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DEPARTMENT OF THE ARMY

CORPS OF ENGINEERS

BEACH EROSION BOARD
OFFICE OF THE CHIEF OF ENGINEERS

WAVE AND
LAKE LEVEL STATISTICS
FOR LAKE ONTARIO

TECHNICAL MEMORANDUM NO. 38

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BEACH EROSION BOARD
CORPS OF ENGINEERS

MARCH 1953

FOREWORD

This is the third of a series of reports to be issued by the Beach Erosion Board under its General Investigations program to provide wave statistics for selected regions. The need for such data is evident, and it is planned ultimately to supply it by actual wave measurement for sufficiently long periods to establish the wave climate at many locations. Suitable instruments for that purpose have not yet been developed and even after they become available much time must pass before the records can attain statistical value. The production of wave statistics by "hindcast" technique, admittedly of presently indeterminate quantitative accuracy, will nevertheless provide the engineer with better wave data than have heretofore been available.

Thorndike Saville, Jr., author of the report, is a Hydraulic Engineer in the Research Division of the Beach Erosion Board under the supervision of Joseph M. Caldwell, Chief of the Division. At the time this report was prepared, the technical staff of the Board was under the general supervision of Colonel E. E. Gesler, President of the Board and R. O. Eaton, Chief Technical Assistant.

The author was aided in the study by Robert F. Dearduff, Hydraulic Engineer; by John C. Fairchild, and Francis W. Kellum in computations and compilations; in map reduction by Philip A. Brown, Edward L. Hoeftman, Duane E. Nelson, Joseph W. Rom, and Lloyd W. Zwingelberg; and in drafting by Wendell E. Reece. The report was edited for publication by Albert C. Rayner. Views and conclusions stated in the report are not necessarily those of the Beach Erosion Board.

TABLE OF CONTENTS

	Page
Introduction	1
Wave Statistics	1
Lake Levels	8

APPENDICES

- A - Wave Statistics for Hamilton, Ontario
- B - Wave Statistics for Rochester, New York
- C - Wave Statistics for Stony Point, New York

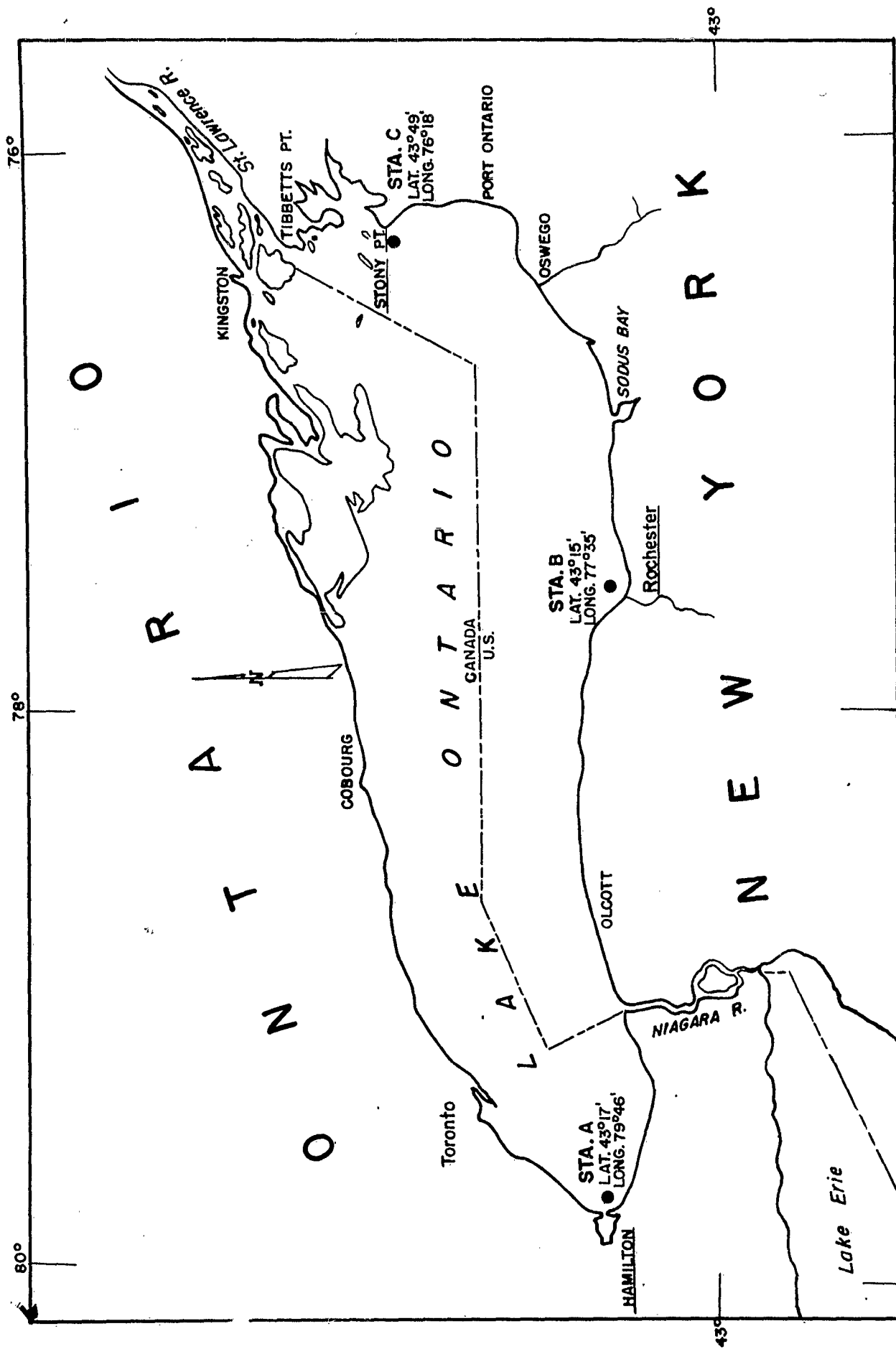


FIG.1 LOCATION OF WAVE HINDCASTING STATIONS FOR LAKE ONTARIO

WAVE AND LAKE LEVEL STATISTICS FOR LAKE ONTARIO

by

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INTRODUCTION

The General Investigations program of the Beach Erosion Board comprises investigations, regional rather than local in scope, designed to improve, simplify, and expedite the solution of local problems, by giving a compilation of all existing data pertinent to shore processes in the particular region. As a first step in the compilation of these data, a study of wave and lake level conditions on the Great Lakes is being made. The results of such a study for Lake Ontario are presented herein.

WAVE STATISTICS

Three stations on Lake Ontario were selected for a comprehensive wave analysis, the locations (see Figure 1) being as follows:

<u>Station</u>	<u>Latitude</u>	<u>Longitude</u>	<u>Vicinity</u>
A	43° 17' N	79° 46' W	Hamilton, Ontario
B	43° 15' N	77° 35' W	Rochester, New York
C	43° 49' N	76° 18' W	Stony Point, New York

These particular stations were selected since it was thought that they would give adequate coverage to the entire lake shore of the United States, and permit interpolation of values between stations, thus giving an accurate representation of wave action at any point along the United States shore line of Lake Ontario.

Wave characteristics were determined from synoptic weather charts for each station for the three-year period 1948-1950. The weather maps used were the North American Surface Synoptic Charts compiled at six-hour intervals by the U. S. Weather Bureau. Fetch areas, and the wind speeds and durations in these areas, were determined directly from the weather maps; these values were used with the curves derived by Sverdrup and Munk (1)* and revised by Arthur (2) and later by Bretschneider (3)

to obtain the hindcast wave characteristics. The only major variation from the usual methods of wave forecasting or hindcasting (4) (other than that the new Bretschneider revised curves were used) was that the surface wind was determined directly from reported observations rather than from a gradient wind determined from the isobar spacing. It was thought that with the lake area so small in comparison to the area of the pressure cell, the isobaric pattern on the surface would be influenced to a large extent by the surface topography, and gradient winds determined from the isobar spacing would not necessarily give true values of wind velocity over the lake surface. Hence reported values of the surface wind could be expected to give a more realistic figure of the wind velocity. Observations have shown (5) that the greater surface friction serves to reduce the wind over land from what it may be over water. Since the reported values were almost always obtained at land stations, the wind speeds used in the analysis may have been lower than those actually occurring over the lake in the generating area. Some compensation was made for this by selecting the top speed of the Beaufort range reported rather than the middle value.

The wave characteristics thus determined are for the significant wave -- that is, the period is that of the predominating waves, and the height is the average of the higher one-third of these predominant waves. These values are summarized for each station in Tables A-1 through C-1 (Appendices A through C). It should also be noted that the wave conditions in these tables are deep water conditions. They must be used in conjunction with refraction diagrams to obtain inshore values. The tables show, for each station, the number of hours' duration that deep water waves of any given height, period, and direction occurred during any month of the three-year period; and also for each month (as summations) the number of hours' occurrence of waves of any particular height and period exclusive of direction; the number of hours' occurrence of waves of any particular height and direction exclusive of period; and the total number of hours' occurrence of waves of any particular height.

As an example of the data presented, from Table B-1 (Table 1 for Station B) for the month of July, waves of 1 to 2-foot height and 3 to 4-second period from the west-northwest occurred for 12 hours during 1948, 12 hours during 1949, and 36 hours during 1950. Thus, waves of this category occurred for a duration of 60 hours during the three-year period and hence can be expected to occur for about 20 hours (on the average) during July of any year in the future. Waves of 1 to 2-foot height and 3 to 4-second period (from all directions) occurred for 156 hours over the three-year period, or an average of 52 hours per year. Waves of 1 to 2-foot height from the west-northwest (all periods) occurred for 66 hours over the three-year period, or an average of 22 hours per year. Waves of 1 to 2-foot height (all periods and all directions) occurred for 252 hours over the three-year period, or an average of 84 hours per year. Tables A-2 through C-2 show the summation of the values in Tables A-1 through C-1 for the entire year and are read similarly to those tables.

During much of the winter season, portions of the lake are covered with ice, and fetch areas are limited considerably. In addition, for a somewhat greater portion of the winter season, the coast area of the lake is covered with ice, and, even though waves are generated in offshore areas, they never reach the shore, being interrupted by the ice around the rim of the lake. No account of this effect of the ice was taken in the actual hindcasting of the waves, and the durations given for the various winter months are computed as though there were no ice on the lake, a fact that should be remembered in using these data.

From yearly records of lake and air temperatures, and the dates of opening and closing of the lake for navigation, an average ice-free period was determined. For Lake Ontario this appeared to run, on the average, from April through November, and the average ice-free period was determined as 1 April - 1 December for all three stations. A summation of the wave data for this ice-free period is shown in Tables A-3 through C-3. These tables are similar to Tables 1 and 2 and represent a summation of the values in Tables 1 for all months from April through November. The durations of waves of particular height and direction have also been tabulated as percentages of time for the three-year period and are shown graphically in the wave roses for the full year and also for the ice-free period in Figures A-1 through C-1. In these roses, as in all other curves contained herein, the durations are percentages of 365 days, for the ice-free period as well as the full year data.

Figures A-2 through C-2 show the total percentages of time that the wave height may be expected to be greater than any particular height throughout the year. They thus show the (average) total duration time of specific waves over the year. Two curves are shown, one based on the data gathered for the entire year, and the other on just the average ice-free period (April through November). For example, at Station B, the total duration of waves in excess of 10 feet in height during the ice-free period is expected to be 0.09 percent of the time; and 0.20 percent of the time during the full year. Hence waves 10 feet or higher can be expected to occur for a total duration of 18 hours ($0.002 \times 365 \times 24$) over the course of each year, and, of this, 8 hours ($0.0009 \times 365 \times 24$) will be during the ice-free portion of the year when the waves will be certain to reach the shore.

Figures A-3 through C-3 show the frequency with which storms resulting in waves higher than a given height can be expected to occur. For example, at Station B, on 0.64 percent of the days each year the waves may be expected to be ten feet or greater in height, and on 0.29 percent of the days they may be expected to reach this height during the ice-free portion of the year. Thus waves ten feet or higher may be expected to occur (on the average) $2\frac{1}{3}$ times each year (0.0064×365), or seven times every three years; of these occurrences, only one (0.0029×365) will be expected to occur during the ice-free portion of the year.

Combining the data obtained from graphs on Figures B-2 and B-3, waves ten feet and higher may be expected to occur at Station B slightly more frequently than twice each year, and the average duration of each storm will be about 8 hours. During the ice-free portion of the year, waves of ten feet and higher may be expected to occur only once, and the duration of this storm is also expected to be about 8 hours.

There are, in general, two methods of plotting points to obtain frequency curves such as those shown in Figures A-3 through C-3. One, based on the so-called theory of sampling, involves the assumption that the known period of record (three years) is a fair average sample of all similar three-year periods over an infinite number of years, and that therefore the largest storm of this three-year period is the median of all storms of the same class in all other three-year periods. This results in a frequency given by the following equation:

$$F = \frac{2N - 1}{2T} \times 100$$

where F = frequency (in percent) of the occurrence of storms equalling or exceeding the given storm

T = number of days of record

N = number of occurrences of a storm equal to or greater than the given storm

The second method essentially considers only the period of record, in which case the frequency becomes

$$F = \frac{N}{T} \times 100$$

Values of F are the abscissa of points on the frequency curve. Using the second equation above, the largest storm which occurred in the known three-year period would have an abscissa of .0914 percent and would represent the storm which would most probably occur once in three years, i.e., would be the "three-year storm", etc. But this would be contrary to the theory of sampling, where (above) the assumption is made that the largest storm in the known three-year period was the median of the largest storms in a long succession of three-year periods. Therefore, over a long period such as 300 years, it will be exceeded not 100 times, but 50 times; i.e., it is by definition not a "3-year storm", but a "6-year storm".

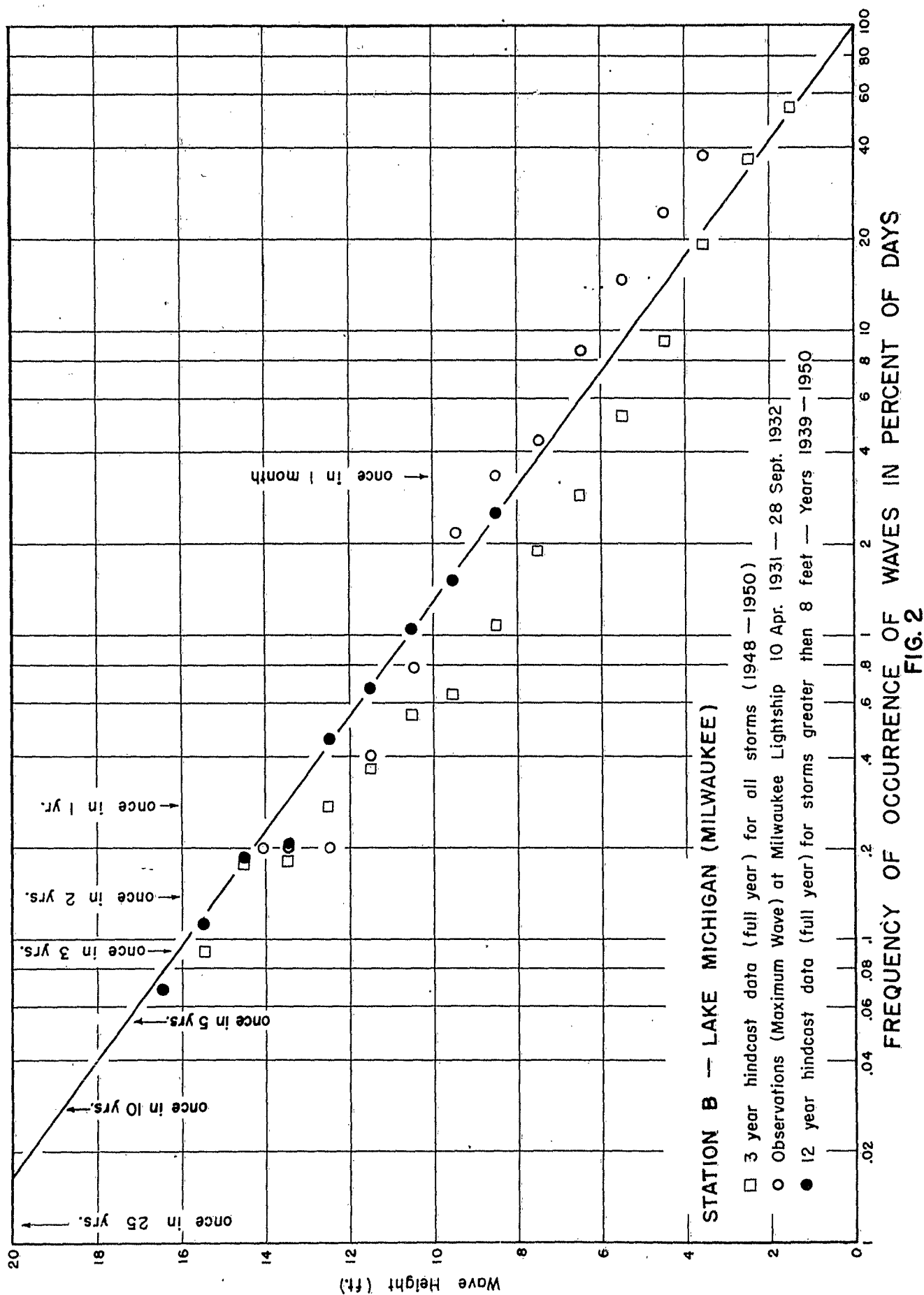
Either of the above two equations could be, and have been used to prepare frequency curves. Although the former is the one most generally used for hydrologic data, the latter method has been used in this case. The use of this formula ($F = 100N/T$) will result in a somewhat more conservative interpretation of the data, and was thought justified in view of the extremely short period of record (3 years).

The points plotted may be represented fairly closely by a continuous curve which frequently approximates a straight line, as may be seen from the figures. The curves shown have, in general, been drawn as lines of visual best fit; occasionally, however, more weight has been placed on the higher values. This tends to give a somewhat more conservative interpretation, which is thought warranted in some cases. The user is free to make his own interpretation of the plotted points. It is thought, also, that the very high waves occurring at Station A (Hamilton) may well represent storm waves of lesser frequency (particularly as there is a very sharp break and steepening of slope in the curve for the higher values), but due to the shortness of the period of observation this could not be determined.

In view of the shortness of the period of record some doubt arose as to the validity of extrapolation from these curves, and as to whether the three years chosen were representative (i.e., that they represent average conditions, and not three years of abnormally high, or low, waves). In a similar report, on Lake Michigan (6), hindcasts were made for one station for a period of 12 years (1939-1950) for all storms which were expected to give waves greater than 8 feet. The points determined were compared to those determined from the three-year data. These points fitted a straight line curve very closely and, though the points mostly lay slightly above those determined from the three-year data, the curve was not greatly different from that which had been drawn from the three-year data. Observations of the "average maximum" wave were obtained at this same station by the Milwaukee lightship over the period 10 April 1931 to 28 September 1932 (7) and these points were also compared to those hindcast. Although the exact correspondence between the significant waves hindcast and the "average maximum" waves observed is not known, values should be closely comparable -- and although the observed points lay somewhat higher for the lower waves, agreement was good for the higher waves. The comparison of these various points is shown in Figure 2.

Although comparisons were made for a station on Lake Michigan rather than on Lake Ontario, it is thought that the same degree of accuracy should be observed on Lake Ontario, and that therefore reasonable confidence can be put in the curves shown, at least for values of the waves occurring with frequencies less than about once in 10 years (with the possible exception of Station A).

Although for structural design purposes the important factor is the size of the maximum probable wave (within a certain time period), for computations involving sand movement and littoral drift, a more desirable parameter would be some averaged factor including within it the effect of both height and period, the variation of these parameters, and the duration that waves of each particular category exist. Present day knowledge indicates that sand movement by wave action is best correlated with the amount of energy transmitted forward (and eventually on to the beach) by the waves. The total energy per unit width in each wave is,



in deep water

$$E_o = \frac{wLH^2}{8} \left[1 - 4.93 \left(\frac{H}{L} \right)^2 \right] = \frac{wg}{16\pi} H^2 T^2 \left[1 - 4.93 \left(\frac{H}{L} \right)^2 \right]$$

where w = unit weight of water = 62.4 lbs./cu. ft.

g = acceleration due to gravity = 32.2 ft./sec./sec.

H = wave height (ft.)

T = wave period (sec.)

L = wave length (ft.)

One-half of this energy is transmitted forward from deep water toward the shore, and it is this amount of energy that eventually reaches the shore line. The total energy transmitted forward in any given period of time (E_T) is then $E_o/2$ times the number of waves occurring in that period of time,

$$\text{and } E_T = \frac{E_o}{2} \frac{(3600t)}{T} = 7.195 \times 10^4 H^2 T t \left[1 - 4.93 \left(\frac{H}{L} \right)^2 \right]$$

where t is the duration of the waves in hours. If some particular time interval (say one month) is considered during which waves of varying height and period pass a given point toward shore, then the heights and associated periods may be tabulated (as in Tables A-1 through C-1) and there will be n groups. If the height of the i th group is represented by its class mark $\bar{H}_i$, and the wave period in that group denoted by T_i , and the duration of the group by t_i , then the total amount of energy transmitted forward during the entire time interval is

$$E_T = E_{T1} + E_{T2} + E_{T3} + \dots + E_{Ti} + \dots + E_{Tn}$$

and

$$E_T = 7.195 \times 10^4 \sum_{i=1}^n \bar{H}_i^2 T_i t_i \left[1 - 4.93 \left(\frac{\bar{H}_i}{L_i} \right)^2 \right]$$

Tables A -4 through C-4 show a tabulation of the average energy transmitted forward from deep water toward the shore during the average ice-free period in each category of height, period, and direction. Thus for Station B, waves of 1 to 2-foot height and 3 to 4-second period from the west-northwest may be expected to transmit forward toward the shore 6214×10^4 foot-pounds per foot of wave crest during the ice-free period of each year. Waves of 1 to 2-foot height and 3 to 4-second period (all directions) would be expected to send forward $31,295 \times 10^4$ foot-pounds per foot of wave crest each ice-free period; waves of 1 to 2-foot height from the west-northwest (all periods) would be expected to send forward 7225×10^4 foot-pounds of energy per foot of wave crest; and waves of 1 to 2-foot height (all periods and directions) would be expected to

transmit toward the shore $37,214 \times 10^4$ foot-pounds of energy per foot of wave crest each ice-free period. Tables A-5 through C-5 show a similar tabulation for the average full year. Since the values in Tables A-1 through C-1 represent significant wave height and period, these energy values are those obtained if the wave system is uniform, and consists only of waves of significant height and period. Wave trains in nature are, however, exceedingly irregular, and have less energy than that determined by the significant wave concept. The relationship between the actual energy contained in any given wave train and that computed from the significant wave has been examined somewhat at Scripps Institution of Oceanography (8) and more recently by Barber (9) and Darbyshire (10), and has been found to be very nearly a constant ratio (on the order of 0.58). The energies given, therefore, may be considered to be the true value of the energy multiplied by some nearly constant value, and hence can be used to determine quite accurately ratios of energies from different directions. These latter represent very closely the ratios of the drift-producing forces. Summations of these energies for each direction and period grouping are shown in Figures A-4 through C-4.

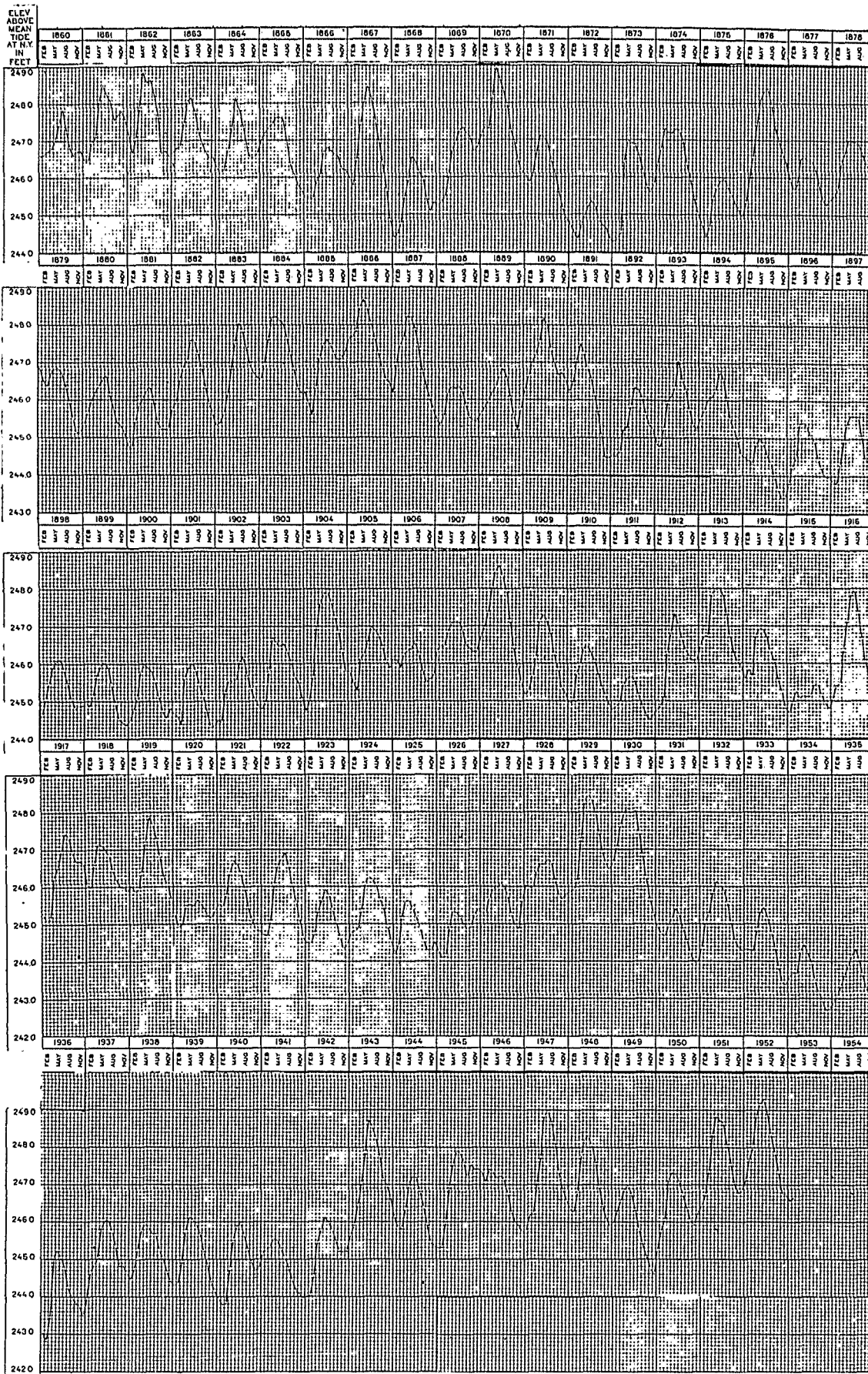
All the wave data given in the tables refer to deep water conditions--that is, depths greater than one-half the wave length. As such, interpolation between stations to obtain values for other points along the shore is quite valid, and it is felt that adequate deep water hindcast values may be thus obtained for all points on the United States shores of Lake Ontario.

Although the deep water data are useful for many types of design work, particularly for preliminary considerations, it is usually the inshore, shallow water data which are of the most interest. These data may be readily obtained from the deep water data through the use of refraction diagrams. A partial example for Ludington Harbor on Lake Michigan has been worked out and presented in the publication dealing with wave statistics on that lake (6), to which the reader may refer if unacquainted with the techniques involved.

LAKE LEVELS*

The levels of the Great Lakes fluctuate from year to year and from month to month during each year, depending upon the volume of water in the lakes. Continuous records of lake levels have been kept by the Corps of Engineers since 1860. A summary of these records for Lake Ontario is shown in Figure 3 which is a hydrograph of the monthly average levels from 1860 to date. The monthly average was chosen to eliminate the effects of short period barometric or wind-induced changes in stage. For Lake Ontario, the average level during the period of record (1860-1952) was 246.00 feet (above mean tide at New York, 1935 Datum) the highest one-month average of 248.97 occurring in May 1870 and July 1947 and the lowest of 242.68 occurring in November 1934. The difference between the highest and lowest monthly average levels is thus 6.29 feet, although the seasonal variation usually ranges between one and two feet

*Much of the following data on lake levels is taken almost verbatim from an unpublished report by the Great Lakes Div., Corps of Engrs., entitled "Preliminary Examination Report on Property Damage on the Great Lakes" issued in June 1952 (11).



MONTHLY MEAN WATER LEVELS OF LAKE ONTARIO
DATA COMPILED BY U.S. LAKE SURVEY, CORPS OF ENGINEERS
FIG. 3

(having an average range of 1.8 feet). The greatest range in level in a single season between the high and low month was 3.5 feet, and the lowest was 0.3 feet. The usual pattern of seasonal variation shows high levels in the summer and low levels in late winter (Figure 4). The highest monthly average level is usually reached in June and the lowest in January, though occasionally seasonal fluctuations have departed greatly from this usual pattern.

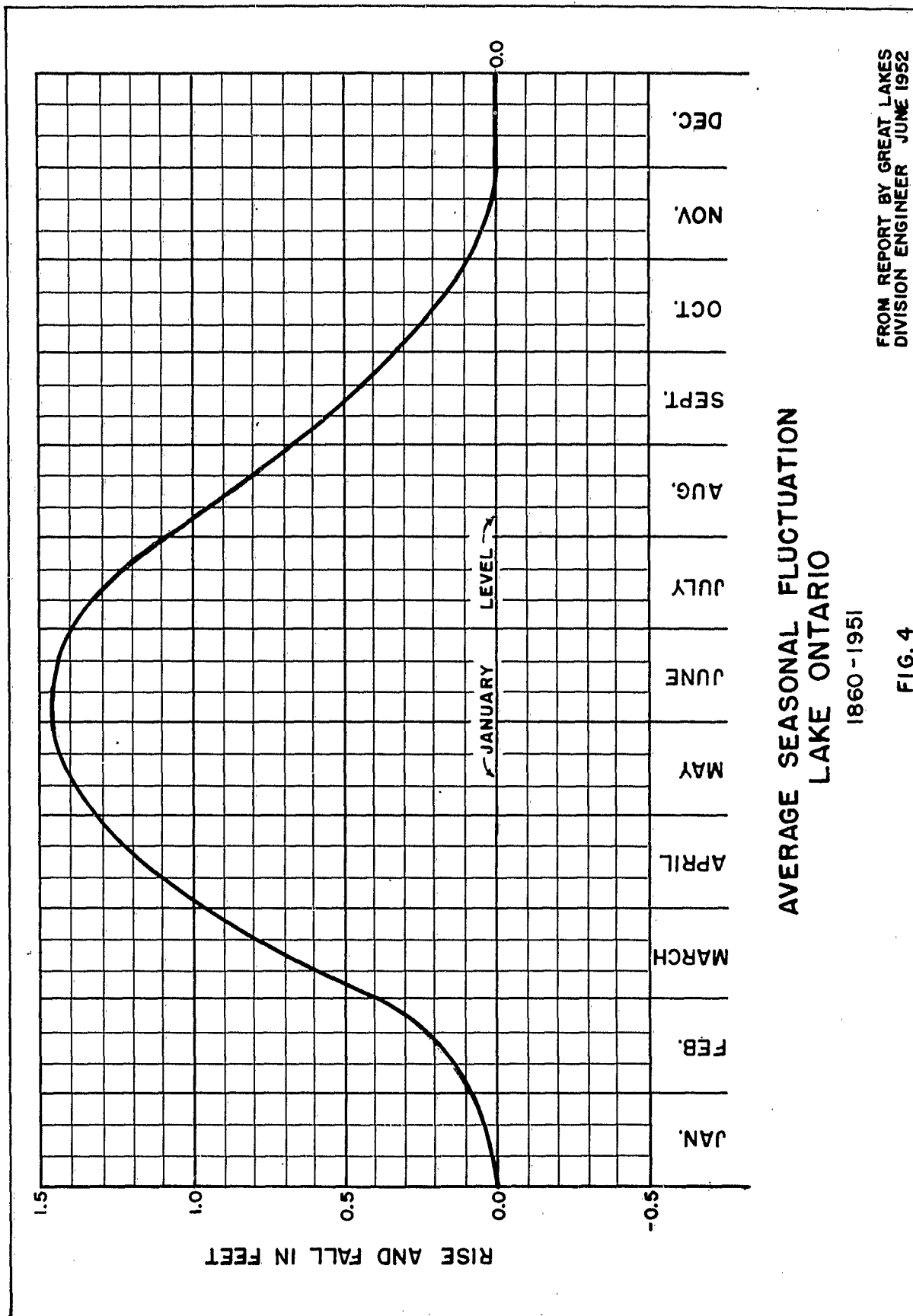
Figure 5 shows the percentage of time that the seasonal high average monthly level reaches various elevations on Lake Ontario for single, two, three, four, and five consecutive years. For example, it shows that the high monthly average each year reached elevation 245 feet or higher 97 percent of the time, reached elevation 246 feet or higher 80 percent of the time, reached elevation 248 feet or higher 20 percent of the time, and so on. It also shows that while the high monthly average level reached 246 feet or higher 80 percent of the time in single years, it reached this elevation only 70 percent of the time in two consecutive years, only 62 percent of the time in three consecutive years, only 51 percent of the time in four consecutive years, and only 46 percent of the time in five consecutive years.

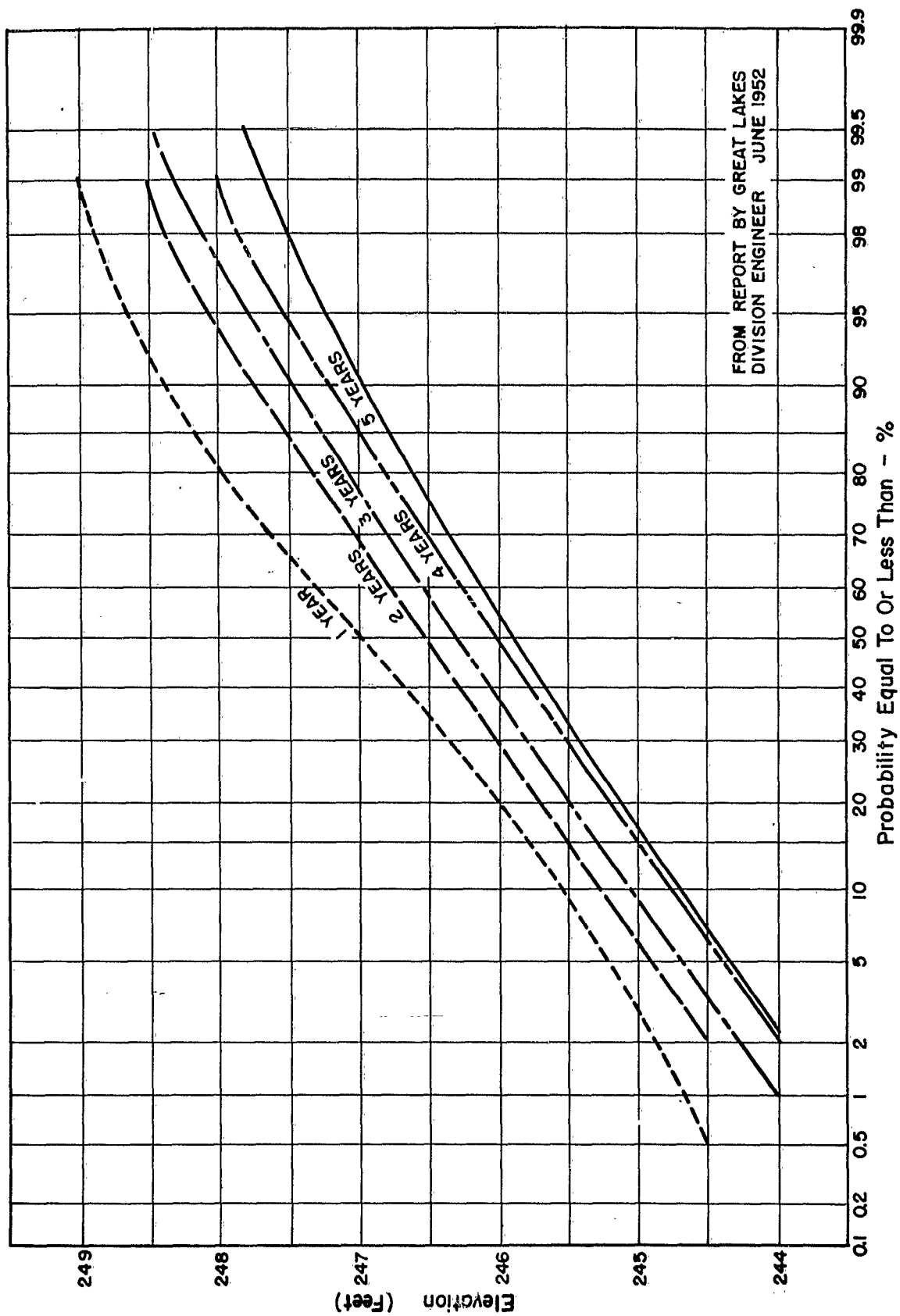
Superimposed on the long range and seasonal fluctuations resulting from the actual quantities of water present in the lake, are daily and even hourly fluctuations resulting from an unbalance or tilting of the lake surface. These are induced primarily by winds, though some have attempted to ascribe them to differential barometric pressures. Figure 6 is derived from data given in a report by the Great Lake Division Engineer (11) and shows the frequency of occurrence of short-period fluctuations at various gage sites on Lake Ontario during the period of record. Short-period rises at intermediate points between gage sites depend upon local conditions, but reference to the figures for points in the vicinity will provide an indication of the rises to be expected.

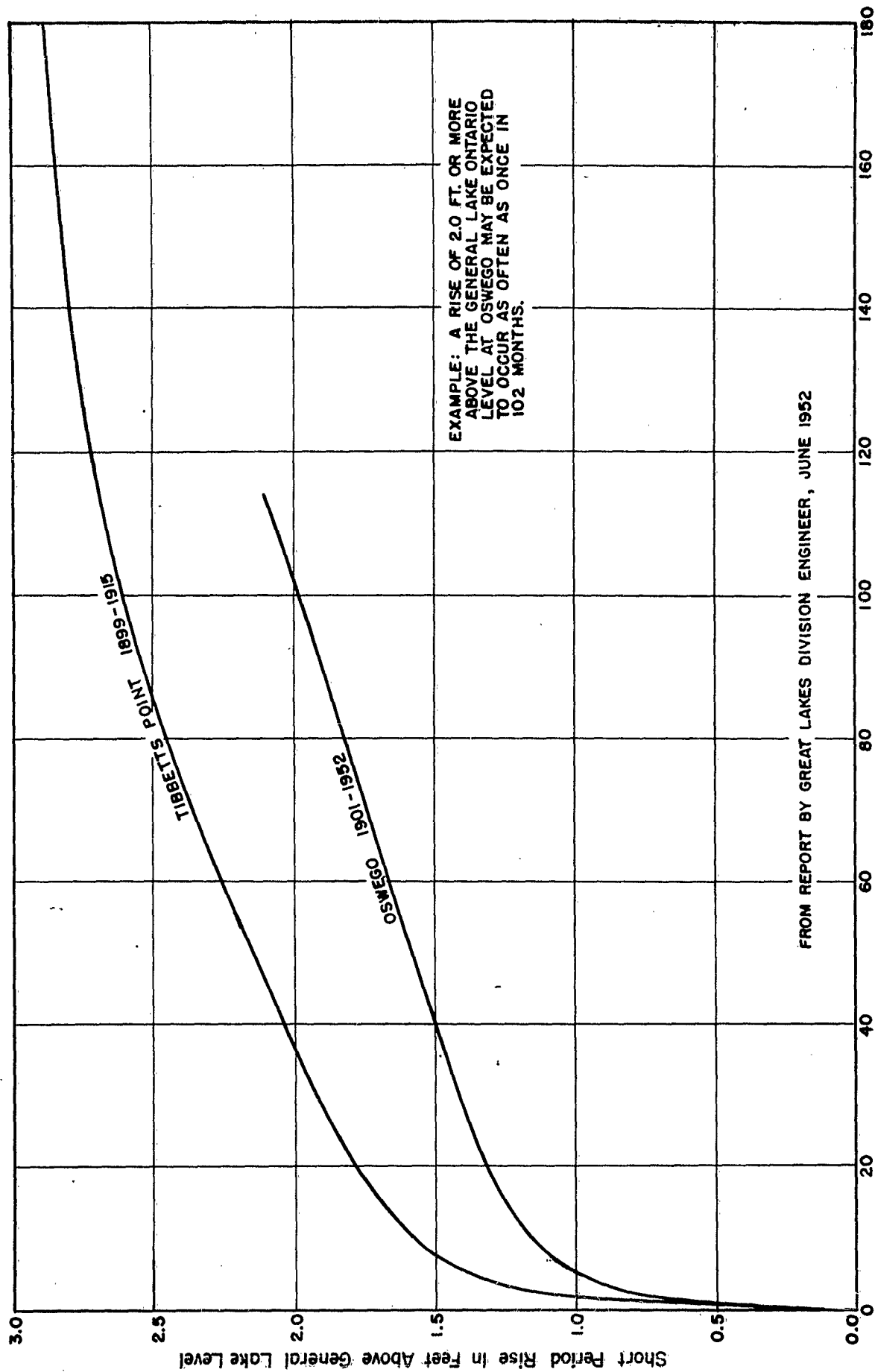
It has been found (12)(13) that, at least for shallow water areas, the rise in level due to wind stress may be predicted quite accurately by the formula

$$S = 1.165 \times 10^{-3} \frac{V^2 F}{D} N \cos \alpha$$

where S is the total set-up (difference in water surface elevations at the windward and leeward sides of the lake) in feet, F is the fetch length in statute miles, V is the average wind velocity over the fetch in miles per hour, D is the average depth in feet of that portion of the lake that is more or less contiguous to the fetch, α is the angle between the wind and the fetch, and N is a shape coefficient dependent on the planform and nearshore hydrography of the particular area. Though methods of computing N are available, unless the area is a very marked convergent bay, it is usually sufficient to assume values of $N = 1$. The actual rise in water surface elevation above still water level will







FREQUENCY OF OCCURRENCE - SHORT PERIOD FLUCTUATIONS
TIBBETTS POINT & OSWEGO - LAKE ONTARIO
FIG. 6

be slightly greater than $S/2$ depending on the nearshore hydrography; an average value of 0.57 has been in general use, and is quite adequate. Although this formula has been checked quite adequately for shallow areas (experimental tanks, the Zuider-Zee, and Lake Okeechobee) extension to deeper waters, as Lake Ontario, may be unwarranted, and it should be used with some caution.

REFERENCES

1. Sverdrup, H. U. and W. H. Munk - Wind Sea and Swell: Theory of Relations for Forecasting, H. O. Pub. 601, 1947.
2. Arthur, R. S. - Revised Wave Forecasting Graphs and Procedures, Scripps Inst. of Oceanog, Wave Report No. 73, 1947 (unpub.)
3. Bretschneider, C. L. - Revised Wave Forecasting Relationships, Proceedings of the 2nd Conf. on Coastal Engineering, 1951.
4. Hydrographic Office - Techniques for Forecasting Wind Waves and Swell, H. O. Pub. 604, 1951.
5. Hydrometeorological Section, U. S. Weather Bureau - Analysis of Winds over Lake Okeechobee During Tropical Storm of August 26-27, 1949, Hydromet. Report 26, 1951.
6. Saville, T., Jr. - Wave and Lake Level Statistics for Lake Michigan, Beach Erosion Board Tech. Memo. 36, 1953.
7. Milwaukee District, Corps of Engineers - Lake Michigan Wave Measurements at Milwaukee, Wisconsin, Misc. rpt. 20/203-1, 1933 (unpub.)
8. Scripps Institution of Oceanography - A Statistical Study of Wave Conditions at Five Open Sea Localities Along the California Coast, Wave Report 68, 1947 (unpub.)
9. Barber, N. F. - Ocean Waves and Swell, London Institution of Civil Engineers, Maritime and Waterways Division, 1950.
10. Darbyshire, J. - The Generation of Waves by Wind, Proceedings of the Royal Society, Series A, Vol. 215, No. 1122, 1952.
11. Great Lakes Division, Corps of Engineers - Preliminary Examination Report on Property Damage on the Great Lakes Resulting from Changes in Lake Level, June 1952 (unpub.).
12. Keulegan, G. H. - Wind Tides in Small Closed Channels, Jour. Res. Nat'l. Bur. Stds., RP 2207, v. 46, n. 5, 1951.
13. Saville, T. Jr. - Wind Set-up and Waves in Shallow Water, Beach Erosion Board Tech. Memo 27, 1952.

WAVE AND LAKE LEVEL STATISTICS

FOR

LAKE ONTARIO

APPENDIX A

WAVE STATISTICS

FOR

STATION A

HAMILTON, ONTARIO

TABLE A-1

[illegible]

FEBRUARY

[illegible]

MARCH 2

[illegible]

TABLE A.1

MAY

111

A-2.

JULY

	Period				3-4 Seconds				4-5 Seconds				5-6 Seconds				2-6 Seconds			
HEIGHT (FEET)	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total
5-	HWSR	.6		.6													.6			
	NF	.6		.6														.6		
	ENE	12	24		36									12	24					
	E		.6	.6														.6		
	RSE		.6	.6														.6		
	TOTAL	24	36	6	66									24	36	6				
1-2	N	.6		.6													.6			
	NF	.6	.6	.6				12									.6	12	12	30
	ENE	.6	.6	.6				6						12	.			12	18	
	E		.6	.6				6							12	.		12	18	
	TOTAL	18	18	12	48			6	12	6	24				24	30	18	72		
2-3	HWSR							18										18		
	ENE									6		6						6		
	E							6				6						6		
	TOTAL							24		6		6						18	12	30
3-4	HWSR							6				6						12		
	NF							6				6						12	6	18
	TOTAL							6				6	18					24	6	30
4-5	NF																			
	TOTAL	42	54	18	114	50	18	6	54	18	6	6	30	6	6	12	6	12	6	24
	CALM TOTAL HOURS																640	661	708	302
																	744	746	744	823

AUGUST

[illegible]

SEPTEMBER.

[illegible]

OCTOMER

NOVEMBER

DECEMBER

A-4

Duration given in hours. Height and period groupings include lower value but not the upper.

TABLE A-3

Duration given in hours. Height and period groupings include lower value but not the upper

A-5

TABLE A-4
STATISTICAL ENERGY DATA FOR LAKE ONTARIO STATION A, HAMILTON, ONTARIO
(ICE-FREE PERIOD (1 APRIL - 30 NOV.)

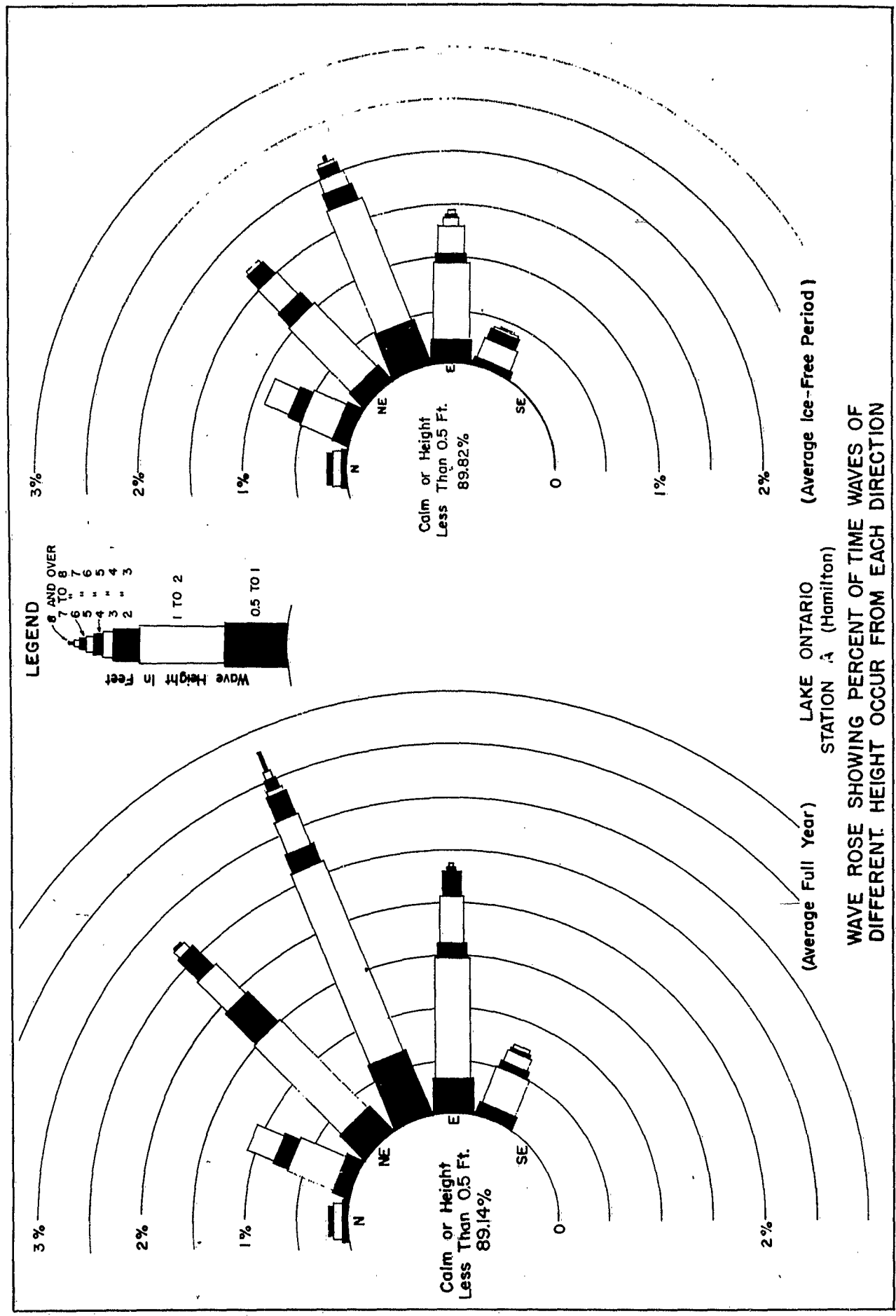
Energy given in foot-pounds per foot of crest per year $\times 10^4$. Height and period groupings include lower value but not the upper

Height (Feet)	Period (Secs)	2-3 Seconds	3-4 Seconds	4-5 Seconds	5-6 Seconds	6-7 Seconds	7-8 Seconds	8-10 Seconds	11-12 Seconds	13-14 Seconds
5-1	N	4.0								4.0
	NNE	12.1								12.1
	NE	18.2								18.2
	ENE	40.8								40.8
	E	18.2		3.6						21.8
1-2	ESE	6.1								6.1
	Total	9.0		3.6						12.6
	N	8.0	1.1							9.1
	NNE	6.1	9.0							15.1
	NE	12.1	30.0							42.1
2-3	ENE	9.1	39.9	11.6						60.6
	E	8.1	20.9	2.9		2.0				34.0
	ESE	4.0	4.5							8.5
	Total	24.5	105.0	14.5		2.0				140.0
	N		6.2							6.2
3-4	NNE		15.2							15.2
	NE		12.4	16.1						28.5
	ENE		12.4	8.0						20.4
	E		9.3							9.3
	Total		6.2	24.1						30.3
4-5	NNE		18.2	6.1						24.3
	NE		6.0	9.6						15.6
	ENE			5.2						5.2
	E		6.0	7.0	19.2					32.2
	Total		36.7	27.7	19.2					93.6
5-6	N			12.9						12.9
	NNE			7.0						19.9
	E			12.9						22.9
	ESE									22.9
	Total			25.8						45.7
6-7	N									
	NNE									
	E									
	ESE									
	Total									
7-8	N									
	NNE									
	E									
	ESE									
	Total									
8-10	N									
	NNE									
	E									
	ESE									
	Total									
11-12	N									
	NNE									
	E									
	ESE									
	Total									
13-14	N									
	NNE									
	E									
	ESE									
	Total									
TOTAL		48.5	20.0	36.4	7.4	2.0	14.2	32.0	8.9	240.6

TABLE A-5
STATISTICAL ENERGY DATA FOR LAKE ONTARIO STATION A, HAMILTON, ONTARIO
FULL YEAR

Energy given in foot-pounds per foot of crest per year $\times 10^4$. Height and period groupings include lower value but not the upper

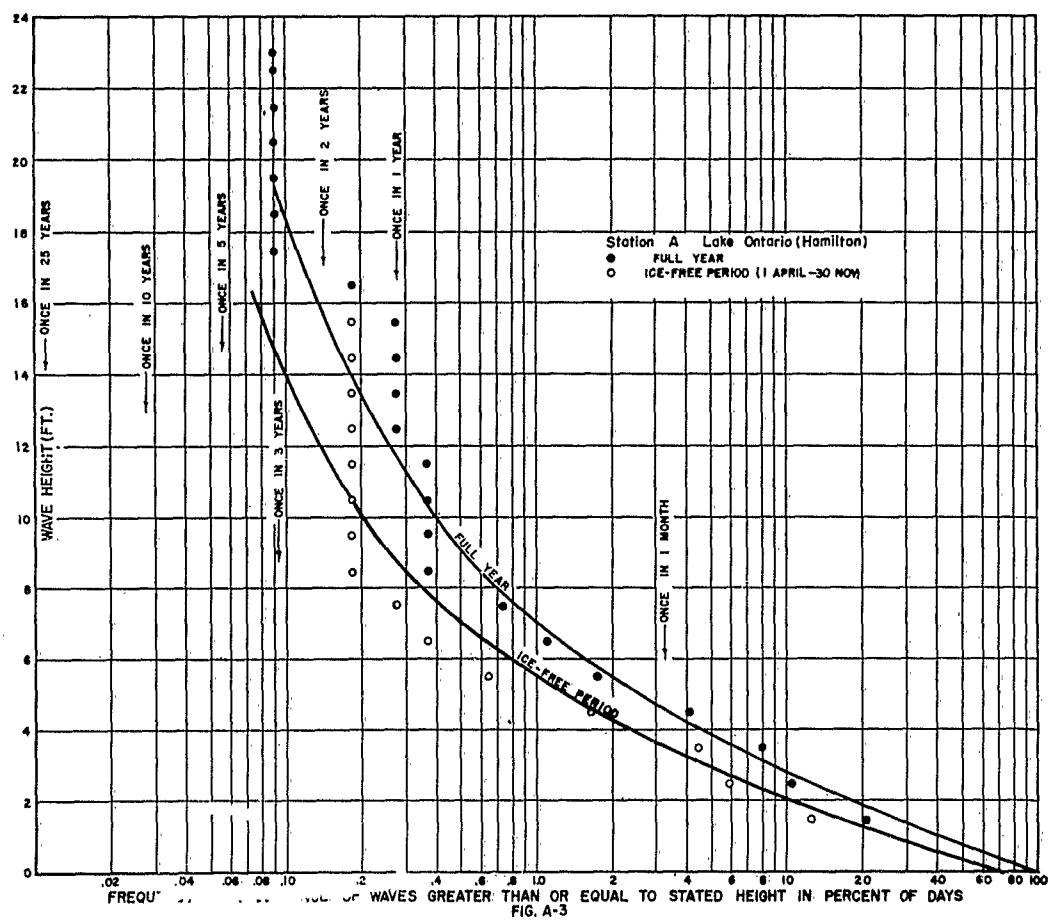
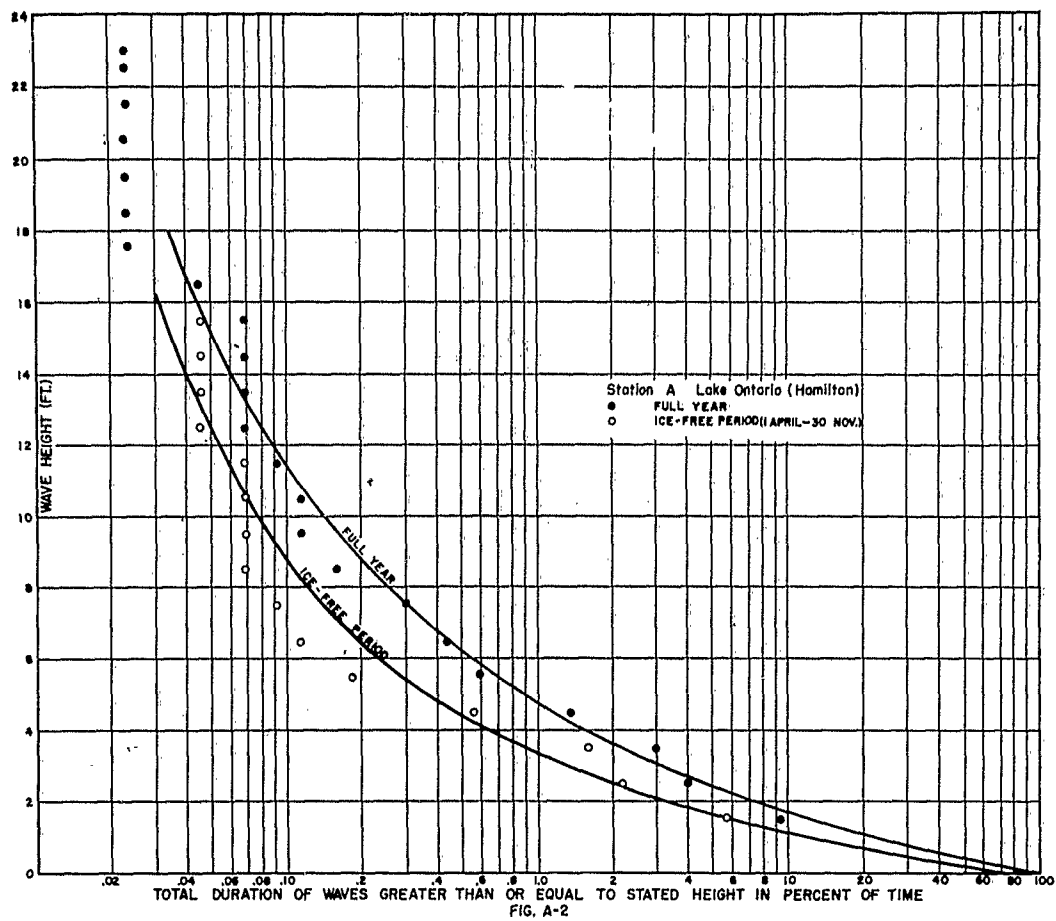
Height (Feet)	Period (Secs)	2-3 Seconds	3-4 Seconds	4-5 Seconds	5-6 Seconds	6-7 Seconds	7-8 Seconds	8-10 Seconds	11-12 Seconds	13-14 Seconds
5-1	N	4.0								4.0
	NNE	12.1								12.1
	NE	18.2								18.2
	ENE	40.8								40.8
	E	18.2		3.6						21.8
1-2	ESE	6.1								6.1
	Total	9.0		3.6						12.6
	N	8.0	1.1							9.1
	NNE	6.1	9.0							15.1
	NE	12.1	30.0							42.1
2-3	ENE	9.1	39.9	11.6						60.6
	E	8.1	20.9	2.9		2.0				34.0
	ESE	4.0	4.5							8.5
	Total	24.5	105.0	14.5		2.0				140.0
	N		6.2							6.2
3-4	NNE		15.2							15.2
	NE		12.4	16.1						28.5
	ENE		12.4	8.0						20.4
	E		9.3							9.3
	Total		6.2	24.1						30.3
4-5	NNE		18.2	6.1						24.3
	NE		6.0	9.6						15.6
	ENE			5.2						5.2
	E		6.0	7.0	19.2					32.2
	Total		36.7	27.7	19.2					93.6
5-6	N			12.9						12.9
	NNE			7.0						19.9
	E			12.9						22.9
	ESE									22.9
	Total			25.8						45.7
6-7	N									
	NNE									
	E									
	ESE									
	Total									
7-8	N									
	NNE									
	E									
	ESE									
	Total									
8-10	N									
	NNE									
	E									
	ESE									
	Total									
11-12	N									
	NNE									
	E									
	ESE									
	Total									
13-14	N									
	NNE									
	E									
	ESE									
	Total									
TOTAL		6.7	36.4	69.1	69.1	32.2	69.1	14.2	8.9	240.6

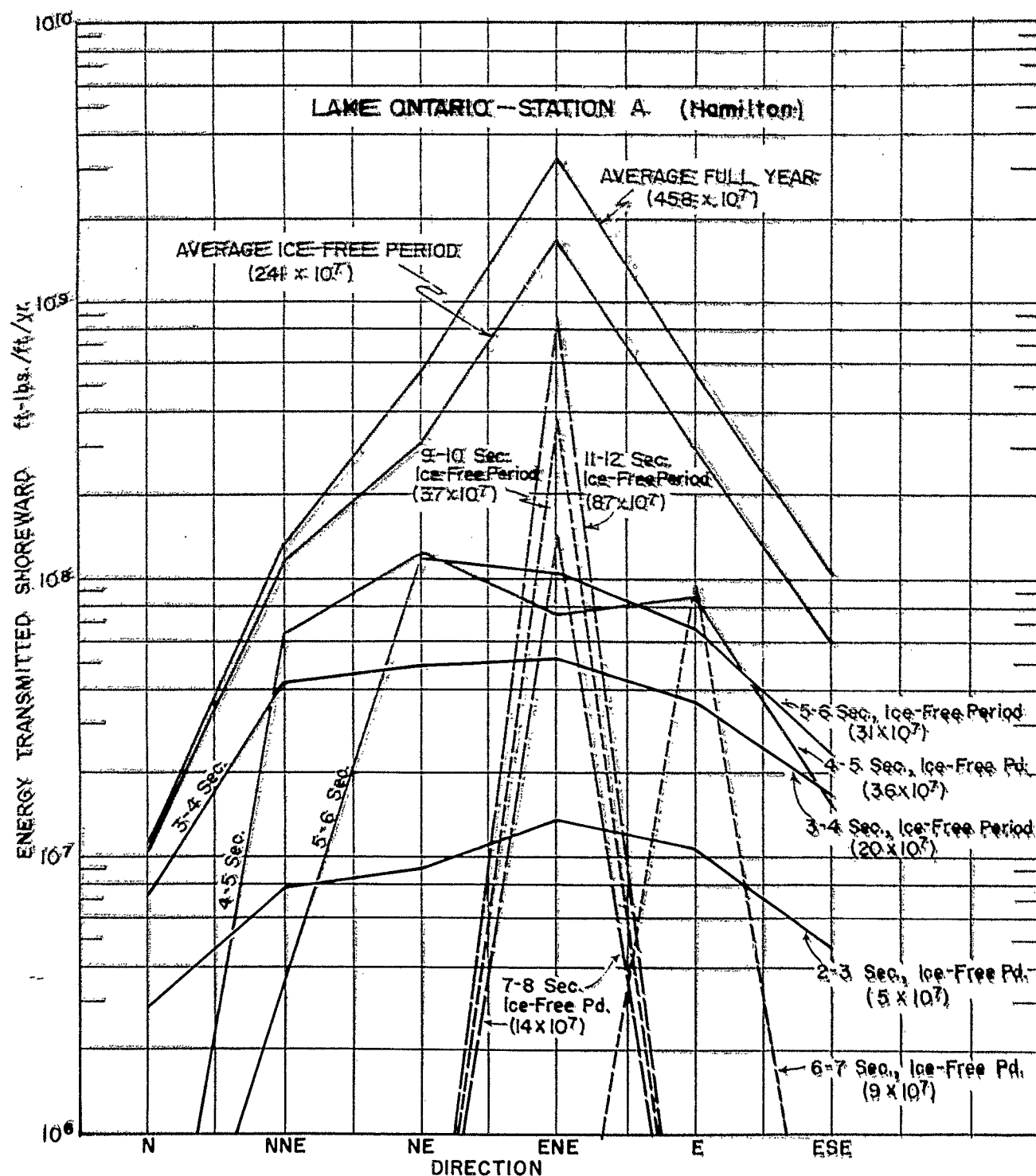


(Average Full Year) LAKE ONTARIO STATION A (Hamilton) (Average Ice-Free Period)

WAVE ROSE SHOWING PERCENT OF TIME WAVES OF DIFFERENT HEIGHT OCCUR FROM EACH DIRECTION

FIG. A-1





AVERAGE AMOUNT OF ENERGY TRANSMITTED SHOREWARD PER FOOT OF CREST LENGTH PER YEAR, IF WAVE SYSTEM IS CONSIDERED AS AN HYPOTHETICAL, UNIFORM SYSTEM COMPOSED OF WAVES OF SIGNIFICANT HEIGHT AND PERIOD ONLY.

FIG. A-4

WAVE AND LAKE LEVEL STATISTICS

FOR

LAKE ONTARIO

APPENDIX B

WAVE STATISTICS

FOR

ROCHESTER, NEW YORK

[illegible]

STATISTICAL HINDCAST DATA FOR LAKE ONTARIO STATION B, ROCHESTER, N.Y.
Duration given in hours. Height and period groupings include lower value but not the upper.

[illegible]

WAVE AND LAKE LEVEL STATISTICS

FOR

LAKE ONTARIO

APPENDIX B

WAVE STATISTICS

FOR

ROCHESTER, NEW YORK

TABLE B-1
STATISTICAL HINDCAST DATA FOR LAKE ONTARIO STATION B, ROCHESTER, N.Y.
Duration given in hours. Height and period groupings include lower value but not the upper.

		2-3 Seconds				3-4 Seconds				4-5 Seconds				5-6 Seconds				6-7 Seconds				2-7 Seconds			
HEIGHT (FEET)		1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total
.5-1	W		12		12																	12		12	
	NW			6	6																		6		6
	N	6	18		24																	6	18		24
	NE	12			12																	12			12
	E	12		12	24																	12		12	24
	TOTAL	30	12	18	60																	30	12	18	60
1-2	W					30			30													30			30
	NW		6		6	12	24	12	48													12	30	12	54
	N			6	6	6	12	6	24													6	12	12	30
	NE		6		6	6	18	6	30													6	24	6	36
	E	6		6	12	6	6	6	18													12	6	12	30
	TOTAL	6	18	12	36	60	72	48	180													66	90	60	216
2-3	W					6	6	6	18				6									6	12	6	24
	NW					12	6	6	18	6	12		18									18	12	6	36
	N							6	6	6		18		18								6		6	12
	NE					6		6	12	12		24										18	12	6	36
	E					6	6	6	18	12	12	24										18	12	6	36
	TOTAL					30	12	18	60	24	48	72										54	60	18	132
3-4	W									6	6	12		6		6						6	12		18
	NW									12	6	18										12	6		18
	N									6		6	12									6	6	6	18
	NE									6	12	18										6	12		18
	E									6	6	12		6		6						6	12	6	24
	TOTAL									36	30	72		12		12						36	42	12	90
4-5	W									6	6	12		6	24	12	42					6	30	18	54
	NW									6	6	12										6	6		12
	N									6		6										6	6		12
	NE									6		6										6	6		12
	E													6	6		12					6	6		12
	TOTAL									12	12	6	30	18	36	12	66					30	48	18	96
5-6	W													6		6		12				12			12
	NW													6	6							6			6
	N													6		6						6			6
	NE													6		6						6			6
	E													12	6	6	24	12				12	24	6	36
	TOTAL													12	6	6	24	12				12	24	6	36
6-7	W													6		6						6			6
	NW													6		6						6			6
	N													6		6						6			6
	NE													6		6						6			6
	E													6		6						6			6
	TOTAL													6		6						6			6
TOTAL	W	36	60	30	126	90	84	66	240	72	90	18	180	36	54	18	108	12	12		24	246	300	132	678
	CALM TOTAL HOURS																					498	444	612	1554

TABLE B-1

STATISTICAL HINDCAST DATA FOR LAKE ONTARIO STATION B, ROCHESTER, N.Y.
Duration given in hours. Height and period groupings include lower value but not the upper.

FEBRUARY.

B-2:

TABLE B-1
STATISTICAL HINDCAST DATA FOR LAKE ONTARIO STATION B, ROCHESTER, N.Y.
Duration given in hours. Height and period groupings include lower value but not the upper.

HEIGHT (FEET)	Period	2-3 Seconds				3-4 Seconds				4-5 Seconds				5-6 Seconds				6-7 Seconds				7-8 Seconds				8-9 Seconds			
		1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total
5-7	WIND			12	12																								
	SW		12		12																								
	SE	6		12	18																								
	NE		6	6	12																								
	NW		6		6																								
	TOTAL	12	30	30	72																								
1-2	WIND				6	36	24	66																					
	SW		6		6	18	18	36																					
	SE		6		6	12	6	18																					
	NE					18	6	24																					
	NW	6			6	18	6	24																					
	TOTAL	6	12		18	66	30	120																					
2-3	WIND				6	6	6	12																					
	SW																												
	SE																												
	NE																												
	NW																												
	TOTAL																												
3-4	WIND					6	18	24																					
	SW					6	12	18																					
	SE																												
	NE																												
	NW																												
	TOTAL					6	18	24																					
4-5	WIND					6	12	12																					
	SW					6	12	12																					
	SE																												
	NE																												
	NW																												
	TOTAL					6	12	12																					
5-6	WIND																												
	SW																												
	SE																												
	NE																												
	NW																												
	TOTAL																												
6-7	WIND																												
	SW																												
	SE																												
	NE																												
	NW																												
	TOTAL																												
7-8	WIND																												
	SW																												
	SE																												
	NE																												
	NW																												
	TOTAL																												
10-11	WIND																												
	SW																												
	SE																												
	NE																												
	NW																												
	TOTAL																												
11-12	WIND																												
	SW																												
	SE																												
	NE																												
	NW																												
	TOTAL																												
TOTAL		18	42	30	90	70	90	66	234	96	90	36	222	24	42	54	120	30	48	78	6	6	12	222	310	204	726		
CALM HOURS																													
TOTAL HOURS																													

TABLE B-1
 STATISTICAL HINDCAST DATA FOR LAKE ONTARIO STATION B, ROCHESTER, N.Y.
 Duration given in hours. Height and period groupings include lower value but not the upper.
 APRIL

APRIL

Period		2-3 Seconds				3-4 Seconds				4-5 Seconds				5-6 Seconds				6-7 Seconds				7-8 Seconds				2-8 Seconds			
HEIGHT (FEET)		1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total
1-1	W	6			6																								
	WNW	12			12																								
5-1	WNW		24	18	42																								
	WNW			6	6																								
	W	6	24	6	36																								
	WNE		6		6																								
	WNE			6	6																								
	ENE	6		12	18																								
	E	24			24																								
	TOTAL	54	54	54	162																								
1-2	W	6			6	6	6	6	18																				
	WNW					30	18	18	66																				
	WNW					6	24	36	66																				
	W	6			6		12	6	18																				
	WNE		6		6		12	6	18																				
	WNE						18	6	24																				
	ENE	6			6		12	6	18																				
	E					36	6	12	54																				
	TOTAL	12	12		24	84	108	90	282																				
2-3	WNW							6	6																				
	WNW							6	6																				
	WNE							6	6																				
	WNE							6	6																				
	ENE							6	6																				
	TOTAL					6	6	12	24	18			18																
3-4	WNW									12	30	18	60																
	WNW									12	12	6	30																
	W									6	6	18	24																
	WNE									6	18	6	30																
	ENE									12	6	18	30																
	TOTAL									6	6	6	12																
4-5	W									48	66	60	174																
	WNW													6	6														
	WNW													12	12														
	W									6	6	12	24																
	WNE									6	6	12	24																
	TOTAL									12	12	12	36																
5-6	WNW									6	6	12	24																
	WNE													6	6														
	ENE													12	12														
	TOTAL													12	12														
6-7	W																												
	WNW																												
	WNE																												
	TOTAL																												
7-8	WNW																												
	WNE																												
	TOTAL																												
8-9	WNW																												
	WNE																												
	TOTAL																												
9-10	WNW																												
	WNE																												
	TOTAL																												
11-12	WNW																												
	WNE																												
	TOTAL																												
TOTAL		66	66	54	186	90	114	102	306	72	66	66	204	60	12	24	96	30	18			48	12						
CALM																													
TOTAL HOURS																													

390 444 474 1308
720 720 720 2160

TABLE B-1
 STATISTICAL HINDCAST DATA FOR LAKE ONTARIO STATION B, ROCHESTER, N.Y.
 Duration given in hours. Height and period groupings include lower value but not the upper.
 MAY

Period	2-3 Seconds				3-4 Seconds				4-5 Seconds				5-6 Seconds				6-7 Seconds				7-8 Seconds																							
	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total																				
5-1	W	18		6	24																18			6	24																			
	W	6		6	12																6			6	12																			
	W	6		6	12																6			6	12																			
	N	24		24	48																24		24	48																				
	NE	24		12	36																24		12	36																				
	NE			18	18																		18	18																				
	E	24	6	12	42																24	6	12	42																				
TOTAL	102	6	36	144																102	6	36	144																					
1-2	W				12			12														12		12																				
	W	6	6	6	18	12	36														18	30	6	54																				
	W	6			6			6													12		12	24																				
	N	6		12	18	12	36	6													24		6	6																				
	NE	6		6	12	6	12	12													24	6	18	48																				
	NE	6			6	18	18														24	18	18	60																				
	E		6		6			6	12	6											12	6	6	24																				
TOTAL	30	12	24	66	36	66	78	222	24											138	78	102	318																					
2-3	W					6		6														6		6																				
	W					6	6	12		18		18										6	12	18																				
	W					6	6	6		6		6									6	12	6	18																				
	N						12	12		18		18										30		30																				
	NE						6	6														6		6																				
	E					6		6													6		6																					
	TOTAL					12	36	48		42		42									12	78		90																				
3-4	N						6	6				12										6		6																				
	W									12	12												12	12																				
	W									6	6	12									6		6	12																				
	N									24	6	30									24		6	30																				
	NE									6	6	12									6		6	12																				
	E									18		12	12								18		12	12																				
	TOTAL									36	36	60	132								36	36	60	132																				
4-5	N								6			12			12							18		18																				
	W											18			18						18		18																					
	N								6			6			12						12		12																					
	NE														6						6		6																					
	NE											6	6									18	18																					
	E											30	18	12	60						36	24	18	78																				
	TOTAL									6	6	6	18			60					36	24	18	78																				
5-6	W											12			12						12			12																				
	W											6			6	12					6		6	12																				
	W											6			6						6		6																					
	TOTAL											24			6	30					24		6	30																				
	W														6							6		6																				
	W														6							6		6																				
	TOTAL														6	30						6		6																				
6-7	W														6						6			6																				
	W														6						6			6																				
	W														6						6			6																				
	TOTAL														6						6			6																				
	W														6						6			6																				
	W														6						6			6																				
	TOTAL														6						6			6																				
TOTAL	192	18	108	250	96	102	78	276	66	84	66	216	60	18	18	96	18				18	372	222	270	664																			
CALM																																												
TOTAL HOURS																																												

TABLE B-1
STATISTICAL HINDCAST DATA FOR LAKE ONTARIO STATION B, ROCHESTER, N.Y.
Duration given in hours. Height and period groupings include lower value but not the upper
JUNE

HEIGHT (FEET)	Period	2-3 Seconds				3-4 Seconds				4-5 Seconds				5-6 Seconds				6-7 Seconds				2-7 Seconds			
		1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total
5-1	WNW			6	6																	6		6	6
	NW	6			12																	6		12	18
	NNW	24			24																	24		6	30
	N	6	6		12																	6		6	12
	NNE		6		6																		6		6
	ENE		6		6																		6		6
1-2	TOTAL	36	12	24	72																	36	12	24	72
	WNW	12		6	18	12	18	24	54													24	18	30	72
	NW		6	6	12	12	6	6	24													12	12	12	36
	NNW																								
	N		6	6	12	18	6	6	30													18	12	12	42
	NNE					6			6														6		6
2-3	ENE		6		6																		6		6
	TOTAL	12	18	18	48	36	30	30	120													60	30	60	150
	W									6			6										6		6
	WNW									6			6										6		6
	NW						6		6				6										6		12
	N					6			6														6		6
3-4	NNE					6			6														6		6
	NE					6			6														6		6
	TOTAL					12	6		18				12									12	18		42
	WNW									12	12	18	42									12	12	18	42
	NW									12	6	6	24									12	6	6	24
	NNW											6	6											6	6
4-5	TOTAL									24	18	30	72									24	18	30	72
	WNW											6	6	12	12							6	6	12	36
	NW											6	6	6	6	12	12					6	6	12	36
	NNW											6	6										6	6	12
	N											6	6	6	6	12	12						6	6	12
	NNE											6	6										6	6	12
5-6	TOTAL									12	6	18	36	6	6	12	36					12	6	18	36
	WNW																								
	NW																								
	NNW																								
	N																								
	NNE																								
6-7	TOTAL																								
	W																								
	WNW																								
	NW																								
	NNW																								
	N																								
TOTAL	TOTAL	48	36	42	126	60	36	30	126	42	30	36	108	6	6	18	30					6	6	12	24
	CALM																								
	TOTAL HOURS																								

JULY

		2-3 Seconds				3-4 Seconds				4-5 Seconds				5-6 Seconds				2-6 Seconds					
HEIGHT (FEET)		1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total		
5-1	WNW	6			6													6			6		
	NW			6	6															6	6		
	NNW		12		12														12		12		
	N			6	6														6		6		
	NNE	6			6													6			6		
	NE		6		6														6		6		
1-2	ENE	6	18		24													6	18		24		
	TOTAL	18	36	12	66													18	36	12	66		
	W	12			12													12			12		
	WNW			6	6	12	12	36	60									12	12	42	66		
	NW	6	12		18	6	18		24									12	30	6	48		
	NNW			6	6			30	30										30	6	36		
2-3	N		18	6	24	6			6									6	18	6	30		
	NNE			6	6															6	6		
	NE	6	6		12	6	6	6	18									12	12	6	30		
	ENE		6		6	12	6		18									12	12	6	24		
	TOTAL	24	42	30	96	42	72	42	156									66	114	72	252		
	W					6			6									6			6		
3-4	WNW									6	12		18					6	12		18		
	NW						6		6		12		12						6		6		
	NNW										6		6						6		6		
	N									12	6		18					12	6		18		
	NNE										6		6					6			6		
	NE																	6			6		
4-5	TOTAL					6	6	12	30	30	60							36	36		72		
	W									6			6					6			6		
	WNW										6	12	18	6				6	6	12	24		
	NW						6	6										6	6		6		
	N																						
	NNE									18			18					18			18		
TOTAL	NE										6	6	12				12	12		6	18		
	TOTAL					6	6	12	24	6	18	48	18				18	48	6	24	78		
	W												6								6		
	WNW																				6		
	NE																6	6	12		12		
	TOTAL									6	6	12	6				6	12	12		12		
TOTAL		42	78	42	162	54	78	48	180	60	36	24	120	24			6	30	180	192	120	492	
		CALM																		564	552	624	1740
		TOTAL HOURS																		244	244	244	2232

OCTOBER

NOVEMBER

B-8

STATISTICAL HINDCAST DATA FOR LAKE ONTARIO STATION B, ROCHESTER, N.Y.
Duration given in hours. Height and period groupings include lower value but not the upper.

DECEMBER

HEIGHT (FEET)	2-3 Seconds				3-4 Seconds				4-5 Seconds				5-6 Seconds				6-7 Seconds				8-7 Seconds											
	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total												
5-1	WNW	6			6													6			6											
	NNW		6		6														6		6											
	NNW		6	6	12														6	6	12											
	N			18	18															18	18											
	NNE	6			6													6			6											
	NE	6	6		12													6	6		12											
	ENE			6	6															6	6											
TOTAL	18	18	30	66													18	18	30	66												
1-2	WNW				18	6	12	36										18	6	12	36											
	NNW				18	6	12	36										18	6	12	36											
	NNW	12			12			18	18									12		18	30											
	N				6	18	6	30										6	18	6	30											
	NNE						6	6											6	6												
	NE				6			6										6			6											
	ENE				6			6										6			6											
TOTAL	12			12	54	30	54	138									66	30	54	150												
2-3	WNW				6			6										6			6											
	N				6	6	6	12										6	6	6	12											
TOTAL				6	6	6	18										6	6	6	18												
3-4	WNW							6	12	12	30		6			6		12	12	12	36											
	NNW							12			12							12			12											
	NNW							18	18										18	18												
	N						6	6	12									6	6		12											
	NNE						6		6									6			6											
	E						6		6									6			6											
	TOTAL							36	18	30	84		6			6		42	18	30	90											
4-5	WNW												6	6	12			6	6	12												
	NNW												12		12			12		12												
	TOTAL												18	6	24			18	6	24												
5-6	WNW												6	6	6	18		6	6	6	18											
	NNW												6		6			6		6												
	TOTAL												12	6	6	24		12	6	6	24											
6-7	WNW																	6	6		6											
	NNW																	6	6		6											
7-8	WNW																	6	6		6											
	NNW																	6	6		6											
	TOTAL																	6	6		6											
TOTAL	30	18	30	78	60	36	60	156	36	18	30	84	24	24	12	60		12	12	150	96											
CALM TOTAL HOURS																	576				648				600				1062			
																	744				744				744				2232			

FULL YEAR

FULL YEAR

Duration given in hours. Height and period groupings include lower value but not the upper.																													
HEIGHT (FEET)	Period	2-3 Seconds				3-4 Seconds				4-5 Seconds				5-6 Seconds				6-7 Seconds				7-8 Seconds				2-8 Seconds			
		1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total
5-1	W	12			12																								
	WNW	42	18	60	120																								
	NW	30	66	78	174																								
	NNW	54	42	36	132																								
	N	96	72	84	252																								
	NNE	108	24	66	192																								
	N	36	36	66	132																								
	E	42	48	42	132																								
1-2	W	18			18	12	18	6	36																				
	WNW	24	12	24	60	162	186	156	504																				
	NW	12	54	24	90	120	178	138	396																				
	NNW	18	24	12	54	36	180	66	252																				
	N	6	42	30	78	150	180	96	366	6																			
	NNE	24	18	24	66	66	78	66	210	12																			
	N	42	24	6	72	114	90	120	324																				
	E	6	30		36	6	48	78	222	6																			
2-3	W					18	6	6	30																				
	WNW					30	30	18	78	48	48																		
	NW					42	18	18	78	30	24																		
	NNW					6	60	66	30	24																			
	N					24	60	12	96	18	36																		
	NNE					30	12	6	48	6	18																		
	N					18	6	12	36	24	18																		
	E					6	18		24	12	12																		
3-4	W					24	6	12	42																				
	WNW					54	6	12	72	12	6																		
	NW					78	54	42	174																				
	NNW					12	18	60	90																				
	N					42	72	24	138																				
	NNE					66	24	36	126																				
	N					24	12	24	60	18																			
	E					30		42	72																				
4-5	W					24	6	12	42																				
	WNW					54	102	114	270	12	6																		
	NW					78	54	42	174																				
	NNW					12	18	60	90																				
	N					42	72	24	138																				
	NNE					66	24	36	126																				
	N					24	12	24	60	18																			
	E					30		42	72																				
5-6	W					24	6	12	42																				
	WNW					54	102	114	270	12	6																		
	NW					78	54	42	174																				
	NNW					12	18	60	90																				
	N					42	72	24	138																				
	NNE					66	24	36	126																				
	N					24	12	24	60	18																			
	E					30		42	72																				
6-7	W					24	6	12	42																				
	WNW					54	102	114	270	12	6																		
	NW					78	54	42	174																				
	NNW					12	18	60	90																				
	N					42	72	24	138																				
	NNE					66	24	36	126																				
	N					24	12	24	60	18																			
	E					30		42	72																				
7-8	W					24	6	12	42																				
	WNW					54	102	114	270	12	6																		
	NW					78	54	42	174																				
	NNW					12	18	60	90																				
	N					42	72	24	138																				
	NNE					66	24	36	126																				
	N					24	12	24	60	18																			
	E					30		42	72																				
8-9	W					24	6	12	42																				
	WNW					54	102	114	270	12	6																		
	NW					78	54	42	174																				
	NNW					12	18	60	90																				
	N					42	72	24	138																				
	NNE					66	24	36	126																				
	N					24	12	24	60	18																			
	E					30		42	72																				
9-10	W					24	6	12	42																				
	WNW					54	102	114	270	12	6																		
	NW					78	54	42	174																				
	NNW					12	18	60	90																				
	N					42	72	24	138																				
	NNE					66	24	36	126																				
	N					24	12	24	60	18																			
	E					30		42	72																				
10-11	W					24	6	12	42																				
	WNW					54	102	114	270	12	6																		
	NW					78	54	42	174																				
	NNW					12	18	60	90																				
	N					42	72	24	138																				
	NNE					66	24	36	126																				
	N					24	12	24	60	18																			
	E					30		4																					

Duration given in hours. Height and period groupings include lower value but not the upper.

CALM
TOTAL HOURS

TABLE B-4

STATISTICAL ENERGY DATA FOR LAKE ONTARIO STATION B, ROCHESTER, N.Y.

ICE-FREE PERIOD (1 APRIL - 30 NOV.)

Energy given in foot-pounds per foot of crest per year $\times 10^6$; Height and period groupings include lower value but not the upper

Height (ft.)	Period							
	Dir.	2-3 Seconds	3-4 Seconds	4-5 Seconds	5-6 Seconds	6-7 Seconds	7-8 Seconds	8-9 Seconds
5-1	W	40						40
	WNW	262						262
	WN	423						423
	NNW	383						383
	N	625						625
	NNE	423						423
	NE	262						262
	ENE	363						363
1-2	E	81						81
	TOTAL	2862						2862
	W	240	565					805
	WNW	801	6214			210		7225
	WN	961	4745					5706
	NNW	320	3728					4048
	N	961	5197	146				6304
	NNE	721	2825	291				3837
2-3	NE	641	4519					5160
	ENE	481	2937	146				3564
	E		565					565
	TOTAL	5126	31295	583		210		37214
	W		937	404				1341
	WNW		1874	4439				6313
	WN		2811	2421				5232
	NNW		3123	2421				5544
3-4	N		4372	3228				7600
	NNE		1824	404				2278
	NE		937	1211				2148
	ENE		937					937
	TOTAL		16865	14528				31393
	W			2366				2366
	WNW			24453	967			25420
	WN		1215	13410				14625
4-5	NNW		608	5521				6129
	N		608	11043				11651
	NNE			11043				11043
	NE			4733	1934			6667
	ENE			8677	967			9644
	E		608	1578				2186
	TOTAL		3039	82824	3868			89731
	W			2578	4723			7301
5-6	WNW			1299	23963			25262
	WN			5196	15976			21172
	NNW			3897				3897
	N			5176	3175			8351
	NNE			1299	1598			2897
	NE			1299	7988			9287
	ENE			1299				1299
	TOTAL			22083	57513			79596
6-7	W				21414			21414
	WNW				7138			7138
	WN				2379			2379
	NNW				4759	2820		4759
	N				2379			2379
	ENE				4759			4759
	TOTAL				42828	2820		45648
	W					19672		19672
7-8	WNW					11803		11803
	WN					15738		15738
	NNW				3315			3315
	TOTAL				3315	47213		50528
	W					14460		14460
	N					5230		5230
	TOTAL					15690		15690
	ENE					6787		6787
8-9	W						9674	9674
	WNW					16723		16723
	WN					16723		16723
	NNW							14172
	TOTAL							14172
	W							14172
	ENE							14172
	TOTAL							28344
9-10	W							14172
	ENE							14172
	TOTAL							28344
	W							14172
	ENE							14172
	TOTAL							28344
	W							14172
	ENE							14172
11-12	TOTAL							28344
	W							14172
	ENE							14172
	TOTAL							28344
	W							14172
	ENE							14172
	TOTAL							28344
	W							14172
TOTAL							28344	
TOTAL	7788	51199	120,018	107,524	89,363	38,038	414,130	

TABLE B-5
STATISTICAL ENERGY DATA FOR LAKE ONTARIO STATION B, ROCHESTER, N.Y.
FULL YEAR

Energy given in foot-pounds per foot of crest per year $\times 10^4$. Height and period groupings include lower value but not the upper

Height (feet)	Period								
	Dir.	2-3 Seconds	3-4 Seconds	4-5 Seconds	5-6 Seconds	6-7 Seconds	7-8 Seconds	2-8 Seconds	
5-1	W	40						40	
	NW	403						403	
	NNW	585						585	
	N	444						444	
	NNE	847						847	
	NE	645						645	
	ENE	764						764	
	E	444						444	
1-2	E	81						81	
	Total	3953						3953	
	W	240	678					918	
	NW	801	9490			210		19501	
	NNW	1202	2457					8659	
	N	721	5710					6031	
	NNE	1041	6892	146				8079	
	NNE	881	3954	291				5126	
2-3	NE	961	6101					7062	
	ENE	641	4180	146				4967	
	E	80	771					871	
	Total	6568	44853	589		210		52214	
	W		1562	404				1966	
	NW		4040	6456				10516	
	NNW		4040	3632				7692	
	N		3435	3632				7067	
3-4	NNE		4927	3632				8629	
	NNE		2498	1614				4112	
	NE		1874	2825				3699	
	ENE		1247	807				2056	
	Total		23795	23002				46737	
	W			5522				5522	
	NW			35497	2901			38398	
	NNW		1823	22876				24699	
4-5	N		608	11832				12440	
	NNE		608	18143				18751	
	NNE			16565				16565	
	NE			7888	2901			19789	
	ENE			2446	1934			11400	
	E		608	3844				4552	
	Total		3647	131733	7736			143116	
	W			2598	6390			8988	
5-6	NW			7795	48524			56319	
	NNW			10393	27159			37552	
	N			7795				7795	
	NNE			4496	3195			3691	
	NNE			1299	1598			2897	
	NE			2598	1183			13781	
	ENE			2598	6793			7391	
	E				1598			1598	
6-7	Total			41572	105440			147012	
	W			1932	2379			4311	
	NW			1932	30931			32863	
	NNW				23793			23793	
	N			1932	7138			9070	
	NNE				4759	2820		7579	
	NE				4759			4759	
	ENE				7138			7138	
7-8	Total			5796	80897	2820		89513	
	W					18672		18672	
	NW				13259	36476		44735	
	NNW					23606		23606	
	N				3315			3315	
	NNE				3315			3315	
	NE								
	ENE					18672		18672	
8-9	Total				19889	94426		114315	
	NW					36612		36612	
	N					5230		5230	
	NNE					5230		5230	
	NE				4401			4401	
	Total				4401	47072		51473	
	NNW					13413		13413	
	ENE					6707		6707	
9-10	Total					20120		20120	
	NW					8361	19388	27749	
	NN					8361		8361	
	ENE					16723		16723	
	Total					33445		52833	
	W						19388	23656	
	NW							11828	
	Total						35484	35484	
10-11	W						14172	14172	
	NW						14172	14172	
	ENE						14172	14172	
	Total						42516	42516	
	W						16042	16042	
	11-12	TOTAL							
12-13	TOTAL								

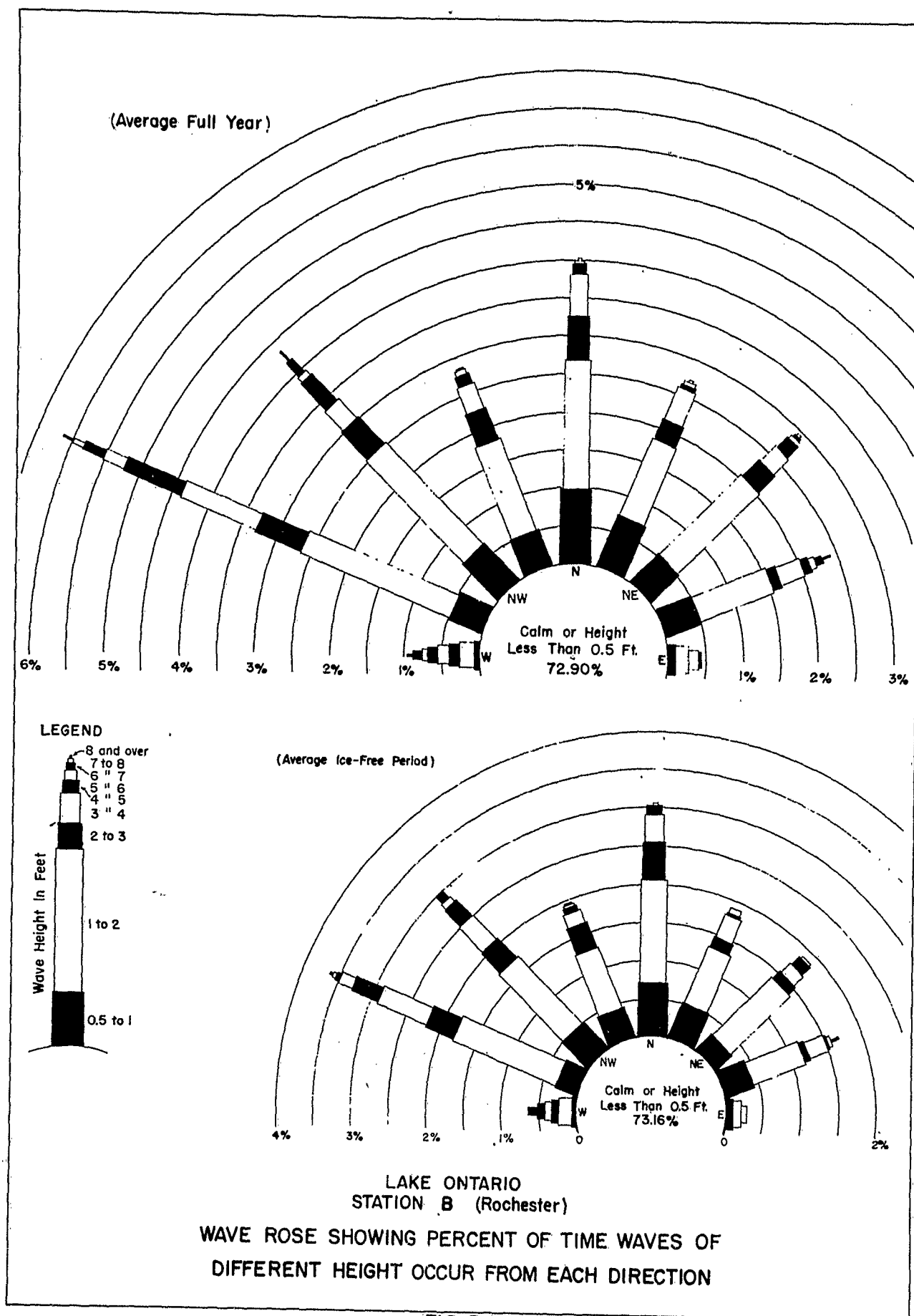
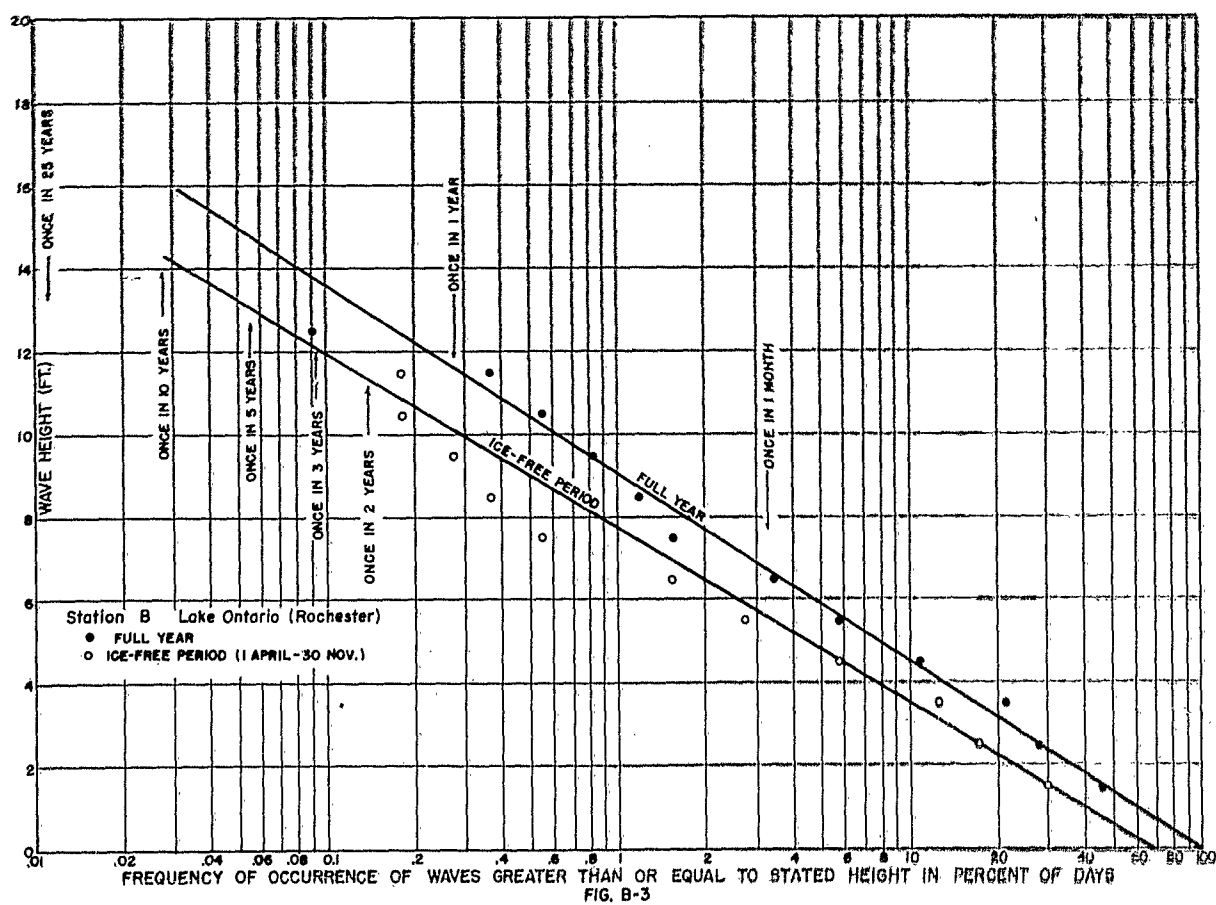
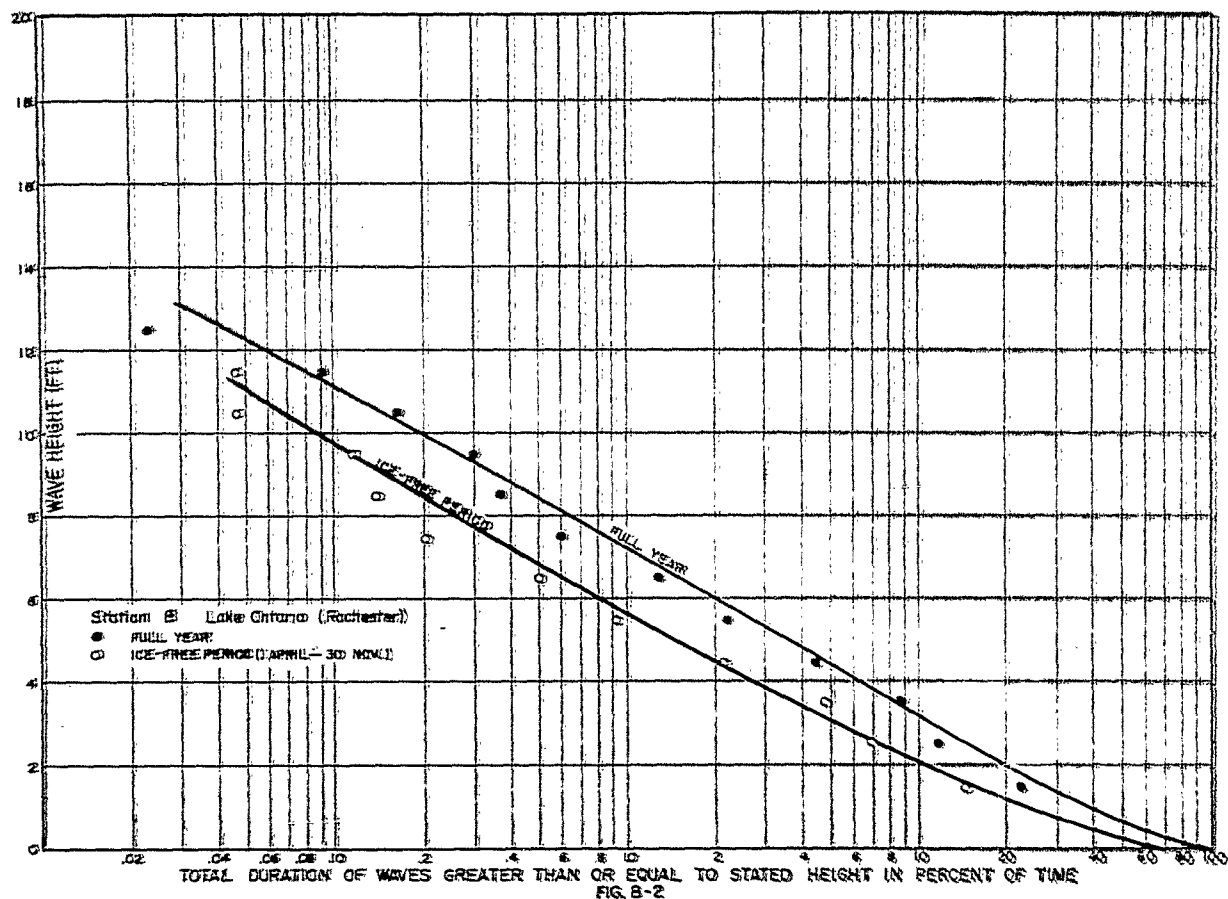
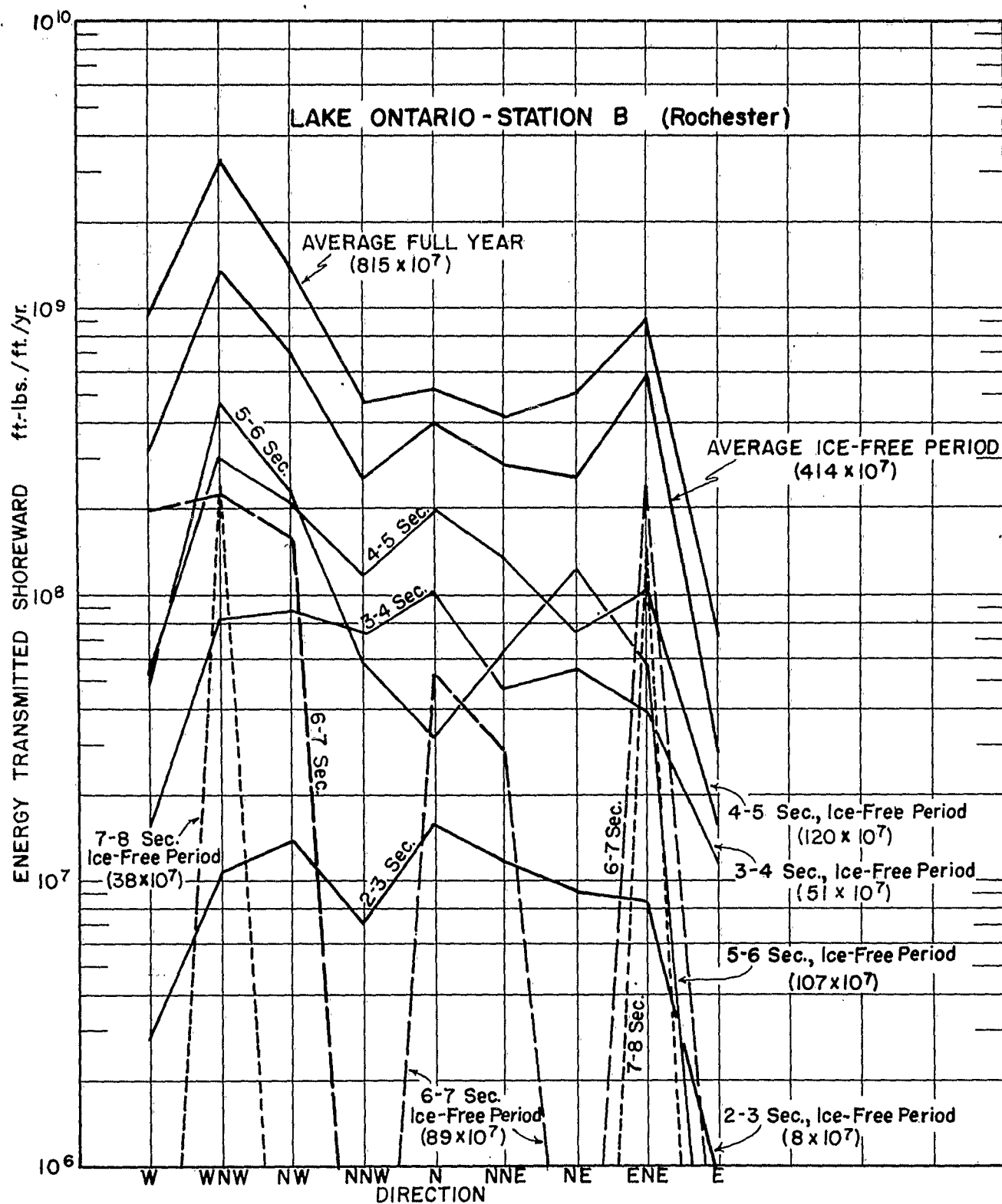


FIG. B-1





AVERAGE AMOUNT OF ENERGY TRANSMITTED SHOREWARD PER FOOT OF CREST LENGTH PER YEAR, IF WAVE SYSTEM IS CONSIDERED AS AN HYPOTHETICAL UNIFORM SYSTEM COMPOSED OF WAVES OF SIGNIFICANT HEIGHT AND PERIOD ONLY

FIG. B-4

WAVE AND LAKE LEVEL STATISTICS

FOR

LAKE ONTARIO

APPENDIX C

WAVE STATISTICS

FOR

STONY POINT, NEW YORK

STATISTICAL HINDCAST DATA FOR LAKE ONTARIO STATION C, STONY POINT, N.Y.
Duration given in hours. Height and period groupings include lower value but not the upper.

[illegible]

TABLE C-1
STATISTICAL HINDCAST DATA FOR LAKE ONTARIO STATION C, STONY POINT, N.Y.
Duration given in hours. Height and period groupings include lower value but not the upper.

Duration given in report height and period

MARCH

HEIGHT (FEET)	Period	2-3 Seconds				3-4 Seconds				4-5 Seconds				5-6 Seconds				6-7 Seconds				7-8 Seconds				8-9 Seconds				9-10 Seconds				10-12 Seconds			
		1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total
5-1	SSH	6	6		12																																
	SHV	6			6																																
	MSH	6	24	6	36																																
	W	6			6																																
	MSH	6	24	6	36																																
1-2	SSH	6			6																																
	SHV	6			6																																
	MSH	6	24	6	36																																
	W	6			6																																
	MSH	6	24	6	36																																
2-3	SSH	6			6																																
	SHV	6			6																																
	MSH	6	24	6	36																																
	W	6			6																																
	MSH	6	24	6	36																																
3-4	SSH	6			6																																
	SHV	6			6																																
	MSH	6	24	6	36																																
	W	6			6																																
	MSH	6	24	6	36																																
4-5	SSH	6			6																																
	SHV	6			6																																
	MSH	6	24	6	36																																
	W	6			6																																
	MSH	6	24	6	36																																
5-6	SSH	6			6																																
	SHV	6			6																																
	MSH	6	24	6	36																																
	W	6			6																																
	MSH	6	24	6	36																																
6-7	SSH	6			6																																
	SHV	6			6																																
	MSH	6	24	6	36																																
	W	6			6																																
	MSH	6	24	6	36																																
7-8	SSH	6			6																																
	SHV	6			6																																
	MSH	6	24	6	36																																
	W	6			6																																
	MSH	6	24	6	36																																
8-9	SSH	6			6																																
	SHV	6			6																																
	MSH	6	24	6	36																																
	W	6			6																																
	MSH	6	24	6	36																																
9-10	SSH	6			6																																
	SHV	6			6																																
	MSH	6	24	6	36																																
	W	6			6																																
	MSH	6	24	6	36																																
10-11	SSH	6			6																																
	SHV	6			6																																
	MSH	6	24	6	36																																
	W	6			6																																
	MSH	6	24	6	36																																
11-12	SSH	6			6																																
	SHV	6			6																																
	MSH	6	24	6	36																																
	W	6			6																																
	MSH	6	24	6	36																																
12-13	SSH	6			6																																
	SHV	6			6																																
	MSH	6	24	6	36																																
	W	6			6																																
	MSH	6	24	6	36																						</										

TABLE C-1
STATISTICAL HINDCAST DATA FOR LAKE ONTARIO STATION Q, STONY POINT, N.Y.
Duration given in hours. Height and period groupings include lower value but not the upper.
JUNE

JUNE.																														
HEIGHT (FEET)	Period	2-3 Seconds				3-4 Seconds				4-5 Seconds				5-6 Seconds				6-7 Seconds				7-8 Seconds				2-8 Seconds				
		1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	
5-1	SSH	12	6		18																				18	6		24		
	SW	24	18		42																				24	18		42		
	W	6	6		12																				6	6		12		
	SWW	12	12		24																				12	12		24		
	WV	6	6		12																				6	6		12		
	TOTAL	36	30		66																					36	30		66	
1-2	SSH		6		6	12	12	24																	18	12	30			
	SW	6			6	12	12	42																	24	42	68	114		
	W		6		6	6	6	12	18	18			6	6											36	18	12	126		
	SWW		6		6	6	6	12	12	30	54														24	6	30	60		
	WV		6		6	6	6	12	12	18	18														12	18	36	66		
	TOTAL	12	30	30	72	78	102	150	326	18	24	42														108	138	204	450	
2-3	SW					6	6		6	6	6														12	12	12			
	SWW					12	6		18	6	6														12	12	24			
	W						6	6	6	6	12														18	6	18			
	SWW						6	6	6	6	6														6	6	6			
	WV						6	6	18	6	6														6	6	12			
	TOTAL					18	30	6	33	24	24															18	36	6	78	
3-4	SSH								6	6	6	12														12	6	18		
	SW								6	12	18	36														6	12	18	36	
	SWW								18	12	24	54														18	18	30	66	
	W								6	12	12	42														18	24	18	60	
	SWW								6	6	24	30														6	24	30		
	TOTAL					6	6		12	34	54	96	204														18	12	36	
4-5	SW																									6	6	6		
	SWW																									6	6	6		
	W																									6	6	18		
	SWW																									12	6	18		
	WV																									6	6	6		
	TOTAL																										6	6	6	
5-6	SSH																									6	6	6		
	SW																									6	6	6		
	W																									6	6	6		
	SWW																									6	6	6		
	WV																									6	6	6		
	TOTAL																										6	6	6	
6-7	SW																									6	6	6		
	W																									6	6	6		
	SWW																									6	6	6		
	WV																													

JULY

JULY

HEIGHT FEET	Period	2-3 Seconds				3-4 Seconds				4-5 Seconds				5-6 Seconds				6-7 Seconds				7-8 Seconds				2-8 Seconds			
		1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total
5-1	SSH	24	18		42																				24	18		42	
	SW	48	36		84																				48	36		84	
	W	12	12		24																				12	12		24	
	SWW	12	12		24																				12	12		24	
	WV	6	6		12																				6	6		12	
	TOTAL	120	114		234																					120	114		234
1-2	SSH	6	6		12	6	6		12																12	6		18	
	SW	12	12		24	12	12		24	18	6		6	30	6										36	30		66	
	W	6	6		12	6	6		12	36	66		36	72											102	48		150	
	SWW	6	6		12	6	6		12	36	66		36	72											54	48		102	
	WV	6	6		12	6	6		12	36	66		36	72											6	12		18	
	TOTAL	54	48		102	72	186		258	288	6		72	72	6											216	114		330
2-3	SSH					6	6		12																6	6		12	
	SW					12	12		24	6	6		12												18	6		24	
	W					6	6		12	36	66		36	72											6	18		24	
	SWW					6	6		12	36	66		36	72											6	18		24	
	WV					6	6		12	36	66		36	72											6	18		24	
	TOTAL					30	72		102	6	30		36													36	72		108
3-4	SSH									6	6		12	18											6	6		12	
	SW									12	24		24	36											18	24		42	
	W									6	6		12	18											6	6		12	
	SWW									12	24		24	36											18	24		42	
	WV									6	6		12	18											6	6		12	
	TOTAL									12	72		72	90												72	90		162
4-5	SSH																												
	SW																												
	W																												
	SWW																												
5-6	SSH																												
	SW																												
	W																												
	SWW																												
6-7	SSH																												
	SW																												
	W																												
	SWW																												
7-8	SSH																												
	SW																												
	W																												
	SWW																												
8-9	SSH																												
	SW																												
	W																												
	SWW																												
9-10	SSH																												

STATISTICAL HINDCAST DATA FOR LAKE ONTARIO STATION O, STONY POINT, N.Y.
Duration given in hours. Height and period groupings include lower value but not the upper.

SEPTEMBER

1

TABLE C-1.
STATISTICAL HINDCAST DATA FOR LAKE ONTARIO STATION C, STONY POINT, N.Y.
Duration given in hours. Height and period groupings include lower value but not the upper.

NOVEMBER

Period	2-3 Seconds				3-4 Seconds				4-5 Seconds				5-6 Seconds				6-7 Seconds				7-8 Seconds				8-9 Seconds				9-10 Seconds				2-10 Seconds				
	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total	1948	1949	1950	Total					
5-7	SEW	24	6	6	36																											24	6	6	36		
	SW	24	18	6	48																												24	18	6	48	
	SWW	18	6		24																												18	6		24	
	W	6		18	24																												6		18	24	
	TOTAL	72	30	30	132																												72	30	30	132	
7-9	SEW	12			12	24			24																									36		36	
	SW	6			6	12	36	30	78																								18	36	30	84	
	SWW	12	6		18	24	18	30	72																								36	24	30	90	
	W	6	6		12	12	18	6	36	12	6		18																					30	30	6	66
	TOTAL	36	24		60	78	84	72	234	12	6		36																				126	114	72	312	
9-11	SEW																																				
	SW																																				
	SWW																																				
	W																																				
	TOTAL																																				
11-13	SEW																																				
	SW																																				
	SWW																																				
	W																																				
	TOTAL																																				
13-15	SEW																																				
	SW																																				
	SWW																																				
	W																																				
	TOTAL																																				
15-17	SEW																																				
	SW																																				
	SWW																																				
	W																																				
	TOTAL																																				
17-19	SEW																																				
	SW																																				
	SWW																																				
	W																																				
	TOTAL																																				
19-21	SEW																																				
	SW																																				
	SWW																																				
	W																																				
	TOTAL																																				
21-23	SEW																																				
	SW																																				
	SWW																																				
	W																																				
	TOTAL																																				
23-25	SEW																																				
	SW																																				
	SWW																																				
	W																																				
	TOTAL																																				
25-27	SEW																																				
	SW																																				
	SWW																																				
	W																																				
	TOTAL																																				
27-29	SEW																																				
	SW																																				
	SWW																																				
	W																																				
	TOTAL																																				
29-31	SEW																																				
	SW																																				
	SWW																																				
	W																																				

DECEMBER

CALM
TOTAL HOURS

Duration given in hours. Height and period groupings include lower value but not the upper.

Duration given in hours. Height and period groupings include lower value but not the upper.

Duration given in hours. Height and period groupings include lower value but not the upper.

CALM
TOTAL HOURS

Duration given in hours. Height and period groupings include lower value but not the upper

CALM	TOTAL HOURS
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	11
12	12
13	13
14	14
15	15
16	16
17	17
18	18
19	19
20	20
21	21
22	22
23	23
24	24
25	25
26	26
27	27
28	28
29	29
30	30
31	31
32	32
33	33
34	34
35	35
36	36
37	37
38	38
39	39
40	40
41	41
42	42
43	43
44	44
45	45
46	46
47	47
48	48
49	49
50	50
51	51
52	52
53	53
54	54
55	55
56	56
57	57
58	58
59	59
60	60
61	61
62	62
63	63
64	64
65	65
66	66
67	67
68	68
69	69
70	70
71	71
72	72
73	73
74	74
75	75
76	76
77	77
78	78
79	79
80	80
81	81
82	82
83	83
84	84
85	85
86	86
87	87
88	88
89	89
90	90
91	91
92	92
93	93
94	94
95	95
96	96
97	97
98	98
99	99
100	100

TABLE C-4
STATISTICAL ENERGY DATA FOR LAKE ONTARIO STATION C, STONY POINT, N.Y.

ICE-FREE PERIOD (1 APRIL-30 NOV.)

Energy given in foot-pounds per foot of crest per year $\times 10^4$; Height and period groupings include lower value but not the upper

Height (Feet)	Period (Secs)	2-2 Seconds	3-4 Seconds	4-5 Seconds	5-6 Seconds	6-7 Seconds	7-8 Seconds	8-9 Seconds	9-10 Seconds	10-12 Seconds
5-1	SEW	1000								500
	SW	1000								1000
	NEW	1000	200							1000
	NW	1000								1000
	MEW	1000								1000
	MW	1000								1000
1-2	SEW	2629	20							2657
	SW	261	2720							262
	NEW	1222	11,911	126						12,979
	NW	1221	10,123	2,030	170					17,250
	MEW	261	4,250	3,057						10,560
	MW	261	4,227							7,200
2-3	SEW	261	2,529							2,560
	SW	100	452							612
	NEW	2627	4500	5,241	170					57,566
	SW		625							625
	NEW		4,005	5,220						7,913
	NW		5,621	10,702	494					17,817
3-4	SEW									9,090
	SW									5,092
	NEW									4,242
	NW									1,341
	MEW									47,320
	MW									11,474
4-5	SEW									21,232
	SW									46,867
	NEW									20,123
	NW									20,390
	MEW									29,302
	MW									1,570
5-6	SEW									161,564
	SW									1,199
	NEW									7,391
	NW									79,976
	MEW									46,310
	MW									7,092
6-7	SEW									3,027
	SW									146,565
	NEW									7,130
	NW									16,655
	MEW									40,009
	MW									41,721
7-8	SEW									19,034
	SW									7,130
	NEW									182,115
	NW									15,710
	MEW									39,791
	MW									8,431
8-9	SEW									3,215
	SW									62,335
	NEW									33,200
	NW									39,707
	MEW									8,201
	MW									81,716
9-10	SEW									26,817
	SW									20,017
	NEW									12,341
	NW									5,634
	MEW									75,807
	MW									65,129
10-11	SEW									49,139
	SW									8,361
	NEW									8,361
	NW									12,505
	MEW									23,656
	MW									23,656
11-12	SEW									42,212
	SW									16,110
	NEW									16,110
	NW									32,220
	MEW									57,060
	MW									57,060
12-13	SEW									22,160
	SW									22,160
	NEW									22,160
	NW									22,160
	MEW									22,160
	MW									22,160
13-14	SEW									22,160
	SW									22,160
	NEW									22,160
	NW									22,160
	MEW									22,160
	MW									22,160
14-15	SEW									22,160
	SW									22,160
	NEW									22,160
	NW									22,160
	MEW									22,160
	MW									22,160
TOTAL		10,676	72,002	100,150	200,976	205,254	166,652	157,120	7686	1,099,644

TABLE C-5
STATISTICAL ENERGY DATA FOR LAKE ONTARIO STATION C, STONY POINT, N.Y.
FULL YEAR

Energy given in foot-pounds per foot of crest per year $\times 10^{-6}$. Height and period groupings include lower value but not the upper

Height (feet)	Period (Secs)	2-3 Seconds	3-4 Seconds	4-5 Seconds	5-6 Seconds	6-7 Seconds	7-8 Seconds	8-9 Seconds	9-10 Seconds	10-12 Seconds
5-1	SSW	706								706
	SW	1280								1280
	WSW	2831	28							1859
	W	887		45						892
	WNW	565								565
1-2	NW	363								363
	NNW	20								20
	Tabl	5161	28	45						5234
	SSW	961	4506							5367
	SW	2483	15252	146						17801
2-3	WSW	1602	18320	2348	178					24448
	W	1121	2038	5677						15836
	WNW	1202	9264							10866
	NW	1091	4519							5560
	NNW	240	452							492
3-4	Tabl	8570	62251	2171	178					80170
	SSW		987							937
	SW		6266	3228						9474
	WSW		7888	16544	494					28846
	W		6266	6860	1882					18588
4-5	WNW		6871	1211						8082
	NW		5809	1614						6223
	NNW		937	444						1341
	Tabl		35854	23861	1876					46121
	SSW		608	13410						16018
5-6	SW		608	26031	1934					28573
	WSW		2430	48118	1333	1144				71835
	W		2430	41019	7337		1322			52594
	WNW			51273						51273
	NW			35487						37320
6-7	NNW			1578						1578
	Tabl			7899	216226	29014	1144	1322		254305
	SSW			2590						2590
	SW			7795	12780	1892				22867
	WSW			12391	187037	5676	2184			127888
7-8	W			6286	70293	20812				37601
	WNW			9094	3195					12282
	NW			3897	1598					5635
	Tabl			42871	196383	28380	2184			268338
	SSW				19276					16276
8-9	SW				26172					26172
	WSW				48241	31074				35865
	W				57183	37885				96588
	WNW				48207					45882
	NW				86176					24474
9-10	Tabl				233171	70509				308680
	SSW				3915					3915
	SW				16574	21447				40181
	WSW				18257	66885				80144
	W				5794	31874	9114			50324
10-11	WNW				11257	3734				17192
	NW				66367	115862	9114			131367
	Tabl					5230				5230
	SSW				4901	48819	6054		7686	53784
	SW					26152	34824			62476
11-12	WSW				17603	5230				22833
	W				4901					4901
	WNW				26485	78655	42378		7686	156924
	NW					20120				20120
	Tabl					5634	23310			82576
12-13	SSW					32532	31080			62402
	SW					5634	18413			19057
	WSW					5634				5634
	W					16302	120718	56370		172010
	WNW						2672			9634
13-14	NW					25084	87248			112322
	Tabl					7011	41807	58165		106383
	SSW						4261			4261
	SW					7811	83661			83661
	WSW						83613	155107		245731
14-15	W						23656			23656
	WNW						35483	24882		62365
	NW							18481		18481
	Tabl						57139	40323		97462
	SSW							16110		16110
15-16	SW							16110		16110
	WSW							14172		14172
	W							16110		16110
	WNW							14172		14172
	Tabl							48370		62502
16-17	SSW							57160		57160
	SW							95100		95100
	WSW							152160		152160
	W							66277		66277
	WNW							66277		66277
17-18	Tabl							132258		132258
	SSW							25590		25590
	SW							25590	28620	51140
	WSW							31880	28620	79708
	W								32684	32684
18-19	WNW							33002		33002
	Tabl									
	SSW									
	SW									
	WSW									
TOTAL		13731	109532	274874	265711	508721	337806	452853	60970	2356418

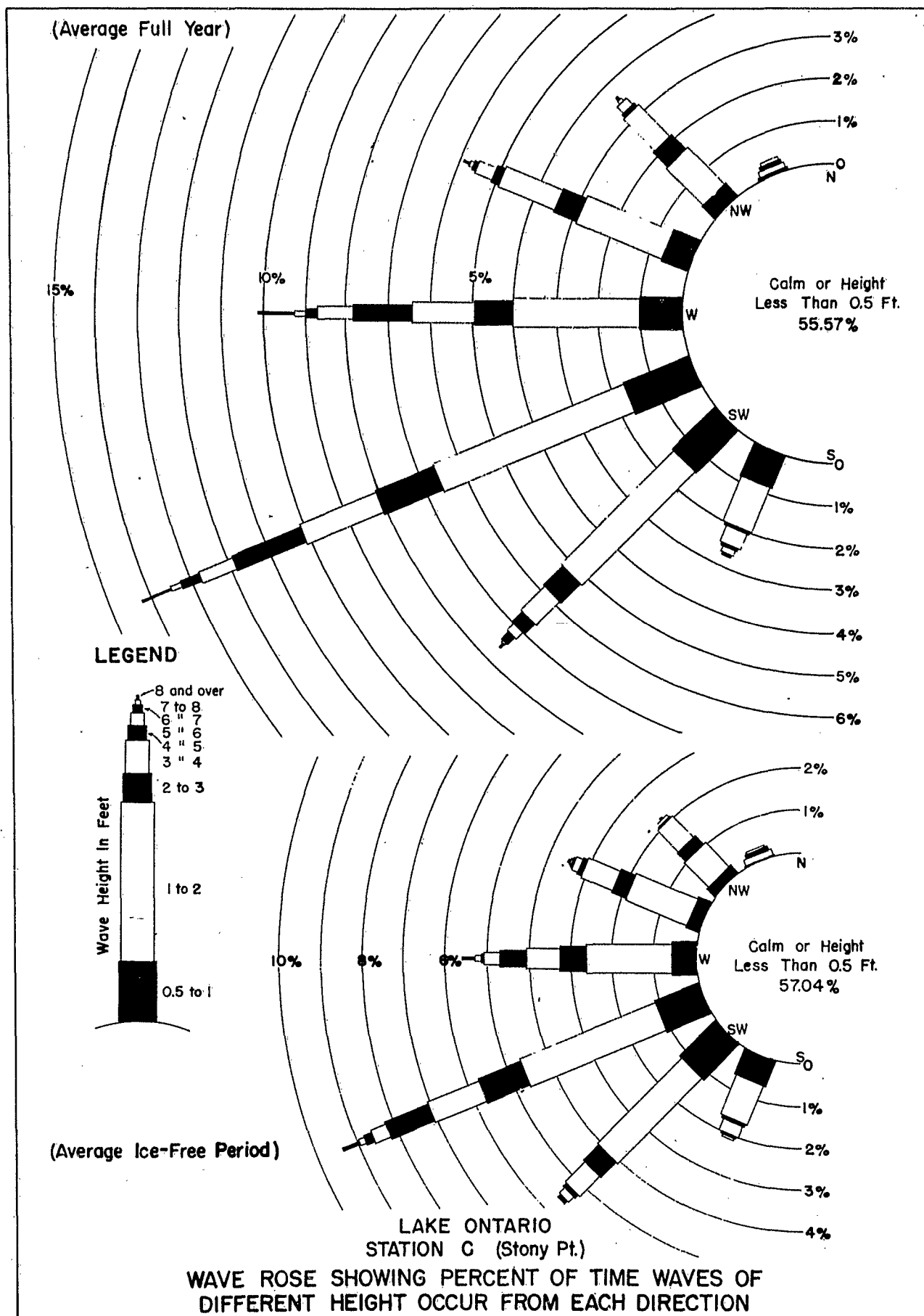
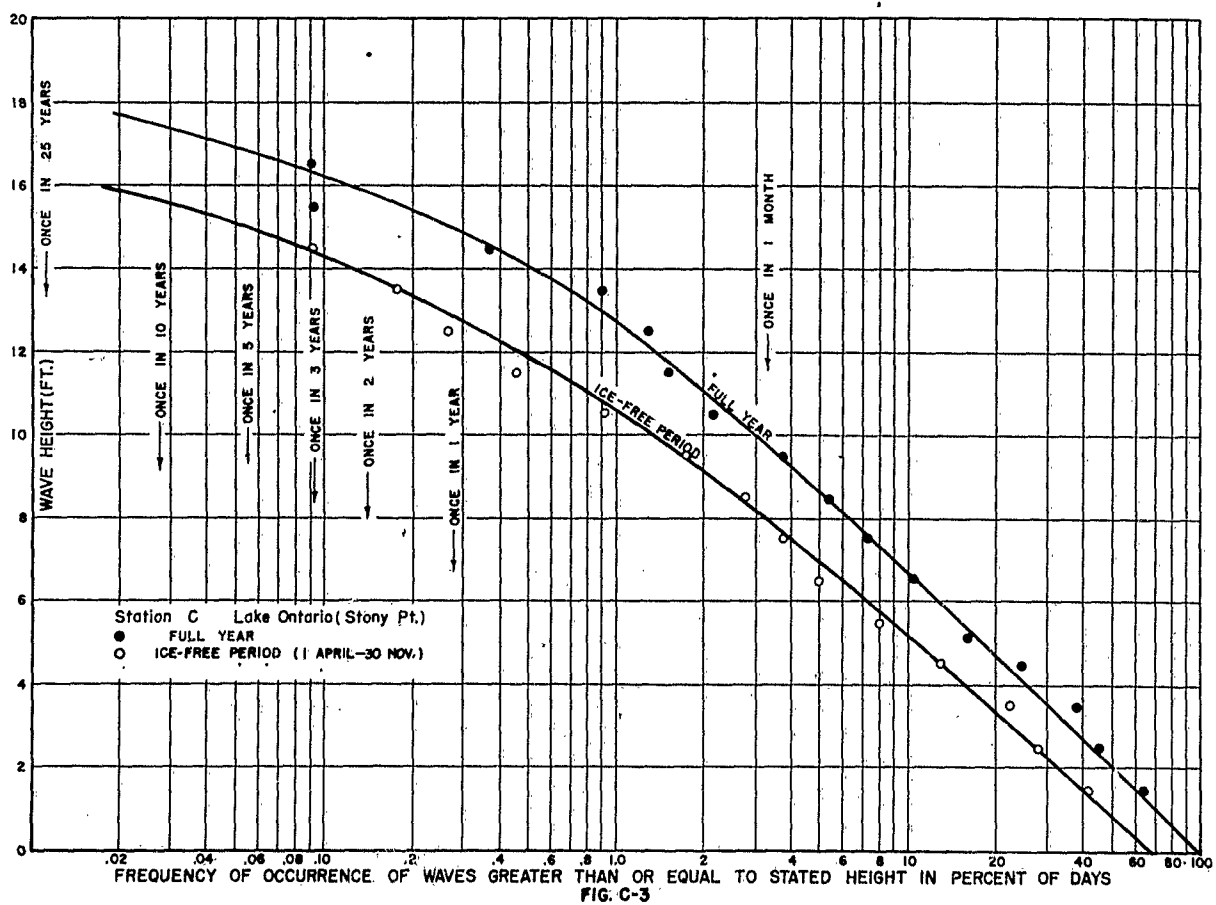
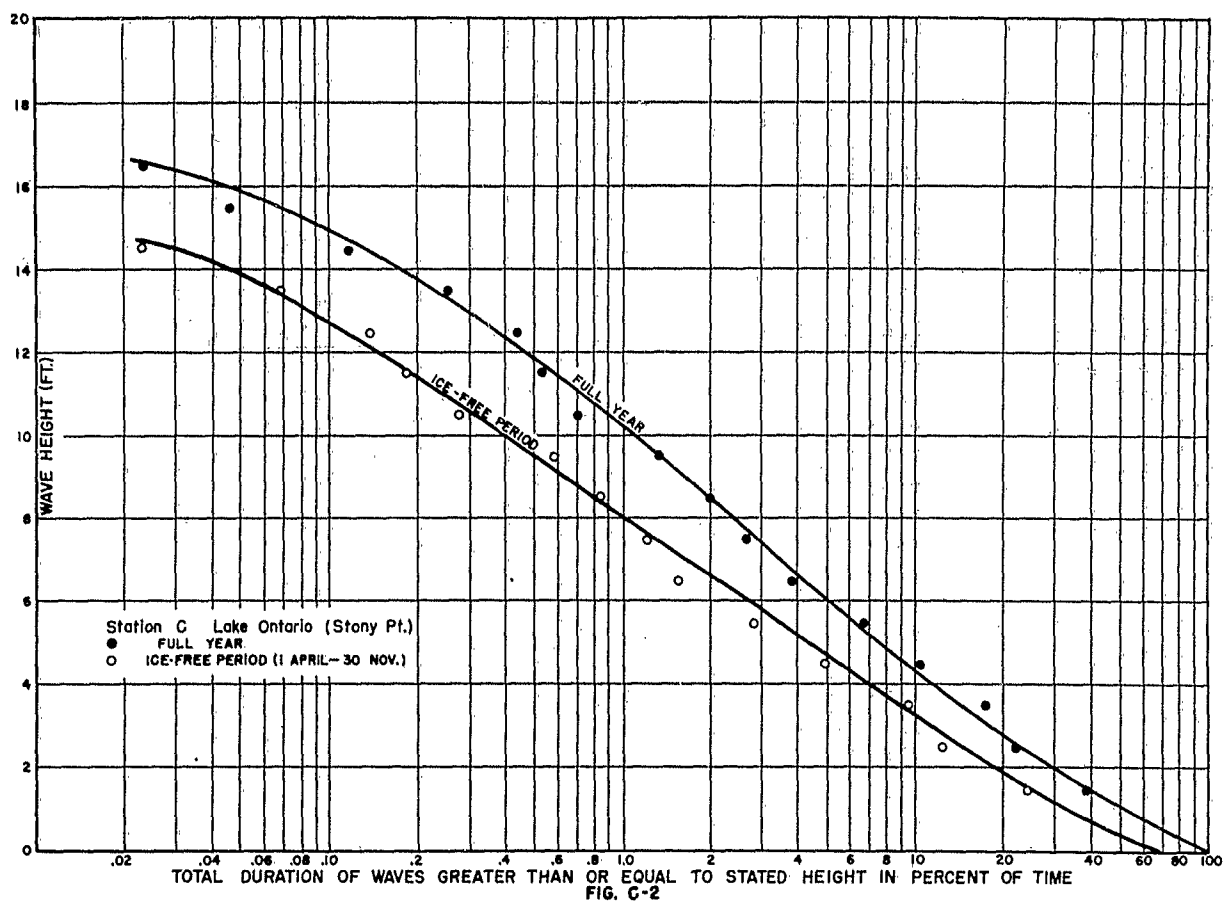
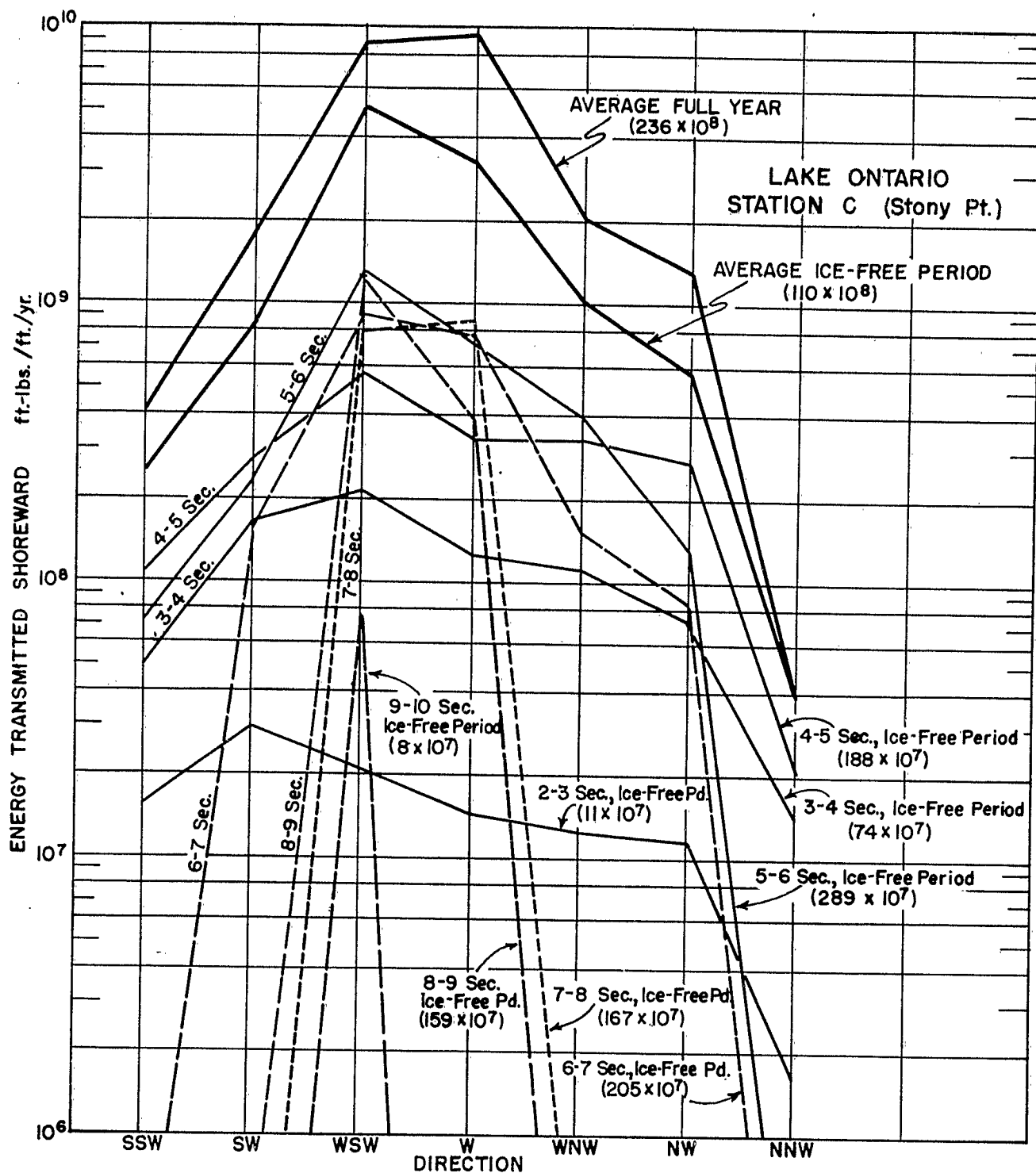


FIG. C-1





AVERAGE AMOUNT OF ENERGY TRANSMITTED SHOREWARD PER FOOT OF CREST LENGTH PER YEAR, IF WAVE SYSTEM IS CONSIDERED AS AN HYPOTHETICAL UNIFORM SYSTEM COMPOSED OF WAVES OF SIGNIFICANT HEIGHT AND PERIOD ONLY

FIG. C-4

D71031