LEV,ALEV,BPWL(79,12,5),RPWL(79,12,5)
      PARAMETER NOYRST=79,NOYRRS=20,NOCOUR=5000,IASIZE=20
      DIMENSION ISTAGE(NOYRST,12,5), IRISE(NOYRRS,12),
     1 VALUE(12),  NRISE(12), IFREQ(NOCOUR), AYINT(50),
     2 ASUMPR(12),  MTHNAM(12), ASTAGE(50), ADAMAGE(50),
     3 ASLOPE(50)
      INTEGER COUNT(16), HSTRIS(16,20,12), RCHLAK(38),
     1 RCHGAG(38)
      DATA RCHLAK /5*1,4*2,2*3,19*4,8*5/
      DATA MTHNAM / 10H   JANUARY, 10H  FEBRUARY,
     1   10H     MARCH, 10H     APRIL, 10H       MAY,
     2   10H      JUNE, 10H      JULY, 10H    AUGUST,
     3   10H SEPTEMBER, 10H   OCTOBER, 10H  NOVEMBER,
     4   10H  DECEMBER /
      DATA RCHGAG /2,2,1,1,1,5,5,4,3,6,6,9,9,7,8,8,7,9,13,12,
     . 12,11,11,10,10,9,13,13,13,13,16,15,14,14,14,14,14,14/
      REWIND 8
      READ (8) COUNT
      READ (8) HSTRIS
      DO 100 I = 1,5
      DO 100  J = 1,LEV
                 DO 90 K = 1,12
   90            ISTAGE ( J,K,I ) = 100. * RPWL(J,K,I) + 0.5
  100 CONTINUE
11000 READ ( 5,5050, END=9999 ) NREACH,NMRCH
 5050 FORMAT ( I2,7X,A4 )
      WRITE ( 6,6000 )
 6000 FORMAT (1H1,48X,'***** INPUT DATA *****',// )
```

FIGURE A1-2(CONT'D)

```
      WRITE ( 6,6010 ) NMRCH
 6010 FORMAT ( 55X, 'REACH', X ,A4, // )
      WRITE ( 6,6020 )
 6020 FORMAT(32X,'STAGE',13X,'DAMAGE',11X,'SLOPE',11X,
     . 'Y-INT',//)
      NCASES = 0
  777 READ ( 5,5020 ) S,D
 5020 FORMAT ( F6.2,F10.2 )
      IF (S .LE. 0. .OR.  D .LE. 0. ) GO TO 203
      NCASES = NCASES + 1
      ASTAGE ( NCASES ) = S
      ADAMAGE (NCASES ) = D
      GO TO 777
  203 NGUAGE = RCHGAG ( NREACH )
      ILAKE = RCHLAK ( NREACH )
      KOUNT = COUNT ( NGUAGE )
      DO 150 J = 1,12
              NRISE (J) = KOUNT
              DO 150 I = 1,KOUNT
  150 IRISE ( I,J ) = HSTRIS ( NGUAGE, I, J )
      CALL STATS ( ASTAGE,ADAMAGE, ASLOPE, AYINT )
      INDX = 0
      TOTPR = 0.00
      DO 500 IMONTH = 1,12
              INDX = INDX + 1
      CALL FREQ (ISTAGE(1,IMONTH,ILAKE), LEV, IRISE(1,IMONTH),
     . NRISE(IMONTH),IFREQ(1),NFREQ,KSTAGE,FRQ )
              STAGE = .01*FLOAT(KSTAGE)
              SUMFR = 0.0
              SUMPR = 0.0
              ICNT  = 0
          DO 300 I = 1,NFREQ
                 IF ( IFREQ(I) .EQ. 0) GO TO 300
                 ICNT = ICNT + 1
                 FR = FRQ*FLOAT(IFREQ(I))
                 SUMFR = SUMFR + FR
                 IF ( STAGE .LE. ASTAGE(1) )   M = 2
                 IF ( STAGE .LE. ASTAGE(1) )   GO TO 95
             DO 80 M = 2, NCASES
               IF(STAGE.GT.ASTAGE(M-1).AND.STAGE.LE.ASTAGE(M))
     .         GO TO 95
   80        CONTINUE
                 M = NCASES
   95            DAMAGE=(STAGE-AYINT(M))/ASLOPE(M)
                 IF ( DAMAGE .LT. 0. ) DAMAGE = 0.
                 PRODUCT = DAMAGE*FR
               PRODUCT = PRODUCT * 1.39855
                 SUMPR = SUMPR + PRODUCT
  300     STAGE = STAGE + 0.01
              ASUMPR (IMONTH) = SUMPR
```

```
           TOTPR = TOTPR + SUMPR
  500 CONTINUE
      WRITE ( 6,6616 )   REGNAM, NMRCH
 6616 FORMAT ( 12X,8A7,12X,A5 )
      DO 666 JJ = 1,12
           WRITE ( 6,6860 ) MTHNAM(JJ), ASUMPR(JJ)
 6860      FORMAT ( 47X, A10, 2X, F10.0 )
  666 CONTINUE
      WRITE ( 6,6865 ) TOTPR
 6865 FORMAT ( /, 36X, 'AVERAGE ANNUAL DAMAGE = ', F10.0 ,
     . ' JULY 1979 DOLLARS ' )
      GO TO 11000
 9999 RETURN
      END
      SUBROUTINE FREQ(ISTAGE, LEV, IRISE, NRISE, IFREQ, NFREQ,
     .  KSTAGE, FRQ)
C
C     THIS SUBROUTINE CALCULATES STORMWATER LEVELS AND THEIR
C   FREQUENCIES.  THE HISTORIC RISES WERE READ IN FROM TAPE8
C   AND ARE IN THE ARRAY IRISE.  THE CALCULATED STORMWATER
C   FREQUENCIES ARE IN THE ARRAY IFREQ.
      DIMENSION ISTAGE(1), IRISE(1), IFREQ(1)
      MAXRISE = 0
      MINRISE = 99999
      J = 0
      DO 10 I = 1,NRISE
           IF ( IRISE(I) .EQ. 0)              GO TO 10
           IF ( IRISE(I) .LT. MINRISE ) MINRISE = IRISE(I)
           IF ( IRISE(I) .GT. MAXRISE ) MAXRISE = IRISE(I)
           J = J + 1
           IRISE(J) = IRISE(I)
   10 CONTINUE
      NRISE = J
      MAXSTG = ISTAGE(1)
      MINSTG = ISTAGE(1)
      DO 20 I = 2,LEV
           IF ( ISTAGE(I) - MAXSTG )  15,20,12
   12      MAXSTG = ISTAGE(I)
           GO TO 20
   15      IF ( ISTAGE(I) - MINSTG ) 17,20,20
   17      MINSTG = ISTAGE(I)
   20 CONTINUE
      KSTAGE = MINSTG + MINRISE
      NFREQ = MAXSTG + MAXRISE - KSTAGE + 1
      DO 30 I = 1,NFREQ
   30 IFREQ(I) = 0
      DO 50 I = 1,NRISE
           IBASE = IRISE(I) - KSTAGE + 1
        DO 40 J = 1,LEV
             ISUB = IBASE + ISTAGE(J)
```

```
   40  IFREQ(ISUB) = IFREQ(ISUB) + 1
   50 CONTINUE
      FRQ = 1.00/FLOAT(NRISE*LEV)
      RETURN
      END
      SUBROUTINE STATS (ASTAGE, ADAMAGE, ASLOPE, AYINT )
C
C     THIS SUBROUTINE CALCULATES THE SLOPES AND INTERCEPTS
C   BETWEEN EACH PAIR OF ADJACENT POINTS ON THE INUNDATION
C   STAGE-DAMAGE CURVE.  IT ALSO OUTPUTS THE STAGE-DAMAGE
C   CURVES, SLOPES AND INTERCEPTS.
C
      DIMENSION ASTAGE(20),ADAMAGE(20),ASLOPE(20),AYINT(20)
      COMMON/A/ NCASES
      ICNT = 1
      WRITE ( 6,6020 ) ICNT,  ASTAGE (ICNT),  ADAMAGE (ICNT)
 6020 FORMAT ( 22X, I5, 5X, F6.2, 6X, F12.2 )
      DO 100 ICNT = 2,NCASES
         ASLOPE(ICNT) = ( ASTAGE(ICNT) - ASTAGE(ICNT-1) ) /
     .                  ( ADAMAGE(ICNT) - ADAMAGE(ICNT-1) )
         AYINT(ICNT) =ASTAGE(ICNT)-ASLOPE(ICNT)*ADAMAGE(ICNT)
         WRITE ( 6,6111 )  ASLOPE (ICNT),   AYINT (ICNT)
 6111    FORMAT ( 62X, F10.8, 10X, F6.2 )
         WRITE ( 6,6020 ) ICNT, ASTAGE (ICNT), ADAMAGE (ICNT)
  100 CONTINUE
      RETURN
      END
      SUBROUTINE EDE2
C
C     THIS SUBROUTINE CALCULATES THE EFFECT OF THE REGULATION
C   PLANS ON EROSION.  THE STAGE-DAMAGE CURVES WERE DERIVED
C   FROM MONTHLY TOE-OF-BLUFF WAVE ENERGY CALCULATIONS, SUP-
C   PLIED BY GROUP 5, CANADA.  EROSION IS ASSUMED TO OCCUR IN
C   THE MONTHS OF MARCH TO DECEMBER.  JANUARY AND FEBRUARY ARE
C   ASSUMED TO BE ICE COVERED AND NOT SUBJECT TO EROSION.
C
C     THE STAGE-DAMAGE CURVES ARE READ IN FROM TAPE7 AND ARE
C   IN THE ARRAY DAML.  THE ARRAYS USED IN THE EVALUATION ARE:
C   DAML  :  STAGE-DAMAGE CURVES
C   DAMX  :  MONTHLY DAMAGES FOR PERIOD-OF-RECORD
C   ADAM  :  AVERAGE MONTHLY DAMAGE FOR A MONTH FOR PERIOD-OF-
C            RECORD
C   DAMM  :  TOTAL DAMAGES BY MONTH FOR PERIOD-OF-RECORD
C   ADAW  :  SAME AS ADAM EXCEPT LEVELS ADJUSTED BY WEAROFF
C   DAMW  :  SAME AS DAMM EXCEPT LEVELS ADJUSTED BY WEAROFF
C    SUM  :  TOTAL DAMAGES FOR A YEAR ( BEFORE WEAROFF )
C
C     WEAROFF IS DEFINED AS THE DIFFERENCE IN LONG-TERM LAKE
C   LEVEL AVERAGE BETWEEN THE REGULATION PLAN AND THE BASE
C   CASE.  IT IS READ IN FROM TAPE10 IN THIS SUBROUTINE.  THE
```

```
C     STAGE-DAMAGE CURVES, MONTHLY MEAN LEVELS, MONTHLY DAMAGES,
C     AVERAGE MONTHLY DAMAGES, TOTAL DAMAGES PER YEAR, AVERAGE
C     ANNUAL DAMAGES BEFORE AND AFTER WEAROFF AND THE DISCOUNTED
C     AVERAGE ANNUAL DAMAGES ARE PRINTED OUT.
C
C
      COMMON/B/REGNAM(8),LEV,ALEV,BPWL(79,12,5),RPWL(79,12,5)
      DIMENSION DAML(19,11) ,DAMM(10),DAMW(10), DAMX(79,10)
      DIMENSION ADAM(10),LAKE(2), ADAW(10), K(79), SUM(79)
      WRITE (6,602)
  602 FORMAT (1H1,//,40X,'REGULATION PLAN MONTHLY MEAN WATER',
     . ' LEVELS' )
      WRITE (6,612) (REGNAM(IK),IK=1,8)
  612 FORMAT (//,33X,16HREGULATION PLAN ,8A7)
 10     READ ( 7,581,END = 1999 ) IRENO,NL, LN
  581 FORMAT ( I5,I3,I3 )
      IF ( IRENO .EQ. 2001 ) GO TO 833
      IF ( IRENO .EQ. 3001 ) GO TO 833
      IF ( IRENO .EQ. 4001 ) GO TO 833
      IF ( IRENO .EQ. 5001 ) GO TO 833
      IF ( IRENO .EQ. 7001 ) GO TO 833
      IF ( IRENO .EQ. 9001 ) GO TO 833
      GO TO 832
  833 DO 830 IS = 1,LEV
        WRITE (6,829) (RPWL(IS,I,LN),I=3,12)
  829   FORMAT (X,10(4X,F6.2))
  830 CONTINUE
  832 CONTINUE
      TDAM = 0.00
      TDAW = 0.00
      READ(10,1081) WEAR
 1081 FORMAT( F6.3)
      WRITE ( 6,604 ) WEAR
  604 FORMAT ( //,50X,10HWEAR-OFF= ,F6.3 )
      WRITE (6,605) IRENO
  605 FORMAT (////,43X,28HSTAGE-DAMAGE CURVE FOR REACH  ,I5)
      WRITE (6,606)
  606 FORMAT (//2X,5HSTAGE,55X,6HDAMAGE )
      WRITE (6,678)
  678 FORMAT (/,X,120(1H*))
      WRITE (6,607)
  607 FORMAT (/,16X,5HMARCH,6X,5HAPRIL,7X,3HMAY,8X,4HJUNE,7X,
     . 4HJULY, 5X,6HAUGUST,2X,9HSEPTEMBER,4X,7HOCTOBER,3X,
     . 8HNOVEMBER,3X, 8HDECEMBER )
      WRITE (6,678)
      DO 100 IA=1,NL
      READ(7,551) DAML(IA,1)
  551 FORMAT(X,F6.2)
  509 FORMAT( 10(F8.0))
      READ(7,509) (DAML(IA,ID),ID=2,11)
```

FIGURE A1-2(CONT'D)

```
      WRITE(6,609) (DAML(IA,IL),IL=1,11)
  609 FORMAT (/,2X,F6.2,2X,10(2X,F9.0))
  100 CONTINUE
      DO 200 JX=3,12
      JA = JX - 2
      DAMW(JA)=0.0
      DAMM(JA) = 0.000
      DO 210 JB=1,LEV
      IF(RPWL(JB,JX,LN).LE.DAML(1,1))DAMX(JB,JA)=DAML(1,JA+1)
      IF(RPWL(JB,JX,LN) .LE. DAML(1,1) ) GO TO 209
      DWAT=RPWL(JB,JX,LN)*2.0
      IWAT=DWAT
      XWAT=FLOAT(IWAT)/2.0
      NWAT = (XWAT-DAML(1,1)) * 2.00 + 1
      XINT=(RPWL(JB,JX,LN)-XWAT)*2.0
      DAMX(JB,JA) =DAML(NWAT,JA+1)+(DAML(NWAT+1,JA+1)-
     .   DAML(NWAT,JA+1))  *XINT
C
C
C   UPDATE TO JULY 1979 DOLLARS---
C
C  AVERAGE 1975 ENR INDEX FOR PRESENT DAMAGES:  1306.
C   JULY 1979 ENR INDEX FOR UPDATE OF DAMAGES: 1826.5
C      FACTOR TO UPDATE = 1826.5/1306. = 1.39855
C
      DAMX(JB,JA) = DAMX(JB,JA)* 1.39855
  209 DAMM(JA) = DAMM(JA) + DAMX(JB,JA)
      IF (ABS(WEAR).LT.0.0001) GO TO 210
      CALL DAW(RPWL,WEAR,DAML,JA,JB,DAMW,LN)
  210 CONTINUE
      ADAM(JA)=DAMM(JA)/ALEV
      TDAM=TDAM+ ADAM(JA)
      IF(ABS(WEAR).LT.0.0001) GO TO 200
      CALL AMD(JA,DAMW,ADAW,TDAW)
  200 CONTINUE
      DO 267 JA=1,LEV
      SUM(JA) = 0.00
      DO 276 JB = 1,10
      SUM(JA) = SUM(JA) + DAMX(JA,JB)
  276 CONTINUE
  267 CONTINUE
      L=0
      K(1) = 1900
      DO 906 I=2,LEV
      L=L+1
      K(I) = K(1) + L
  906 CONTINUE
      WRITE(6,678)
      WRITE(6,654)
  654 FORMAT(X,1H*,110X,9HYEARLY  * )
```

```
      WRITE(6,690)
  690 FORMAT (//,X,6H* YEAR,7X,5HMARCH,5X,5HAPRIL,6X,3HMAY,7X,
     . 4HJUNE,6X,4HJULY,4X,6HAUGUST,3X,7HSEPTEMB,3X,7HOCTOBER,
     . 3X,7HNOVEMBR,2X,8HDECEMBER,4X,7HTOTAL * ,/)
      WRITE (6,678)
      WRITE(6,1002)
      DO 808 I=1,LEV
      WRITE(6,615) K(I), (DAMX(I,JA), JA=1,10), SUM(I)
  615 FORMAT (X,1H*,I5,1X,10(F8.0,2X),X,F8.0,X,2H *)
  808 CONTINUE
      WRITE(6,1002)
      WRITE(6,1002)
      WRITE(6,910)(ADAM(I),I=1,10),TDAM
 1002 FORMAT(X,1H*,118X,1H* )
      WRITE(6,1002)
  910 FORMAT(X,1H*,3X,3HAVE ,10(F8.0,2X),XX,F8.0,X,2H *)
      WRITE(6,1002)
      IF(ABS(WEAR).LT.0.00010) TDAW=TDAM
      WRITE(6,710)TDAM,TDAW
  710 FORMAT(X,'*',10X,'AVE. ANNUAL DAMAGE BEFORE WEAROFF= ',
     . F12.0,' JULY 1979 DOLLARS',/,X,'*',10X,'AVE. ANNUAL',
     . ' DAMAGE AFTER WEAROFF= ',F12.0, 'JULY 1979 DOLLARS' )
      CALL EC(TDAM,TDAW,SPW,AAV)
      WRITE(6,1002)
      WRITE(6,5000)SPW
      WRITE(6,1002)
5000  FORMAT(X,1H*,10X,'PRESENT VALUE OF DAMAGE FOR 50 YEAR',
     .  ' PERIOD= ', F11.0)
      WRITE (6,613) AAV
  613 FORMAT(/,1H*,9X,'AVERAGE ANNUAL DAMAGE FOR THE 50-YEAR',
     . ' PERIOD=' , F12.0,' JULY 1979 DOLLARS' )
      WRITE(6,1000)
      WRITE(6,678)
1000  FORMAT(1H1)
      GO TO 10
 1999 RETURN
      END
      SUBROUTINE DAW(RPWL,WEAR,DAML,JA,JB,DAMW,LN)
C
C     THIS SUBROUTINE CALCULATES THE MONTHLY DAMAGES AFTER
C   THE MEAN LEVELS ARE ADJUSTED BY THE WEAROFF.
C
      DIMENSION RPWL(79,12,5), DAML(19,11), DAMW(10)
      JX = JA + 2
      THRESH = RPWL(JB,JX,LN) + WEAR
      IF ( THRESH .LE. DAML(1,1) ) DAMX = DAML(1,JA+1)
      IF ( THRESH .LE. DAML(1,1) ) GO TO 987
      DWAT= (RPWL(JB,JX,LN)+WEAR) * 2.0
      IWAT = DWAT
      XWAT = FLOAT(IWAT)/2.00
```

FIGURE A1-2(CONT'D)

```
      NWAT = (XWAT-DAML(1,1)) * 2.00 + 1.00
      XINT = (RPWL(JB,JX,LN)+WEAR-XWAT) * 2.00
      DAMX=DAML(NWAT,JA+1)+(DAML(NWAT+1,JA+1)-DAML(NWAT,JA+1))
     .  *XINT
C
C
C       UPDATE THE DOLLARS TO JULY 1979---
C    AVE. 1975 ENR INDEX FOR PRESENT DAMAGES: 1306.
C    JULY 1979 ENR INDEX FOR UPDATE OF DAMAGE:1826.5
C    FACTOR TO UPDATE=1826.5/1306. = 1.39855
      DAMX = DAMX * 1.39855
  987 DAMW(JA) = DAMW(JA)+ DAMX
      RETURN
      END
      SUBROUTINE AMD(JA,DAMW,ADAW,TDAW)
C
C     THIS SUBROUTINE TAKES THE TOTAL DAMAGES FOR A MONTH
C    ( AFTER WEAROFF ) AND CALCULATES THE AVERAGE MONTHLY DAM-
C    AGES.  IT ALSO CALCULATES THE AVERAGE ANNUAL DAMAGES AFTER
C    WEAROFF.
C
      COMMON/B/REGNAM(8),LEV,ALEV,BPWL(79,12,5),RPWL(79,12,5)
      DIMENSION DAMW(10), ADAW(10)
C
      ADAW(JA) = DAMW(JA)/ALEV
      TDAW = TDAW+ ADAW(JA)
      RETURN
      END
      SUBROUTINE EC(TDAM,TDAW,SPW,AAV)
C
C
C     THIS SUBROUTINE TAKES THE AVERAGE ANNUAL DAMAGES BEFORE
C    AND AFTER WEAROFF AND CALCULATES AN AVERAGE ANNUAL DAMAGE
C    FROM THE TWO.  THE DIFFERENCE BETWEEN THE TWO DAMAGES IN-
C    PUT ARE AMORTIZED OVER A PERIOD OF 50 YEARS AT AN INTEREST
C    RATE OF 8.5%.  THE PRESENT WORTH OF 50 YEARS OF DAMAGES
C    IS DETERMINED AND AN AVERAGE ANNUAL DAMAGE IS CALCULATED.
C
      SPW=0.0
      AAV = 0.00
      DO 100 I=1,50
      T=FLOAT(I)
      A=(TDAW-TDAM)/50.0
      D=A*T+ TDAM
      PW=D/(1.085**T)
      SPW=SPW+ PW
100   CONTINUE
      DR = 0.085
      AAV = SPW*DR / (1.00 - (( 1.00 + DR )**(-T)))
      RETURN
```

ANNEX A2
STAGE-DAMAGE CURVES
AND HISTORIC RISE DATA

FIGURE A2-1

U.S. EROSION STAGE-DAMAGE CURVES

REACH	# of LEVELS	LAKE
2001	18	1

Stage	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
241.50	41757.	44872.	10169.	8193.	5358.	5023.	5816.	13864.	25383.	53545.
242.00	49426.	53188.	12479.	9912.	6631.	6362.	7233.	16755.	30283.	62553.
242.50	58635.	63211.	15393.	12033.	8238.	8093.	9041.	20304.	36244.	73235.
243.00	69764.	75345.	19065.	14678.	10281.	10314.	11307.	24691.	43488.	85971.
243.50	83292.	90090.	23731.	17993.	12892.	13205.	14276.	30126.	52362.	101208.
244.00	99823.	108151.	29714.	22168.	16241.	16967.	18071.	36891.	63301.	119558.
244.50	120184.	130420.	37471.	27515.	20595.	21933.	23005.	45407.	76852.	141805.
245.00	145499.	158091.	47652.	34424.	26298.	28519.	29490.	56180.	93818.	168984.
245.50	177312.	192860.	61180.	43511.	33900.	37360.	38107.	69964.	115294.	202527.
246.00	217864.	237097.	79520.	55677.	44202.	49426.	49728.	87869.	142820.	244452.
246.50	270416.	294292.	104913.	72399.	58557.	66237.	65745.	111499.	178741.	297652.
247.00	339990.	369725.	141079.	96173.	79240.	90335.	88427.	143490.	226727.	366578.
247.50	434757.	471993.	194579.	131591.	110628.	126513.	121947.	188362.	292930.	458432.
248.00	569161.	616198.	278340.	188351.	162555.	185237.	175179.	255157.	389115.	586183.
248.50	769523.	829977.	418482.	287516.	257155.	290117.	268150.	362560.	538499.	773652.
249.00	1053210.	1129582.	624135.	429432.	385263.	431453.	396660.	511252.	746305.	1030339.
249.50	1392586.	1477552.	848272.	578849.	507133.	573034.	528106.	673315.	979138.	1320222.

FIGURE A2-1(CONT'D)

```
 250.00
1600000.1600000.1060000. 710000. 620000. 610000. 640000. 830000.1210000.1620000.
 2002 17  1
 242.00
  33527.  36330.   7459.   8594.   3995.   3679.   4153.  11512.  23697.  40282.
 242.50
  41719.  45312.   9887.  10807.   5317.   5044.   5576.  14730.  29475.  49508.
 243.00
  52081.  56751.  13178.  13681.   7114.   6941.   7544.  18926.  36789.  61048.
 243.50
  65259.  71352.  17647.  17432.   9571.   9600.  10246.  24431.  46131.  75578.
 244.00
  82145.  90135.  23813.  22390.  12948.  13351.  14026.  31731.  58117.  94001.
 244.50
 103932. 114508.  32350.  29043.  17690.  18726.  19329.  41460.  73623. 117569.
 245.00
 132357. 146412.  44407.  38141.  24402.  26486.  26888.  54610.  93872. 148022.
 245.50
 169880. 188706.  61724.  50874.  34102.  37911.  37839.  72588. 120631. 187901.
 246.00
 220337. 245673.  87261.  69268.  48488.  55041.  54106.  97680. 156572. 241117.
 246.50
 289892. 324153. 126350.  97077.  70734.  81642.  79112. 133723. 206009. 313993.
 247.00
 389958. 436506. 190086. 142287. 107668. 125243. 119983. 188290. 276916. 418025.
 247.50
 546128. 608627. 305902. 225754. 177741. 204341. 195086. 280250. 387458. 577916.
 248.00
 785348. 863915. 498574. 222277. 291876. 335520. 319195. 423529. 554951. 821333.
 248.50
1097559.1197682. 741100. 538497. 429220. 503891. 474948. 600220. 764870.1142569.
 249.00
1450052.1593518. 992837. 714542. 571163. 688315. 640517. 800265.1004751.1502176.
 249.50
1819588.2028184.1231497. 872868. 702197. 870683. 799245.1019984.1272440.1870160.
 250.00
2220000.2400000.1470000.1030000. 830000.1060000. 960000.1220000.1540000.2240000.
 2003 18  1
```

FIGURE A2-1(CONT'D)

```
241.50
  57519.  45997.  12213.   7854.   6060.   5610.   6097.  16988.  31697.  66967.
242.00
  66710.  54045.  14837.   9294.   7403.   6927.   7501.  20114.  37302.  76941.
242.50
  77561.  63661.  18080.  11112.   9073.   8576.   9268.  23895.  44008.  88617.
243.00
  90410.  75179.  22107.  13351.  11169.  10666.  11492.  28480.  52068. 102322.
243.50
 105688.  89037.  27143.  16128.  13817.  13361.  14310.  34070.  61776. 118475.
244.00
 123937. 105775.  33465.  19601.  17179.  16722.  17911.  40920.  73534. 137606.
244.50
 145828. 126089.  41458.  23987.  21487.  21113.  22532.  49373.  87844. 160363.
245.00
 172233. 150870.  51637.  29582.  27056.  26835.  28521.  59870. 105355. 187588.
245.50
 204274. 181281.  64701.  36806.  34341.  34372.  36349.  73001. 126929. 220351.
246.00
 243416. 218860.  81644.  46289.  43999.  44429.  46699.  89590. 153698. 260062.
246.50
 291616. 265667. 103874.  58959.  57007.  58072.  60562. 110765. 187198. 308583.
247.00
 351542. 324538. 133492.  76264.  74892.  76951.  79457. 138148. 229593. 368450.
247.50
 426967. 399496. 173739. 100616. 100180. 103787. 105801. 174191. 283987. 443217.
248.00
 523515. 496602. 230081. 136345. 137467. 143430. 143769. 222810. 355139. 538116.
248.50
 650259. 625596. 312385. 191912. 195729. 205232. 201155. 290899. 451005. 661381.
249.00
 817005. 795610. 427930. 272496. 278259. 294879. 283342. 383640. 578876. 821652.
249.50
1023165.1006623. 568651. 366764. 373158. 399322. 380730. 497899. 737385.1020327.
250.00
1230000.1210000. 710000. 460000. 470000. 505000. 480000. 620000. 895000.1220000.
 2004 18  1
 241.50
```

FIGURE A2-1(CONT'D)

5197.	4359.	1338.	311.	270.	202.	387.	873.	2622.	4135.
242.00									
5860.	4609.	1554.	374.	330.	250.	460.	1019.	2994.	4665.
242.50									
6616.	5542.	1809.	452.	406.	309.	551.	1191.	3423.	5272.
243.00									
7481.	6265.	2110.	546.	499.	386.	661.	1396.	3920.	5968.
243.50									
8472.	7096.	2465.	663.	617.	481.	796.	1643.	4500.	6769.
244.00									
9609.	8052.	2887.	808.	764.	604.	963.	1937.	5177.	7693.
244.50									
10919.	9156.	3389.	988.	952.	761.	1170.	2293.	5971.	8763.
245.00									
12432.	10436.	3991.	1215.	1191.	966.	1428.	2725.	6906.	10006.
245.50									
14186.	11926.	4716.	1500.	1498.	1233.	1753.	3253.	8011.	11458.
246.00									
16225.	13668.	5593.	1866.	1899.	1584.	2169.	3902.	9326.	13160.
246.50									
18610.	15715.	6663.	2338.	2424.	2054.	2704.	4710.	10899.	15167.
247.00									
21412.	18138.	7982.	2957.	3123.	2691.	3403.	5725.	12798.	17553.
247.50									
24729.	21029.	9627.	3784.	4075.	3570.	4337.	7020.	15112.	20410.
248.00									
28693.	24522.	11723.	4925.	5408.	4821.	5618.	8706.	17970.	23875.
248.50									
33508.	28827.	14482.	6589.	7377.	6693.	7464.	10978.	21578.	28152.
249.00									
39449.	34202.	18167.	9021.	10282.	9501.	10167.	14093.	26222.	33527.
249.50									
46676.	40791.	22824.	12197.	14143.	13298.	13790.	18150.	32078.	40182.
250.00									
54000.	47000.	26000.	15000.	18000.	16500.	16000.	22000.	38000.	47000.
2005 18	1								
241.50									
44081.	42328.	15704.	5287.	5496.	4425.	7221.	11513.	24621.	36748.

FIGURE A2-1(CONT'D)

```
 242.00
  53227.  50844.  19499.   6807.   7123.   5774.   9146.  14432.  30258.  44491.
 242.50
  64419.  61242.  24285.   8804.   9277.   7577.  11645.  18164.  37294.  54006.
 243.00
  78150.  73998.  30331.  11450.  12142.  10004.  14895.  22945.  46118.  65754.
 243.50
  95062.  89707.  38024.  14973.  15977.  13282.  19174.  29108.  57232.  80327.
 244.00
 115965. 109148.  47867.  19705.  21147.  17760.  24840.  37108.  71318.  98453.
 244.50
 141921. 133335.  60536.  26126.  28192.  23933.  32436.  47590.  89269. 121168.
 245.00
 174331. 163617.  76990.  34945.  37893.  32553.  42727.  61432. 112320. 149804.
 245.50
 215055. 201813.  98565.  47224.  51438.  44748.  56881.  79937. 142169. 186187.
 246.00
 266626. 250425. 127239.  64638.  70690.  62309.  76703. 105036. 181241. 232845.
 246.50
 332614. 313021. 166034.  89941.  98706.  88231. 105103. 139761. 233089. 293425.
 247.00
 418321. 395011. 219987. 128053. 141077. 127960. 147192. 189247. 303233. 373450.
 247.50
 532306. 505313. 298351. 188798. 209165. 192687. 212853. 263269. 401052. 482013.
 248.00
 685307. 653948. 410096. 281716. 312135. 291695. 312339. 371185. 537788. 629771.
 248.50
 880771. 843482. 552669. 399478. 441635. 417677. 442390. 510596. 715746. 819558.
 249.00
1115190.1070085. 715667. 527030. 581080. 554252. 583429. 669116. 928404.1048452.
 249.50
1384018.1327317. 886823. 645304. 713519. 681165. 713825. 827374.1163579.1303554.
 250.00
1600000.1570000.1040000. 760000. 840000. 810000. 840000. 980000.1400000.1550000.
   4  2
 3001 14  2
 568.00
  38642.  34092.  24642.   9030.   1680.   2590.   3570.   8051.  10781.  21981.
```

FIGURE A2-1(CONT'D)

```
 568.50
  52993.   46273.   34512.   12881.    2590.    3851.    5320.   11691.   15261.   30732.
 569.00
  73084.   63213.   48583.   18481.    3990.    5671.    7981.   17081.   21841.   43262.
 569.50
 101367.   86875.   68674.   26742.    6161.    8471.   12181.   25201.   31781.   61394.
 570.00
 141548.  120617.   97655.   38922.    9730.   12810.   18901.   37662.   47323.   88275.
 570.50
 198602.  169200.  139799.   57403.   15541.   19531.   29402.   56913.   70144.  128318.
 571.00
 280507.  239625.  201962.   85615.   25201.   30381.   46693.   87575.  102836.  186422.
 571.50
 399724.  341551.  295068.  129858.   41793.   48303.   75184.  136509.  154149.  275116.
 572.00
 576975.  489399.  436757.  201332.   71614.   79594.  124397.  216803.  235634.  412045.
 572.50
 845581.  712363.  658040.  322860.  128528.  138678.  214003.  355902.  370673.  626188.
 573.00
1267147. 1061824. 1013732.  540363.  245785.  256006.  382223.  606727.  594756.  968368.
 573.50
1918116. 1605057. 1584196.  917755.  480719.  486809.  696962. 1060564.  965078. 1499421.
 574.00
2865973. 2413816. 2444968. 1502501.  856362.  846911. 1191962. 1751436. 1500541. 2234115.
 574.50
4088457. 3482710. 3617889. 2228584. 1231304. 1232564. 1759417. 2530723. 2120288. 3050224.
 3002 14  2
 568.00
  19026.   20747.    7489.    3233.    1489.    1954.    4977.    5931.   11281.   16653.
 568.50
  25469.   27702.   10373.    4629.    2209.    2884.    6838.    8141.   14723.   22352.
 569.00
  34261.   37145.   14490.    6675.    3280.    4280.    9466.   11257.   19305.   30097.
 569.50
  46402.   50007.   20398.    9722.    4931.    6420.   13211.   15677.   25492.   40773.
 570.00
  63311.   67707.   28934.   14304.    7489.    9699.   18654.   22026.   33958.   55612.
 570.50
```

FIGURE A2-1(CONT'D)

```
 87129.  92246.  41448.  21282.  11560.  14793.  26678.  31284.  45704.  76453.
571.00
121227. 126646.  60125.  32097.  18096.  22864.  38750.  45007.  62288. 106225.
571.50
170815. 175560.  88524.  49216.  28888.  35936.  57403.  65847.  86292. 149603.
572.00
244616. 246361. 132833.  76779.  47332.  57706.  87245.  98549. 122320. 214542.
572.50
357842. 351492. 204331. 122925.  80337.  95688. 137322. 152371. 179398. 315696.
573.00
538844. 513794. 325791. 204518. 143462. 166210. 227126. 245965. 274458. 477161.
573.50
829909. 771691. 539565. 350213. 266573. 297415. 387125. 404081. 423456. 723522.
574.00
1251318.1148885. 877032. 572337. 459345. 496234. 622949. 620716. 612343.1032194.
574.50
1748575.1609741.1299418. 838375. 662839. 726546. 881358. 847470. 816535.1358334.
3003 14  2
568.00
 87254. 128687.  13588.  16711.   5056.   5000.   8439.  22287.  50542.  76491.
568.50
102087.  79168.  16711.  19778.   6302.   6245.  10428.  26934.  59074.  89559.
569.00
119635.  93239.  20633.  23514.   7881.   7826.  12937.  32604.  69186. 105005.
569.50
140472. 110061.  25522.  28031.   9908.   9833.  16060.  39519.  81157. 123334.
570.00
165287. 130174.  31675.  33515.  12473.  12380.  20001.  47958.  95414. 145119.
570.50
194880. 154302.  39444.  40244.  15782.  15651.  24983.  58293. 112422. 171087.
571.00
230346. 183374.  49278.  48515.  20020.  19871.  31303.  70989. 132776. 202111.
571.50
272913. 218450.  61788.  58739.  25540.  25299.  39333.  86603. 157220. 239287.
572.00
324236. 260980.  77792.  71453.  32752.  32381.  49612. 105898. 186720. 283974.
572.50
386340. 312730.  98388.  87402.  42214.  41638.  62828. 129784. 222428. 347193.
```

FIGURE A2-1(CONT'D)

```
573.00
461790. 376004. 125007. 107534.  54742.  53850.  79930. 159488. 265906. 403199.
573.50
553894. 453592. 159692. 133204.  71490.  70096. 102217. 196627. 319124. 538410.
574.00
666986. 549452. 205178. 166235.  94150.  91938. 131475. 243284. 384704. 579807.
574.50
806658. 668584. 265385. 209286. 125137. 121698. 170232. 302320. 466102. 699367.
3004 14  2
568.00
119332.  80753.  41109.  16912.  22460.  12939.  16379.  44248.  91993. 164869.
568.50
132861.  90328.  46339.  19295.  25382.  14781.  18820.  49946. 103019. 181572.
569.00
148056. 101144.  52292.  22040.  28723.  16935.  21655.  56435. 115460. 200144.
569.50
165135. 113370.  59075.  25208.  32555.  19439.  24960.  63837. 129516. 220820.
570.00
148366. 127213.  66825.  28876.  36957.  22358.  28825.  72290. 145414. 243875.
570.50
206041. 142914.  75690.  33135.  42026.  25771.  33351.  81964. 163422. 269616.
571.00
230509. 160749.  85857.  38083.  47880.  29780.  36603. 125782. 183853. 298404.
571.50
258176. 181042.  97541.  43849.  54674.  34502.  44928. 105797. 207072. 330658.
572.00
289513. 204182. 111003.  50596.  62548.  40081.  52337. 120468. 233507. 366858.
572.50
325072. 230621. 126558.  58536.  71740.  46709.  61131. 137400. 263663. 407576.
573.00
365510. 260898. 144590.  67842.  82513.  54618.  71609. 156829. 298142. 453476.
573.50
411600. 295668. 165566.  78887.  95194.  64108.  84159. 179740. 337668. 505349.
574.00
464275. 335387. 190077.  92033. 110202.  75565.  99275. 206237. 383093. 564142.
574.50
524656. 382031. 218866. 107780. 128083.  89497. 117595. 237234. 435510. 634269.
 2  3
```

FIGURE A2-1(CONT'D)

```
4001 17   3
569.50
   357.    427.    313.    221.     99.    147.    159.    302.    309.    262.
570.00
   520.    604.    453.    328.    147.    210.    236.    438.    431.    397.
570.50
   752.    865.    667.    482.    221.    302.    357.    637.    607.    526.
571.00
  1097.   1244.    980.    722.    335.    442.    541.    939.    861.    762.
571.50
  1617.   1805.   1454.   1090.    516.    659.    825.   1389.   1241.   1115.
572.00
  2394.   2644.   2176.   1657.    810.    998.   1270.   2077.   1805.   1650.
572.50
  3576.   3908.   3281.   2556.   1289.   1551.   1974.   3138.   2655.   2474.
573.00
  5395.   5845.   5005.   3988.   2091.   2452.   3109.   4795.   3970.   3764.
573.50
  8227.   8854.   7723.   6331.   3472.   3981.   4968.   7428.   6039.   5826.
574.00
 12721.  13615.  12102.  10253.   5933.   6648.   8098.  11715.   9384.   9214.
574.50
 20016.  21353.  19353.  17052.  10503.  11509.  13560.  18903.  15000.  14985.
575.00
 32187.  34375.  31844.  29418.  19541.  20955.  23632.  31510.  24925.  25286.
575.50
 50796.  54402.  51114.  48487.  33362.  35546.  39214.  50977.  39866.  40389.
576.00
 69626.  74800.  70551.  64614.  42609.  46311.  52733.  69852.  53570.  53548.
576.50
 80730.  87152.  81359.  73103.  45979.  50509.  59772.  79946.  61661.  60265.
577.00
 84460.  90596.  83621.  74790.  46473.  50969.  60736.  82137.  65085.  62172.
577.50
 84943.  91296.  83967.  74951.  46517.  51135.  60791.  82373.  65693.  62482.
4002 17   3
569.50
  1497.   1540.   1343.    542.    172.    280.    369.    509.    434.    708.
```

FIGURE A2-1(CONT'D)

570.00									
1950.	1989.	1746.	731.	242.	383.	503.	684.	577.	935.
570.50									
2550.	2580.	2281.	988.	342.	530.	693.	924.	770.	1242.
571.00									
3349.	3362.	2994.	1347.	489.	738.	956.	1256.	1035.	1657.
571.50									
4416.	4399.	3955.	1848.	706.	1031.	1332.	1717.	1397.	2218.
572.00									
5856.	5784.	5256.	2556.	1023.	1456.	1872.	2364.	1899.	2985.
572.50									
7808.	7654.	7036.	3564.	1499.	2072.	2650.	3280.	2597.	4045.
573.00									
10482.	10197.	9497.	5019.	2220.	2983.	3791.	4597.	3583.	5521.
573.50									
14177.	13693.	12943.	7151.	3337.	4354.	5491.	6511.	4995.	7601.
574.00									
19348.	18572.	17844.	99872.	5101.	6465.	8068.	9347.	7055.	10586.
574.50									
26706.	25509.	24962.	15184.	7976.	9837.	12083.	13656.	10142.	14963.
575.00									
37395.	35647.	35586.	22865.	12913.	15511.	18597.	20452.	14947.	21537.
575.50									
52421.	49876.	50861.	34143.	20146.	23790.	28149.	30305.	21736.	30646.
576.00									
69979.	66234.	68272.	46454.	26836.	31522.	37953.	40714.	28799.	40671.
576.50									
85443.	81030.	82701.	54428.	30049.	36220.	43905.	47618.	34204.	49033.
577.00									
95716.	91424.	92141.	57962.	31021.	38141.	46084.	50950.	37225.	53311.
577.50									
100772.	96953.	97484.	59337.	31254.	38569.	46651.	51930.	38065.	55030.
6 4									
5001 16	4								
574.50									
3575.	1424.	3217.	542.	163.	147.	704.	3994.	2093.	1505.
575.00									
3861.	1710.	3504.	829.	354.	243.	990.	4280.	2380.	1792.

FIGURE A2-1(CONT'D)

575.50									
4824.	2201.	4277.	1096.	482.	335.	1305.	5189.	2946.	2283.
576.00									
6049.	2846.	5251.	1459.	664.	463.	1727.	6322.	3666.	2935.
576.50									
7608.	3700.	6486.	1956.	921.	650.	2299.	7742.	4590.	3781.
577.00									
9614.	4838.	8077.	2640.	1286.	923.	3077.	9547.	5781.	4896.
577.50									
12207.	6370.	10142.	3594.	1814.	1328.	4138.	11857.	7340.	6380.
578.00									
15590.	8454.	12862.	4944.	2589.	1939.	5616.	14863.	9405.	8381.
578.50									
20049.	11322.	16506.	6883.	3747.	2882.	7694.	18830.	12190.	11107.
579.00									
26008.	15334.	21481.	9731.	5525.	4383.	10683.	24179.	16029.	14902.
579.50									
34131.	21079.	28455.	14048.	8348.	6855.	15088.	31589.	21488.	20328.
580.00									
45558.	29616.	38609.	20867.	13094.	11166.	21869.	42285.	29633.	28433.
580.50									
62689.	43022.	54383.	32535.	22008.	19477.	33248.	58931.	42927.	41674.
581.00									
91349.	66216.	81544.	54863.	41245.	37723.	54891.	88252.	67900.	66347.
581.50									
132233.	101205.	123010.	90498.	70476.	66835.	87492.	131823.	104863.	102631.
582.00									
181270.	143556.	173821.	132119.	102494.	99339.	125629.	183729.	145333.	142539.
5002 16	4								
574.50									
1047.	1156.	114.	100.	27.	21.	22.	185.	334.	996.
575.00									
1238.	1442.	209.	138.	55.	31.	41.	281.	525.	1283.
575.50									
1537.	1778.	280.	182.	76.	43.	57.	361.	666.	1539.
576.00									
1915.	2201.	379.	241.	106.	61.	79.	467.	848.	1858.
576.50									

FIGURE A2-1(CONT'D)

2397.	2741.	517.	322.	148.	89.	112.	607.	1083.	2259.
577.00									
3014.	3432.	711.	434.	209.	131.	159.	794.	1391.	2765.
577.50									
3812.	4326.	986.	590.	299.	194.	228.	1044.	1797.	3413.
578.00									
4855.	5496.	1384.	815.	433.	292.	333.	1385.	2337.	4253.
578.50									
6234.	7044.	1969.	1142.	635.	446.	496.	1857.	3064.	5355.
579.00									
8093.	9132.	2851.	1631.	952.	697.	755.	2519.	4055.	6828.
579.50									
10649.	12008.	4215.	2391.	1468.	1119.	1185.	3478.	5438.	8842.
580.00									
14291.	16095.	6413.	3633.	2356.	1871.	1941.	4919.	7430.	11681.
580.50									
19768.	22207.	10178.	5854.	4043.	3340.	3407.	7247.	10473.	15901.
581.00									
28838.	32144.	17371.	10483.	7799.	6713.	6728.	11513.	15677.	22762.
581.50									
43157.	47739.	29866.	18451.	14445.	12620.	12728.	18580.	23947.	33287.
582.00									
61810.	68017.	46652.	27918.	21976.	19904.	19717.	27561.	34223.	47021.
5003 16	4								
574.50									
11460.	14325.	2196.	1337.	382.	191.	286.	2865.	5730.	12415.
575.00									
15263.	17786.	2575.	1707.	683.	372.	507.	3464.	6473.	15821.
575.50									
18955.	21933.	3454.	2244.	941.	527.	703.	4457.	8210.	18985.
576.00									
23618.	27154.	4674.	2968.	1303.	745.	972.	5760.	10454.	22926.
576.50									
29564.	33804.	6370.	3971.	1831.	1096.	1375.	7486.	13360.	27857.
577.00									
37174.	42335.	8758.	5346.	2172.	1613.	1954.	9782.	17165.	34104.
577.50									
47019.	53358.	12150.	7280.	2585.	2069.	2812.	12874.	22170.	42097.

FIGURE A2-1(CONT'D)

578.00									
57267.	59325.	20423.	7848.	2999.	2482.	4001.	21602.	22336.	46657.
578.50									
71010.	72375.	26369.	10837.	3516.	2896.	5573.	27330.	27981.	56832.
579.00									
88465.	88899.	34455.	15118.	5098.	4188.	7818.	34775.	35272.	69634.
579.50									
110832.	110056.	45644.	21292.	7486.	6163.	11075.	44589.	44807.	85900.
580.00									
139806.	137531.	61475.	30453.	11189.	9285.	15790.	57712.	57453.	106799.
580.50									
177922.	173889.	84504.	44372.	17124.	14436.	23215.	75642.	74546.	134067.
581.00									
229129.	223193.	119279.	66387.	27103.	23411.	34766.	100945.	98309.	170383.
581.50									
300459.	292787.	174871.	103521.	45344.	40556.	54206.	138710.	132929.	220370.
582.00									
407185.	398737.	273160.	174117.	84091.	78548.	91225.	201530.	188439.	293955.
5004 16	4								
574.50									
191.	382.	95.	48.	29.	19.	29.	115.	105.	286.
575.00									
470.	591.	237.	95.	42.	28.	45.	169.	152.	405.
575.50									
659.	808.	344.	149.	65.	42.	71.	247.	220.	565.
576.00									
931.	1117.	503.	237.	104.	68.	107.	366.	321.	796.
576.50									
1328.	1562.	746.	371.	163.	107.	169.	546.	473.	1129.
577.00									
1917.	2206.	1117.	594.	262.	178.	267.	819.	710.	1613.
577.50									
2806.	3163.	1697.	960.	428.	292.	431.	1244.	1078.	2336.
578.00									
4179.	4618.	2618.	1576.	707.	503.	704.	1922.	1674.	3427.
578.50									
6276.	6892.	4117.	2634.	1188.	886.	1171.	3028.	2677.	5119.
579.00									

FIGURE A2-1(CONT'D)

9400.	10522.	6651.	4520.	2060.	1626.	2012.	4908.	4419.	7816.
579.50									
14314.	16543.	11173.	8054.	3743.	3194.	3619.	8277.	7576.	12307.
580.00									
22650.	26637.	20029.	15087.	7410.	6872.	7035.	14584.	13675.	20415.
580.50									
37661.	44139.	38429.	29753.	16287.	16199.	14795.	27296.	25551.	36212.
581.00									
63175.	72353.	70338.	56098.	32627.	33085.	28799.	49652.	44671.	61005.
581.50									
99027.	111019.	112392.	90547.	52990.	53528.	47004.	79372.	66079.	90420.
582.00									
142156.	154643.	158270.	125506.	72231.	70906.	66097.	110196.	86120.	120753.
5005 16	4								
574.50									
57.	57.	10.	5.	5.	3.	5.	14.	29.	48.
575.00									
80.	80.	11.	8.	9.	5.	8.	21.	33.	62.
575.50									
112.	112.	18.	11.	12.	8.	11.	32.	50.	87.
576.00									
156.	159.	29.	19.	20.	12.	18.	48.	75.	121.
576.50									
220.	226.	45.	31.	32.	21.	30.	73.	116.	172.
577.00									
314.	325.	73.	50.	51.	34.	48.	112.	178.	247.
577.50									
454.	473.	117.	82.	82.	58.	79.	175.	277.	361.
578.00									
664.	696.	194.	138.	137.	101.	133.	278.	438.	536.
578.50									
987.	1043.	325.	234.	229.	180.	230.	453.	703.	813.
579.00									
1499.	1598.	560.	412.	399.	330.	413.	754.	1151.	1263.
579.50									
2320.	2516.	1002.	750.	724.	642.	772.	1304.	1937.	2022.
580.00									
3722.	4100.	1904.	1432.	1408.	1337.	1563.	2354.	3373.	3395.

FIGURE A2-1(CONT'D)

580.50									
6317.	6819.	3764.	2871.	2962.	2992.	3330.	4400.	6120.	5985.
581.00									
10710.	11115.	6955.	5241.	5666.	5675.	6125.	7797.	10598.	10267.
581.50									
16490.	16779.	10794.	7894.	8838.	8404.	8929.	11851.	16091.	15426.
582.00									
22836.	22724.	14330.	10010.	11507.	10273.	11089.	15313.	21182.	20105.
5006 16	4								
574.50									
66850.	85950.	28650.	14325.	6685.	11460.	28650.	23875.	19100.	38200.
575.00									
80274.	104758.	40183.	20865.	8303.	15776.	35344.	31505.	23627.	46633.
575.50									
90851.	116713.	46238.	24309.	9898.	18303.	39414.	35022.	26776.	53041.
576.00									
103015.	130272.	53321.	28386.	11831.	21285.	44070.	39046.	30437.	60430.
576.50									
117043.	145702.	61631.	33225.	14180.	24817.	49429.	43665.	34708.	68975.
577.00									
133262.	163319.	71419.	38989.	17045.	29023.	55629.	48997.	39709.	78880.
577.50									
152084.	183509.	82999.	45886.	20557.	34051.	62844.	55196.	45597.	90408.
578.00									
173998.	206738.	96755.	54166.	24885.	40092.	71301.	62449.	52574.	103868.
578.50									
199622.	233594.	113186.	64165.	30254.	47401.	81287.	71006.	60880.	119646.
579.00									
229718.	264807.	132928.	76315.	36961.	56303.	93185.	81185.	70847.	138245.
579.50									
265250.	301310.	156813.	91173.	45420.	67250.	107513.	93428.	82893.	160281.
580.00									
307472.	344309.	185961.	109498.	56193.	80854.	124970.	108331.	97596.	186582.
580.50									
358027.	395421.	221896.	132345.	70115.	98001.	150371.	126755.	115755.	218255.
581.00									
419225.	456861.	266789.	161228.	88444.	120048.	173862.	149981.	138537.	256861.
581.50									

FIGURE A2-1(CONT'D)

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494111. 531896. 323952. 198485. 113276. 149288. 209315. 180114. 167783. 304774.
582.00
587645. 625353. 398508. 247845. 148113. 189549. 256876. 220558. 206348. 365586.
13   4
7001 16   4
574.50
   307.    453.    347.    331.    195.    183.    179.    315.    162.    217.
575.00
   376.    545.    421.    406.    246.    231.    223.    393.    205.    266.
575.50
   463.    659.    513.    498.    311.    293.    282.    494.    261.    329.
576.00
   571.    800.    627.    613.    395.    373.    355.    620.    333.    410.
576.50
   708.    976.    771.    758.    338.    477.    456.    782.    427.    513.
577.00
   880.   1195.    950.    944.    647.    611.    575.    825.    549.    645.
577.50
  1097.   1469.   1177.   1179.    831.    787.    737.   1261.    710.    817.
578.00
  1376.   1816.   1465.   1483.   1075.   1020.    950.   1611.    922.   1042.
578.50
  1733.   2258.   1834.   1877.   1399.   1328.   1235.   2069.   1206.   1339.
579.00
  2196.   2824.   2308.   2391.   1834.   1742.   1615.   2672.   1588.   1737.
579.50
  2804.   3555.   2928.   3072.   2421.   2303.   2133.   3473.   2111.   2279.
580.00
  3610.   4512.   3745.   3984.   3229.   3069.   2849.   4551.   2833.   3026.
580.50
  4698.   5782.   4840.   5228.   4360.   4140.   3875.   4361.   3853.   4084.
581.00
  6209.   7502.   6347.   6968.   5987.   5678.   5333.   8078.   5339.   5634.
581.50
  8408.   9914.   8517.   9507.   8437.   7998.   7603.  11072.   7611.   8034.
582.00
 11501.  13227.  11520.  13123.  11996.  11338.  10942.  15333.  10983.  11604.
002 16   4   7
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FIGURE A2-1(CONT'D)

574.50									
2710.	11716.	2720.	954.	283.	518.	1054.	4415.	1564.	3088.
575.00									
3408.	5592.	3342.	1197.	377.	674.	1339.	5514.	2015.	3921.
575.50									
4297.	6834.	4121.	1512.	505.	883.	1711.	6905.	2609.	4992.
576.00									
5428.	8389.	5099.	1918.	684.	1158.	2196.	8669.	3389.	6374.
576.50									
6884.	10346.	6333.	2450.	928.	1531.	2834.	10919.	4422.	8163.
577.00									
8759.	12823.	7902.	3152.	1026.	2032.	3682.	13798.	5797.	10494.
577.50									
11185.	15974.	9907.	4085.	1732.	2715.	4819.	17501.	7638.	13544.
578.00									
14349.	20020.	12490.	5345.	2395.	3658.	6359.	22220.	10116.	17562.
578.50									
18500.	25248.	15846.	7064.	3340.	4973.	8472.	28529.	13502.	22894.
579.00									
23991.	32071.	20255.	9447.	4704.	6836.	11420.	36718.	18154.	30034.
579.50									
31337.	41064.	26122.	12818.	6715.	9533.	15609.	47575.	24631.	39704.
580.00									
41304.	53087.	34069.	17698.	9755.	11401.	21702.	62161.	33818.	53160.
580.50									
55095.	69465.	45107.	25018.	14531.	19723.	30848.	82112.	47153.	71637.
581.00									
74818.	92449.	61095.	36635.	22533.	29877.	45268.	110204.	67264.	98623.
581.50									
104552.	126290.	85851.	56695.	37295.	48088.	69551.	151594.	99271.	115706.
582.00									
146994.	174322.	121332.	86875.	59415.	75674.	106665.	209998.	146799.	198535.
7003 17	4								
574.50									
19255.	24238.	7837.	2118.	1476.	1811.	5361.	8058.	10065.	18185.
575.00									
22493.	27871.	9291.	2654.	1857.	2262.	6468.	9560.	11636.	20997.
575.50									

FIGURE A2-1(CONT'D)

26329.	32115.	11054.	3335.	2342.	2833.	7824.	11367.	13486.	24280.
576.00									
30888.	37096.	13194.	4202.	2967.	3565.	9496.	13559.	15675.	28124.
576.50									
36319.	42961.	15812.	5316.	3779.	4506.	11563.	16224.	18282.	32636.
577.00									
42815.	49900.	19026.	6750.	2839.	5727.	14133.	19482.	21512.	37951.
577.50									
50020.	58151.	23007.	8612.	6236.	7317.	17349.	23488.	25133.	44236.
578.00									
60019.	68017.	27970.	11046.	8093.	9413.	21401.	28449.	29657.	51701.
578.50									
71423.	79898.	34215.	14854.	10599.	12201.	26548.	34646.	35174.	60614.
579.00									
85335.	94320.	42151.	18541.	14009.	15957.	33154.	42459.	41957.	71330.
579.50									
102431.	111995.	52366.	24342.	18735.	21099.	41733.	52426.	50399.	84325.
580.00									
123646.	133917.	65726.	32338.	25416.	28274.	53059.	65340.	61056.	100260.
580.50									
150496.	161532.	83569.	43650.	34920.	38558.	68329.	82424.	74785.	120117.
581.00									
184390.	197073.	108133.	60264.	49786.	53915.	89604.	105757.	93060.	145506.
581.50									
229189.	244277.	143464.	85933.	73148.	78164.	120633.	138934.	118449.	179145.
582.00									
287795.	306882.	193389.	123626.	107939.	114003.	164079.	184482.	151976.	222473.
582.50									
360440.	385481.	255748.	169712.	150705.	158067.	217506.	239262.	191501.	273690.
7004 17	4								
574.50									
4153.	6058.	1515.	410.	356.	357.	1064.	1369.	2292.	3849.
575.00									
4868.	6922.	1822.	525.	448.	455.	1313.	1634.	2629.	4447.
575.50									
5726.	7932.	2204.	674.	566.	583.	1573.	1955.	3025.	5147.
576.00									
6748.	9115.	2680.	871.	720.	751.	1923.	2346.	3492.	5971.

FIGURE A2-1(CONT'D)

```
576.50
  7974.  10515.   3276.   1239.    923.    974.   2362.   2827.   4047.   6943.
577.00
  9476.  12178.   4031.   1478.   1192.   1272.   2915.   3422.   4710.   8094.
577.50
 11251.  14173.   4998.   1945.   1555.   1677.   3618.   4163.   5507.   9464.
578.00
 13445.  16588.   6250.   2583.   2049.   2231.   4523.   5096.   6476.  11107.
578.50
 16152.  19548.   7894.   3467.   2740.   3004.   5704.   6290.   7667.  13089.
579.00
 19529.  23230.  10105.   4715.   3725.   4106.   7276.   7842.   9155.  15509.
579.50
 23805.  27902.  13108.   6523.   5175.   5712.   9418.   9917.  11054.  18502.
580.00
 29353.  33988.  17378.   9248.   7404.   8150.  12453.  12800.  13570.  22290.
580.50
 36813.  42233.  23721.  13584.  11032.  12054.  16988.  17013.  17052.  27247.
581.00
 46745.  53468.  32924.  20151.  16619.  18004.  23504.  22882.  21648.  33570.
581.50
 58952.  67655.  44744.  28421.  23573.  25541.  31534.  29762.  27015.  41136.
582.00
 72941.  83843.  57776.  37166.  30601.  33031.  39999.  36732.  32716.  49603.
582.50
 91157. 100272.  70064.  45361.  36838.  39801.  48101.  43734.  38468.  58790.
7005 16   4
574.50
 62668.  86364.  23084.  22279.   5468.  12602.  19814.   7984.  30974.  24345.
575.00
 72945.  98472.  27831.  26393.   6857.  15140.  23212.   9549.  35337.  32067.
575.50
 85064. 112534.  33638.  31345.   8622.  18254.  27270.  11459.  40417.  33987.
576.00
 99394. 128917.  40772.  37380.  10881.  22096.  32150.  13807.  46368.  40278.
576.50
116393. 148082.  49566.  44564.  13790.  26859.  38058.  16711.  53358.  47834.
577.00
```

FIGURE A2-1(CONT'D)

136629.	170589.	60453.	53391.	17549.	32805.	45241.	20331.	61614.	56950.
577.50									
160812.	197154.	73999.	64201.	22441.	40267.	54052.	24861.	71418.	67976.
578.00									
189843.	228678.	90954.	77525.	28858.	49693.	66438.	30591.	83138.	81395.
578.50									
224885.	266318.	112307.	94064.	37352.	61713.	78535.	37946.	97251.	97811.
579.00									
267445.	311582.	139421.	114778.	48645.	77170.	95707.	47451.	114411.	118036.
579.50									
319543.	366495.	190837.	141010.	63923.	97289.	117692.	59964.	135508.	137651.
580.00									
383943.	433826.	219295.	174697.	84876.	123854.	146350.	76764.	161851.	174908.
580.50									
464616.	517552.	278821.	218829.	114216.	159646.	184574.	99970.	195427.	215603.
581.00									
567574.	623735.	359271.	278382.	156621.	209341.	237404.	133509.	239758.	269405.
581.50									
702781.	762241.	471945.	362574.	220999.	281841.	314452.	185124.	300928.	343665.
582.00									
882425.	778324.	630680.	482137.	317944.	383916.	424960.	261699.	384754.	444724.
7006 17	4								
574.50									
120489.	89205.	30909.	34875.	11704.	13696.	19227.	25065.	62278.	67317.
575.00									
134517.	100064.	35433.	39380.	13663.	15706.	22226.	29168.	70662.	76603.
575.50									
150371.	112375.	40757.	44535.	15986.	18051.	25744.	33985.	80281.	87255.
576.00									
168323.	126363.	46916.	50448.	18750.	20793.	29889.	39660.	91345.	99499.
576.50									
188686.	142284.	54099.	57244.	22043.	24032.	34784.	46355.	104092.	113596.
577.00									
211841.	160435.	62499.	65081.	25984.	27784.	40586.	57188.	119405.	129858.
577.50									
238225.	181189.	72348.	74144.	30720.	32247.	47485.	63643.	135874.	148656.
578.00									
268364.	204968.	83935.	84663.	36434.	37538.	55723.	74785.	155683.	170437.

FIGURE A2-1(CONT'D)

```
578.50
302887. 232293.  97617.  96923.  43363.  43844.  65605.  88064. 178763. 195742.
579.00
342550. 263786. 113834. 111274.  51806.  51399.  77514. 103942. 205747. 225231.
579.50
388274. 300214. 133145. 128166.  62161.  60508.  91940. 122997. 237428. 259716.
580.00
441191. 342517. 156264. 148166.  74960.  71575. 109533. 145977. 274798. 300211.
580.50
502702. 391880. 184116. 171158.  90913.  86437. 131144. 173838. 319126. 348004.
581.00
574593. 449806. 217935. 200790. 111033. 101964. 157934. 207849. 372033. 404773.
581.50
659126. 518272. 259408. 235860. 136790. 123157. 191529. 249750. 435837. 472762.
582.00
759489. 599911. 310973. 279381. 170463. 150466. 234356. 302052. 513571. 573000.
582.50
879786. 698380. 376272. 334595. 215691. 186738. 290124. 368365. 609685. 656439.
7007 16  4
574.50
 49404.  42175.  22776.  15303.   9451.   7906.  10950.  37124.  66621.  66100.
575.00
 54377.  46495.  25378.  17294.  10847.   9058.  12414.  41249.  73316.  72539.
575.50
 59900.  51305.  28312.  19569.  12469.  10397.  14093.  45865.  80749.  79666.
576.00
 66041.  56667.  34632.  22169.  14357.  11954.  16023.  51038.  89009.  87564.
576.50
 72881.  62654.  35380.  25150.  16561.  13770.  18245.  56842.  98197.  96326.
577.00
 80508.  69352.  39638.  28574.  19139.  15895.  20810.  63363. 108431. 106058.
577.50
 89030.  76861.  44481.  32514.  22163.  18390.  23782.  70702. 119844. 116882.
578.00
 98564.  82290.  50002.  37063.  25719.  21329.  27231.  78978. 132588. 128939.
578.50
109251.  94792.  56317.  42328.  29917.  24802.  31247.  88323. 146842. 142390.
579.00
```

FIGURE A2-1(CONT'D)

```
121257. 105515.  63558.  48441.  34892.  28924.  35942.  98904. 162808. 157422.
579.50
134774. 117655.  71895.  55569.  40807.  33838.  41450. 110908. 180724. 174253.
580.00
150030. 131445.  81527.  63910.  47875.  39724.  47941. 124569. 200869. 193139.
580.50
167303. 147172.  92709.  73716.  56363.  46818.  55630. 140162. 223571. 214378.
581.00
186917. 165182. 105756.  85313.  66614.  55420.  64791. 158028. 249220. 238333.
581.50
209283. 185912. 121072.  99116.  79082.  65931.  75778. 178587. 278286. 265434.
582.00
234908. 209912. 139188. 115674.  94367.  78898.  89069. 202373. 311343. 296210.
7008 16   4
574.50
  7097.   6878.   4418.   3793.   2997.   2774.   2593.   4955.   6435.   6562.
575.00
  7905.   7672.   4954.   4273.   3405.   3155.   2951.   5574.   7197.   7333.
575.50
  8817.   8566.   5561.   4819.   3894.   3595.   3364.   6277.   8057.   8203.
576.00
  9843.   9577.   6250.   5442.   4461.   4101.   3840.   7074.   9028.   9185.
576.50
 11004.  10717.   7034.   6153.   5116.   4686.   4390.   7979.  10126.  10294.
577.00
 12316.  12009.   7926.   6969.   5877.   5365.   5027.   9009.  11369.  11551.
577.50
 13802.  13472.   8944.   7905.   6761.   6152.   5765.  10184.  12780.  12969.
578.00
 15488.  15135.  10108.   8983.   7791.   7069.   6624.  11524.  14382.  14580.
578.50
 17407.  17025.  11441.  10224.   8994.   8139.   7624.  13057.  16205.  16411.
579.00
 19592.  19181.  12974.  11661.  10404.   9390.   8792.  14812.  18283.  18495.
579.50
 22087.  21644.  14740.  13325.  12059.  10858.  10160.  16828.  20659.  20873.
580.00
 24945.  24465.  16782.  15274.  14010.  12588.  11769.  19148.  23378.  23592.
```

FIGURE A2-1(CONT'D)

580.50									
28224.	27706.	19151.	17524.	16316.	14633.	13668.	21825.	26501.	26709.
581.00									
32002.	31440.	21911.	20176.	19056.	17059.	15916.	24924.	30099.	30293.
581.50									
36368.	35758.	25141.	23301.	22351.	19955.	18592.	28524.	34258.	34428.
582.00									
41439.	40776.	28947.	27005.	26248.	23431.	21794.	32727.	39086.	39217.
7009 16	4								
574.50									
30187.	25701.	13040.	8613.	8330.	8557.	8794.	18203.	31205.	31980.
575.00									
35098.	30113.	15555.	10285.	10060.	10235.	10549.	21452.	36246.	37167.
575.50									
40901.	35344.	18597.	12309.	12179.	12274.	12688.	25319.	42173.	43265.
576.00									
47768.	41558.	28207.	14774.	14782.	14759.	15297.	29926.	49150.	50446.
576.50									
55923.	48967.	26790.	17783.	17993.	17804.	18499.	35430.	57388.	58923.
577.00									
65640.	57820.	32290.	21476.	21973.	21550.	22443.	42019.	67137.	68960.
577.50									
77251.	68436.	39045.	26032.	26926.	26186.	27323.	49934.	78706.	80875.
578.00									
91184.	81216.	47387.	31681.	33128.	31950.	33388.	59465.	92483.	95066.
578.50									
107979.	96661.	57737.	38729.	40936.	39170.	40978.	70993.	108952.	112026.
579.00									
128321.	115430.	70673.	47593.	50849.	48283.	50535.	84991.	128721.	132387.
579.50									
153120.	138370.	86965.	58840.	63536.	59894.	62669.	102085.	152578.	156949.
580.00									
183567.	166618.	107689.	73265.	79958.	74857.	78239.	123090.	181552.	186757.
580.50									
221314.	201728.	134396.	92033.	101502.	94436.	98466.	149125.	217020.	223207.
581.00									
268726.	245934.	175332.	116926.	130283.	120584.	125215.	181779.	260903.	268236.
581.50									

FIGURE A2-1(CONT'D)

329384.	302555.	216461.	150830.	169675.	156482.	161440.	223396.	315981.	324576.
582.00									
405922.	374401.	278298.	195755.	222228.	204105.	209167.	275819.	384588.	394329.
7010 16	4								
574.50									
76.	110.	96.	74.	83.	81.	76.	161.	76.	92.
575.00									
98.	175.	121.	96.	108.	105.	99.	205.	99.	118.
575.50									
127.	221.	155.	126.	141.	137.	130.	263.	129.	153.
576.00									
165.	281.	198.	164.	184.	179.	171.	337.	169.	199.
576.50									
217.	357.	254.	217.	244.	236.	225.	435.	223.	260.
577.00									
286.	458.	329.	286.	322.	312.	300.	562.	297.	341.
577.50									
378.	591.	428.	382.	430.	415.	400.	732.	397.	452.
578.00									
505.	768.	562.	515.	578.	558.	539.	960.	537.	604.
578.50									
684.	1006.	749.	701.	784.	755.	732.	1268.	732.	816.
579.00									
939.	1332.	1008.	967.	1080.	1035.	1008.	1692.	1014.	1116.
579.50									
1311.	1790.	1386.	1361.	1514.	1443.	1412.	2289.	1430.	1556.
580.00									
1882.	2454.	1953.	1968.	2182.	2062.	2032.	3156.	2066.	2223.
580.50									
2825.	3478.	2870.	2985.	3300.	3086.	3059.	4493.	3104.	3309.
581.00									
4321.	5030.	4301.	4577.	5066.	4659.	4681.	6533.	4747.	5037.
581.50									
6273.	7086.	6203.	6660.	7312.	6674.	6763.	9260.	7014.	7317.
582.00									
8464.	9475.	8348.	9032.	9770.	8966.	9063.	12453.	9482.	9849.
7011 16	4								
574.50									

FIGURE A2-1(CONT'D)

1847.	2732.	1006.	757.	359.	297.	454.	1108.	542.	867.
575.00									
2315.	3400.	1317.	962.	476.	399.	603.	1418.	698.	1106.
575.50									
2915.	4248.	1732.	1231.	632.	538.	803.	1824.	902.	1416.
576.00									
3682.	5327.	2287.	1587.	845.	729.	1075.	2357.	1170.	1822.
576.50									
4669.	6708.	3033.	2063.	1137.	994.	1447.	3063.	1528.	2356.
577.00									
5948.	8663.	4043.	2706.	1539.	1367.	1960.	4001.	2008.	3067.
577.50									
7618.	10792.	5421.	3585.	2102.	1895.	2670.	5264.	2657.	4016.
578.00									
9817.	13804.	7316.	4806.	2896.	2654.	3665.	6977.	3545.	5301.
578.50									
12743.	17775.	9958.	6527.	4033.	3763.	5078.	9328.	4776.	7062.
579.00									
16688.	23075.	13688.	9005.	5701.	5425.	7116.	12608.	6516.	9518.
579.50									
22114.	30256.	19057.	12671.	8219.	7983.	10119.	17271.	9035.	13019.
580.00									
29807.	40221.	27009.	18310.	12204.	12122.	14709.	24114.	12839.	18199.
580.50									
41203.	54552.	39292.	27493.	18988.	19304.	22116.	34607.	18873.	26195.
581.00									
57476.	74737.	57764.	41547.	29381.	30332.	33125.	49924.	27672.	37519.
581.50									
77670.	100711.	81775.	59449.	41794.	43606.	47111.	69441.	38304.	51251.
582.00									
100604.	131554.	108451.	78042.	54622.	56603.	62679.	91682.	49879.	66163.
7012 16	4								
574.50									
526.	833.	301.	207.	68.	68.	53.	191.	112.	259.
575.00									
637.	999.	379.	252.	87.	88.	68.	232.	138.	315.
575.50									
774.	1200.	475.	308.	112.	116.	87.	283.	170.	385.

FIGURE A2-1(CONT D)

576.00										
	943.	[illegible]	599.	380.	145.	[illegible]	113.	347.	212.	474.
576.50										
	1154.	1748.	758.	470.	189.	199.	147.	427.	265.	584.
577.00										
	1415.	2120.	964.	585.	247.	263.	192.	529.	336.	724.
577.50										
	1748.	2580.	1230.	735.	326.	351.	255.	659.	429.	903.
578.00										
	2169.	3156.	1580.	931.	433.	472.	341.	829.	555.	1136.
578.50										
	2708.	3882.	2042.	1191.	582.	642.	464.	1053.	728.	1441.
579.00										
	3410.	4807.	2663.	1542.	791.	883.	642.	1355.	972.	1850.
579.50										
	4340.	6004.	3513.	2030.	1096.	1237.	909.	1773.	1326.	2409.
580.00										
	5601.	7590.	4709.	2735.	1560.	1773.	1333.	2378.	1861.	3208.
580.50										
	7381.	9769.	6467.	3818.	2315.	2640.	2053.	3302.	2717.	4408.
581.00										
	9869.	12763.	9011.	5415.	3473.	3969.	3174.	4658.	3999.	6089.
581.50										
	13032.	16562.	12288.	7396.	4900.	5621.	4534.	6318.	5629.	8105.
582.00										
	16652.	20952.	16045.	9561.	6350.	7370.	5794.	8036.	7246.	10274.
7013 16	4									
574.50										
	3629.	2392.	1803.	929.	945.	838.	958.	1807.	3339.	3149.
575.00										
	4493.	2993.	2257.	1190.	1220.	1070.	1247.	2295.	4196.	3945.
575.50										
	5578.	3759.	2833.	1529.	1584.	1374.	1630.	2926.	5290.	4959.
576.00										
	6944.	4736.	3577.	1976.	2069.	1775.	2140.	3745.	6691.	6256.
576.50										
	8670.	5991.	4538.	2566.	2715.	2314.	2826.	4815.	8493.	7924.
577.00										

FIGURE A2-1(CONT'D)

10864.	7610.	5787.	3356.	3590.	3040.	3753.	6221.	10824.	10080.
577.50									
13670.	9718.	7426.	4422.	4787.	4033.	5019.	8081.	13856.	12887.
578.00									
17285.	12479.	9596.	5878.	6443.	5412.	6766.	10568.	17830.	16567.
578.50									
21982.	16135.	12497.	7902.	8776.	7360.	9207.	13929.	23080.	21443.
579.00									
28162.	21036.	16436.	10773.	12128.	10177.	12677.	18532.	30095.	27981.
579.50									
36432.	27724.	21887.	14972.	17069.	14378.	17719.	24964.	39610.	36899.
580.00									
47798.	37109.	29664.	21406.	24674.	20949.	25322.	34239.	52840.	49418.
580.50									
63998.	50764.	41197.	31838.	36992.	31849.	37284.	48104.	71808.	67496.
581.00									
86241.	69712.	57277.	46598.	54848.	47597.	54510.	67417.	97760.	92285.
581.50									
113326.	92921.	77149.	63380.	76003.	65326.	75749.	91431.	130291.	123405.
582.00									
143733.	118554.	98970.	80114.	96439.	82159.	98357.	118681.	168099.	158717.
7 5									
9001 10	5								
598.00									
4768.	5953.	4361.	3740.	5403.	4896.	3910.	7184.	6651.	6632.
598.50									
5366.	6640.	4892.	4257.	6122.	5531.	4487.	8056.	7487.	7401.
599.00									
6048.	7418.	5493.	4854.	6948.	6262.	5160.	9048.	8442.	8273.
599.50									
6826.	8301.	6180.	5547.	7900.	7106.	5947.	10177.	9534.	9266.
600.00									
7717.	9306.	6963.	6352.	9002.	8083.	6869.	11470.	10784.	10401.
600.50									
8741.	10456.	7862.	7291.	10282.	9220.	7956.	12950.	12221.	11701.
601.00									
9921.	11773.	8896.	8393.	11771.	10546.	9242.	14654.	13879.	13196.
601.50									

FIGURE A2-1(CONT'D)

11285.	13221.	10091.	9691.	13516.	12103.	10770.	16621.	15797.	14926.
602.00									
12872.	[illegible]	11492.	11229.	15569.	13941.	12595.	18905.	18028.	16936.
602.50									
14729.	17092.	13111.	13064.	18002.	16127.	14793.	21572.	20635.	19288.
9002 10	5								
598.00									
11471.	11670.	9695.	4052.	3219.	1720.	2656.	9285.	13811.	11192.
598.50									
12933.	13133.	11017.	4700.	3704.	2016.	3061.	10405.	15328.	12585.
599.00									
14604.	14804.	12542.	5461.	4272.	2370.	3538.	11681.	17036.	14172.
599.50									
16519.	16715.	14308.	6357.	4938.	2796.	4104.	13141.	18966.	15984.
600.00									
18719.	18908.	16356.	7417.	5723.	3312.	4775.	14816.	21155.	18056.
600.50									
21254.	21430.	18742.	8675.	6654.	3937.	5577.	16745.	23642.	20433.
601.00									
24185.	24339.	21527.	10173.	7763.	4701.	6541.	18977.	26480.	23169.
601.50									
27587.	27708.	24792.	11963.	9093.	5638.	7707.	21571.	29733.	26328.
602.00									
31552.	31625.	28636.	14117.	10699.	6802.	9126.	24602.	33479.	29993.
602.50									
36198.	36198.	33181.	16722.	12659.	8257.	10869.	28168.	37818.	34263.
9003 10	5								
598.00									
15221.	10316.	10646.	3874.	4412.	2140.	3024.	12389.	22782.	15871.
598.50									
16688.	11286.	11685.	4362.	4980.	2444.	3422.	13576.	24709.	17422.
599.00									
18316.	12364.	12842.	4920.	5632.	2797.	3882.	14895.	26825.	19145.
599.50									
20127.	13566.	14129.	5558.	6379.	3210.	4416.	16364.	29153.	21062.
600.00									
22144.	14909.	15566.	6292.	7242.	3692.	5038.	18005.	31719.	23198.
600.50									

FIGURE A2-1(CONT'D)

24396.	16414.	17173.	7139.	8240.	4258.	5765.	19843.	34554.	25584.
601.00									
26920.	18107.	18976.	8118.	9398.	4927.	6622.	21908.	37696.	28259.
601.50									
29754.	20018.	21004.	9259.	10749.	5721.	7635.	24236.	41186.	31265.
602.00									
32950.	22186.	23278.	10592.	12335.	6669.	8842.	26873.	45081.	34654.
602.50									
36571.	24658.	25888.	12161.	14208.	7808.	10291.	29875.	49443.	38494.
9004 10	5								
598.00									
3542.	8422.	5168.	2484.	799.	521.	524.	1975.	3151.	3596.
598.50									
4269.	9838.	6165.	3003.	991.	664.	669.	2407.	3661.	4258.
599.00									
5162.	11516.	7376.	3641.	1236.	850.	858.	2944.	4454.	5061.
599.50									
6265.	13511.	8860.	4430.	1546.	1093.	1104.	3618.	5332.	6039.
600.00									
7632.	15890.	10686.	5409.	1947.	1411.	1429.	4464.	6415.	7237.
600.50									
9341.	18742.	12945.	6633.	2466.	1833.	1860.	5536.	7760.	8713.
601.00									
11486.	22173.	15756.	8174.	3145.	2398.	2439.	6905.	9445.	10547.
601.50									
14203.	26329.	19280.	10133.	4043.	3162.	3224.	8669.	11577.	12845.
602.00									
17673.	31397.	23734.	12650.	5253.	4213.	4304.	10968.	14303.	15757.
602.50									
22157.	37633.	29417.	15933.	7697.	5682.	5819.	14007.	17837.	19493.
9005 10	5								
598.00									
3684.	2925.	1660.	585.	47.	206.	419.	1769.	1723.	4261.
598.50									
4213.	3364.	1943.	711.	62.	255.	511.	2050.	1978.	4854.
599.00									
4828.	3877.	2281.	867.	83.	316.	626.	2384.	2275.	5548.
599.50									

FIGURE A2-1(CONT'D)

5544.	4479.	2686.	1061.	112.	393.	767.	2780.	2624.	6344.
600.00									
6382.	5108.	3173.	1303.	151.	493.	945.	3256.	3040.	7282.
600.50									
7367.	6025.	3761.	1606.	205.	623.	1171.	3828.	3534.	8384.
601.00									
8529.	7022.	4477.	1991.	284.	792.	1458.	4524.	4130.	9687.
601.50									
9911.	8216.	5357.	2484.	396.	1058.	1830.	5380.	4853.	11240.
602.00									
11566.	9660.	6446.	3125.	562.	1325.	2317.	6445.	5749.	13109.
602.50									
13570.	11427.	7818.	3971.	816.	1756.	2967.	7795.	6875.	15387.
9006 10	5								
598.00									
29480.	19518.	5802.	3960.	1952.	1313.	2320.	9033.	19223.	33040.
598.50									
34864.	23262.	7164.	4856.	2275.	1674.	2948.	10946.	22872.	38992.
599.00									
41322.	27790.	8883.	5963.	2664.	2147.	3754.	13299.	27283.	46145.
599.50									
49093.	33290.	11046.	7359.	3126.	2753.	4800.	16242.	32634.	54766.
600.00									
58459.	39987.	13794.	9111.	3682.	3555.	6163.	19896.	39147.	65190.
600.50									
69807.	48191.	17293.	11330.	4366.	4611.	7948.	24480.	47124.	77872.
601.00									
83634.	58293.	21782.	14162.	5207.	6013.	10302.	30270.	56958.	93390.
601.50									
100511.	70752.	27578.	17799.	6257.	7893.	13449.	37651.	69084.	112469.
602.00									
121258.	86215.	35120.	22527.	7604.	10435.	17677.	47151.	84268.	136053.
602.50									
146845.	105683.	45044.	28745.	9372.	13939.	23434.	59517.	103459.	165589.
9007 10	5								
598.00									
15016.	12912.	13631.	3443.	9048.	7643.	8443.	13511.	16744.	8183.
598.50									

FIGURE A2-1(CONT'D)

	16605.	14284.	15040.	3911.	10038.	8499.	9358.	14742.	18177.	9020.
599.00	18376.	15819.	16614.	4446.	11173.	9466.	10386.	16105.	19759.	9958.
599.50	20361.	17534.	18376.	5065.	12404.	10555.	11543.	17615.	21501.	11007.
600.00	22583.	19458.	20351.	5778.	13822.	11783.	12850.	19294.	23429.	12185.
600.50	25076.	21618.	22570.	6603.	15427.	13178.	14331.	21161.	25566.	13513.
601.00	27878.	24046.	25069.	7560.	17250.	14761.	16010.	23249.	27942.	15014.
601.50	31037.	26785.	27888.	8673.	19323.	16565.	17923.	25583.	30592.	16714.
602.00	34605.	29880.	31568.	9972.	21692.	18628.	20108.	28204.	33556.	18645.
602.50	38644.	33385.	34701.	11492.	24406.	20995.	22614.	31160.	36887.	20852.
603.00	43227.	37371.	38827.	13283.	27529.	23720.	25504.	34505.	40648.	23383.

FIGURE A2-2

CANADIAN EROSION STAGE-DAMAGE CURVE

LAKE HURON

575.00	34538.	13665.	6798.	11866.	601.	3440.	4645.	5152.	19684.	26180.	
575.50	38299.	15780.	7802.	13155.	741.	4041.	5437.	5973.	22244.	29299.	
576.00	42532.	18248.	8975.	14604.	916.	4749.	6373.	6938.	25164.	32836.	
576.50	47310.	21136.	10349.	16238.	1137.	5590.	7484.	8072.	28503.	36854.	
577.00	52715.	24524.	11957.	18086.	1416.	6594.	8803.	9413.	32326.	41434.	
577.50	58851.	28503.	13854.	20187.	1767.	7792.	10375.	10998.	36721.	46663.	
578.00	65841.	33190.	16098.	22578.	2215.	9228.	12255.	12879.	41778.	52653.	
578.50	73834.	38725.	18765.	25316.	2787.	10950.	14510.	15124.	47618.	59533.	01
579.00	83014.	45283.	21951.	28464.	3521.	13022.	17225.	17810.	54381.	67465.	
579.50	93609.	53075.	25784.	32099.	4470.	15526.	20512.	21042.	62242.	76638.	
580.00	105904.	62372.	30419.	36331.	5707.	18570.	24504.	24946.	71415.	87295.	
580.50	120248.	73506.	36071.	41288.	7328.	22286.	29386.	29695.	82169.	99732.	
581.00	137106.	86905.	43019.	47141.	9475.	26846.	35395.	35512.	94847.	114326.	
581.50	157059.	103120.	51640.	54131.	12346.	32485.	42857.	42697.	109883.	131561.	
582.00	180898.	122869.	62463.	62576.	16234.	39527.	52205.	51662.	127865.	152070.	
582.50	209667.	147126.	76241.	72951.	21584.	48424.	64074.	63002.	149589.	176708.	
583.00	244838.	177244.	94087.	85957.	29100.	59861.	79399.	77593.	176181.	206679.	
575.00	1800.	810.	285.	460.	0.	0.	140.	225.	870.	1150.	
575.50	2100.	980.	350.	540.	0.	120.	170.	280.	1050.	1400.	
576.00	2450.	1180.	440.	620.	0.	145.	220.	360.	1250.	1650.	
576.50	2850.	1450.	540.	720.	0.	185.	270.	450.	1500.	1950.	
577.00	3207.	1740.	676.	848.	128.	229.	340.	572.	1826.	2370.	
577.50	3856.	2098.	828.	986.	167.	288.	430.	714.	2195.	2808.	
578.00	4509.	2535.	1018.	1149.	216.	364.	544.	894.	2644.	3336.	
578.50	5289.	3070.	1255.	1345.	283.	462.	692.	1123.	3194.	3976.	02
579.00	6225.	3727.	1553.	1582.	371.	588.	883.	1416.	3868.	4755.	
579.50	7354.	4538.	1931.	1869.	489.	752.	1131.	1791.	4700.	5708.	
580.00	8722.	5540.	2410.	2222.	648.	968.	1456.	2275.	5728.	6878.	
580.50	10389.	6786.	3024.	2658.	863.	1252.	1884.	2903.	7008.	8322.	
581.00	12433.	8341.	3815.	3204.	1160.	1632.	2452.	3722.	8608.	10117.	
581.50	14958.	10296.	4844.	3897.	1570.	2143.	3214.	4801.	10622.	12362.	
582.00	18100.	12768.	6196.	4787.	2147.	2842.	4247.	6232.	13178.	15192.	
582.00	22046.	15923.	7991.	5955.	2971.	3814.	5664.	8153.	16452.	18795.	
583.00	27059.	19995.	10416.	7522.	4174.	5196.	7654.	10770.	20701.	23436.	
575.00	3897.	2743.	914.	409.	406.	163.	275.	882.	2203.	2816.	
575.50	3528.	3103.	1068.	487.	479.	196.	330.	1040.	2543.	3213.	
576.00	4023.	3514.	1249.	582.	567.	238.	396.	1228.	2939.	3672.	
576.50	4592.	3986.	1462.	697.	674.	288.	478.	1452.	3401.	4201.	
577.00	5249.	4527.	1715.	836.	802.	351.	577.	1719.	3941.	4814.	
577.50	6006.	5149.	2015.	1005.	959.	428.	699.	2039.	4574.	5525.	04
578.00	6883.	5867.	2372.	1211.	1149.	525.	849.	2423.	5316.	6351.	
578.50	7898.	6695.	2797.	1462.	1382.	646.	1035.	2884.	6189.	7312.	
579.00	9077.	7655.	3306.	1771.	1669.	797.	1264.	3440.	7219.	8436.	
579.50	10448.	8770.	3915.	2152.	2024.	987.	1550.	4112.	8434.	9750.	
580.00	12048.	10068.	4649.	2623.	2464.	1229.	1907.	4926.	9879.	11294.	
580.50	13918.	11587.	5535.	3209.	3014.	1538.	2356.	5918.	11594.	13114.	
581.00	16113.	13369.	6610.	3942.	3706.	1934.	2924.	7129.	13642.	15266.	
581.50	18696.	15470.	7919.	4863.	4583.	2449.	3647.	8616.	16095.	17822.	
582.00	21748.	17960.	9525.	6032.	5703.	3123.	4577.	10452.	19047.	20874.	
582.50	25373.	20930.	11508.	7527.	7149.	4016.	5784.	12733.	22623.	24538.	
583.00	29704.	24498.	13978.	9461.	9041.	5222.	7374.	15593.	26982.	28973.	

575.00	5000.	5000.	1570.	460.	420.	215.	360.	1250.	3300.	4900.	
575.50	5850.	5550.	1850.	580.	545.	270.	440.	1510.	3900.	5700.	
576.00	6800.	6400.	2200.	840.	800.	330.	540.	1820.	4650.	6600.	
576.50	8000.	7400.	2600.	1050.	980.	420.	670.	2200.	5600.	7600.	
577.00	9100.	8600.	3100.	1300.	1200.	520.	830.	2700.	6700.	8900.	
577.50	10900.	9900.	3650.	1600.	1490.	640.	1010.	3200.	7990.	10100.	
578.00	12896.	11558.	4309.	1991.	1824.	803.	1269.	3908.	9550.	11816.	
578.50	14987.	13329.	5134.	2442.	2222.	1000.	1571.	4736.	11278.	13772.	
579.00	17443.	15398.	6132.	3002.	2717.	1250.	1951.	5751.	13343.	16084.	05
579.50	20337.	17826.	7340.	3701.	3337.	1570.	2431.	6998.	15817.	18821.	
580.00	23754.	20680.	8809.	4577.	4114.	1980.	3041.	8536.	18789.	22072.	
580.50	27800.	24048.	10601.	5680.	5099.	2509.	3818.	10437.	22371.	25946.	
581.00	32602.	28035.	12798.	7075.	6351.	3196.	4816.	12798.	26702.	30580.	
581.50	38322.	32774.	15502.	8851.	7954.	4096.	6104.	15740.	31956.	36143.	
582.00	45160.	38435.	18948.	11124.	10025.	5284.	7780.	19425.	38359.	42852.	
582.50	53367.	45231.	23013.	14056.	12720.	6867.	9977.	24068.	46198.	50986.	
583.00	63265.	53443.	28236.	17873.	16268.	9005.	12890.	29954.	55852.	60906.	

LAKE ST-CLAIR

570.00	220.	170.	0.	0.	0.	0.	0.	0.	0.	110.	
570.50	330.	260.	0.	0.	0.	0.	0.	0.	150.	180.	
571.00	500.	400.	110.	0.	0.	0.	0.	0.	230.	280.	
571.50	760.	620.	180.	120.	0.	0.	0.	150.	370.	440.	
572.00	1160.	960.	290.	200.	110.	130.	160.	250.	580.	700.	
572.50	1770.	1500.	480.	320.	180.	210.	260.	410.	920.	1100.	
573.00	2700.	2310.	780.	520.	310.	350.	460.	680.	1460.	1750.	
573.50	4050.	3580.	1300.	840.	520.	590.	780.	1140.	2300.	2800.	
574.00	6195.	5592.	2172.	1388.	865.	986.	1368.	1891.	3681.	4385.	
574.50	9474.	8609.	3500.	2192.	1488.	1629.	2273.	3138.	5773.	6879.	03
575.00	14643.	13396.	5692.	3500.	2575.	2715.	3862.	5270.	9132.	10902.	
575.50	22931.	21040.	9434.	5692.	4506.	4606.	6658.	8911.	14543.	17459.	
576.00	36448.	33471.	15911.	9514.	8066.	7985.	11666.	15207.	23433.	28361.	
576.50	59076.	54068.	27557.	16393.	14824.	14241.	20879.	26410.	38379.	46887.	
577.00	98441.	89409.	49502.	29649.	28442.	26511.	38660.	47008.	64407.	79875.	
577.50	172261.	154299.	95363.	58895.	59801.	54168.	76656.	88524.	114070.	142693.	
578.00	328229.	290373.	208527.	139917.	149552.	132535.	173126.	189298.	229084.	278043.	
570.00	180.	150.	0.	0.	0.	0.	0.	0.	0.	110.	
570.50	280.	240.	0.	0.	0.	0.	0.	0.	150.	180.	
571.00	440.	370.	100.	0.	0.	0.	0.	0.	230.	280.	
571.50	700.	580.	170.	100.	0.	0.	0.	150.	370.	460.	
572.00	1100.	920.	290.	170.	130.	120.	150.	250.	600.	730.	
572.50	1710.	1450.	480.	270.	210.	190.	250.	440.	960.	1180.	
573.00	2720.	2300.	780.	450.	370.	320.	450.	730.	1540.	1900.	04
573.50	4320.	3600.	1300.	740.	630.	520.	780.	1250.	2480.	3020.	
574.00	6767.	5698.	2192.	1205.	1096.	877.	1370.	2164.	3918.	4876.	
574.50	10602.	8904.	3589.	2000.	1890.	1479.	2383.	3616.	6301.	7808.	
575.00	16766.	14109.	6000.	3288.	3260.	2548.	4137.	6109.	10137.	12602.	
575.50	26793.	22547.	10164.	5561.	5671.	4438.	7287.	10465.	16547.	20574.	
576.00	43340.	36546.	17479.	9616.	10109.	7945.	13068.	18109.	27259.	33998.	
576.50	71257.	60216.	30820.	17095.	18437.	14602.	23917.	31834.	45560.	57038.	
577.00	119994.	101530.	56217.	31697.	34957.	28081.	45121.	57285.	77750.	98269.	
577.50	212483.	179060.	110488.	64928.	72819.	59696.	91119.	109009.	139692.	177636.	
578.00	407433.	344778.	247057.	157280.	176622.	149199.	206703.	234099.	288617.	350641.	

LAKE ERIE

567.50	60.	60.	42.	32.	16.	13.	17.	36.	55.	43.	
568.00	75.	76.	54.	42.	22.	18.	23.	47.	70.	55.	
568.50	94.	95.	69.	55.	29.	24.	30.	62.	89.	70.	
569.00	122.	121.	88.	73.	40.	32.	41.	81.	114.	91.	
569.50	151.	154.	114.	98.	54.	45.	56.	107.	147.	118.	
570.00	193.	198.	149.	131.	75.	62.	77.	142.	190.	154.	
570.50	247.	255.	194.	176.	104.	86.	106.	190.	248.	203.	
571.00	319.	332.	257.	239.	145.	121.	148.	255.	325.	269.	01
571.50	416.	435.	342.	328.	205.	172.	208.	347.	430.	360.	
572.00	548.	577.	463.	454.	294.	250.	297.	477.	577.	489.	
572.50	734.	776.	636.	639.	431.	371.	431.	668.	787.	679.	
573.00	1004.	1068.	897.	921.	653.	570.	646.	958.	1097.	966.	
573.50	1398.	1501.	1296.	1357.	1024.	904.	996.	1400.	1555.	1387.	
574.00	1937.	2109.	1854.	1990.	1560.	1392.	1489.	2021.	2188.	1948.	
574.50	2599.	2870.	2544.	2800.	2233.	1995.	2102.	2806.	2980.	2640.	
575.00	3364.	3724.	3320.	3730.	2953.	2629.	2795.	3720.	3889.	3420.	
567.50	900.	930.	850.	320.	115.	120.	150.	420.	690.	570.	
568.00	1190.	1230.	1100.	440.	170.	170.	210.	570.	910.	740.	
568.50	1550.	1620.	1450.	610.	240.	230.	300.	770.	1190.	990.	
569.00	2058.	2183.	1895.	842.	345.	324.	418.	1050.	1571.	1308.	
569.50	2676.	2843.	2473.	1153.	487.	454.	587.	1417.	2058.	1735.	
570.00	3493.	3717.	3236.	1586.	693.	639.	829.	1919.	2715.	2310.	02
570.50	4577.	4883.	4256.	2195.	990.	908.	1175.	2615.	3596.	3088.	
571.00	6027.	6442.	5627.	3051.	1423.	1296.	1674.	3587.	4792.	4153.	
571.50	7977.	8546.	7483.	4271.	2058.	1868.	2404.	4946.	6424.	5612.	
572.00	10622.	11403.	10017.	6024.	3003.	2715.	3475.	6869.	8673.	7634.	
572.50	14246.	15326.	13507.	8567.	4420.	3993.	5067.	9617.	11803.	10468.	
573.00	19274.	20760.	18375.	12302.	6587.	5951.	7465.	13595.	16207.	14488.	
573.50	26370.	28404.	25268.	17878.	9953.	9018.	11140.	19443.	22507.	20297.	
574.00	36607.	39350.	35218.	26385.	15333.	13970.	16919.	28231.	31703.	28931.	
574.50	51888.	55473.	50027.	39777.	24287.	22337.	26367.	41914.	45598.	42341.	
575.00	75815.	80307.	73303.	62105.	40437.	37749.	42925.	64466.	67681.	64481.	
567.50	84.	90.	63.	47.	28.	21.	22.	48.	80.	67.	
568.00	107.	114.	81.	63.	38.	28.	29.	63.	104.	86.	
568.50	136.	145.	104.	84.	51.	38.	40.	84.	134.	111.	
569.00	174.	186.	135.	112.	69.	53.	55.	113.	175.	145.	
569.50	223.	240.	176.	152.	95.	73.	77.	151.	229.	189.	
570.00	287.	310.	231.	206.	131.	102.	107.	204.	301.	248.	03
570.50	372.	404.	305.	282.	182.	143.	151.	278.	397.	329.	
571.00	486.	530.	407.	390.	256.	204.	214.	381.	528.	439.	
571.50	640.	702.	549.	543.	363.	295.	309.	529.	709.	593.	
572.00	855.	943.	751.	767.	525.	435.	452.	744.	962.	813.	
572.50	1163.	1289.	1050.	1106.	778.	660.	680.	1071.	1331.	1144.	
573.00	1630.	1817.	1521.	1646.	1227.	1054.	1070.	1595.	1897.	1670.	
573.50	2319.	2602.	2245.	2486.	1901.	1704.	1699.	2399.	2716.	2428.	
574.00	3223.	3644.	3204.	3645.	2806.	2574.	2544.	3496.	3788.	3390.	
574.50	4301.	4899.	4347.	5049.	3880.	3551.	3546.	4803.	5095.	4529.	
575.00	5498.	6297.	5597.	6600.	5029.	4559.	4599.	6220.	6563.	5772.	

567.50	4123.	6510.	3038.	955.	0.	326.	282.	673.	868.	1107.	
568.00	5317.	8138.	3906.	1259.	0.	456.	391.	890.	1128.	1454.	
568.50	7053.	10091.	4991.	1606.	0.	608.	521.	1172.	1476.	1910.	
569.00	8789.	12586.	6293.	2105.	0.	803.	716.	1519.	1888.	2517.	
569.50	11284.	15624.	8029.	2713.	217.	1063.	955.	1996.	2430.	3298.	
570.00	14756.	19313.	10199.	3537.	326.	1432.	1302.	2604.	3147.	4340.	
570.50	19096.	23870.	13020.	4557.	456.	1910.	1736.	3429.	4123.	5685.	
571.00	24521.	30163.	16601.	5968.	651.	2582.	2387.	4492.	5317.	7595.	
571.50	31465.	37324.	21266.	7595.	955.	3450.	3255.	5859.	6944.	9982.	05
572.00	41013.	46438.	27125.	9982.	1345.	4557.	4340.	7704.	8897.	13020.	
572.50	53165.	57505.	34286.	12912.	1931.	6076.	5859.	9982.	11284.	16926.	
573.00	68776.	71951.	43973.	16631.	2801.	8170.	7940.	13050.	14841.	22347.	
573.50	87167.	88727.	55580.	21654.	3984.	10885.	10742.	17267.	19085.	29479.	
574.00	111104.	110149.	70768.	28440.	5746.	14580.	14639.	23041.	24773.	39182.	
574.50	142489.	137810.	90893.	37795.	8402.	19777.	20240.	31009.	32452.	52462.	
575.00	184066.	173930.	117887.	50904.	12473.	27199.	28412.	42213.	43107.	70942.	
567.50	1250.	1450.	610.	240.	200.	140.	300.	645.	1600.	1750.	
568.00	1550.	1800.	780.	320.	250.	180.	390.	820.	2000.	2150.	
568.50	1920.	2200.	980.	410.	340.	240.	500.	1050.	2440.	2600.	
569.00	2400.	2700.	1250.	520.	440.	315.	650.	1300.	3000.	3250.	
569.50	2950.	3350.	1580.	570.	560.	410.	840.	1650.	3660.	4000.	
570.00	3600.	4200.	2000.	860.	720.	530.	1100.	2100.	4500.	4950.	06
570.50	4500.	5100.	2500.	1100.	920.	700.	1400.	2640.	5500.	6000.	
571.00	5550.	6400.	3200.	1400.	1200.	900.	1800.	3320.	6700.	7400.	
571.50	6800.	7800.	4000.	1800.	1500.	1150.	2350.	4200.	8200.	9200.	
572.00	8548.	9745.	5141.	2295.	1942.	1514.	3111.	5284.	10025.	11277.	
572.50	10480.	11991.	6463.	2958.	2498.	1960.	3952.	6704.	12300.	13884.	
573.00	12895.	14806.	8156.	3827.	3233.	2555.	5045.	8538.	15146.	17150.	
573.50	15927.	18347.	10334.	4983.	4204.	3350.	6476.	10919.	18727.	21256.	
574.00	19755.	22827.	13154.	6525.	5505.	4422.	8369.	14035.	23265.	26457.	
574.50	24621.	28531.	16841.	8613.	7268.	5892.	10898.	18137.	29064.	33091.	
575.00	30868.	35856.	21705.	11474.	9685.	7933.	14320.	23603.	36537.	41626.	
567.50	1350.	1350.	700.	300.	230.	190.	350.	780.	1620.	1590.	
568.00	1670.	1700.	8[illegible]0.	380.	290.	235.	440.	960.	2000.	1980.	
568.50	2020.	2100.	1100.	480.	370.	300.	560.	1200.	2490.	2480.	
569.00	2500.	2620.	1370.	610.	440.	370.	720.	1500.	3050.	3050.	
569.50	3100.	3300.	1700.	760.	590.	480.	910.	1860.	3800.	3850.	
570.00	3800.	4100.	2100.	960.	750.	600.	1180.	2300.	4700.	4800.	07
570.50	4600.	5100.	2600.	1210.	960.	760.	1500.	2800.	5800.	6000.	
571.00	5700.	6400.	3300.	1520.	1210.	950.	1900.	3600.	7200.	7400.	
571.50	7000.	7900.	4050.	1910.	1520.	1200.	2800.	4400.	8800.	9200.	
572.00	8521.	9937.	5027.	2423.	1951.	1521.	3073.	5485.	10964.	11684.	
572.50	10492.	12239.	6333.	3098.	2504.	1959.	3888.	6928.	13414.	14377.	
573.00	12968.	15125.	8013.	3983.	3232.	2543.	4946.	8789.	16476.	17749.	
573.50	16091.	18759.	10185.	5150.	4198.	3319.	6325.	11201.	20322.	22000.	
574.00	20054.	23359.	13007.	6704.	5490.	4368.	8142.	14349.	25187.	27387.	
574.50	25126.	29218.	15705.	8792.	7240.	5797.	10556.	18491.	31384.	34264.	
575.00	31660.	36732.	21590.	11639.	9638.	7776.	13808.	23998.	39350.	43123.	

567.50	320.	315.	160.	110.	0.	0.	0.	145.	320.	360.	
568.00	375.	370.	195.	135.	0.	0.	0.	170.	380.	430.	
568.50	440.	430.	240.	165.	0.	0.	0.	220.	460.	520.	
569.00	530.	510.	290.	200.	0.	0.	0.	270.	540.	620.	
569.50	630.	600.	360.	250.	0.	0.	0.	335.	650.	740.	
570.00	743.	700.	435.	303.	86.	62.	119.	410.	774.	888.	
570.50	892.	834.	530.	373.	110.	79.	153.	509.	922.	1063.	
571.00	1072.	996.	648.	460.	141.	100.	197.	633.	1102.	1275.	08
571.50	1290.	1193.	795.	569.	181.	128.	255.	790.	1320.	1534.	
572.00	1557.	1432.	976.	706.	232.	165.	331.	987.	1585.	1849.	
572.50	1884.	1724.	1203.	879.	300.	213.	431.	1238.	1910.	2235.	
573.00	2285.	2083.	1487.	1097.	390.	277.	564.	1556.	2309.	2709.	
573.50	2782.	2525.	1845.	1374.	509.	362.	741.	1964.	2803.	3296.	
574.00	3398.	3074.	2298.	1730.	670.	477.	980.	2489.	3417.	4027.	
574.50	4170.	3761.	2876.	2190.	888.	634.	1304.	3169.	4189.	4942.	
575.00	5143.	4630.	3620.	2790.	1189.	854.	1748.	4059.	5167.	6101.	
567.50	1750.	1300.	930.	520.	190.	0.	200.	680.	2000.	2100.	
568.00	2100.	1550.	1100.	640.	240.	120.	250.	820.	2400.	2500.	
568.50	2500.	1850.	1350.	780.	335.	160.	335.	1000.	2800.	3000.	
569.00	2900.	2200.	1600.	960.	415.	205.	415.	1210.	3300.	3500.	
569.50	3450.	2640.	1800.	1180.	520.	270.	520.	1500.	3900.	4075.	
570.00	4051.	3208.	2264.	1444.	624.	346.	610.	1794.	4527.	4856.	09
570.50	4779.	3809.	2711.	1764.	780.	440.	764.	2195.	5360.	5744.	
571.00	5647.	4532.	3253.	2160.	978.	562.	959.	2691.	6359.	6806.	
571.50	6684.	5400.	3912.	2650.	1229.	720.	1207.	3304.	7560.	8078.	
572.00	7927.	6446.	4714.	3259.	1548.	924.	1523.	4067.	9008.	9607.	
572.50	9420.	7710.	5694.	4018.	1956.	1193.	1928.	5017.	10759.	11448.	
573.00	11219.	9241.	6897.	4967.	2480.	1548.	2450.	6206.	12883.	13674.	
573.50	13395.	11102.	8378.	6161.	3156.	2017.	3124.	7698.	15469.	16372.	
574.00	16035.	13373.	10208.	7668.	4031.	2643.	4001.	9580.	18608.	19655.	
574.50	19252.	16154.	12482.	9579.	5174.	3484.	5149.	11964.	22510.	23670.	
575.00	23191.	19577.	15323.	12021.	6679.	4623.	6663.	15001.	27298.	28602.	
567.50	520.	390.	270.	145.	0.	0.	0.	170.	550.	610.	
568.00	610.	460.	320.	180.	0.	0.	0.	210.	660.	720.	
568.50	720.	550.	380.	220.	120.	0.	100.	260.	780.	860.	
569.00	841.	657.	450.	273.	149.	83.	124.	311.	920.	1013.	
569.50	989.	779.	536.	336.	185.	107.	155.	382.	1093.	1196.	
570.00	1165.	925.	641.	415.	232.	137.	195.	471.	1301.	1414.	10
570.50	1376.	1102.	768.	513.	291.	177.	246.	583.	1551.	1676.	
571.00	1629.	1315.	923.	636.	366.	229.	312.	724.	1855.	1992.	
571.50	1935.	1574.	1114.	792.	462.	298.	397.	901.	2224.	2374.	
572.00	2305.	1889.	1350.	989.	586.	390.	507.	1126.	2675.	2838.	
572.50	2756.	2274.	1643.	1240.	746.	512.	652.	1414.	3227.	3403.	
573.00	3309.	2747.	2010.	1562.	956.	675.	844.	1782.	3907.	4097.	
573.50	3990.	3332.	2473.	1977.	1234.	897.	1100.	2259.	4750.	4953.	
574.00	4837.	4061.	3063.	2518.	1605.	1201.	1445.	2881.	5802.	6019.	
574.50	5901.	4978.	3825.	3230.	2110.	1624.	1918.	3700.	7125.	7356.	
575.00	7253.	6147.	4824.	4182.	2812.	2224.	2581.	4796.	8808.	9056.	

567.50	126.	101.	71.	48.	25.	16.	23.	57.	146.	155.	
568.00	152.	123.	88.	61.	33.	21.	30.	72.	177.	188.	
568.50	184.	151.	108.	78.	42.	28.	39.	92.	217.	229.	
569.00	224.	185.	134.	100.	55.	37.	52.	117.	266.	279.	
569.50	273.	227.	167.	129.	73.	51.	69.	151.	327.	341.	
570.00	334.	281.	210.	166.	96.	69.	91.	195.	405.	419.	
570.50	412.	348.	264.	216.	128.	95.	123.	253.	503.	517.	
571.00	511.	435.	336.	284.	172.	132.	166.	332.	628.	643.	11
571.50	640.	549.	432.	376.	235.	187.	229.	440.	791.	806.	
572.00	811.	700.	564.	505.	328.	268.	322.	590.	1006.	1023.	
572.50	1051.	911.	756.	694.	477.	401.	468.	810.	1300.	1322.	
573.00	1396.	1215.	1046.	981.	720.	620.	707.	1145.	1718.	1749.	
573.50	1867.	1623.	1435.	1380.	1051.	926.	1044.	1609.	2283.	2339.	
574.00	2434.	2116.	1896.	1880.	1454.	1309.	1456.	2192.	2973.	3057.	
574.50	3045.	2672.	2420.	2465.	1904.	1748.	1919.	2879.	3785.	3855.	
575.00	3709.	3279.	3019.	3110.	2364.	2199.	2401.	3636.	4704.	4732.	
567.50	1666.	1224.	653.	441.	59.	62.	103.	270.	525.	1137.	
568.00	2070.	1529.	833.	566.	84.	84.	140.	354.	662.	1445.	
568.50	2579.	1914.	1066.	730.	112.	112.	196.	466.	836.	1843.	
569.00	3222.	2405.	1367.	942.	155.	152.	273.	618.	1066.	2358.	
569.50	4043.	3033.	1768.	1224.	214.	208.	382.	827.	1370.	3030.	
570.00	5090.	3838.	2293.	1597.	301.	286.	538.	1109.	1777.	3912.	
570.50	6442.	4879.	2996.	2097.	423.	398.	761.	1504.	2327.	5074.	
571.00	8188.	6227.	3940.	2772.	603.	556.	1084.	2057.	3086.	6625.	13
571.50	10475.	7992.	5220.	3692.	864.	789.	1563.	2846.	4142.	8704.	
572.00	13495.	10326.	6976.	4959.	1258.	1134.	2275.	3984.	5609.	11525.	
572.50	17535.	13439.	9412.	6734.	1864.	1662.	3353.	5646.	7688.	15409.	
573.00	23023.	17656.	12852.	9266.	2818.	2495.	5022.	8070.	10720.	20823.	
573.50	30586.	23479.	17811.	12983.	4381.	3869.	7685.	11733.	15263.	28557.	
574.00	41163.	31717.	25173.	18669.	7110.	6308.	12122.	17519.	22218.	39924.	
574.50	56514.	43901.	36636.	27994.	12342.	11162.	20049.	27317.	33236.	57092.	
575.00	79841.	63120.	55979.	45038.	23722.	22326.	35455.	45318.	51570.	83411.	
567.50	906.	901.	375.	344.	241.	118.	276.	592.	1072.	830.	
568.00	1096.	1080.	467.	434.	309.	152.	344.	722.	1287.	1005.	
568.50	1329.	1298.	584.	548.	397.	197.	431.	884.	1550.	1218.	
569.00	1613.	1564.	730.	695.	511.	255.	540.	1083.	1871.	1480.	
569.50	1965.	1889.	917.	883.	661.	333.	679.	1332.	2264.	1804.	
570.00	2399.	2289.	1155.	1125.	855.	437.	857.	1644.	6045.	2203.	14
570.50	2937.	2783.	1458.	1440.	1109.	575.	1085.	2037.	3344.	2697.	
571.00	3605.	3395.	1849.	1850.	1444.	761.	1379.	2533.	4083.	3310.	
571.50	4440.	4159.	2351.	2385.	1887.	1010.	1761.	3163.	5002.	4078.	
572.00	5488.	5117.	3004.	3087.	2474.	1350.	2259.	3969.	6150.	5040.	
572.50	6808.	6326.	3853.	4016.	3259.	1813.	2911.	5003.	7593.	6254.	
573.00	8480.	7864.	4969.	5250.	4311.	2452.	3776.	6342.	9418.	7795.	
573.50	10614.	9834.	6444.	6903.	5733.	3340.	4932.	8086.	11741.	9767.	
574.00	13355.	12384.	8414.	9135.	7671.	4588.	6490.	10380.	14721.	12315.	
574.50	16907.	15722.	11074.	12178.	10341.	6361.	8621.	13428.	18580.	15646.	
575.00	21561.	20148.	14717.	16372.	14065.	8924.	11580.	17529.	23635.	20056.	

LAKE ONTARIO

241.00	8103.	7654.	2854.	895.	710.	576.	1044.	2044.	5345.	5392.	
241.50	9747.	9226.	3535.	1129.	908.	746.	1329.	2549.	6588.	6576.	
242.00	11755.	11153.	4386.	1429.	1164.	969.	1701.	3188.	8143.	8217.	
242.50	14217.	13516.	5461.	1814.	1498.	1265.	2186.	4001.	10085.	10183.	
243.00	17245.	16430.	6821.	2313.	1934.	1659.	2821.	5040.	12523.	12658.	
243.50	20987.	20039.	8549.	2957.	2507.	2184.	3658.	6374.	15592.	15780.	
244.00	25629.	24527.	10755.	3802.	3262.	2890.	4771.	8093.	19468.	19738.	
244.50	31421.	30139.	13589.	4909.	4270.	3847.	6260.	10327.	24386.	24782.	
245.00	38683.	37198.	17251.	6378.	5621.	5152.	8268.	13246.	30653.	31239.	
245.50	47853.	46134.	22022.	8340.	7451.	6955.	11006.	17093.	38679.	39562.	
246.00	59518.	57539.	28295.	10995.	9963.	9471.	14778.	22213.	49028.	50367.	01
246.50	74495.	72230.	36637.	14644.	13466.	13041.	20059.	29108.	62473.	64526.	
247.00	93958.	91385.	47907.	19767.	18469.	18215.	27588.	38538.	80114.	83297.	
247.50	119674.	116778.	63486.	27200.	25884.	25978.	38637.	51734.	103601.	108609.	
248.00	154642.	151371.	85944.	38677.	37730.	38498.	55739.	70988.	135649.	143726.	
248.50	203345.	199540.	119153.	56989.	57183.	59020.	82921.	99932.	180372.	193565.	
249.00	268656.	264177.	164352.	82126.	83586.	87133.	120722.	139781.	240664.	261221.	
249.50	351170.	346190.	220338.	112100.	114905.	121337.	168713.	189872.	317386.	346744.	
250.00	448766.	443783.	284167.	144278.	148591.	158900.	223688.	248776.	409170.	448145.	
250.50	558918.	553081.	353460.	176862.	182249.	197080.	279832.	313453.	515509.	562701.	
251.00	679075.	668841.	426225.	209249.	214073.	229897.	328551.	377560.	633382.	685652.	
251.50	801627.	782362.	495123.	239156.	242485.	255212.	367434.	432795.	753734.	809003.	
252.00	917499.	886759.	554675.	263048.	263827.	273587.	397023.	480014.	867932.	920712.	
241.00	1642.	2849.	1374.	322.	56.	86.	109.	364.	1220.	1851.	
241.50	1871.	3208.	1555.	378.	70.	105.	136.	428.	1399.	2114.	
242.00	2137.	3620.	1764.	445.	88.	130.	170.	506.	1606.	2421.	
242.50	2446.	4094.	2007.	525.	111.	161.	214.	599.	1848.	2778.	
243.00	2809.	4642.	2290.	622.	141.	200.	269.	712.	2132.	3195.	
243.50	3236.	5277.	2621.	739.	178.	249.	340.	848.	2465.	3686.	
244.00	3739.	6017.	3011.	881.	227.	313.	432.	1016.	2859.	4263.	
244.50	4338.	6882.	3473.	1054.	291.	395.	551.	1222.	3325.	4947.	
245.00	5053.	7899.	4023.	1267.	373.	502.	706.	1478.	3882.	5761.	
245.50	5915.	9101.	4683.	1532.	482.	642.	911.	1798.	4550.	6735.	
246.00	6960.	10532.	5483.	1863.	628.	829.	1182.	2202.	5357.	7908.	02
246.50	8240.	12247.	6462.	2282.	824.	1080.	1547.	2719.	6341.	9331.	
247.00	9825.	14320.	7676.	2822.	1092.	1423.	2043.	3389.	7552.	11073.	
247.50	11816.	16856.	9203.	3530.	1467.	1900.	2732.	4275.	9064.	13228.	
248.00	14356.	20001.	11168.	4486.	2007.	2584.	3711.	5477.	10983.	15929.	
248.50	17673.	23980.	13774.	5834.	2825.	3602.	5148.	7169.	13479.	19381.	
249.00	22154.	29182.	17411.	7891.	4181.	5241.	7387.	9707.	16856.	23927.	
249.50	28401.	36141.	22626.	11095.	6409.	7884.	10934.	13601.	21549.	30049.	
250.00	36665.	44970.	29307.	15144.	9155.	11252.	15695.	18610.	27659.	37889.	
250.50	46491.	55186.	36698.	19109.	12003.	15029.	21005.	24069.	34707.	47562.	
251.00	57078.	66615.	44636.	23166.	14737.	18774.	26383.	29701.	42246.	57863.	
251.50	67777.	79057.	52874.	27470.	17319.	22157.	31429.	35186.	50201.	69068.	
252.00	78339.	92133.	60989.	31596.	19639.	24906.	35535.	40087.	58163.	80461.	

241.00	5816.	9185.	5023.	1174.	173.	374.	501.	1642.	3751.	6775.	
241.50	6713.	10392.	5750.	1405.	222.	462.	632.	1953.	4329.	7811.	
242.00	7776.	11790.	6606.	1691.	288.	574.	801.	2333.	5014.	9030.	
242.50	9045.	13418.	7621.	2049.	377.	718.	1022.	2802.	5830.	10471.	
243.00	10568.	15327.	8833.	2500.	497.	905.	1312.	3386.	6809.	12183.	
243.50	12412.	17580.	10294.	3075.	661.	1150.	1698.	4122.	7995.	14230.	
244.00	14662.	20262.	12075.	3820.	892.	1478.	2220.	5061.	9444.	16693.	
244.50	17438.	23490.	14273.	4800.	1221.	1924.	2934.	6277.	11237.	19682.	
245.00	20904.	27422.	17032.	6113.	1701.	2547.	3931.	7883.	13488.	23347.	
245.50	25299.	32292.	20563.	7915.	2425.	3448.	5361.	10055.	16367.	27901.	
246.00	30985.	38455.	25208.	10468.	3564.	4812.	7477.	13087.	20140.	33660.	
246.50	38548.	46505.	31564.	14267.	5490.	7031.	10772.	17522.	25270.	41150.	03
247.00	49020.	57485.	40739.	20295.	9020.	10948.	16246.	24407.	32614.	51288.	
247.50	63407.	72240.	53421.	28934.	14159.	16799.	24457.	34458.	42753.	64754.	
248.00	81779.	90416.	69246.	39427.	19791.	23146.	34409.	46671.	55359.	81375.	
248.50	102166.	110651.	86059.	50414.	24886.	28612.	44126.	59144.	69237.	100089.	
249.00	122628.	131196.	101948.	60729.	28768.	32878.	52353.	70575.	83028.	119974.	
249.50	143043.	150886.	116539.	69009.	31623.	36597.	58564.	79939.	96192.	140377.	
250.00	162714.	169053.	129651.	75039.	33644.	39864.	63323.	87608.	108034.	160735.	
250.50	181139.	186539.	141950.	79819.	34947.	42280.	67151.	94021.	118221.	180640.	
251.00	197544.	203407.	153096.	83997.	35709.	43917.	70301.	99446.	127006.	199259.	
251.50	210978.	219447.	163790.	87664.	36264.	45507.	72832.	104482.	135065.	215729.	
252.00	221589.	235005.	173548.	90907.	36689.	46943.	74498.	109265.	142614.	229879.	
241.00	13687.	2674.	2655.	927.	277.	253.	718.	6608.	2296.	10698.	
241.50	15003.	2999.	3012.	1086.	327.	291.	839.	7195.	2606.	11667.	
242.00	16457.	3370.	3420.	1275.	385.	335.	982.	7846.	2962.	12733.	
242.50	18068.	3792.	3890.	1499.	455.	389.	1150.	8569.	3371.	13907.	
243.00	19853.	4274.	4431.	1766.	539.	452.	1350.	9376.	3841.	15201.	
243.50	21835.	4826.	5055.	2085.	641.	527.	1587.	10280.	4383.	16631.	
244.00	24039.	5459.	5779.	2467.	763.	617.	1870.	11294.	5010.	18213.	
244.50	26493.	6188.	6618.	2927.	913.	727.	2209.	12436.	5735.	19967.	05
245.00	29232.	7029.	7597.	3481.	1095.	860.	2614.	13727.	6579.	21915.	
245.50	32295.	8005.	8742.	4153.	1320.	1024.	3103.	15194.	7562.	24085.	
246.00	35729.	9142.	10086.	4970.	1599.	1228.	3694.	16868.	8712.	26509.	
246.50	39590.	10472.	11672.	5970.	1947.	1483.	4412.	18789.	10064.	29224.	
247.00	43943.	12038.	13556.	7200.	2386.	1807.	5291.	21008.	11659.	32280.	
247.50	48871.	13894.	15807.	8725.	2947.	2225.	6374.	23589.	13553.	35734.	
248.00	54473.	16114.	18520.	10633.	3673.	2773.	7722.	26619.	15818.	39664.	
248.50	60878.	18798.	21824.	13048.	4632.	3512.	9421.	30215.	18550.	44170.	
249.00	68254.	22091.	25903.	16150.	5928.	4538.	11599.	34543.	21884.	49392.	
249.50	76833.	26215.	31036.	20222.	7748.	6029.	14460.	39859.	26017.	55535.	
250.00	86985.	31563.	37708.	25768.	10467.	8368.	18389.	46606.	31276.	62949.	
250.50	99178.	38651.	46585.	33513.	14624.	12098.	23915.	55396.	38103.	72081.	
251.00	113526.	47476.	57732.	43550.	19955.	16879.	30948.	66243.	46649.	83002.	
251.50	129921.	57632.	70748.	55142.	25735.	21874.	38864.	78751.	56621.	95291.	
252.00	148233.	68420.	84963.	67491.	31652.	26454.	47357.	92546.	67619.	108439.	

241.00	21098.	4416.	4434.	1726.	529.	453.	1318.	9897.	3922.	16188.	
241.50	22918.	4907.	4973.	1995.	615.	517.	1517.	10711.	4400.	17510.	
242.00	24913.	5460.	5584.	2308.	716.	593.	1749.	11609.	4943.	18954.	
242.50	27102.	6083.	6278.	2675.	835.	682.	2020.	12603.	5558.	20532.	
243.0[illegible]	29506.	6787.	7070.	3107.	977.	786.	2336.	13704.	6259.	22259.	
243[illegible]	32152.	7585.	7974.	3615.	1147.	911.	2707.	14930.	7057.	24151.	
244[illegible]	35067.	8491.	9010.	4215.	1349.	1061.	3142.	16297.	7968.	26229.	
244.[illegible]	38285.	9523.	10199.	4926.	1594.	1241.	3655.	17827.	9012.	28515.	
245.00	41842.	10702.	11570.	5772.	1890.	1459.	4262.	19546.	10210.	31035.	
245.50	45784.	12055.	13157.	6781.	2252.	1727.	4982.	21487.	11590.	33820.	
246.00	50161.	13613.	15000.	7991.	2695.	2058.	5841.	23687.	13185.	36906.	
246.50	55035.	15417.	17151.	9449.	3244.	2471.	6872.	26195.	15036.	40337.	
247.00	60479.	17516.	19678.	11218.	3930.	2994.	8116.	29073.	17194.	44166.	06
247.50	66580.	19978.	22666.	13379.	4799.	3666.	9631.	32398.	19724.	48462.	
248.00	73450.	22889.	26229.	16045.	5914.	4545.	11493.	36275.	22711.	53311.	
248.50	81229.	26373.	30525.	19371.	7374.	5725.	13814.	40847.	26270.	58828.	
249.00	90104.	30607.	35782.	23593.	9340.	7362.	16762.	46321.	30561.	65177.	
249.50	100350.	35883.	42363.	29091.	12104.	9754.	20626.	53029.	35830.	72613.	
250.00	112343.	42607.	50795.	36439.	16117.	13371.	25832.	61449.	42420.	81479.	
250.50	126173.	50806.	61167.	45742.	21260.	18016.	32342.	71641.	50470.	91822.	
251.00	141682.	60072.	73084.	56394.	26839.	22966.	39649.	83268.	59701.	103246.	
251.50	158815.	69799.	85966.	67763.	32508.	27629.	47504.	95996.	69740.	115503.	
252.00	177454.	79949.	99611.	79756.	37977.	31763.	55590.	109266.	80455.	128568.	
241.00	15300.	3100.	0.	0.	0.	0.	0.	6050.	5450.	14500.	
241.50	17800.	3710.	0.	0.	0.	0.	0.	7000.	6540.	16800.	
242.00	20456.	4508.	2932.	1312.	513.	540.	867.	8040.	7728.	19114.	
242.50	23443.	5397.	3569.	1658.	663.	678.	1099.	9270.	9135.	22085.	
243.00	26922.	6476.	4356.	2104.	857.	859.	1399.	10720.	10825.	25552.	
243.50	30980.	7791.	5329.	2673.	1111.	1094.	1787.	12444.	12858.	29612.	
244.00	35733.	9394.	6542.	3409.	1445.	1399.	2290.	14502.	15313.	34372.	
244.50	41313.	11360.	8057.	4363.	1888.	1801.	2944.	16974.	18291.	39972.	
245.00	47891.	13781.	9963.	5605.	2479.	2331.	3801.	19964.	21913.	46579.	
245.50	55672.	16771.	12367.	7232.	3271.	3041.	4927.	23601.	26339.	54397.	
246.00	64921.	20490.	15422.	9377.	4341.	3995.	6423.	28060.	31777.	63684.	07
246.50	75963.	25138.	19335.	12224.	5798.	5297.	8418.	33580.	38485.	74760.	
247.00	89226.	30990.	24385.	16037.	7808.	7096.	11108.	40473.	46816.	88040.	
247.50	105254.	38420.	30973.	21194.	10612.	9616.	14771.	49179.	57239.	104053.	
248.00	124779.	47954.	39672.	28256.	14592.	13212.	19833.	60323.	70380.	123494.	
248.50	148789.	60345.	51339.	38074.	20364.	18470.	26951.	74818.	87127.	147310.	
249.00	178682.	76748.	67320.	52012.	28990.	26399.	37207.	94063.	108762.	176825.	
249.50	216565.	99056.	89899.	72426.	42485.	38943.	52520.	120368.	137258.	214023.	
250.00	266029.	130934.	123639.	104074.	65490.	60551.	76915.	158101.	176055.	262228.	
250.50	332483.	177803.	175651.	154643.	105614.	98741.	117066.	214323.	230556.	326268.	
251.00	418027.	240107.	245898.	224944.	159481.	150912.	172944.	290647.	302612.	408643.	
251.50	522058.	313996.	330149.	308047.	218639.	207348.	237519.	382861.	391165.	508625.	
252.00	641714.	395029.	420726.	397167.	275903.	261955.	302856.	483015.	494155.	623147.	

241.00	376.	350.	211.	311.	336.	226.	219.	374.	527.	433.
241.50	435.	416.	256.	372.	402.	273.	262.	431.	603.	494.
242.00	504.	495.	311.	447.	483.	332.	314.	499.	692.	564.
242.50	585.	590.	380.	539.	581.	403.	377.	580.	796.	646.
243.00	681.	705.	465.	651.	701.	492.	453.	675.	919.	742.
243.50	796.	845.	570.	788.	848.	601.	547.	789.	1063.	854.
244.00	932.	1015.	701.	957.	1029.	736.	662.	924.	1234.	986.
244.50	1095.	1223.	864.	1167.	1252.	904.	805.	1088.	1438.	1142.
245.50	1292.	1477.	1069.	1428.	1530.	1114.	981.	1285.	1681.	1326.
245.50	1530.	1791.	1328.	1754.	1876.	1377.	1202.	1526.	1973.	1546.
246.00	1820.	2180.	1658.	2165.	2310.	1710.	1478.	1820.	2326.	1810.
246.50	2176.	2664.	2079.	2685.	2858.	2132.	1828.	2184.	2755.	2128.
247.00	2617.	3271.	2622.	3349.	3555.	2671.	2274.	2637.	3282.	2514.
247.50	3169.	4040.	3331.	4205.	4449.	3368.	2847.	3208.	3933.	2989.
248.00	3871.	5023.	4266.	5322.	5608.	4276.	3595.	3938.	4746.	3581.
248.50	4778.	6298.	5523.	6803.	7134.	5480.	4586.	4890.	5779.	4332.
249.00	5984.	7988.	7254.	8807.	9181.	7112.	5932.	6164.	7119.	5315.
249.50	7668.	10309.	9737.	11617.	12019.	9415.	7841.	7966.	8935.	6681.
250.00	10115.	13605.	13433.	15706.	16093.	12782.	10650.	10605.	11471.	8630.
250.50	13343.	17934.	18469.	21285.	21635.	17310.	14394.	14094.	14688.	11090.
251.00	17035.	23088.	24578.	28157.	28468.	22772.	18990.	18192.	18532.	13804.
251.50	21054.	28937.	31314.	35883.	36155.	28920.	24158.	22626.	22966.	16662.
252.00	25394.	35309.	38176.	44040.	44347.	35497.	29574.	27296.	27863.	19780.

08

FIGURE A2-3

U.S. INUNDATION STAGE-DAMAGE CURVES

1 REACH 2001

245.30	.1
245.50	21.0
246.00	206.3
246.50	630.3
247.00	1214.8
247.50	1893.8
248.00	2634.8
248.50	3417.0
249.00	4281.3

2 REACH 2002

246.00	.1
246.25	15003.0
246.50	33539.6
246.75	56478.7
247.00	86484.8
247.25	120903.0
247.50	165912.1
247.75	220633.6
248.00	283291.2
248.25	379488.3
248.50	489800.4
248.75	612470.1
249.00	746619.0

3 REACH 2003

245.25	.1
245.50	1566.2
246.00	5796.8
246.50	12338.6
247.00	21544.8
247.50	33052.5
248.00	46222.0
248.50	60766.6
249.00	75683.7

4 REACH 2004

238.00	.1
299.00	.2

5 REACH 2005

245.50	.1
245.75	2626.2
246.00	5835.0
246.25	9769.6
246.50	14582.8
246.75	20417.9
247.00	27704.5
247.25	36013.0
247.50	45200.1
247.75	55552.3
248.00	66926.4
248.25	78739.7
248.50	91135.6
248.75	103818.0
249.00	116939.7

6 REACH 3001

570.75	.1
571.00	4689.0
571.50	9387.6
572.00	17829.8
572.50	23932.3
573.00	35659.7
573.50	52553.6
574.00	109796.3
574.50	189090.0
575.00	287168.5
575.50	401673.0
576.00	5161[illegible]7.5
576.50	640041.0
576.67	703835.0
577.20	879793.7

7 REACH 3002

572.00	.4
572.35	64940.0
572.85	123004.0
573.35	166552.0
573.85	209336.0
574.35	320880.0
574.85	650164.0
575.35	747192.0
575.85	844984.0
576.30	949652.0
576.67	1084116.0
577.20	1354572.0

8 REACH 3003

570.60	.3
571.00	1758.0
571.40	3846.0
571.80	6480.0
572.30	12966.0
573.00	25908.0
573.60	38862.0
574.10	51822.0
574.48	66000.0
575.00	90180.0
575.50	120060.0

9 REACH 3004

573.00	.1
573.50	27083.8

FIGURE A2-3(CONT'D)

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574.00   57653.3
574.50   92167.0
575.00  135409.4
575.50  186072.2
576.00  241548.1
576.50  300519.4
577.00  360359.7

10 REACH 4001
575.00        .1
575.10    6939.0
575.20   17657.9
575.30   27752.3
575.40   41628.4
575.50   57405.0
575.60   76323.6
575.70  104706.2
575.80  154538.1
575.90  257362.9
576.00  324222.5
576.10  353235.4
576.20  378466.5
576.30  403697.6
576.40  427668.1
576.50  454159.8
576.60  482551.9
576.70  518498.1
576.80  568330.0
576.90  618161.9
577.00  667363.5
577.10  720356.5
577.20  779662.0

11 REACH 4002
575.00        .1
575.10    1838.4
575.20    4679.5
575.30    7353.5

575.40   11030.2
575.50   15208.4
575.60   20222.1
575.70   27742.7
575.80   40945.6
575.90   68187.0
576.00   85902.2
576.10   93590.0
576.20  100275.0
576.30  106960.0
576.40  113310.7
576.50  120330.0
576.60  159365.6
576.70  137376.7
576.80  150579.6
576.90  163782.5
577.00  176818.2
577.10  190856.7
577.20  206566.5

12 REACH 5001
579.00        .1
579.25    4555.3
579.50   11756.0
579.75   17829.8
580.00   29967.9
580.25   40969.5
580.50   54626.0
580.75   72073.8
581.00   93704.6
581.25  117598.7
581.50  144911.7
581.75  171088.2
582.00  203711.0

13 REACH 5002
579.00        .1
579.25      80.2

579.50     208.2
579.75     315.1
580.00     530.0
580.25     725.8
580.50     964.5
580.75    1274.9
581.00    1656.9
581.25    2081.9
581.50    2559.4
581.75    3027.3
582.00    3600.3

14 REACH 5003
579.20        .1
579.40     601.6
579.60    1260.6
579.80    2053.2
580.00    2865.0
580.25    4096.9
580.50    5672.7
580.75    7563.6
581.00    9769.6
581.25   12415.0
581.50   15375.5
581.75   18593.8
582.00   22060.5

15 REACH 5004
579.40        .1
579.60    7105.2
579.80   14134.0
580.00   21678.5
580.25   33291.3
580.50   44913.6
580.75   57051.7
581.00   70746.4
581.50  100752.5
582.00  133604.5
```

582.50	169799.0
583.00	208094.5
583.50	249255.0
584.00	290415.5
584.50	332053.5

16 REACH 5005

579.40	.1
579.60	1021.8
579.80	1995.9
580.00	3208.8
580.25	4755.9
580.50	6532.2
580.75	8423.1
581.00	10390.4
581.50	14697.4
582.00	19338.7
582.50	24705.8
583.00	30407.2
583.50	36337.7
584.00	42306.5
584.50	48351.6

17 REACH 5006

579.20	.1
579.40	923.5
579.60	1944.4
579.80	3161.0
580.00	4421.6
580.25	6322.1
580.50	8747.8
580.75	11670.1
581.00	15069.9
581.25	19147.7
581.50	23722.2
581.75	28679.6
582.00	34026.6

FIGURE A2-3(CONT'D)

18 REACH 7001

579.00	.1
579.25	178.6
579.50	462.2
579.75	701.0
580.00	1177.5
580.25	1609.2
580.50	2148.7
580.75	2831.6
581.00	3681.5
581.25	4622.2
581.50	5691.8
581.75	6723.2
582.00	8002.9

19 REACH 7002

578.00	.1
578.50	115.6
579.00	299.9
579.50	552.0
580.00	909.2
580.50	1365.6
581.00	1943.4
581.50	2731.3
582.00	3676.7

20 REACH 7003

578.00	.1
578.50	2737.0
579.00	7298.1
579.50	13532.3
580.00	22041.4
580.50	33148.0
581.00	46069.2
581.50	62944.0
582.00	83619.8
582.50	106425.2

21 REACH 7004

578.00	.1
578.50	9.5
579.00	24.8
579.50	46.8
580.00	76.4
580.50	114.6
581.00	159.5
581.50	217.7
582.00	289.4
582.50	367.7

22 REACH 7005

500.00	.1
800.00	0.2

23 REACH 7006

578.50	.1
579.00	5281.1
579.50	13780.6
580.00	25264.5
580.50	39045.2
581.00	56268.6
581.50	76944.3
582.00	101516.5
582.50	129765.4
583.00	160774.2

24 REACH 7007

578.00	.1
578.50	81.2
579.00	221.6
579.50	437.4
580.00	748.7
580.50	1136.4
581.00	1594.8
581.50	2096.2
582.00	2621.5

FIGURE A2-3(CONT'D)

```
25 REACH 7008
500.00        .1
900.00       0.2

26 REACH 7009
578.00        .1
578.50     464.1
579.00    1237.7
579.50    2294.9
580.00    3713.0
580.50    5621.1
581.00    7812.9
581.50   10648.2
582.00   14153.1
582.50   18049.5

27 REACH 7010
577.50        .1
578.00     111.7
578.50     266.4
579.00     472.7
579.50     735.3
580.00    1069.6
580.50    1452.6
581.00    1921.5
581.50    2449.6
582.00    3008.2

28 REACH 7011
577.50        .1
578.00     608.3
578.50    1450.6
579.00    2573.7
579.50    4001.4
580.00    5825.5
580.50    7908.4
581.00   10457.2
581.50   13341.3
582.00   16378.2

29 REACH 7012
578.00        .1
578.50     619.8
579.00    1606.3
579.50    2958.6
580.00    4875.3
580.50    7324.8
581.00   10423.8
581.50   14649.7
582.00   19720.7

30 REACH 7013
578.00        .1
578.50     640.8
579.00    1660.7
579.50    3058.9
580.00    5039.5
580.50    7573.1
581.00   10777.2
581.50   15146.3
582.00   20389.2

31 REACH 9001
600.00        .1
600.50      98.4
601.00     260.7
601.50     475.6
602.00     781.2
602.50    1175.6
603.00    1677.0
603.50    2334.0
604.00    3141.9

32 REACH 9002
600.25        .1
600.50    2767.6
601.00   10676.9
601.50   21349.0
602.00   36571.7
602.50   56932.3
603.00   83424.0
603.50  118611.0

33 REACH 9003
600.00        .1
600.50    1010.4
601.00    2635.8
601.50    4964.1
602.00    8346.7
602.50   12653.7
603.00   18316.9
603.50   25918.7

34 REACH 9004
600.00        .1
600.50     255.0
601.00     664.7
601.50    1252.0
602.00    2104.8
602.50    3190.7
603.00    4619.3
603.50    6536.0

35 REACH 9005
600.00        .1
600.50     219.6
601.00     573.0
601.50    1079.1
602.00    1814.5
602.50    2750.4
603.00    3982.3
603.50    5634.5
```

FIGURE A2-3(CONT'D)

36 REACH 9006	
600.00	.1
600.50	50.6
601.00	132.7
601.50	250.2
602.00	421.2
602.50	637.9
603.00	923.5
603.50	1307.4
37 REACH 9007	
600.00	.1
600.50	768.8
601.00	2005.5
601.50	3777.0
602.00	6350.7
602.50	9626.4
603.00	13938.2
603.50	19720.7

FIGURE A2-4

CANADIAN INUNDATION STAGE-DAMAGE CURVES

(GREAT LAKES)

LAKE HURON

579.50	.00	
580.00	.01	
580.50	0.02	
581.00	11842.60	
581.50	54947.34	01
582.00	141027.05	
582.50	278757.15	
583.00	477495.84	
579.50	0.00	
580.00	971.36	
580.50	3885.45	
581.00	9272.09	03
581.50	18768.47	
582.00	33798.09	
582.50	55038.23	
583.00	83581.26	
579.50	0.00	
580.00	686.46	
580.50	2745.85	
581.00	6614.38	04
581.50	13263.71	
582.00	23644.28	
582.50	38147.37	
583.00	57880.06	
579.50	.00	
580.00	.01	
580.50	0.02	
581.00	3995.80	05
581.50	18850.38	
582.00	49607.29	
582.50	100006.83	
583.00	173790.71	
579.50	.00	
580.00	.01	
580.50	.02	
581.00	0.03	06
581.50	4401.75	
582.00	17255.83	
582.50	40399.71	
583.00	76034.64	
579.50	.00	
580.00	.01	
580.50	.02	
581.00	0.03	07
581.50	9244.24	
582.00	33784.71	
582.50	75761.70	
583.00	138960.91	

LAKE ST. CLAIR

575.50	0.00	
576.00	19517.33	
576.50	91487.47	
577.00	243633.91	
577.50	481723.12	
578.00	794000.36	DR4
578.50	1174699.13	
579.00	1639455.48	
575.50	0.00	
576.00	15327.01	
576.50	87582.92	
577.00	301762.97	01
577.50	691506.98	
578.00	1232530.57	
578.50	1900947.50	
579.00	2699942.61	
575.00	0.00	
575.50	4525.65	
576.00	32584.69	
576.50	115609.81	
577.00	265779.14	02
577.50	476921.34	
578.00	742289.06	
578.50	1061964.59	
575.00	0.00	
575.50	2306.02	
576.00	23060.21	
576.50	86580.60	03
577.00	220120.16	
577.50	431749.97	
578.00	718430.28	
578.50	1077540.60	
575.50	0.00	
576.00	10618.09	
576.50	70079.38	
577.00	228771.54	04
577.50	516039.09	
578.00	934391.77	
578.50	1479582.34	
579.00	2163773.34	

LAKE ERIE

574.50	0.00		574.00	0.00	
575.00	3388.42		574.50	21508.82	
575.50	15345.09		575.00	78604.96	
576.00	38678.24		575.50	175590.19	
576.50	73976.21		576.00	391318.33	
577.00	122638.91		576.50	726820.38	
577.50	185544.78		577.00	1214128.48	Pelee
578.00	264607.29	DR2	577.50	1872938.32	Island
578.50	364724.62		578.00	2732935.63	
579.00	489181.58		578.50	3803826.03	
579.50	636414.34		579.00	5175697.71	
580.00	803680.74		579.50	6871659.33	
574.50	0.00		571.00	0.00	
575.00	2576.98		571.50	129.43	
575.50	11670.33		572.00	1347.09	
576.00	29415.78		572.50	5041.37	
576.50	56260.78		573.00	11293.54	
577.00	93270.00		573.50	19445.79	
577.50	141111.50		574.00	29263.07	
578.00	201240.54		574.50	40839.50	05
578.50	277382.30	DR1	575.00	54884.17	
579.00	372034.97		575.50	72419.10	
579.50	484009.21		576.00	93068.51	
580.00	611219.53		576.50	115464.85	
573.00	0.00		574.00	0.00	
573.50	4181.29		574.50	1849.22	
574.00	18935.73		575.00	17572.05	
574.50	47728.67		575.50	64125.59	
575.00	91286.12		576.00	142516.51	
575.50	151335.55		576.50	244747.85	
576.00	228960.94		577.00	367975.00	06
576.50	326523.52	01	577.50	513593.52	
577.00	450067.58		578.00	690569.62	
577.50	603646.58		578.50	911314.16	
578.00	785330.76		579.00	1174534.54	
578.50	991736.30		579.50	1465494.08	
571.50	0.00		573.00	0.00	
572.00	943.44		573.50	2706.61	
572.50	5494.63		574.00	12962.59	
573.00	13887.71		574.50	35850.96	
573.50	25769.82		575.00	71778.86	
574.00	42663.68		575.50	120085.60	
574.50	65525.36	02	576.00	181278.01	
575.00	95604.06		576.50	258409.01	07
575.50	134979.92		577.00	362258.10	
576.00	183310.88		577.50	495356.72	
576.50	238667.04		578.00	652301.14	
577.00	301566.24		578.50	828327.27	
570.50	0.00		571.50	0.00	
571.00	19.13		572.00	48.52	
571.50	166.37		572.50	194.18	
572.00	453.38		573.00	463.50	
572.50	857.39		573.50	885.24	
573.00	1387.13		574.00	1514.41	
573.50	2033.41	03	574.50	2405.74	09
574.00	2805.02		575.00	3643.33	
574.50	3784.60		575.50	5315.34	
575.00	4981.10		576.00	7467.72	
575.50	6316.07		576.50	10148.46	
576.00	7775.80		577.00	13418.41	
574.00	0.00		574.00	0.00	
574.50	3708.56		574.50	6476.07	
575.00	29880.03		575.00	25914.87	
575.50	104705.13		575.50	61859.40	
576.00	256483.38		576.00	118144.63	
576.50	486979.70		576.50	202113.82	
577.00	796119.41	04	577.00	321070.73	
577.50	1185227.32		577.50	486239.84	11
578.00	1661079.08		578.00	709388.11	
578.50	2240134.67		578.50	996644.72	
579.00	2934352.44		579.00	1354418.30	
579.50	3730310.06		579.50	1790926.82	

LAKE ERIE

572.50	0.00	
573.00	201.04	
573.50	804.50	
574.00	1920.35	
574.50	3667.66	
575.00	6274.39	
575.50	9967.26	
576.00	15094.74	12
576.50	22022.12	
577.00	30939.66	
577.50	42046.32	
578.00	55594.11	
573.50	0.00	
574.00	3348.12	
574.50	17092.63	
575.00	44705.12	
575.50	90173.78	
576.00	157946.67	
576.50	260949.23	
577.00	407543.92	13
577.50	601547.82	
578.00	845409.65	
578.50	1138844.61	
579.00	1482464.74	
573.00	0.00	
573.50	842.12	
574.00	2867.61	
574.50	6068.34	
575.00	10716.26	
575.50	17068.61	
576.00	25358.32	14
576.50	36418.09	
577.00	50751.20	
577.50	68161.14	
578.00	88890.36	
578.50	113088.08	
572.00	0.00	
572.50	106.93	
573.00	407.20	
573.50	941.82	
574.00	1759.13	
574.50	2937.65	
575.00	4502.09	
575.50	6573.77	15
576.00	9309.42	
576.50	12716.49	
577.00	16802.54	
577.50	21607.01	

LAKE ONTARIO

245.00	0.00	
245.50	345.03	
246.00	1380.10	
246.50	3293.43	
247.00	5985.68	
247.50	9369.02	
248.00	13449.27	
248.50	18475.38	01
249.00	24733.01	
249.50	32195.32	
250.00	40601.52	
245.00	0.00	
245.50	292.51	
246.00	1170.02	
246.50	2789.05	
247.00	5327.42	
247.50	8964.35	
248.00	13866.31	02
248.50	20415.55	
249.00	29025.35	
249.50	39833.37	
250.00	52967.58	
248.00	0.00	
248.50	2201.60	
249.00	8902.10	
249.50	21302.39	
250.00	40846.99	
250.50	75341.55	
251.00	134471.36	
251.50	227416.97	03
252.00	362906.45	
252.50	551086.29	
253.00	814277.01	
248.00	0.00	
248.50	6311.99	
249.00	25247.94	
249.50	60701.63	
250.00	122427.94	
250.50	223132.81	
251.00	379846.30	
251.50	625378.46	05
252.00	1016311.73	
252.50	1565167.60	
253.00	2276208.73	
244.50	0.00	
245.00	1201.61	
245.50	4806.44	
246.00	11469.93	
246.50	21747.34	
247.00	40900.30	
247.50	84449.60	06
248.00	155435.70	
248.50	253367.01	
249.00	399581.25	
249.50	630499.98	
245.50	0.00	
246.00	605.80	
246.50	2423.19	
247.00	5782.61	
247.50	11032.85	
248.00	29390.34	07
248.50	62719.20	
249.00	106805.55	
249.50	161737.84	
250.00	227771.40	
250.50	305119.85	
248.00	0.00	
248.50	45192.31	
249.00	181464.50	
249.50	434162.18	
250.00	849172.94	08
250.50	1445268.96	
251.00	2211578.81	
251.50	3209538.73	
252.00	4614482.25	
252.50	6526843.73	
253.00	9000853.95	
248.00	0.00	
248.50	70472.97	
249.00	281304.62	
249.50	670934.74	
250.00	1318004.76	
250.50	2236288.95	09
251.00	3419647.62	
251.50	4942557.89	
252.00	6886277.23	
252.50	9267783.22	
253.00	12128452.04	
247.00	0.00	
247.50	15665.46	
248.00	62661.85	
248.50	149533.95	
249.00	284826.57	
249.50	477084.51	12
250.00	734852.56	
250.50	1078068.58	
251.00	1528094.57	
251.50	2092051.18	
252.00	2775634.96	

FIGURE A2-5

U.S. HISTORIC RISE DATA

20 GAUGE 2030 2003, 2004, 2005

2030	1958	35	50	20	39	55	52	35	51	53	57	75	73
2030	1959	82	54	55	50	43	31	55	50	57	58	46	53
2030	1960	49	68	30	77	27	31	61	54	64	69	75	67
2030	1961	55	103	48	80	61	31	36	51	40	70	71	87
2030	1962	71	52	76	64	60	53	42	36	67	42	47	46
2030	1963	56	67	63	69	114	44	40	89	73	56	45	53
2030	1964	85	55	82	52	63	49	25	40	50	64	44	34
2030	1965	35	53	38	55	35	27	16	20	22	89	89	39
2030	1966	86	56	55	41	69	74	41	41	41	44	27	50
2030	1967	38	82	28	54	37	26	23	36	40	52	35	32
2030	1968	68	51	62	23	28	36	23	49	47	61	42	64
2030	1969	54	53	40	53	36	22	50	51	60	47	81	64
2030	1970	45	41	76	84	50	42	41	63	52	61	64	60
2030	1971	52	75	72	47	34	22	41	46	35	63	50	75
2030	1972	133	63	65	58	35	28	78	56	56	88	49	82
2030	1973	65	36	73	37	40	53	60	52	74	99	63	69
2030	1974	113	73	79	47	53	41	74	53	58	65	40	34
2030	1975	95	70	73	58	19	36	32	43	32	41	51	42
2030	1976	92	83	90	43	39	43	48	54	59	72	41	70
2030	1977	51	51	95	42	33	29	23	33	29	43	53	69

20 GAUGE 2058 2001, 2002

2058	1956	31	81	49	112	62	32	62	47	48	56	35	25
2058	1958	24	35	36	31	37	43	35	47	32	61	26	22
2058	1959	21	15	65		53	45	53	49	55	47	45	57
2058	1960	21	43	39	89	27	37	38	59	66	49	29	47
2058	1961	41	103	55	51	44	19	27	31	30	41	25	22
2058	1962	25	38	53	50	27	14	34	38	65	49	61	27
2058	1963	69	41	103	67	86	58	25	45	65	81	47	68
2058	1965	43	36	63	71	59	63	44	48	58	45	60	49
2058	1966	62	37	61	44	54	50	49	41	38	58	64	38
2050	1967	50	62	36	48	53	38	30	39	42	36	40	61
2058	1968	42	25	85	59	36	67	24	87	34	66	64	35
2050	1969	38	41	12	73	57	40	56	61	58	55	52	32
2058	1970	30	35	57	93	60	59	19	58	42	51	30	31

FIGURE A2-5(CONT'D)

2058	1971	37	37	43	51	47	57	46	45	34	90	37	72
2058	1972	49	32	48	58	51	46	50	47	52	51	102	89
2058	1973	50	22	90	29	45	55	54	49	65	79	36	47
2058	1974	60	26	64	68	73	35	61	55	63	57	35	55
2058	1975	52	57	53	33	28	26	25	34	28	40	21	39
2058	1976	60	67	75	43	29	28	36	45	62	40	43	23
2058	1977	28	25	87	32	30	30	30	45	37	32	24	67
20 GAUGE 3038		3004											
3038	1958				155	052	107	083	069	135	146	189	146
3038	1959	257	108	329	168	65	54	94	63	92	201	160	109
3038	1960	153	147	97	150	76	118	113	69	76	139	154	128
3038	1961	81	163	65	192	71	101	56	102	166	79	156	248
3038	1962	173	185	076	124	080	082	108	064	131	112	183	175
3038	1963	170	056	136	139	091	094	116	166	115	089	165	226
3038	1964	206	083	286	102	134	090	074	080	121	171	281	150
3038	1965	245	119	147	094	074	072	138	124	097	153	335	078
3038	1966	172	121	117	092	069	112	077	071	174	173	208	180
3038	1967	133	402	093	147	079	081	061	115	080	341	194	134
3038	1968	195	126	149	126	089	079	056	086	083	131	168	341
3038	1969	174	098	099	074	162	082	088	069	065	126	185	143
3038	1970	146	062	226	265	088	095	102	084	144	428	236	213
3038	1971	296	159	200	131	126	106	055	074	119	087	131	210
3038	1972	163		105	066	036		064	061	077	102	173	240
3038	1973	088	109	197	143	062	085	087	061	103	140	211	184
3038	1974	153	088	169	146	081	090	092	094	154	107	190	166
3038	1975	173	201	166	206	067	075	056	051	106	071	364	279
3038	1976	143	120	169	062	116	069	070	085	118	163	096	154
3038	1977	179	101	171	158	085	077	095	065	150	137	145	225
20 GAUGE 3063		3003											
3063	1958	077	059	049	062	066	102	062	111	117	108	111	067
3063	1959	098	071	075	175	107	056	093	068	108	082	097	108
3063	1960	078	084	102	083	053	065	096	093	201	101	109	120
3063	1961	066	212	093	122	093	115	095	161	077	079	077	075
3063	1962	123	129	064	105	053	102	092	132	105	101	171	105
3063	1963	094	055	083	120	098	186	064	097	120	096	094	084
3063	1964	102	060	107	059	071	108	134	145	056	136	104	130
3063	1965	138	118	068	054	072	084	094	093	119	111	143	138
3063	1966	073	064	074	105	125	121	102	123	090	144	135	068

FIGURE A2-5(CONT'D)

3063	1967	109	095	070	078	120	055	057	085	084	094	095	081
3063	1968	074	070	087	083	062	135	048	158	090	084	096	101
3063	1969	061	032	050	130	072	061	049	044	048	068	068	111
3063	1970	064	062	064	073	065	047	063	052	062	058	091	135
3063	1971	066	098	069	076	048	064	053	069	047	063	091	127
3063	1972	093	066	064	071	054	099	105	048	083	091	185	081
3063	1973	119	056	117	090	038	097	068	043	068	069	098	062
3063	1974	073	063	067	083	060	070	076	038	089	120	121	135
3063	1975	071	054	074	108	065	105	049	079	054	092	111	094
3063	1976	132	084	088	101	080	060	057	063	136	104	083	086
3063	1977	079	060	132	078	098	085	064	063	069	080	061	183
20 GAUGE 3085		3001, 3002											
3085	1958	173	194	192	179	125	125	143	163	157	207	245	154
3085	1959	100	228	303	168	123	119	145	140	162	194	207	242
3085	1960	193	285	245	171	129	125	220	118	156	158	155	301
3085	1961	188	130	373	248	136	328	077	146	106	127	129	206
3085	1962	262	157	240	155	124	186	194	132	136	118	251	232
3085	1963	131	057	155	266	150	102	137	138	251	128	155	183
3085	1964	396	129	368	192	138	206	139	147	147	125	151	294
3085	1965	327	184	330	186	099	202	137	135	137	293	211	335
3085	1966	277	110	171	533	138	144	126	125	309	169	228	230
3085	1967	314	249	139	150	210	146	101	135	157	218	235	232
3085	1968	126	128	188	114	164	272	156	129	093	103	281	217
3085	1969	149	131	196	271	123	135	196	082	143	183	104	252
3085	1970	114	120	239	266	120	130	143	122	184	144	178	277
3085	1971	208	316	159	157	133	170	125	146	105	150	218	285
3085	1972	163	120	253	266	165	091	130	183	136	153	385	235
3085	1973	287	200	188	331	149	282	378	083	135	228	172	186
3085	1974	179	136	276	355	184	142	145	114	166	163	314	372
3085	1975	194	200	394	271	071	123	116	154	360	346	210	262
3085	1976	164	164	239	381	178	138	100	133	155	124	126	175
3085	1977	159	095	305	181	287	230	129	134	116	172	207	441
20 GAUGE 4052		4001, 4002											
4052	1957	088	083	058	073	045	019	033	029	014	036	050	067
4052	1958	33	50	58	67	23	28	21	41	41	31	53	53
4052	1959	67	23	83	36	32	24	28	44	38	49	50	57
4052	1960	67	63	77	45	39	51	19	18	57	44	46	31
4052	1961	36	57	67	70	28	49	20	20	39	32	50	42

FIGURE A2-5(CONT'D)

4052	1962	92	52	55	49	34	49	37	42	31	31	28	45
4052	1964	59	58	38	30	77	69	22	28	20	32	50	52
4052	1965	57	46	39	32	37	22	24	21	30	37	23	39
4052	1965	85	76	89	35	25	34	21	38	32	38	37	59
4052	1966	63	45	48	104	24	26	41	26	51	39	34	40
4052	1967	50	47	38	36	32	46	25	32	31	41	30	48
4052	1968	99	14	75	57	31	54	23	25	51	30	30	44
4052	1969	112	50	63	42	54	39	23	37	63	40	30	34
4052	1970	60	55	64	80	30	20	18	16	22	24	49	40
4052	1971	70	56	66	24	27	27	21	21	20	41	43	64
4052	1972	41	33	40	74	25	20	18	19	20	23	62	53
4052	1973	54	57	70	65	35	35	22	23	28	43	28	32
4052	1974	35	32	44	45	44	25	33	32	41	28	38	54
4052	1975	40	39	36	31	27	27	37	55	14	34	37	29
4052	1976	50	106	47	73	28	18	34	34	32	51	52	33
20 BAUGE 5014		5003,5006											
5014	1953	067	76	49	53	48	98	125	45	77	74	95	58
5014	1954	079	54	80	60	51	90	78	62	79	80	60	36
5014	1957	064	57	47	55	52	55	67	56	50	42	65	62
5014	1958	063	62	38	63	42	51	43	61	57	82	97	53
5014	1960	060	47	50	137	48	75	53	87	81	82	49	92
5014	1961	067	65	65	85	42	66	34	57	68	53	70	90
5014	1962	070	45	55	69	51	38	49	47	61	55	68	91
5014	1963	050	31	51	97	105	44	37	43	90	61	84	56
5014	1964	058	43	70	57	52	76	60	54	70	80	69	83
5014	1965	090	84	40	66	62	40	28	58	56	74	91	120
5014	1967	099	57	70	56	44	59	31	44	56	108	65	65
5014	1968	064	50	44	51	62	48	36	94	37	74	57	75
5014	1969	075	49	35	50	70	58	24	40	42	61	56	88
5014	1970	041	44	36	44	38	38	35	43	55	57	74	106
5014	1971	076	53	52	54	40	37	32	52	37	55	57	70
5014	1972	062	78	64	38	26	41	42	33	50	87	45	69
5014	1973	055	46	130	44	49	43	45	56	51	67	58	55
5014	1974	074	62	54	44	47	55	65	88	43	66	77	48
5014	1975	059	48	44	72	34	36	54	32	45	63	63	73
5014	1976	051	50	53	46	44	42	43	63	58	55	41	36
20 BAUGE 5034		5004,5005											
5034	1956	072	067	150	160	121	075	076	073	099	192	120	088

FIGURE A2-5(CONT'D)

5034	1957	102	102	143	110	137	101	148	113	151	214	119	242
5034	1958	224	037	061	252	146	120	096	101	172	139	190	103
5034	1959	047	034	098	078	123	092	065	117	167	110	142	198
5034	1960	107	138	076	110	083	097	091	101	179	125	122	163
5034	1961	074	083	080	114	179	186	060	109	186	055	034	107
5034	1962	140	037	039	140	105	161	079	100	170	099	169	169
5034	1963	117	042	084	341	286	124	096	173	238	122	134	068
5034	1964	085	078	266	174	229	128	116	131	154	136	111	205
5034	1965	083	066	137	102	115	137	082	180	162	129	148	368
5034	1966	136	041	102	159	118	116	135	097	118	092	266	104
5034	1967	315	110	063	094	041	124	068	117	126	095	160	088
5034	1968	073	056	082	088	074	099	107	131	091	089	257	144
5034	1969	062	022	106	237	136	095	079	099	091	160	106	161
5034	1970	100	067	240	183	101	081	081	070	097	091	145	116
5034	1971	062	120	120	114	059	119	119	157	077	109	087	255
5034	1973	110	060	348	203	158	132	088	080	137	112	140	245
5034	1974	048	080	086	111	081	084	094	061	136	179	134	158
5034	1975	125	095	129	217	116	095	084	101	115	171	200	140
5034	1976	047	075	101	098	107	206	093	142	095	137	091	
20 GAUGE 5080		5001, 5002, 7001											
5080	1956	054	54	50	66	58	74	43	232	49	55	204	91
5080	1957	050	54	65	48	61	48	116	40	46	34	138	89
5080	1958	054	42	38	56	42	66	64	52	49	67	104	60
5080	1959	055	77	58	80	49	40	34	39	131	80	67	64
5080	1960	135	65	70	79	59	42	65	53	49	54	125	75
5080	1961	055	53	65	39	44	56	38	37	56	91	80	93
5080	1962	081	39	46	62	58	56	33	47	108	58	76	60
5080	1963	047	96	57	67	37	53	35	51	30	46	58	82
5080	1964	078	53	62	83	70	59	74	64	73	84	70	53
5080	1965	098	73	50	65	49	70	55	48	73	64	119	50
5080	1966	081	57	72	91	77	32	51	34	55	63	93	61
5080	1967	096	55	50	58	56	50	45	52	47	65	55	56
5080	1968	051	35	53	61	47	63	82	52	39	58	99	114
5080	1969	047	53	41	44	41	61	42	67	47	51	42	79
5080	1970	095	69	41	82	44	47	34	30	74	67	66	64
5080	1972	080	49	57	42	33	27	43	54	59	59	41	86
5080	1973	042	33	60	89	40	54	34	37	56	35	59	61
5080	1974	060	52	61	50	45	44	42	42	51	53	43	57

FIGURE A2-5(CONT'D)

5080	1975	133	47	57	60	55	38	51	47	53	66	151	90
5080	1976	074	77	64	42	37	53	74	46	101	63	54	78
20 GAUGE 7023		7007, 7008											
7023	1956	040	65	111	83	64	45	64	41	57	53	111	77
7023	1957	042	40	47	92	66	40	90	61	38	56	106	57
7023	1958	052	52	33	88	50	43	57	58	55	59	95	77
7023	1960	058	62	49	112	72	61	49	44	58	64	112	54
7023	1961	045	52	64	66	67	51	46	42	63	54	74	91
7023	1962	095	57	53	68	64	66	38	48	66	48	56	57
7023	1963	092	71	74	77	81	81	53	64	60	64	93	75
7023	1964	109	51	73	83	88	59	53	57	98	55	80	64
7023	1965	095	93	102	85	70	69	51	81	70	57	127	82
7023	1966	089	54	99	130	90	50	77	54	74	72	75	113
7023	1967	115	79	66	84	76	58	47	44	31	79	57	96
7023	1968	057	61	58	73	67	77	63	54	56	60	93	104
7023	1969	149	35	55	71	57	86	54	51	56	81	44	94
7023	1970	062	59	43	89	54	46	48	43	70	63	68	51
7023	1971	096	58	56	58	71	43	44	44	42	57	72	112
7023	1972	097	43	52	95	31	30	36	44	56	61	70	93
7023	1973	079	52	55	61	63	55	29	41	59	61	90	79
7023	1974	042	35	60	67	59	59	48	41	40	53	55	70
7023	1975	106	54	85	78	48	54	27	42	46	48	81	54
7023	1976	097	50	78	60	41	46	49	39	40	56	44	74
20 GAUGE 7044		7005, 7006											
7044	1954	128	160	154	146	150	163	227	146	082	109	071	132
7044	1955	117	090	119	139	120	074	082	089	111	113	116	144
7044	1956	106	117	180	197	190	098	116	092	082	086	116	095
7044	1957	139	158	120	115	101	072	091	144	090	188	143	141
7044	1958	116	084	085	165	108	117	090	096	121	135	156	125
7044	1959	122	107	144	131	105	150	104	099	139	133	146	127
7044	1960	054	080	265	124	088	104	147	128	095	116	117	126
7044	1961	089	130	154	179	143	098	091	093	158	206	155	105
7044	1962	167	088	081	129	188	102	095	127	124	091	118	104
7044	1963	168	135	110	216	139	159	164	191	201	124	135	080
7044	1964	192	102	159	150	144	109	159	099	124	091	108	241
7044	1965	153	182	110	122	115	090	094	128	130	146	154	331
7044	1966	117	076	142	136	146	131	150	124	103	086	233	090
7044	1967	192	156	121	100	110	087	039	104	078	067	089	105

FIGURE A2-5(CONT'D)

7044	1968	120	086	118	063	067	087	065	057	062	086	167	219
7044	1969	075	069	132	134	078	133	102	054	076	159	083	101
7044	1970	099	188	153	154	122	109	134	063	078	092	099	127
7044	1974	091	101	117	068	096	100	065	055	107	091	096	172
7044	1975	092	104	112	129	053	070	054	081	113	114	121	127
7044	1976	089	082	120	169	077	070	090	080	091	102	115	086
20 GAUGE 7058		7003, 7004											
7058	1952	120	071	124	104	084	102	110	055	070	067	117	070
7058	1954	086	093	217	127	087	086	084	106	071	065	069	073
7058	1955	131	070	096	096	083	052	042	048	050	070	101	098
7058	1956	056	078	095	129	081	051	053	076	072	050	079	071
7058	1957	064	60	64	81	61	56	86	48	48	86	113	87
7058	1958	50	68	53	106	61	81	56	47	66	68	114	61
7058	1959	66	100	103	87	102	64	57	41	112	59	87	127
7058	1960	96	117	61	100	65	62	81	63	64	60	89	73
7058	1961	47	60	97	99	68	52	53	48	95	92	95	91
7058	1962	129	77	44	68	105	64	54	49	68	49	67	61
7058	1963	109	55	70	96	128	97	103	71	110	44	86	61
7058	1964	82	53	121	86	57	72	62	64	50	41	75	90
7058	1965	93	83	73	101	81	52	50	58	59	84	76	155
7058	1966	69	40	97	38	70	59	100	66	43	62	108	100
7058	1970	53	61	53	92	74	48	72	40	55	121	74	84
7058	1972	69	45	98	73	34	81	40	58	64	107	88	98
7058	1973	74	64	67	25	69	56	32	30	59	84	81	97
7058	1974	56	123	71	73	58	101	46	45	46	62	52	93
7058	1975	46	104	81	89	47	60	41	52	52	64	60	88
7058	1976	63	102	90	127	43	61	43	58	53	64	79	53
20 GAUGE 7072		7002, 7010, 7011, 7012, 7013											
7072	1956	040	89	112	100	73	63	111	60	93	72	168	74
7072	1957	44	54	96	110	72	45	67	40	39	41	140	72
7072	1958	43	39	30	114	63	99	59	56	61	60	125	65
7072	1959	55	21	75	85	103	70	53	48	112	82	87	124
7072	1960	63	66	55	120	66	64	73	51	57	47	113	73
7072	1961	65	46	88	86	86	43	56	57	85	67	112	100
7072	1962	84	46	86	85	99	112	54	58	66	63	77	50
7072	1963	87	24	137	93	79	69	85	67	42	48	54	81
7072	1964	83	70	77	73	135	63	127	85	87	84	77	73
7072	1965	103	99	92	86	52	60	48	61	65	57	128	94

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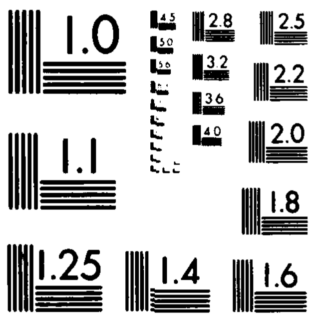
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FIGURE A2-5(CONT'D)

7072	1966	78	48	129	107	90	52	51	67	63	62	74	122
7072	1967	93	38	55	59	36	39	28	29	29	70	44	75
7072	1968	43	44	42	55	64	68	35	50	43	51	75	90
7072	1969	68	27	45	71	50	78	46	36	46	74	41	89
7072	1970	50	40	56	106	46	42	37	32	67	76	98	59
7072	1971	109	116	51	58	78	31	27	55	33	51	59	120
7072	1972	92	46	46	83	28	29	44	25	57	56	71	123
7072	1974	55	34	66	51	53	47	42	46	54	52	40	80
7072	1975	116	60	118	71	46	47	37	45	103	40	70	61
7072	1976	58	50	79	46	33	42	36	39	40	51	60	59
20 GAUGE 9016		9003, 9004, 9005, 9006, 9007, 9008											
	1915	68	71	44	46	74	76	50	62	123	61	68	54
	1916	110	54	30	83	134	87	56	65	49	134	83	106
	1917	74	47	73	58	56	105	150	121	78	80	82	103
	1918	54	68	59	40	122	113	61	88	59	72	75	50
	1919	59	49	71	67	75	56	77	74	82	116	90	115
	1921	87	66	129	81	135	130	62	158	143	65	70	70
	1920	38	28	60	39	95	132	81	64	95	83	75	78
	1922	96	57	54	71	46	92	57	118	121	111	57	92
	1923	83	63	42	24	55	78	60	53	43	84	83	74
	1924	81	57	28	23	46	136	90	159	80	76	143	83
	1925	44	49	43	60	57	85	94	53	88	84	44	70
	1926	50	32	58	54	44	71	108	71	150	70	76	66
	1927	57	40	48	67	139	132	67	46	59	80	92	116
	1928	77	38	53	127	17	62	113	96	75	95	62	84
	1929	73	35	105	127	120	81	80	67	57	85	65	132
9016	1930	071	56	39	44	131	110	141	66	66	67	73	76
9016	1931	035	63	49	93	93	84	156	40	136	78	71	64
9016	1932	107	72	59	39	85	76	105	52	78	76	64	53
9016	1934	051	43	40	82	98	160	202	167	97	103	97	63
9016	1935	094	88	80	66	34	112	153	92	70	85	64	53
20 GAUGE 9064		9002											
9064	1958	130	70	46	111	57	87	68	72	51	48	141	80
9064	1959	73	57	59	63	73	66	48	76	56	56	82	43
9064	1960	60	71	53	94	51	62	51	60	89	63	63	94
9064	1961	54	54	61	58	70	54	37	35	82	69	89	59
9064	1962	101	65	43	73	96	47	35	50	43	73	52	65
9064	1963	86	61	69	62	58	61	40	81	76	41	44	59

FIGURE A2-5(CONT'D)

9065	1964	111	49	53	75	79	59	44	66	93	68	76	57
	1965	68	64	65	47	72	61	61	48	100	52	117	84
	1966	92	63	98	114	52	46	57	43	65	77	71	70
	1967	155	53	60	138	93	60	40	41	47	68	57	72
	1968	55	70	72	70	44	71	56	59	60	62	72	146
	1969	59	29	37	81	48	80	37	42	44	73	54	51
	1970	43	45	63	99	64	57	66	42	50	61	79	139
	1971	59	53	48	66	77	56	48	44	48	84	71	58
	1972	119	62	42	53	39	32	35	49	67	61	92	125
	1973	61	44	60	66	69	56	47	50	55	86	86	64
	1974	56	48	73	54	63	44	50	50	44	59	98	62
	1975	80	69	168	65	62	53	38	45	50	57	121	67
	1976	88	60	102	66	38	47	68	40	55	58	63	78
	1977	51	84	77	55	43	45	65	60	105	79	93	85

20 GAUGE 9070 9001

9070	1957	68	39	59	54	51	50	54	39	42	45	49	49
9070	1958	54	59	37	64	43	76	37	36	33	32	91	53
9070	1960	60	55	38	65	47	38	32	48	101	55	115	83
9070	1961	46	42	50	52	54	44	27	29	60	59	78	50
9070	1962	80	55	44	59	89	46	36	42	40	52	45	61
9070	1963	73	50	56	44	46	52	33	62	49	34	47	126
9070	1964	93	42	46	57	72	59	36	65	86	58	54	53
	1965	63	59	54	42	57	62	48	39	85	39	95	68
	1966	83	58	79	89	40	39	49	35	44	64	62	64
9070	1967	111	42	58	101	41	51	30	30	37	50	48	62
	1968	52	58	54	63	40	81	54	59	47	42	60	100
	1969	52	31	34	58	42	57	35	40	34	57	43	45
	1970	38	52	66	88	57	43	52	29	48	51	61	94
	1971	59	67	79	39	61	60	34	30	39	67	63	54
	1972	98	56	42	48	28	41	41	46	48	51	66	81
	1973	42	38	59	53	37	66	33			40	62	51
	1974	48	46	65	42	54	42	42	42	41	44	75	45
	1975	71	55	114	52	53	46	34	41	46	43	97	63
	1976	76	48	73	54	30	37	42	40	47	52	58	66
9070	1977	45	72	61	37	32	41	56	59	79	53	78	69

FIGURE A2-6

CANADIAN HISTORICAL STORM RISE DATA

20 PORT WELLER

39	67	71	110	94	36	96	62	44	31	43	23	1976
48	42	57	110	27	20	39	34	28	20	20	33	1975
42	73	27	40	87	66	76	48	57	53	27	31	1974
64	27	149	76	42	28	66	48	48	41	39	47	1973
58	39	40	58	23	25	13	26	53	49	36	55	1972
44	48	46	51	20	12	23	32	32	41	55	73	1971
30	28	58	66	39	32	20	50	27	31	36	48	1970
47	30	32	60	47	24	41	53	46	38	38	31	1969
41	34	62	35	43	51	24	32	28	41	41	53	1968
64	47	39	53	48	38	23	27	41	32	47	43	1967
53	34	33	39	30	21	24	21	33	34	51	35	1966
55	62	55	62	38	33	30	17	23	23	55	27	1965
57	47	78	73	41	27	34	36	47	60	44	43	1964
42	55	69	60	51	24	27	34	78	50	41	40	1963
57	43	51	69	41	25	28	31	39	26	41	60	1962
43	33	46	67	39	16	25	32	33	32	31	41	1961
48	62	49	13	28	24	44	38	51	36	34	32	1960
42	33	49	42	19	25	41	33	41	31	20	44	1959
26	36	20	34	21	16	21	23	20	30	33	28	1958
25	25	27	30	20	50	27	38	30	36	33	41	1957

20 TORONTO

53	80	80	73	32	35	49	48	44	39	41	35	1976
48	73	62	44	25	32	46	36	44	38	28	49	1975
48	40	33	48	50	23	43	44	57	55	57	31	1974
69	25	60	39	21	25	51	48	49	43	48	50	1973
64	43	42	60	26	28	12	28	51	55	43	78	1972
55	55	51	64	19	30	34	41	28	38	51	64	1971
34	33	60	75	48	41	21	47	31	38	39	44	1970
47	38	34	64	50	32	44	50	49	43	42	39	1969
49	33	67	39	43	57	25	42	33	44	39	58	1968
82	47	38	51	42	42	21	43	40	35	39	51	1967
67	36	36	43	40	31	30	33	41	41	57	58	1966
60	67	62	73	41	57	32	28	32	31	67	34	1965
69	53	73	73	60	35	42	49	51	66	49	49	1964
49	64	69	69	53	44	27	38	60	55	39	51	1963
76	49	55	73	55	51	33	39	46	33	50	55	1962
43	46	48	71	145	34	31	40	41	40	40	43	1961
46	71	47	80	32	31	50	42	49	42	33	34	1960
40	33	53	49	20	32	30	31	53	39	25	53	1959
33	41	25	31	16	20	24	28	23	24	33	26	1958
24	25	28	33	28	32	26	33	21	33	25	44	1957

20 COBOURG

53	75	103	46	25	26	41	47	55	34	43	25	1976
47	69	53	33	23	33	39	41	40	26	43	30	1975
66	27	71	60	106	34	71	58	57	47	69	33	1974
42	24	53	41	34	30	51	50	53	71	48	46	1973
82	36	41	53	26	25	19	36	49	44	39	76	1972
41	38	42	51	20	24	31	34	25	25	42	67	1971
20	21	38	58	42	23	26	35	33	30	34	46	1970
64	42	31	64	36	16	30	50	57	41	26	20	1969
33	30	60	34	42	39	28	36	30	34	41	67	1968
46	64	32	43	36	31	28	38	35	27	34	48	1967
48	34	62	62	39	27	33	33	[illegible]	[illegible]	41	47	1966
60	55	51	60	39	35	32	27	[illegible]	[illegible]	89	40	1965
78	46	60	76	57	69	35	58	[illegible]	[illegible]	69	80	1964
51	62	71	76	62	78	38	55	51	[illegible]	51	55	1963
118	80	78	82	110	103	51	53	50	35	27	39	1962
50	60	82	100	62	47	35	41	43	82	94	67	1961
53	71	36	135	53	73	48	41	57	82	46	53	1960
114	114	75	94	60	44	89	32	62	115	106	73	1959
53	48	24	80	36	46	40	71	51	69	60	38	1958
43	40	51	62	53	71	48	66	51	51	102	109	1957

13 BAR POINT

70	81	69	81	47	54	47	66	16	42	46	47	1979
165	17	131	86	102	34	85	55	67	33	35	120	1978
138	59	123	92	128	57	78	88	44	104	95	202	1977
160	128	134	118	78	87	51	67	73	94	91	149	1976
136	138	145	136	30	44	73	136	124	160	178	117	1975
131	142	189	182	309	60	47	44	78	92	142	160	1974
226	140	120	234	185	243	35	33	107	96	128	164	1973
121	96	135	175	85	69	87	140	100	114	276	138	1972
177	186	128	115	94	175	89	100	76	104	159	242	1971
104	92	193	163	87	96	00	96	146	94	165	248	1970
107	153	125	171	94	00	00	66	113	125	75	167	1969
115	107	131	89	182	171	103	85	98	103	217	168	1968
237	206	115	104	136	100	64	92	128	171	153	167	1967

15 KINGSVILLE												
148	85	142	100	154	95	66	84	72	125	132	136	1977
138	118	163	159	102	73	60	80	98	87	83	124	1976
122	117	190	147	62	69	89	111	132	159	163	138	1975
128	122	146	175	117	62	80	71	87	0	156	218	1974
157	100	120	199	83	188	60	53	82	128	113	139	1973
109	87	125	125	75	60	55	00	89	78	235	121	1972
167	160	125	87	92	164	80	94	51	00	114	189	1971
106	66	149	146	92	100	85	92	113	71	153	196	1970
102	26	94	145	71	60	98	75	98	143	69	139	1969
98	100	125	67	92	80	00	73	96	76	215	104	1968
153	142	89	71	92	83	55	82	94	145	125	132	1967
174	60	139	257	82	107	114	80	132	114	138	145	1966
215	139	215	100	71	115	83	78	89	161	149	110	1965
293	69	256	103	94	110	80	104	80	104	115	182	1964
118	64	111	128	96	182	82	92	129	96	107	132	1963
19 ERIEAU												
52	42	83	66	70	63	81	49	52	107	61	77	1977
51	82	85	107	55	57	49	40	44	48	51	50	1976
58	57	73	73	41	51	41	64	55	57	62	71	1975
160	48	67	53	49	50	69	38	49	67	73	115	1974
67	38	304	73	139	73	39	39	51	62	64	60	1973
55	33	53	69	26	32	27	00	00	48	132	82	1972
91	80	50	64	62	43	50	40	28	28	57	71	1971
75	38	85	71	62	57	36	48	47	46	75	87	1970
51	28	46	103	64	51	46	39	49	66	41	73	1969
67	46	92	69	69	96	40	42	49	46	110	87	1968
94	82	44	47	41	60	30	42	41	71	60	73	1967
76	33	46	118	43	66	39	53	62	69	73	73	1966
103	73	87	47	36	49	47	51	53	67	57	62	1965
78	25	104	83	44	44	51	67	33	53	62	71	1964
71	36	87	76	69	76	60	55	71	41	55	71	1963
103	53	66	64	53	71	60	60	66	64	87	71	1962
49	69	69	94	39	67	41	80	78	58	64	64	1961
85	75	51	76	51	67	67	51	87	71	51	62	1960
43	32	87	98	71	47	58	40	53	64	64	94	1959
20 PORT STANLEY												
60	85	100	38	60	67	71	66	64	69	66	57	1976
107	117	89	87	55	69	49	60	62	47	142	122	1975
109	64	85	66	57	66	120	102	41	60	125	57	1974
71	41	76	91	55	87	98	83	00	57	100	87	1973
87	67	103	94	69	49	78	66	00	87	85	83	1972
96	117	78	96	104	146	73	103	73	62	115	142	1971
62	53	163	161	82	89	87	62	100	73	117	121	1970
98	53	69	92	115	83	167	69	55	87	109	85	1969
55	64	98	118	62	53	82	110	85	71	114	142	1968
76	153	55	87	55	57	28	46	00	118	78	117	1967
91	80	80	67	66	64	80	75	85	100	113	110	1966
145	83	115	85	60	43	64	78	82	82	185	69	1965
161	51	192	94	83	107	76	121	60	83	121	80	1964
75	41	89	00	00	138	53	89	89	85	82	98	1963
163	60	66	106	89	78	82	82	98	98	102	82	1962
64	69	62	115	51	57	80	167	146	82	107	107	1961
66	89	76	89	71	85	67	98	60	125	100	67	1960
118	57	143	121	78	49	85	57	82	104	92	60	1959
127	53	26	94	48	76	64	102	87	82	159	80	1958
67	41	94	118	107	107	131	111	78	80	188	114	1957
18 PORT DOVER												
220	133	206	156	93	92	118	85	201	177	188	315	1977
175	170	278	192	120	80	107	114	152	153	132	168	1976
204	237	181	214	60	87	62	67	91	94	403	00	1975
210	142	207	192	121	103	76	85	146	100	271	197	1974
221	117	201	184	80	92	98	110	100	138	295	226	1973
303	167	89	96	78	58	94	110	96	139	203	232	1972
298	197	270	163	128	146	78	102	00	127	172	405	1971
197	98	278	259	124	100	118	92	201	138	315	259	1970
195	117	132	111	239	92	147	102	80	138	231	178	1969
201	160	140	142	110	117	76	107	98	171	278	292	1968
165	466	107	167	91	103	73	124	110	546	234	226	1967
209	147	136	115	102	94	89	110	168	254	315	201	1966
376	253	165	172	96	96	143	135	125	189	425	114	1965
276	140	359	129	185	109	102	107	160	175	406	171	1964
184	82	164	156	87	152	134	125	184	127	220	250	1963
239	229	89	161	127	89	142	69	145	125	220	231	1962
122	139	114	212	79	134	62	121	273	100	229	287	1961
00	206	102	185	127	135	140	69	94	142	182	150	1960

20 PORT COLBORNE												
195	140	188	71	159	82	103	121	147	190	135	170	1976
281	345	281	310	100	118	76	92	107	121	408	422	1975
321	235	279	262	142	140	91	131	221	139	393	273	1974
312	161	273	204	98	128	128	71	122	185	415	310	1973
474	253	256	132	94	71	132	160	143	192	317	350	1972
412	237	295	152	164	189	104	160	104	186	220	461	1971
265	121	376	329	150	142	164	117	293	237	384	301	1970
265	136	172	135	345	129	168	124	120	179	290	212	1969
276	203	199	182	175	125	103	134	139	214	356	496	1968
228	668	132	226	129	138	98	214	128	586	214	289	1967
265	199	161	132	143	143	113	127	260	301	440	254	1966
488	334	217	243	114	143	175	177	150	225	537	154	1965
354	181	436	160	223	122	114	128	221	246	500	223	1964
331	78	178	220	110	189	197	147	254	153	307	331	1963
337	300	96	223	171	103	181	104	229	174	276	298	1962
177	185	103	232	115	199	98	177	320	134	300	382	1961
256	248	139	281	167	192	196	145	111	174	264	240	1960
415	146	468	312	104	75	197	98	132	290	267	181	1959
395	135	66	306	103	150	161	138	232	256	348	220	1958
207	121	159	207	154	282	87	186	209	220	540	196	1957
20 GODERICH												
85	76	96	51	64	41	50	46	82	92	51	67	1976
82	98	76	78	44	36	50	38	50	76	82	82	1975
117	114	67	53	38	55	49	58	67	78	73	55	1974
71	58	114	43	71	60	35	55	60	134	83	53	1973
110	100	76	48	40	41	36	36	60	122	58	87	1972
177	62	78	87	64	82	53	125	80	82	111	128	1971
55	73	104	98	96	76	60	53	139	89	143	164	1970
131	100	76	78	69	85	60	76	67	107	67	113	1969
111	113	82	62	62	121	62	150	78	107	124	121	1968
106	117	87	100	67	128	60	51	85	128	111	85	1967
96	87	87	85	71	82	60	67	76	110	114	87	1966
89	117	49	78	60	00	00	00	00	136	117	83	1965
92	67	120	69	92	78	73	60	87	110	96	107	1964
73	60	120	69	92	78	73	60	87	110	96	107	1963
100	62	42	71	53	67	62	66	85	67	67	100	1962
78	76	76	64	53	60	40	60	85	73	89	104	1961
103	69	64	107	53	53	67	51	89	114	100	110	1960
66	76	76	94	55	41	82	57	78	96	83	102	1959
100	96	32	62	51	55	51	62	76	103	172	89	1958
178	92	71	64	53	73	80	57	83	53	104	92	1957
20 KINGSTON												
69	28	100	39	53	26	69	55	44	82	153	66	1955
69	60	114	57	30	44	48	42	64	184	60	78	1954
82	115	107	50	62	55	48	47	58	50	85	87	1953
89	46	64	41	42	48	34	69	57	94	71	58	1952
96	58	106	78	23	48	49	92	66	78	87	94	1951
220	107	82	53	33	32	51	55	44	82	82	64	1950
114	60	51	60	25	28	33	40	121	76	78	89	1949
71	62	113	73	41	24	51	42	47	71	80	73	1948
96	57	152	69	115	41	36	42	80	51	80	85	1947
87	80	91	83	36	48	50	73	64	39	78	117	1946
103	51	134	66	82	48	41	38	48	57	57	57	1945
51	76	53	57	41	43	41	34	89	46	41	69	1944
83	62	96	66	76	31	44	51	62	55	67	67	1943
121	83	85	41	53	39	40	42	66	60	87	125	1942
66	53	85	73	25	41	41	50	92	76	67	80	1941
78	44	67	82	82	57	31	57	46	46	98	60	1940
92	98	53	75	34	38	57	57	94	76	100	57	1939
53	41	67	55	47	49	30	80	78	31	64	113	1938
104	113	26	76	57	25	42	51	78	67	114	80	1937
96	109	131	55	66	47	32	44	39	62	98	85	1936
16 BELLE RIVER												
15	25	95	86	89	56	55	44	31	70	64	79	1977
47	104	39	92	44	27	43	48	47	94	54	52	1976
45	40	70	113	20	35	29	33	36	60	83	46	1975
60	00	78	63	47	39	54	33	51	73	48	98	1974
70	62	80	45	00	43	44	35	43	50	65	00	1973
37	00	52	52	42	104	26	37	00	53	90	33	1972
74	57	59	00	62	122	59	123	60	68	69	106	1971
65	60	55	86	00	65	59	47	48	58	94	123	1970
67	52	53	81	76	42	83	68	55	36	00	53	1969
67	72	90	102	58	102	59	109	56	57	44	66	1968
50	60	40	64	55	64	68	64	75	58	59	90	1967
65	46	53	68	77	50	55	70	73	58	199	93	1966
93	176	49	53	32	45	100	65	57	84	81	160	1965
118	52	120	70	81	80	79	56	75	69	67	40	1964
105	20	87	148	104	190	49	95	108	79	78	42	1963
100	61	60	82	70	112	61	66	62	72	101	76	1962

16 LA SALLE

243	265	274	226	177	178	170	196	189	228	249	320	1977
256	260	268	234	206	184	189	209	224	229	229	254	1976
302	237	297	253	167	201	201	260	254	285	304	230	1975
262	243	256	268	228	189	209	212	237	00	00	339	1974
292	239	237	296	213	00	00	00	226	277	252	270	1973
262	248	00	257	188	199	202	00	00	224	00	00	1972
205	00	159	158	140	146	00	00	00	114	00	180	1971
182	213	212	272	198	209	213	219	239	216	277	199	1970
271	194	232	243	206	181	00	206	226	263	217	249	1969
227	229	244	201	288	274	209	211	218	245	314	292	1968
303	235	208	214	217	205	205	207	234	243	251	251	1967
00	00	00	00	00	185	219	224	294	271	266	269	1966
289	224	187	186	00	00	195	214	240	298	278	271	1965
341	158	00	209	199	202	194	251	241	291	277	274	1964
265	188	260	253	217	209	238	216	267	212	230	264	1963
00	00	206	229	226	354	244	231	227	228	258	283	1962

16 AMHERSTBURG

210	210	271	193	263	191	170	170	00	222	219	294	1977
213	224	249	243	186	174	166	183	192	193	186	224	1976
216	210	286	241	145	171	171	224	223	259	267	240	1975
00	00	233	256	207	157	174	169	196	180	263	317	1974
00	00	00	276	375	263	153	149	186	245	214	232	1973
225	193	216	227	157	159	164	204	180	191	314	192	1972
267	252	205	191	146	219	175	00	00	00	00	281	1971
147	170	251	240	163	174	00	183	214	183	243	281	1970
227	156	199	222	172	151	00	168	195	230	177	228	1969
182	194	220	176	262	244	176	174	182	258	294	262	1968
286	236	176	182	182	170	158	267	00	220	230	218	1967
00	00	00	00	00	142	182	183	273	236	235	306	1966
264	183	300	188	142	202	180	171	186	256	242	234	1965
334	137	274	178	161	165	156	194	172	206	214	247	1964
197	156	220	228	181	210	195	175	228	176	214	243	1963
00	00	175	178	179	207	202	186	181	187	236	251	1962

17 BURLINGTON

147	82	122	70	43	36	27	43	67	81	73	93	1977
87	81	85	58	41	39	49	51	48	40	50	37	1976
63	00	118	97	41	37	296	41	51	56	50	75	1975
122	83	122	92	60	22	56	60	98	63	56	91	1974
101	73	74	268	35	39	59	58	56	60	61	98	1973
90	54	91	50	41	53	39	44	59	62	103	107	1972
78	109	70	66	27	23	42	38	41	47	66	145	1971
36	37	104	81	48	00	00	00	00	00	00	00	1970
56	50	75	83	53	48	48	53	51	60	00	65	1969
53	50	67	56	74	57	29	52	37	52	80	125	1968
166	65	53	58	54	46	24	42	44	53	55	90	1967
76	69	66	93	63	64	37	45	72	66	72	88	1966
78	111	118	78	47	49	41	37	40	54	97	76	1965
90	96	151	91	61	00	00	76	58	00	66	134	1964
00	74	112	86	59	37	33	39	87	00	47	84	1963
133	131	62	79	69	69	52	50	105	48	112	104	1962
92	97	116	82	50	42	34	48	54	42	62	73	1961

20 TECUMSEH

0	0	108	62	85	58	58	24	43	67	39	84	1977
62	0	47	119	43	24	59	44	50	57	60	33	1976
53	47	72	62	27	37	29	61	49	72	36	57	1975
46	61	65	67	50	45	31	33	57	33	69	105	1974
56	31	91	99	45	46	37	22	31	59	47	39	1973
0	0	0	79	34	34	25	28	32	41	107	53	1972
66	57	53	32	31	37	42	33	29	0	0	0	1971
54	53	80	101	39	44	29	34	32	33	49	65	1970
0	48	55	65	58	0	38	35	33	0	33	0	1969
69	63	0	42	79	102	42	51	27	55	86	52	1968
96	47	50	35	36	38	32	30	49	49	38	66	1967
92	53	63	142	51	35	37	37	69	42	77	65	1966
99	77	121	45	38	41	38	47	37	60	49	96	1965
111	0	0	0	0	46	40	46	51	47	40	76	1964
106	22	91	81	58	69	45	45	85	36	58	56	1963
105	59	64	40	40	66	40	45	60	47	74	60	1962
36	69	85	86	40	70	47	34	43	48	51	66	1961
82	76	81	50	48	53	29	29	88	45	76	60	1960
63	25	93	35	42	49	42	51	53	55	74	59	1959
115	42	49	72	38	42	28	40	57	42	69	71	1958

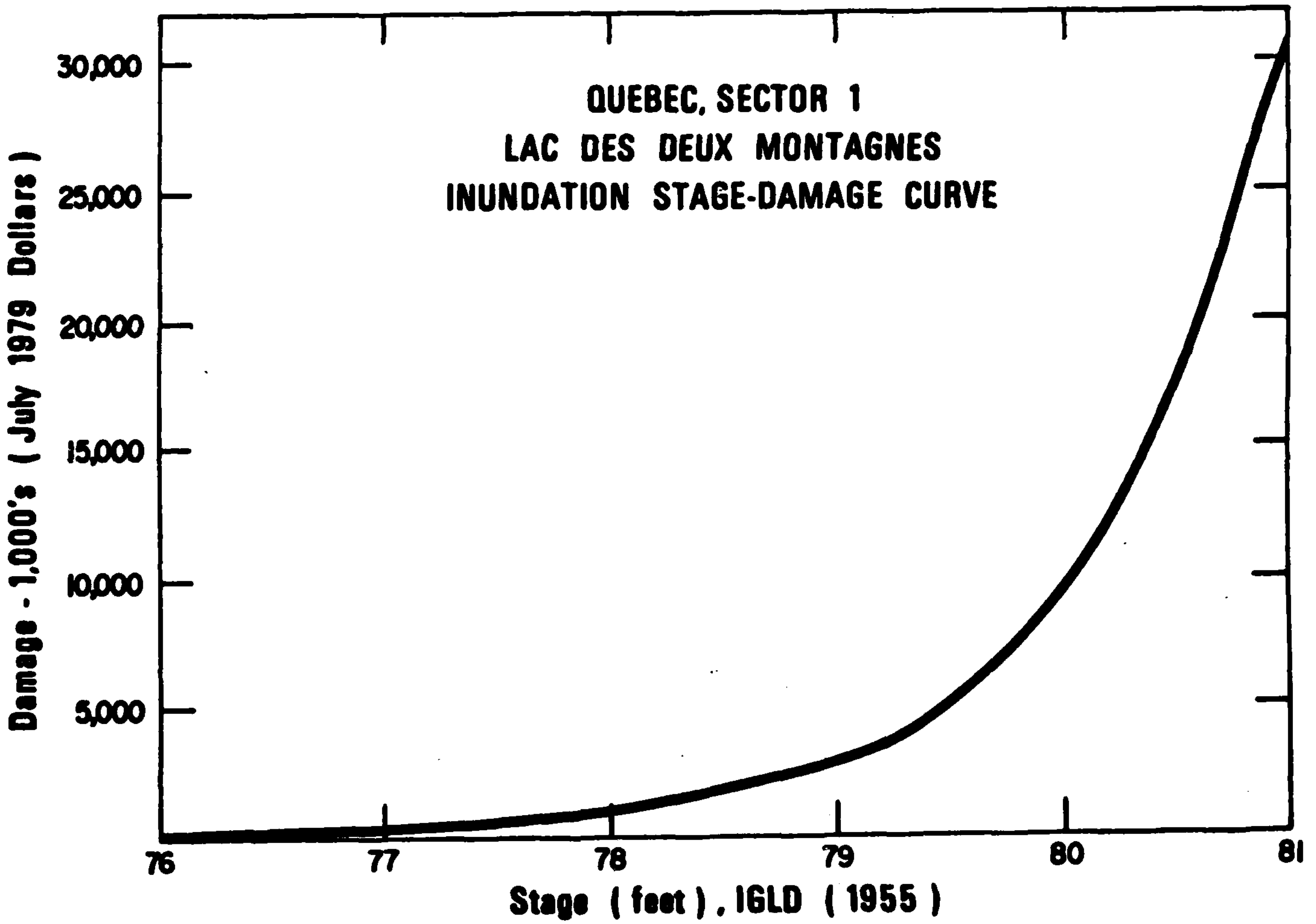
ANNEX A3

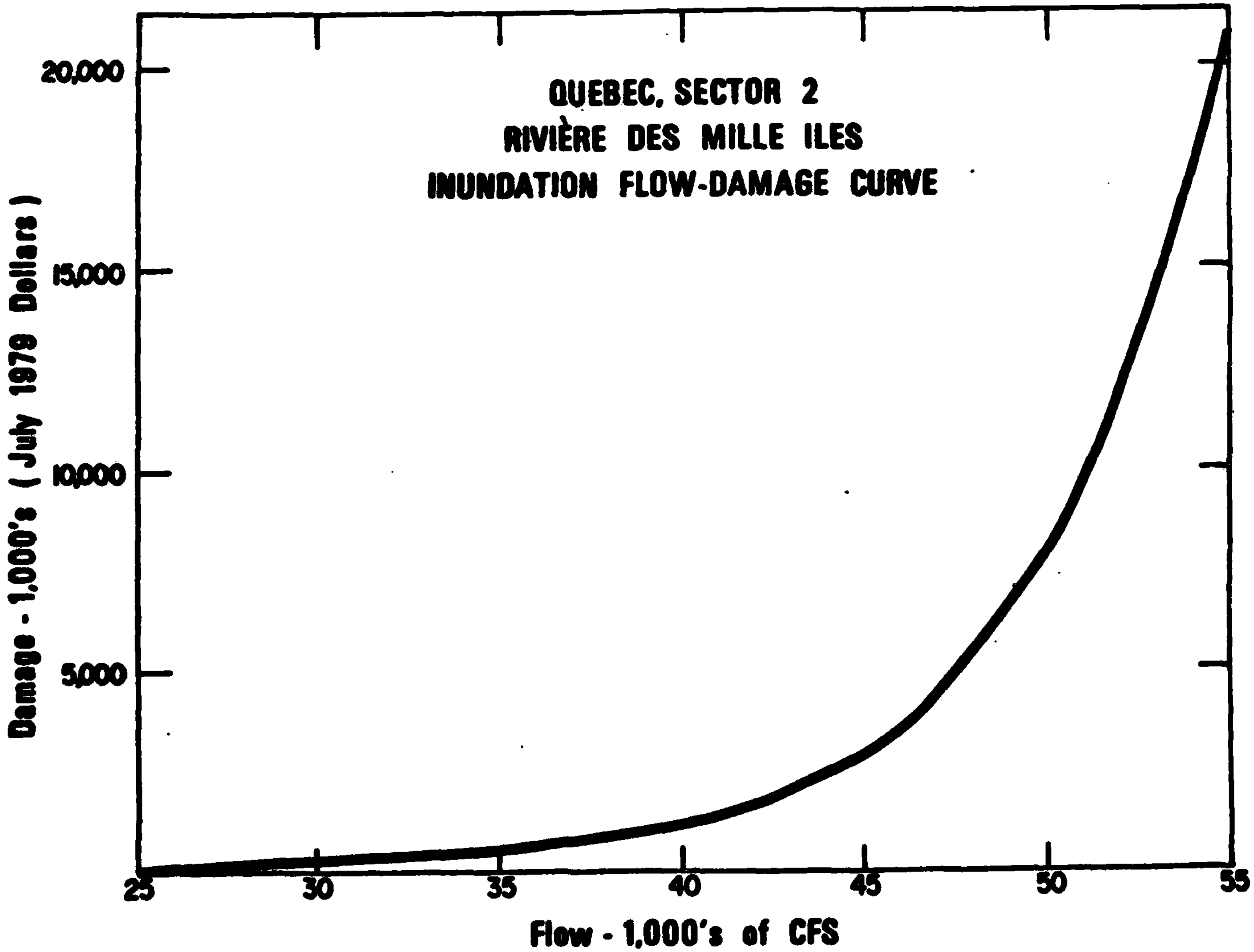
DERIVATION OF FLOW-DAMAGE CURVE

FOR THE CANADIAN REACH OF THE ST. LAWRENCE RIVER

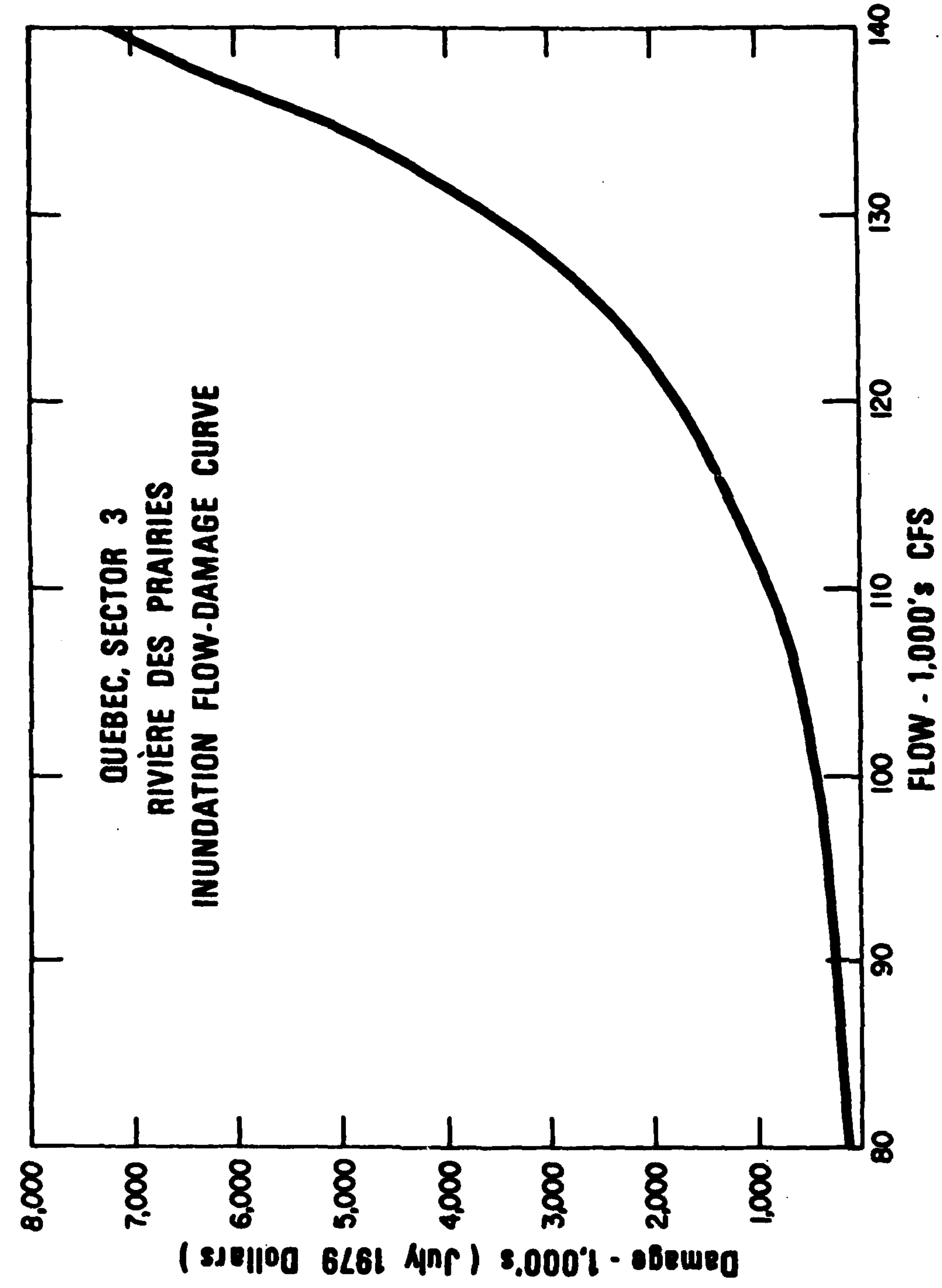
TABLE A3-1 PARAMETERS USED TO DETERMINE THE STAGE OR FLOW DAMAGE CURVES

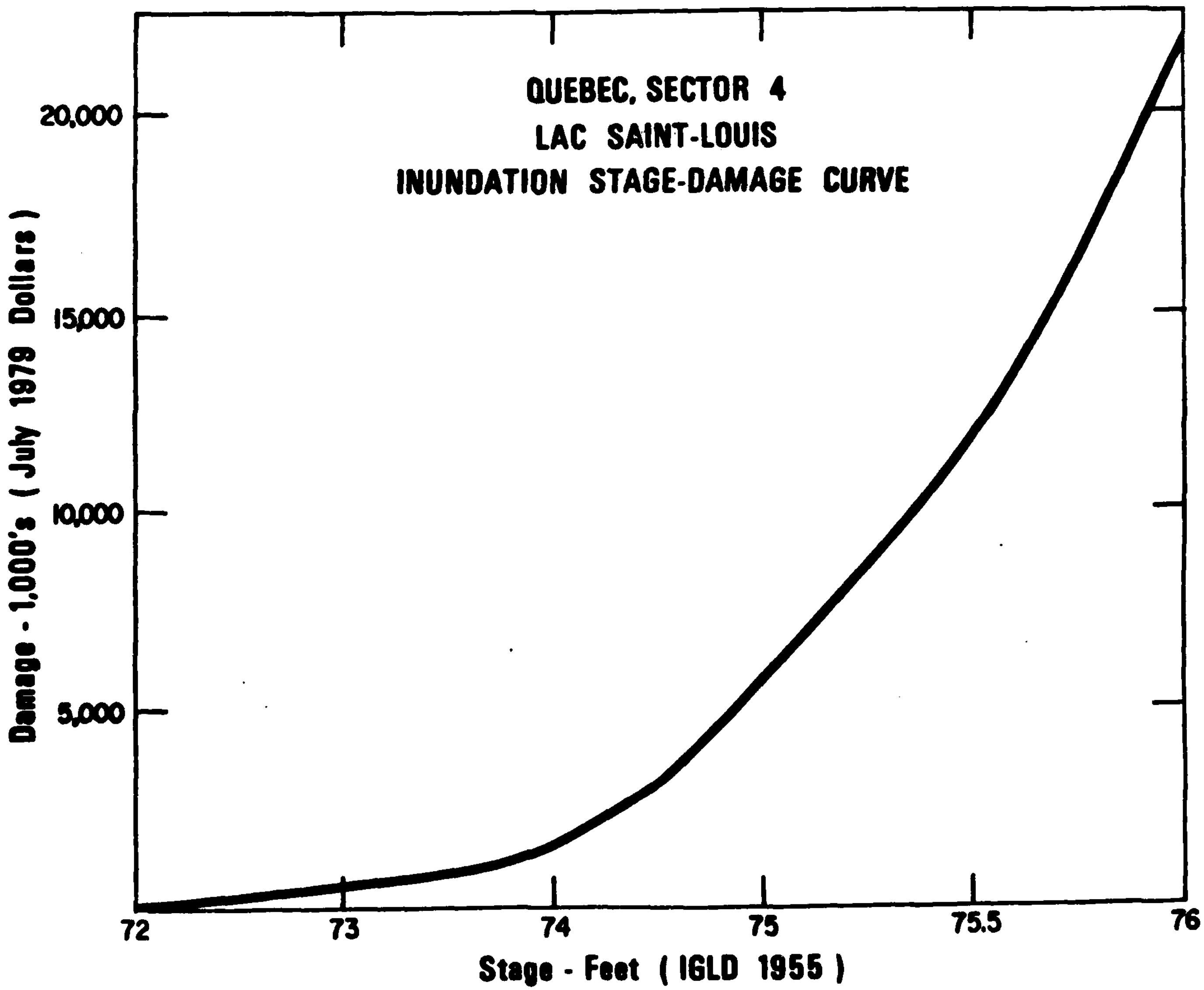
	Sector 1 Lac des Deux Montagnes (in feet)	Sector 2 Rivières des Mille Iles (in cfs)	Sector 3 Rivière des Prairies (in cfs)	Sector 4 Lac Saint-Louis (in feet)	Sector 5 Région aval (in cfs)
Level or flow					
p = .5	76.39	27 470	80 517	72.15	503 140
1974	79.11	46 500	119 010	74.37	642 990
1976	79.59	49 100	129 958	74.54	686 070
Damages ($000, July 1979)					
p = .5	100	100	100	100	100
1974	3 648	4 138	2 216	2 483	1 662
1976	4 450	6 416	2 857	2 879	5 733


QUEBEC, SECTOR 1
LAC DES DEUX MONTAGNES
INUNDATION STAGE-DAMAGE CURVE
Damage - 1,000's (July 1979 Dollars)
30,000
25,000
20,000
15,000
10,000
5,000
76
77
78
79
80
81
Stage (feet) , IGLD (1955)



QUEBEC, SECTOR 2
RIVIÈRE DES MILLE ILES
INUNDATION FLOW-DAMAGE CURVE
Damage - 1,000's (July 1979 Dollars)
20,000
15,000
10,000
5,000
25
30
35
40
45
50
55
Flow - 1,000's of CFS


QUEBEC, SECTOR 3
RIVIÈRE DES PRAIRIES
INUNDATION FLOW-DAMAGE CURVE
FLOW - 1,000's CFS
80
90
100
110
120
130
140
Damage - 1,000's (July 1979 Dollars)
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000


QUEBEC, SECTOR 4
LAC SAINT-LOUIS
INUNDATION STAGE-DAMAGE CURVE
20,000
15,000
10,000
5,000
Damage - 1,000's (July 1979 Dollars)
72
73
74
75
75.5
76
Stage - Feet (IGLD 1955)

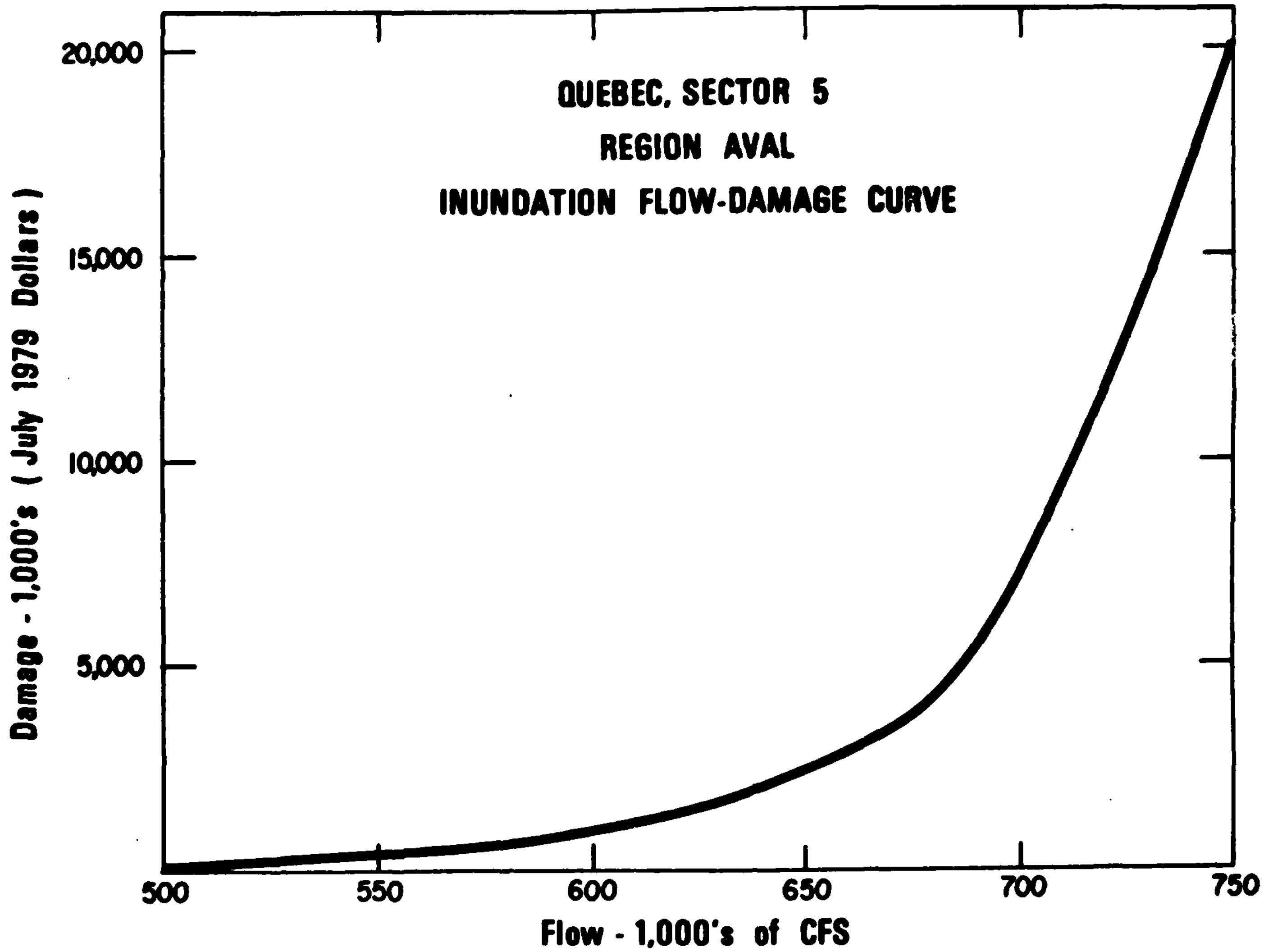

QUEBEC, SECTOR 5
REGION AVAL
INUNDATION FLOW-DAMAGE CURVE
Damage - 1,000's (July 1979 Dollars)
20,000
15,000
10,000
5,000
500
550
600
650
700
750
Flow - 1,000's of CFS

TABLE ~~2.01~~ A3-2 RESULTS OF THE SIMULATION BY THE HYDRODYNAMIC MODEL FOR VARIOUS COMBINATIONS OF INPUT PARAMETERS

$Q_{Cornwall}$: 250,000

Q_{Local} : 0

	OTTAWA RIVER OUTFLOW AT CARILLON (in '000 cfs)					
	100	150	200	250	300	350
Sector 1 (level in feet)	72.80	74.50	76.05	77.52	78.93	80.29
Sector 2 (flow in '000 cfs)	7.8	16.4	25.2	34.2	43.2	52.1
Sector 3 (flow in '000 cfs)	46.9	63.1	79.2	95.0	110.2	124.6
Sector 4 (level in feet)	70.16	70.83	71.53	72.19	72.86	73.52
Sector 5 (flow in '000 cfs)	357.1	404.2	452.2	500.7	549.5	598.6

TABLE A3-3 ~~2.02~~ RESULTS OF THE SIMULATION BY THE HYDRODYNAMIC MODEL FOR VARIOUS COMBINATIONS OF INPUT PARAMETERS

$Q_{Cornwall}$: 250,000

Q_{Local} : 20,000

	OTTAWA RIVER OUTFLOW AT CARILLON (in '000 cfs)					
	100	150	200	250	300	350
Sector 1 (level in feet)	72.93	74.60	76.15	77.61	79.02	80.37
Sector 2 (flow in '000 cfs)	8.3	16.8	25.6	34.6	43.6	52.5
Sector 3 (flow in '000 cfs)	46.9	63.9	80.0	95.7	110.8	125.2
Sector 4 (level in feet)	70.71	71.39	72.05	72.70	73.35	74.01
Sector 5 (flow in '000 cfs)	376.1	423.9	472.0	520.7	569.4	618.8

TABLE A3-4 ~~2.05~~ RESULTS OF THE SIMULATION BY THE HYDRODYNAMIC MODEL FOR VARIOUS COMBINATIONS OF INPUT PARAMETERS

$Q_{Cornwall}$: 250,000

Q_{Local} : 40,000

	OTTAWA RIVER OUTFLOW AT CARILLON (in '000 cfs)					
	100	150	200	250	300	350
Sector 1 (level in feet)	73.09	74.72	76.26	77.71	79.09	80.45
Sector 2 (flow in '000 cfs)	8.8	17.3	26.1	35.1	44.0	53.0
Sector 3 (flow in '000 cfs)	48.2	64.9	81.0	96.6	111.5	126.0
Sector 4 (level in feet)	71.26	71.91	72.56	73.19	73.83	74.49
Sector 5 (flow in '000 cfs)	396.1	443.7	492.3	540.8	589.7	639.6

TABLE ~~3.04~~ A3-5 RESULTS OF THE SIMULATION BY THE HYDRODYNAMIC MODEL FOR VARIOUS COMBINATIONS OF INPUT PARAMETERS

$Q_{Cornwall}$: 250,000

Q_{Local} : 60,000

	OTTAWA RIVER OUTFLOW AT CARILLON (in '000 cfs)					
	100	150	200	250	300	350
Sector 1 (level in feet)	73.43	74.86	76.38	77.81	79.21	80.53
Sector 2 (flow in '000 cfs)	9.4	17.9	26.5	35.6	44.6	53.3
Sector 3 (flow in '000 cfs)	49.6	66.0	85.2	97.5	112.5	126.6
Sector 4 (level in feet)	71.77	72.41	73.05	73.68	74.32	74.93
Sector 5 (flow in '000 cfs)	415.6	463.8	515.3	561.0	610.1	659.6

TABLE ~~2.05~~ A3-6 RESULTS OF THE SIMULATION BY THE HYDRODYNAMIC MODEL FOR VARIOUS COMBINATIONS OF INPUT PARAMETERS

$Q_{Cornwall}$: 250,000

Q_{Local} : 80,000

	OTTAWA RIVER OUTFLOW AT CARILLON (in '000 cfs)					
	100	150	200	250	300	350
Sector 1 (level in feet)	73.54	75.08	76.55	77.94	79.31	80.62
Sector 2 (flow in '000 cfs)	10.15	18.7	27.5	36.5	45.5	53.9
Sector 3 (flow in '000 cfs)	51.35	67.2	82.8	98.3	112.9	127.5
Sector 4 (level in feet)	72.25	72.90	73.52	74.15	74.76	75.38
Sector 5 (flow in '000 cfs)	435.9	484.0	532.7	581.5	630.7	680.0

TABLE ~~2.00~~ A3-7 RESULTS OF THE SIMULATION BY THE HYDRODYNAMIC MODEL FOR VARIOUS COMBINATIONS OF INPUT PARAMETERS

$Q_{Cornwall}$: 290,000

Q_{Local} : 60,000

	OTTAWA RIVER OUTFLOW AT CARILLON (in '000 cfs)					
	100	150	200	250	300	350
Sector 1 (level in feet)	73.68	75.19	76.66	78.06	79.41	80.72
Sector 2 (flow in '000 cfs)	11.0	19.4	28.1	36.9	45.7	54.4
Sector 3 (flow in '000 cfs)	53.1	68.8	84.3	99.7	114.3	128.4
Sector 4 (level in feet)	72.69	73.34	73.97	74.57	75.18	75.8
Sector 5 (flow in '000 cfs)	454.6	502.9	551.6	600.6	649.7	699.3

TABLE ~~2.17~~ A3-8 RESULTS OF THE SIMULATION BY THE HYDRODYNAMIC MODEL FOR VARIOUS COMBINATIONS OF INPUT PARAMETERS

$Q_{Cornwall}$: 310,000

Q_{Local} : 60,000

	OTTAWA RIVER OUTFLOW AT CARILLON (in '000 cfs)					
	100	150	200	250	300	350
Sector 1 (level in feet)	73.91	75.37	76.81	78.19	79.52	80.83
Sector 2 (flow in '000 cfs)	12.1	20.2	28.9	37.6	46.3	55.0
Sector 3 (flow in '000 cfs)	55.1	70.4	85.8	100.8	115.3	129.3
Sector 4 (level in feet)	73.13	73.78	74.4	74.99	75.6	76.22
Sector 5 (flow in '000 cfs)	473.9	522.6	571.4	620.2	669.6	718.7

TABLE ~~2.08~~ A3-9 RESULTS OF THE SIMULATION BY THE HYDRODYNAMIC MODEL FOR VARIOUS COMBINATIONS OF INPUT PARAMETERS

$Q_{Cornwall}$: 330,000

Q_{Local} : 60,000

	OTTAWA RIVER OUTFLOW AT CARILLON (in '000 cfs)					
	100	150	200	250	300	350
Sector 1 (level in feet)	74.16	75.57	76.96	78.33	79.65	80.95
Sector 2 (flow in '000 cfs)	13.3	21.2	30.0	38.3	47.0	55.6
Sector 3 (flow in '000 cfs)	57.3	72.1	87.0	102.1	116.4	130.4
Sector 4 (level in feet)	73.54	74.21	74.8	75.41	76.02	76.64
Sector 5 (flow in '000 cfs)	493.4	541.9	591.4	640.0	689.1	738.2

TABLE ~~2.09~~ A3-10 RESULTS OF THE SIMULATION BY THE HYDRODYNAMIC MODEL FOR VARIOUS COMBINATIONS OF INPUT PARAMETERS

$Q_{Cornwall}$: 350,000

Q_{Local} : 60,000

	OTTAWA RIVER OUTFLOW AT CARILLON (in '000 cfs)					
	100	150	200	250	300	350
Sector 1 (level in feet)	74.43	75.78	77.14	78.48	79.78	81.08
Sector 2 (flow in '000 cfs)	14.6	22.2	30.6	39.0	47.8	56.4
Sector 3 (flow in '000 cfs)	59.8	74.0	88.6	103.4	117.6	131.5
Sector 4 (level in feet)	73.94	74.61	75.22	75.82	76.44	77.06
Sector 5 (flow in '000 cfs)	512.8	561.6	610.8	660.0	709.2	758.3

TABLE A3-11 RESULTS OF THE SIMULATION BY THE HYDRODYNAMIC MODEL FOR VARIOUS COMBINATIONS OF INPUT PARAMETERS

$Q_{Cornwall}$: 370,000

Q_{Local} : 60,000

	OTTAWA RIVER OUTFLOW AT CARILLON (in '000 cfs)					
	100	150	200	250	300	350
Sector 1 (level in feet)	74.74	76.0	77.32	78.63	79.93	81.22
Sector 2 (flow in '000 cfs)	16.1	23.4	31.5	39.9	48.6	57.1
Sector 3 (flow in '000 cfs)	62.7	76.1	90.4	104.8	118.9	132.7
Sector 4 (level in feet)	74.32	75.0	75.62	76.23	76.85	77.47
Sector 5 (flow in '000 cfs)	532.2	581.8	630.4	679.6	728.7	778.1

TABLE ~~3.01~~ A3-12 DAMAGES ASSOCIATED WITH THE OUTPUT PARAMETERS OF THE HYDRODYNAMIC MODEL (in $000)

$Q_{Cornwall}$: 250,000

Q_{Local} : 0

	OTTAWA RIVER OUTFLOW AT CARILLON (in '000 cfs)					
	100	150	200	250	300	350
Sector 1 Lac des Deux Montagnes	1	10	68	416	2 364	12 636
Sector 2 Rivière des Mille Iles	2	12	65	370	2 111	11 822
Sector 3 Rivière des Frairies	10	31	97	298	876	2 439
Sector 4 Lac Saint-Louis	6	15	42	106	276	705
Sector 5 Region aval	4	11	32	91	262	757
TOTAL	23	79	303	1 280	5 893	28 359

TABLE ~~3.02~~ A3-13 DAMAGES ASSOCIATED WITH THE OUTPUT PARAMETERS OF THE HYDRODYNAMIC MODEL (in $000)

$Q_{Cornwall}$: 250,000

Q_{Local} : 20,000

	OTTAWA RIVER OUTFLOW AT CARILLON (in '000 cfs)					
	100	150	200	250	300	350
Sector 1 Lac des Deux Montagnes	2	11	77	465	2 641	13 946
Sector 2 Rivière des Mille Iles	3	13	70	399	2 280	12 774
Sector 3 Rivière des Prairies	10	33	102	313	915	2 545
Sector 4 Lac Saint-Louis	13	34	87	219	554	1 416
Sector 5 Región aval	6	17	49	140	402	1 172
TOTAL	33	108	385	1 536	6 792	31 853

TABLE ~~3.15~~ A3-H DAMAGES ASSOCIATED WITH THE OUTPUT PARAMETERS OF THE HYDRODYNAMIC MODEL (in $000)

$Q_{Cornwall}$: 250,000

Q_{Local} : 40,000

	OTTAWA RIVER OUTFLOW AT CARILLON (in '000 cfs)					
	100	150	200	250	300	350
Sector 1 Lac des Deux-Montagnes	2	13	88	526	2 879	15 391
Sector 2 Rivière des Mille-Iles	3	14	77	440	2 464	14 073
Sector 3 Rivière des Prairies	11	35	110	333	961	2 694
Sector 4 Lac Saint-Louis	28	71	180	441	1 096	2 804
Sector 5 Region aval	10	27	76	217	624	1 837
TOTAL	53	160	531	1 956	8 025	36 799

TABLE ~~3-04~~ A3-15 DAMAGES ASSOCIATED WITH THE OUTPUT PARAMETERS OF THE HYDRODYNAMIC MODEL (in $000)

$Q_{Cornwall}$: 250,000

Q_{Local} : 60,000

	OTTAWA RIVER OUTFLOW AT CARILLON (in '000 cfs)					
	100	150	200	250	300	350
Sector 1 Lac des Deux-Montagnes	3	16	102	594	3 338	16 986
Sector 2 Rivière des Mille-Iles	3	16	83	485	2 768	14 914
Sector 3 Rivière des Prairies	12	38	148	355	1 032	2 811
Sector 4 Lac Saint-Louis	58	145	361	885	2 202	5 246
Sector 5 Region aval	15	41	125	336	971	2 832
TOTAL	90	256	819	2 655	10 310	42 784

TABLE ~~2.15~~ A3-16 DAMAGES ASSOCIATED WITH THE OUTPUT PARAMETERS OF THE HYDRODYNAMIC MODEL (in $000)

$Q_{Cornwall}$: 250,000

Q_{Local} : 80,000

	OTTAWA RIVER OUTFLOW AT CARILLON (in '000 cfs)					
	100	150	200	250	300	350
Sector 1 Lac des Deux Montagnes	3	21	126	698	3 776	18 979
Sector 2 Rivière des Mille Iles	4	18	101	577	3 294	16 751
Sector 3 Rivière des Prairies	13	41	125	376	1 062	2 997
Sector 4 Lac Saint-Louis	116	292	705	1 728	4 118	9 953
Sector 5 Region aval	22	64	182	523	1 516	4 402
TOTAL	158	435	1 239	3 904	13 766	53 082

TABLE ~~3-06~~ A5,7 DAMAGES ASSOCIATED WITH THE OUTPUT PARAMETERS OF THE HYDRODYNAMIC MODEL (in $000)

$Q_{Cornwall}$: 290,000

Q_{Local} : 60,000

	OTTAWA RIVER OUTFLOW AT CARILLON (in '000 cfs)					
	100	150	200	250	300	350
Sector 1 Lac des Deux Montagnes	4	24	144	809	4 271	21 468
Sector 2 Rivière des Mille Iles	4	21	113	623	3 424	18 454
Sector 3 Rivière des Prairies	15	46	139	416	1 173	3 195
Sector 4 Lac Saint-Louis	216	546	1 338	3 143	7 488	18 097
Sector 5 Region aval	34	96	274	790	2 286	6 683
TOTAL	273	732	2 008	5 781	18 642	67 897

TABLE A3-18 DAMAGES ASSOCIATED WITH THE OUTPUT PARAMETERS OF THE HYDRODYNAMIC MODEL (in $000)

$Q_{Cornwall}$: 310,000

Q_{Local} : 60,000

	OTTAWA RIVER OUTFLOW AT CARILLON (in '000 cfs)					
	100	150	200	250	300	350
Sector 1 Lac des Deux Montagnes	5	29	173	950	4 891	24 585
Sector 2 Rivière des Mille Iles	5	25	132	714	3 846	20 727
Sector 3 Rivière des Prairies	18	52	155	449	1 259	3 406
Sector 4 Lac Saint-Louis	405	1 021	2 467	5 713	13 613	22 120
Sector 5 Region aval	51	146	420	1 208	3 516	10 168
TOTAL	479	1 273	3 348	9 034	27 126	81 006

TABLE ~~3.08~~ A5-A DAMAGES ASSOCIATED WITH THE OUTPUT PARAMETERS OF THE HYDRODYNAMIC MODEL (in $000)

$Q_{Cornwall}$: 330,000

Q_{Local} : 60,000

	OTTAWA RIVER OUTFLOW AT CARILLON (in '000 cfs)					
	100	150	200	250	300	350
Sector 1 Lac des Deux Montagnes	7	38	209	1 128	5 746	28 505
Sector 2 Rivière des Mille Iles	7	30	164	817	4 404	23 280
Sector 3 Rivière des Prairies	20	58	169	493	1 362	3 683
Sector 4 Lac Saint-Louis	725	1 883	4 360	10 388	22 120	22 120
Sector 5 Region aval	78	222	648	1 253	5 360	13 504
TOTAL	837	2 230	5 548	14 679	38 988	93 091

TABLE ~~3-09~~ A3-20 DAMAGES ASSOCIATED WITH THE OUTPUT PARAMETERS OF THE HYDRODYNAMIC MODEL (in $000)

$Q_{Cornwall}$: 350,000

Q_{Local} : 60,000

	OTTAWA RIVER OUTFLOW AT CARILLON (in '000 cfs)					
	100	150	200	250	300	350
Sector 1 Lac des Deux Montagnes	9	49	260	1 358	6 739	33 458
Sector 2 Rivière des Mille Iles	8	36	184	436	5 142	27 180
Sector 3 Rivière des Prairies	24	67	180	540	1 483	3 982
Sector 4 Lac Saint-Louis	1 282	3 327	7 926	18 619	22 120	22 120
Sector 5 Region aval	118	340	985	2 856	8 279	20 000
TOTAL	1 442	3 818	9 545	24 309	43 764	106 740

TABLE A5-21 ~~2.10~~ DAMAGES ASSOCIATED WITH THE OUTPUT PARAMETERS OF THE HYDRODYNAMIC MODEL (in $000)

$Q_{Cornwall}$: 370,000

Q_{Local} : 60,000

	OTTAWA RIVER OUTFLOW AT CARILLON (in '000 cfs)					
	100	150	200	250	300	350
Sector 1 Lac des Deux-Montagnes	14	64	325	1 633	8 108	39 758
Sector 2 Rivière des Mille Iles	11	46	219	1 114	6 004	31 134
Sector 3 Rivière des Prairies	30	78	215	597	1 626	4 337
Sector 4 Lac Saint-Louis	2 202	5 795	14 007	22 120	22 120	22 120
Sector 5 Región aval	180	526	1 506	4 365	12 624	20 000
TOTAL	2 436	6 509	16 271	29 829	50 482	117 341

TABLE A3-22 SUMMARY OF DAMAGES UNDER VARIOUS COMBINATIONS OF INPUT PARAMETERS (in $000)

	Cornwall inflow (in '000 cfs) 250	250	250	250	250	290	310	330	350	370
	Local inflow (in '000 cfs) 0	20	40	60	80	60	60	60	60	60
Ottawa River at Carillon (in '000 cfs)										
100	23	33	53	90	158	279	479	837	1 442	2 436
150	79	108	160	256	435	732	1 273	2 230	3 818	6 509
200	303	385	531	819	1 239	2 008	3 348	5 548	9 545	16 271
250	1 280	1 536	1 956	2 655	3 904	5 781	9 034	14 679	24 309	29 829
300	5 893	6 792	8 025	10 310	13 766	18 642	27 126	38 988	43 764	50 481
350	23 359	31 853	36 799	42 784	53 082	67 897	81 006	93 091	106 740	117 341

A3-23

TABLE ~~4-1~~ CHARACTERISTIC POINTS OF THE FREQUENCY DISTRIBUTIONS OF THE OTTAWA RIVER AND LOCAL INFLOWS

Frequency	Ottawa River at Carillon (in cfs)	Local Inflow (in cfs)
.99	103 225	17 121
.98	110 111	20 200
.95	121 553	25 525
.90	132 924	31 035
.80	148 463	38 677
.50	184 696	56 193
.20	231 982	76 929
.10	262 282	88 668
.05	290 887	98 627
.02	327 473	109 913
.01	354 842	117 414

DERIVATION OF TABLES A3-24 and A3-25

As an example, consider the derivation of the expected damages for an inflow at Cornwall of 250,000 cfs and a local inflow of 60,000 cfs. Table A3-22 lists the damages that would occur for these conditions with varying Ottawa River flows, while Table A3-23 lists the probabilities of selected Ottawa River ~~flows~~ f lows.

Based on this information, the expected damages were calculated for Cornwall and local inflows of 250,000 cfs and 60,000 cfs repsectively by the following method.

OTTAWA RIVER FLOW AT CARILLON ('000 cfs)	DAMAGES ($000)	AVERAGE DAMAGES FOR INTERVAL ($000)	FREQUENCY OF EXCEEDANCE OF OTTAWA RIVER FLOW	FREQUENCY OF OCCURANCE OF INTERVALS	EXPECTED DAMAGES AT INTERVAL ($000)
350	42784		.011		
		26547.0		.027	716.8
300	10310		.038		
		6482.5		.092	596.4
250	2655		.130		
		1737.0		.250	434.3
200	819		.380		
		537.5		.410	220.4
150	256		.790		
		173.0		.203	35.2
100	90		.993		

Therefore the total expected damages for the given Cornwall and local inflow conditions is the summation of the right column, which is $2,003,000. This value is included in Table A3-24 for the given ~~in~~flow conditions. However, this value also applies for any other combination of Cornwall outflow ~~and~~ local flows totalling 310,000 cfs. Thus damages of $2,003,000 are given in Table A3-24, for flow conditions of 270 and 40, 290 and 20, and 310 and 0 thousand cfs for Cornwall and local inflows respectively.

A similar exercise was completed for other flow combinations to obtain all of the values given in Table A3-24.

This computational method was repeated using the damages listed in Table A3-24 and the probabilities of local inflow given in Table A3-23. The result of this was Table A3-25, which tabulates damages for given Cornwall ~~in~~flows. This table was used for evaluating the regulation plans. out

TABLE ~~4.2~~ A3-24. EXPECTED LEVELS OF DAMAGES FOR COMBINATIONS OF CORNWALL AND LOCAL INFLOWS.

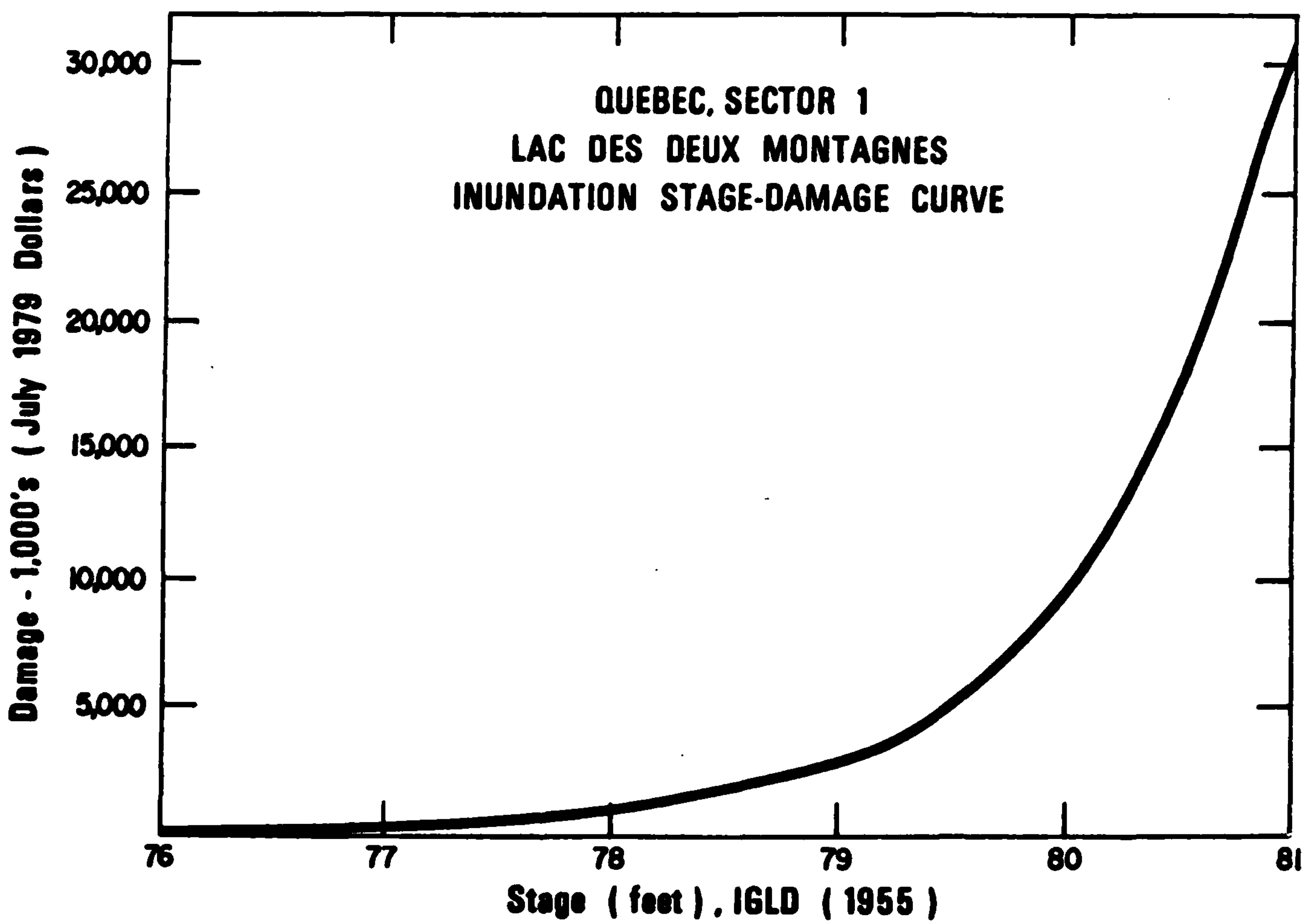
Cornwall Inflow (in '000 cfs)	Expected Levels of Damages for Combinations of Cornwall and Local Inflows Local Inflow (in '000 cfs)							Expected levels of damages for Cornwall inflow
	0	20	40	60	80	100	120	
250	1 079	1 213	1 538	2 003	2 762	3 929	5 796	2 179
270	1 213	1 538	2 003	2 762	3 929	5 796	8 686	3 025
290	1 538	2 003	2 762	3 9 29	5 796	8 686	12 668	4 336
310	2 003	2 762	3 929	5 796	8 686	12 668	17 300	6 315
330	2 762	3 929	5 796	8 686	12 668	17 300	25 000	9 188
~~380~~ 350	3 929	5 796	8 686	12 668	17 300	23 000	36 000	13 214

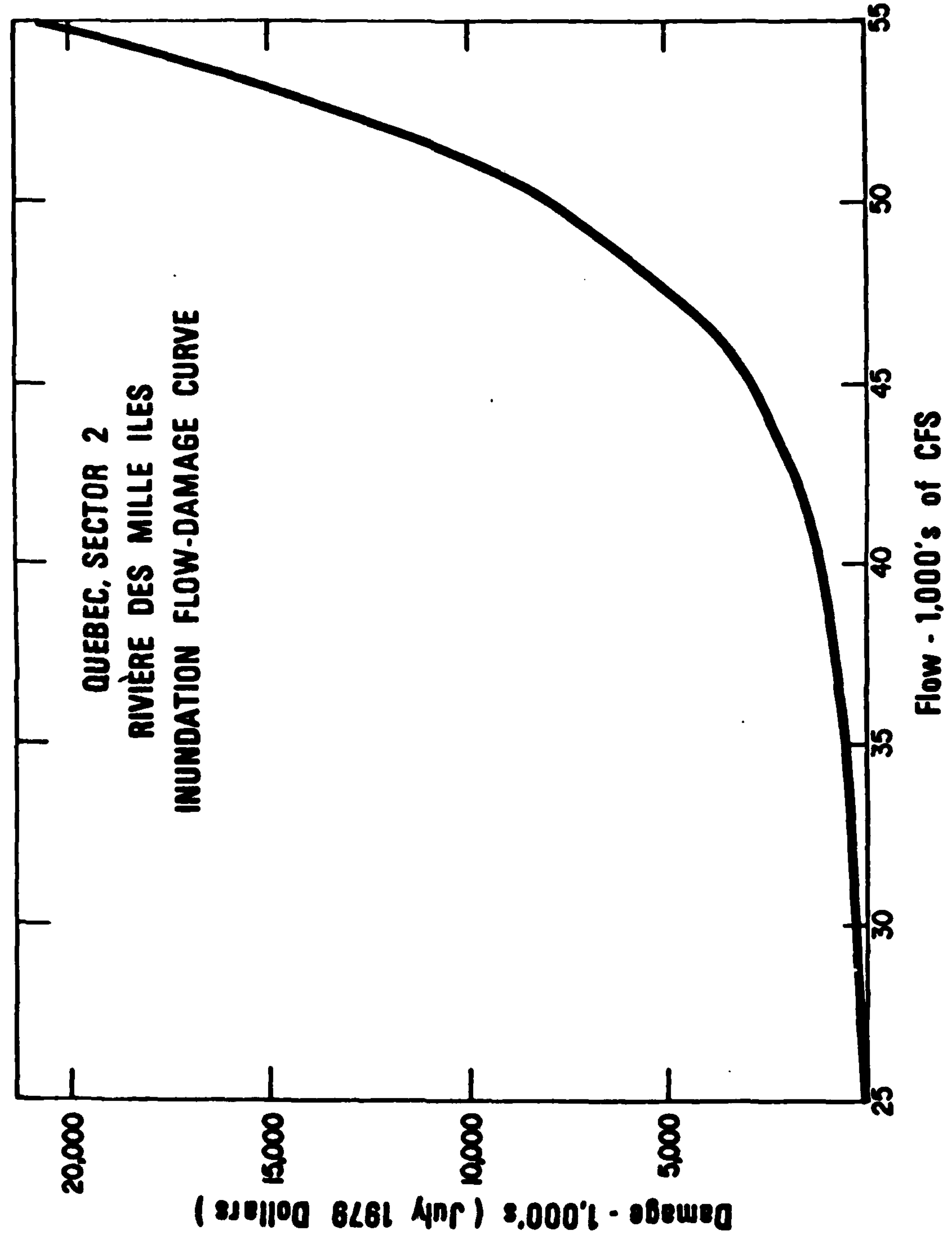
TABLE A3-25

CORNWALL ~~IN~~ OUT FLOW - DAMAGE CURVE

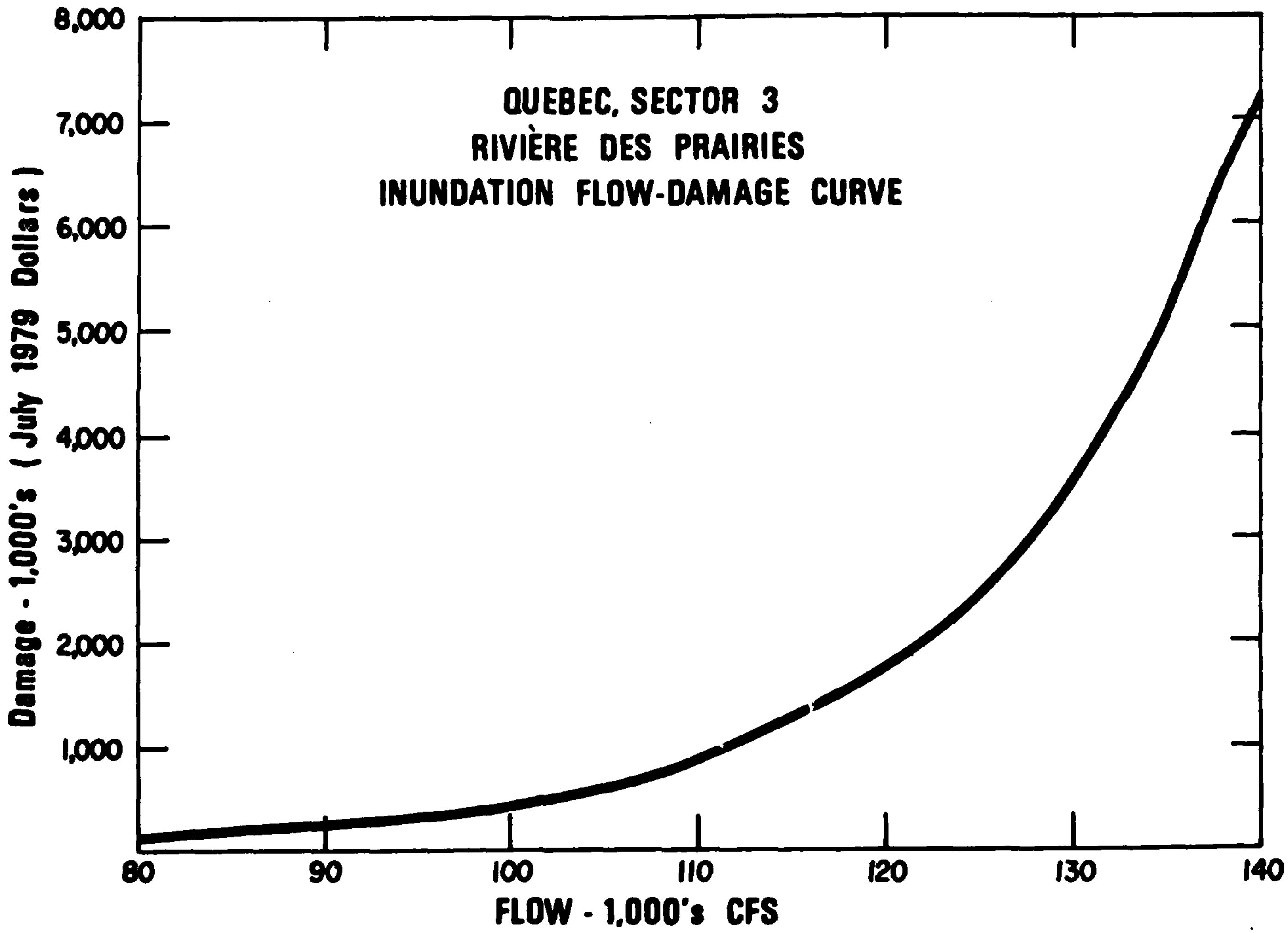
QUEBEC REACH, ST.LAWRENCE RIVER

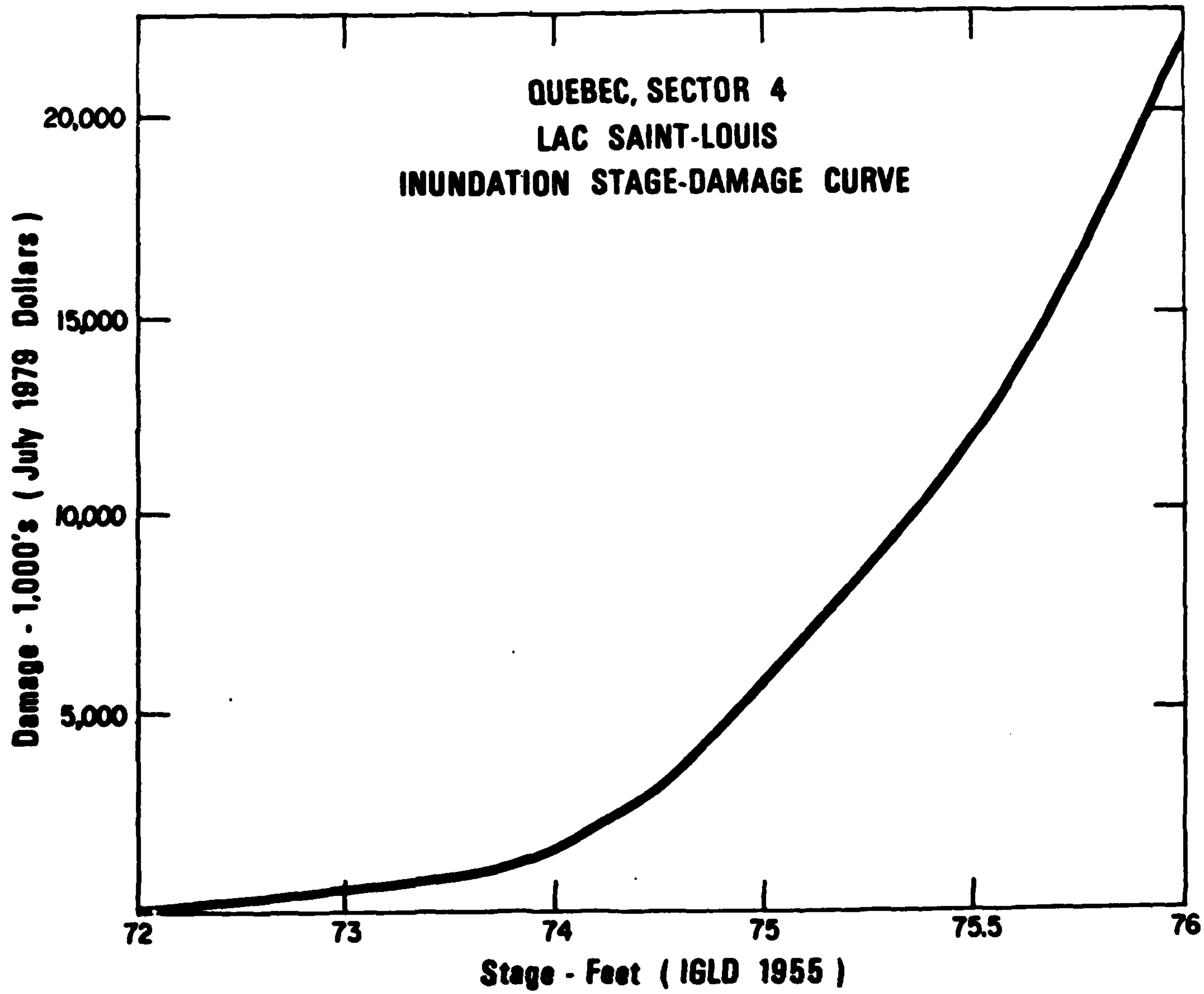
CORNWALL ~~IN~~ OUT FLOW (in '000 cfs)	DAMAGES ($'000, July 79)
180	598
185	654
190	717
195	785
200	859
205	941
210	1031
215	1129
220	1236
225	1354
230	148[illegible]
235	1623
240	1778
245	1947
250	2132
255	2335
260	2557
265	2800
270	3067
275	3358
280	3678
285	4028
290	4411
295	4830
300	5290
305	5793
310	6344
315	6948
320	7608
325	8332
330	9125
335	9993
340	10943
345	11984
350	13124

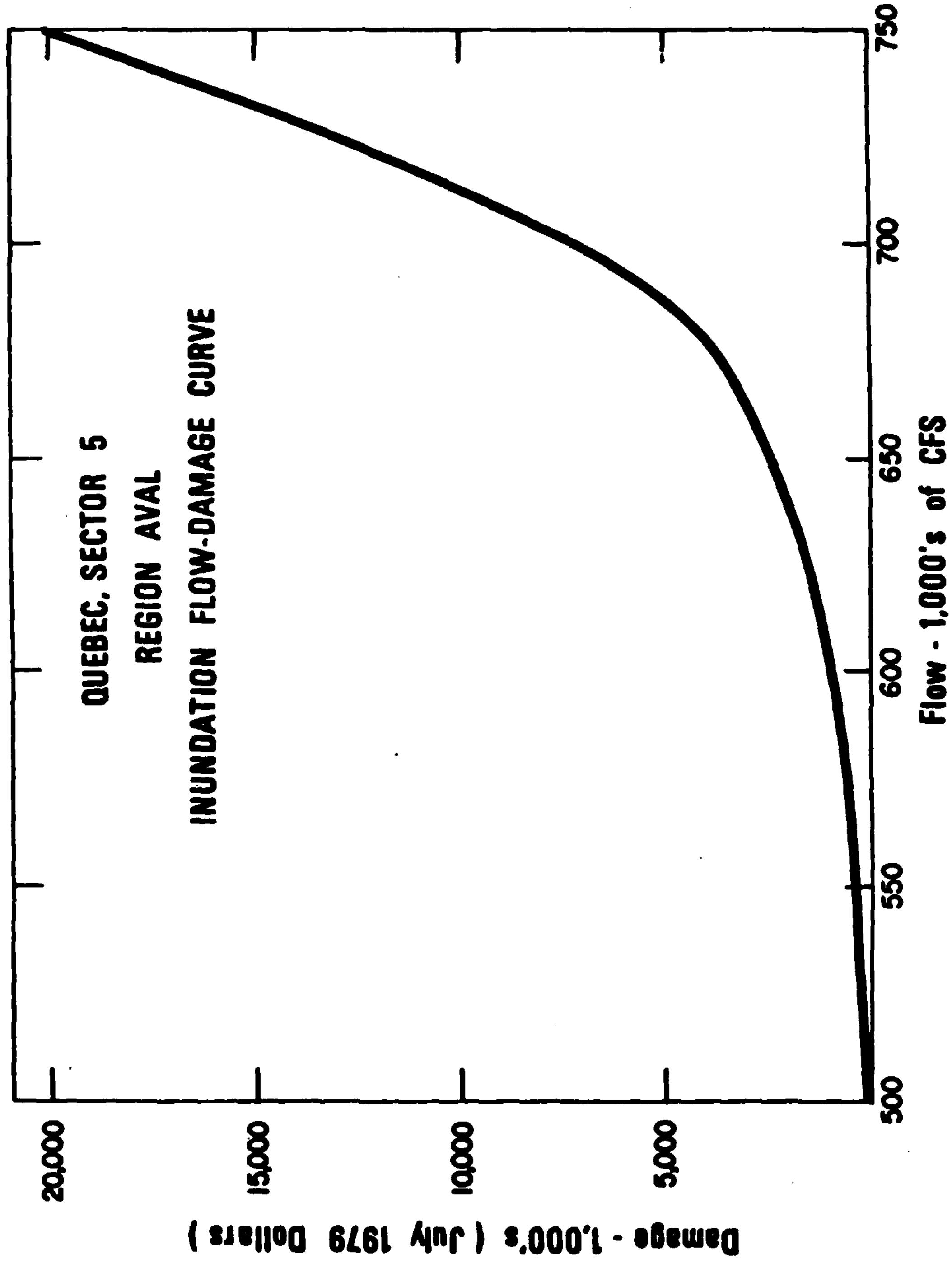

QUEBEC, SECTOR 1
LAC DES DEUX MONTAGNES
INUNDATION STAGE-DAMAGE CURVE
Damage - 1,000's (July 1979 Dollars)
30,000
25,000
20,000
15,000
10,000
5,000
76
77
78
79
80
81
Stage (feet), IGLD (1955)



QUEBEC, SECTOR 2
RIVIÈRE DES MILLE ILES
INUNDATION FLOW-DAMAGE CURVE
Damage - 1,000's (July 1979 Dollars)
20,000
15,000
10,000
5,000
Flow - 1,000's of CFS
25
30
35
40
45
50
55


QUEBEC, SECTOR 3
RIVIÈRE DES PRAIRIES
INUNDATION FLOW-DAMAGE CURVE
Damage - 1,000's (July 1979 Dollars)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
80
90
100
110
120
130
140
FLOW - 1,000's CFS


QUEBEC, SECTOR 4
LAC SAINT-LOUIS
INUNDATION STAGE-DAMAGE CURVE
Damage - 1,000's (July 1979 Dollars)
20,000
15,000
10,000
5,000
72
73
74
75
75.5
76
Stage - Feet (IGLD 1955)


QUEBEC, SECTOR 5
REGION AVAL
INUNDATION FLOW-DAMAGE CURVE
Damage - 1,000's (July 1979 Dollars)
20,000
15,000
10,000
5,000
Flow - 1,000's of CFS
500
550
600
650
700
750

```
      PROGRAM MF(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
C THIS PROGRAM COMPUTES THE FREQUENCY OF MONTHLY CORNWALL OUTFLOWS.
C FOR EACH YEAR, THE HIGHER OF THE APRIL AND MAY FLOWS IS SELECTED.  THE
C SELECTED FLOWS ARE THEN ORDERED FROM HIGHEST TO LOWEST AND THE FREQUENCY
C WITH WHICH EACH VALUE IS EXCEEDED IS CALCULATED.
      DIMENSION F(12),X(77),WORD(8),WRD(8)
10     CONTINUE
C INSERT BLANK CARD AT THE FRONT OF EACH DATA SET.
       READ(5,12) SKIP
       IF(EOF(5)) 9,25
25     CONTINUE
12     FORMAT(A1)
C INSERT TWO TITLE CARDS.
       READ(5,13)WORD
       READ(5,13)WRD
13     FORMAT(8A10)
       PRINT 14,WORD,WRD
14     FORMAT(//////1X,8A10/1X,8A10//1X,*PERCENTAGE OF THE 77 *
     * *YEARS THAT HAD THEIR MAXIMUM*/1X,* MONTHLY FLOW EQUAL TO*
     * * OR GREATER THAN THE SHOWN VALUES*//1X,*FLOW (TCFS)    *
     * *PER CENT*//)
      DO 1 I=1,77
C READ 77 YEARS OF MONTHLY MEAN CORNWALL OUTFLOW DATA.
      READ(5,2) F
2      FORMAT(12F6.2)
11    XX=0.0
       DO 3 N=4,5
      IF(F(N).GE.XX) XX=F(N)
3     CONTINUE
1     X(I)=XX
      VX=0.0
      VN=10000.0
      DO 4 I=1,77
      IF(X(I).GE.VX)VX=X(I)
       IF(X(I).LT.VN)VN=X(I)
4      CONTINUE
      VX=AINT(VX+.5)+2.0
      VN=AINT(VN+.5)-2.0
      SL=VX
7      COUNT=0.0
      DO 5 I=1,77
      IF(X(I).GE.SL) COUNT=COUNT+1.0
5      CONTINUE
      FR=COUNT/0.77
      PRINT 6,SL,FR
6     FORMAT(2F10.2)
      SL=SL-1.0
      IF(SL.LT.VN) 8,7
8      CONTINUE
      GOTO 10
9      CONTINUE
      PRINT 20
20      FORMAT(/////10X,*ALL SETS PROCESSED*)
       STOP
      END
```

A3-98

ANNEX A4

REFERENCES

REFERENCES

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5. Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data, "Coordinated Great Lakes Physical Data", 1977.

6. Fisheries and Environment Canada/Ontario Ministry of Natural Resources, "Great Lakes Flood and Erosion Prone Area Maps", 1978.

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9. Great Lakes Basin Commission, "Summary of Existing and Projected Land Use Information for the Great Lakes Coastal Counties", 1978.

10. International Joint Commission, "Further Regulation of the Great Lakes", 1976.

11. U.S. Army Corps of Engineers, Detroit District, "After Action Report Operation Foresight", 1975.

12. U.S. Army Corps of Engineers, North Central Division, "Great Lakes Shoreline Damage Survey", 1978.

ANNEX A5
MEMBERSHIP

ALPHABETICAL LIST OF PARTICIPANTS
IN COASTAL ZONE STUDY

NAME	AGENCY	PARTICIPATION	PERIOD
Bagheiai, Cyrus	COE (U.S.)[1]	Member, Coastal Zone Sub.	9/77-9/79
Baird, William	DPW (Canada)[7]	Associate	
Borek, Paul	GLBC (U.S.)[2]	Member, Coastal Zone Sub.	4/80-*
Brown, Douglas	DOE (Canada)[3]	Member, Coastal Zone Sub. Chairman, Canadian Section	9/77-12/79
Carpentier, Andre	EQ (Canada)[4]	Member, Coastal Zone Sub.	9/77-*
Clemens, Robert	GLBC (U.S.)	Member, Coastal Zone Sub.	8/78-4/80
Haras, William	DFO (Canada)[5]	Member, Coastal Zone Sub. Secretary, Canadian Section	9/77-*
Irvin, Richard	NYDS (U.S.)[6]	Member, Coastal Zone Sub.	9/77-*
Isoo, Mitchell	COE (U.S.)	Member, Coastal Zone Sub. Secretary, U.S. Section	9/77-4/80
Johnson, Charles	COE (U.S.)	Associate	
Kangas, John	COE (U.S.)	Member, Coastal Zone Sub. Secretary, U.S. Section	5/79-* 5/80-*
Kolberg, Ted	DPW (Canada)	Member, Coastal Zone Sub.	9/77-*
Kotas, Jerry	GLBC (U.S.)	Member, Costal Zone Sub.	9/77-7/78
Moulton, Ralph	DOE (Canada)	Member, Coastal Zone Sub. Chairman, Canadian Section	9/79-* 1/80-*
Pelletier, Jean-Yves	DOE (Canada)	Member, Coastal Zone Sub.	9/77-*
Pieczynski, Thomas	COE (U.S.)	Member, Coastal Zone Sub.	9/77-*
Strelchuk, David	OMNR (Canada)[8]	Member, Coastal Zone Sub.	9/77-*
Todd, Malcolm	COE (U.S.)	Member, Coastal Zone Sub. Chairman, U.S. Section	9/77-*
Worte, Charles	DOE (Canada)	Member, Coastal Zone Sub.	9/78-8/79

* Present
1. (COE) U.S. Army Corps of Engineers
2. (GLBC) Great Lakes Basin Commission
3. (DOE) Department of Environment
4. (EQ) Environnement Quebec
5. (DFO) Department of Fisheries and Oceans
6. (NYDS) New York Department of State
7. (DPW) Department of Public Works
8. (OMNR) Ontario Ministry of Natural Resources

ANNEX A6

CONVERSION FACTORS

(BRITISH TO METRIC UNITS)

1 cubic foot per second (cfs) = 0.028317 cubic metres per second (cms)

1 cfs-month = 0.028317 cms-month

1 foot = 0.30480 metres

1 inch = 2.54 centimetres

1 mile (statute) = 1.6093 kilometres

1 ton (short) = 907.18 kilograms

1 square mile = 2.5900 square kilometres

1 cubic mile = 4.1682 cubic kilometres

Temperature in Celsius: °C = (°F - 32) X 1.8

1 acre-feet = 1,233.5 cubic metres

1 gallon (U.S.) = 3.7853 litres

1 gallon (British) = 4.5459 litres

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