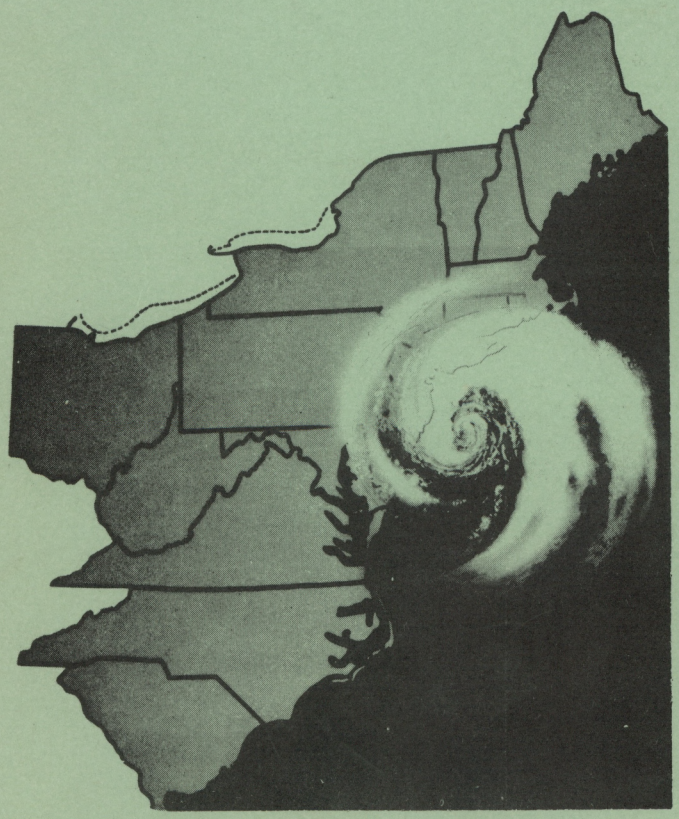
U. S. DEPARTMENT OF COMMERCE • ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
Weather Bureau

TECHNICAL MEMORANDUM No. 19

Snowfall Statistics for Williamsport, Pennsylvania

Jack L. Hummel



EASTERN REGION

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TECHNICAL MEMORANDUM No.

EASTERN REGION TECHNICAL MEMORANDUM

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UNITED STATES DEPARTMENT OF COMMERCE
ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
U. S. WEATHER BUREAU EASTERN REGION

TECHNICAL MEMORANDUM NO. 19

Snowfall Statistics For Williamsport, Pennsylvania

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Montoursville, Pa.

Scientific Services
January 1967

Introduction

A climatological study is presented of 893 snowfalls with accumulations of half inch or more that occurred at Williamsport, Pennsylvania, during a 70-year period of record from February 1, 1895 through January 31, 1965. This investigation answers questions of the following type:

1. For the period of record, how often did a snowfall of 0.5 inches or more occur in any semi-monthly period of the snow season?

2. Given the occurrence of a snowfall greater than or equal to 0.5 inches, what are the chances of it occurring in the following classes:

   a. 1-2 inches,

   b. 3-4 inches,

   c. 5-7 inches,

   d. 8-10 inches,

   e. more than 10 inches?

These categories were chosen since, in this part of the country, a snowfall of 1-2 inches is considered light, that of 3-4 inches is considered moderate, those of 5-7 and 8-10 inches are considered heavy and a snowfall of 11 inches or more is considered severe.

An analysis of 70 snow seasons using the Lieblein Method (1) (2) is presented to determine the probability of a seasonal extreme-value of snowfall from a single storm. This analysis also enables the determination of the amount of time that can be expected to pass (return period) before another snowfall at least as big as the first one occurs.

The probability of occurrence on or prior to any particular day for the first and last snowfalls of the season for different amounts is computed.

Snowfall measurements were taken near the center of Williamsport until December 1943. After that the measurements were taken at the Williamsport-Lycoming County Airport.

Results

Figure 1 is a table of the incidence of snowfalls greater than indicated amounts that occurred during semi-monthly periods from February 1, 1895 through January 31, 1965. To illustrate the use of this table, consider the first half of March. The table shows that 47% of the snowfalls that occurred during this period netted 3 inches or more. A further breakdown shows that 26% yielded 5 inches or more (heavy snow) and in 6% of the cases, snowfalls with accumulations of 11 inches or more (severe) occurred.

Figure 1 also presents the incidence of snowfalls showing the total number and percentages that occurred in each category for all semi-monthly periods combined during the period of study.

Figures 2 and 3 illustrate the incidence of individual snowfalls, by categories, that occurred during semi-monthly periods of the snow seasons from February 1, 1895 through January 31, 1965.

Figure 2 also compares the first 35 years of record with the last 35 years. To illustrate the use of Figure 2, again consider the first half of March. Note that:

1. 53% of the snowstorms are between 0.5 - 2 inches.
2. 21% of the snowstorms are between 3-4 inches.
3. 10% of the snowstorms are between 5-7 inches.
4. 10% of the snowstorms are between 8-10 inches.
5. 6% of the snowstorms are greater than 10 inches.

Of the 94 snowstorms during this period of consideration, 20 netted 3-4 inches with 8 occurring during the years from 1895 to 1929 and 12 during 1930-1964.

Figure 4 shows the incidence of severe snowfalls both in order of severity and by the calender month in which they occurred. Severe snowstorms that occurred between February 1895 and June 1, 1966, have been included in this table.

Figure 5, the preparation and usage of which is explained in detail in (1), shows the average time interval between successive snowstorm accumulations for individual storms, each storm of which

had at least as much snowfall accumulation as the first. To illustrate the use of this figure, let us determine the return period, T, of a 15-inch snowfall. We move horizontally from the point on the ordinate representing 15 inches until we intersect the fitted line. We then proceed vertically up from this point of intersection until we intersect the number representing the return period (years). In this case we find a 7 year return period. A seven year snowstorm is said to be one that happens, on the average, once every seven years. As quoted from reference (1) page 3, "this extreme value distribution has some very interesting peculiarities. The median is considerably smaller than the mean, and, in fact, is 0.69T." This means that there is a 50-50 chance that the seven-year snowstorm will occur within 4.8 years. "On the other hand, the probability that the event will happen within its return period is only 0.63." The seven year snowstorm, therefore, has only a 63% chance of happening at all within seven years even though, on the average, it occurs once every seven years.

Utilizing Figure 5, one can compute the probability that a snowstorm greater than any interested amount can occur in any predetermined number of years (1). The probability W(V) that an event will happen within V years is $W(V) = 1-g^V$ where g = 1-P, and P is the event's probability (1/P =T). If P is less than about 0.1 and T greater thab 10, the above equation can be approximated by

$$W(V) \approx 1- \exp(-V/T)$$

where T is the return period determined by utilizing Figure 5. To illustrate, let us consider the largest single snowstorm that was recorded at Williamsport, 24.1 inches. For this event, it is found from Figure 5, that the return period, T, =69 years. The probability that the 24.1 inch snowfall will occur in 71 years, the period of record, is computed using the approximation equation

$$W(24.1) = 1 - \exp(-71/69) = 1-0.36 = 64\%$$

Thus, there is a 64% chance of a snowfall of at least 24.1 inches occurring in the next 71 years. Figure 5 also enables us to determine the probability that the maximum snowfall from an individual storm will not exceed a given amount during a snow season. To determine this we enter the ordinate at the maximum snowfall of interest, move horizontally until we intersect the fitted line, and then determine the probability by moving vertically down until we intersect the probability values listed on the abscissa. To illustrate, the probability that a single snowstorm will not exceed

five inches in a season is 12%; that it will not exceed 17 inches is 91%. This also means that in 88% of the years a snowfall will exceed 5 inches and in only 9% of the years will it exceed 17 inches. A slight variation of this procedure enables us to determine from this graph that there is a 50% probability that the maximum snowfall in any season will not exceed 9.4 inches; a 70% probability that it won't exceed 11.8 inches.

Figures 6 and 7 can be utilized to determine the probability that the first and last measurable, two inch and four inch snowfall will occur prior to a certain date. These graphs were prepared after determining that the data fitted a normal distribution (2). Illustrating the use of Figures 6 and 7, there is a 40% probability that the first snowfall of at least four inches will occur on or before December 19, and a 40% probability that the last snowfall of at least four inches will occur on or before February 26.

Conclusions:

1. On a yearly basis about 2/5 of the snowfalls are 3 inches or more and only 1/5 yield heavy snowfalls (5 inches or more).

2. The period from the middle of January to the middle of February is the snowiest time of the year. About 28% of the snowfalls occurred during this period. This period also contains the greatest frequency of heavy snows (5 inches or more). About 34% of all heavy snows occur between January 16 and February 15.

3. The greatest snowstorm ever recorded in Williamsport was 24.1 inches on January 12-13, 1964. The second maximum was 23.0 inches on February 22, 1902.

4. Comparing the first 35 years on record with the last 35, it is found that the percentages change very little with respect to each individual category of snow fall amounts.

5. There is a 50% probability that the maximum snowfall in any season will not exceed 9.4 inches.

Suggestions For Future Research

An interesting investigation would be to supplement this study by incorporating the results of an examination of weather maps for those storms that gave snows of more than 10 inches. One method of attack might be a detailed study of the storm tracks, noting

the distance and the direction of the surface and 500-mb low centers from Williamsport at the time the snow began and ended as well as the central pressure along the track of each cyclone. Synoptic climatology of this nature would be a further aid in forecasting severe snowfalls at Williamsport, Pa.

References

(1) United States Weather Bureau, "Climatological Services Memorandum No. 89", August 11, 1961, Pages 1 - 11

(2) United States Weather Bureau, "Climatology At Work", October 1960, Pages 56 - 59

Incidence Of Snowfalls Greater Than Indicated Amounts

Period	0.5" or more	3" or more		5" or more		8" or more		11" or more	
	No.	No.	%	No.	%	No.	%	No.	%
October									
15 - 31	2	0	0	0	0	0	0	0	0
November									
1 - 15	16	5	31	2	13	1	6	1	6
16 - 30	40	7	18	2	5	2	5	0	0
December									
1 - 15	93	35	38	13	14	8	9	2	2
16 - 31	108	40	37	20	19	5	5	1	1
January									
1 - 15	105	41	39	19	18	8	8	4	4
16 - 31	125	55	44	24	19	10	8	2	2
February									
1 - 15	124	53	43	30	24	12	10	5	4
16 - 29	99	34	34	16	16	9	9	6	6
March									
1 - 15	94	44	47	24	26	15	16	6	6
16 - 31	57	26	46	17	30	8	14	3	5
April									
1 - 15	23	11	48	7	30	2	9	1	4
16 - 30	7	3	43	1	14	0	0	0	0
Totals	893	354	40	175	20	80	9	31	3.5

Figure 1 - Semi-monthly incidence of snowfall greater than indicated amounts occurring in individual storms at Williamsport, Pa., for the period February 1, 1895 through January 31, 1965.

Incidence Of Snowfalls In Selected Categories

Month & Period	Depth of Snowfall in Inches									
	1 - 2		3 - 4		5 - 7		8 - 10		11 or more	
	No.	%	No.	%	No.	%	No.	%	No.	%
OCT 15-31										
1895-1929	1	100	0	0	0	0	0	0	0	0
1930-1964	1	100	0	0	0	0	0	0	0	0
1895-1964	2	100	0	0	0	0	0	0	0	0
NOV 1-15										
1895-1929	4	67	2	33	0	0	0	0	0	0
1930-1964	7	70	1	10	1	10	0	0	1	10
1895-1964	11	69	3	19	1	6	0	0	1	6
NOV 16-30										
1895-1929	14	88	2	12	0	0	0	0	0	0
1930-1964	19	79	3	13	0	0	2	8	0	0
1895-1964	33	82	5	13	0	0	2	4	0	0
DEC 1-15										
1895-1929	28	58	12	25	2	4	5	11	1	2
1930 1964	30	67	10	22	3	7	1	2	1	2
1895-1964	58	63	22	24	5	5	6	6	2	2
DEC 16-31										
1895-1929	33	65	10	19	5	10	3	6	0	0
1930-1964	35	60	10	18	10	18	1	2	1	2
1895-1964	68	62	20	19	15	14	4	4	1	1
JAN 1-15										
1896-1930	31	58	11	21	5	9	3	6	3	6
1931-1965	33	63	11	21	6	12	1	2	1	2
1896-1965	64	61	22	21	11	10	4	4	4	4
JAN 16-31										
1896-1930	36	55	19	29	7	10	3	4	1	2
1931-1965	34	58	12	20	7	12	5	8	1	2
1896-1965	70	56	31	25	14	11	8	6	2	2
FEB 1-15										
1895-1929	37	57	12	18	8	12	5	8	3	5
1930-1964	34	58	11	19	10	17	2	3	2	3
1895-1964	71	57	23	19	18	14	7	6	5	4

Figure 2

(Continued)

Incidence of Snowfalls In Selected Categories (Cont'd)

Month & Period	Depth of Snowfall in Inches									
	1 - 2		3 - 4		5 - 7		8 - 10		11 or more	
	No.	%	No.	%	No.	%	No.	%	No.	%
FEB 16-29										
1895-1929	31	63	9	18	4	8	2	4	3	6
1930-1964	34	68	9	18	3	6	1	2	3	6
1895-1964	65	66	18	18	7	7	3	3	6	6
MAR 1-15										
1895-1929	27	57	8	17	4	9	5	11	3	6
1930-1964	23	49	12	26	5	11	4	8	3	6
1895-1964	50	53	20	21	9	10	9	10	6	6
MAR 16-31										
1895-1929	14	60	3	13	2	9	2	9	2	9
1930-1964	17	50	6	18	7	19	3	9	1	4
1895-1964	31	54	9	16	9	16	5	9	3	5
APR 1-15										
1895-1929	5	56	1	11	2	22	0	0	1	11
1930-1964	7	51	3	21	3	21	1	7	0	0
1895-1964	12	52	4	18	5	22	1	4	1	4
APR 16-30										
1895-1929	2	50	2	50	0	0	0	0	0	0
1930-1964	2	67	0	0	1	33	0	0	0	0
1895-1964	4	57	2	29	1	14	0	0	0	0
Yearly Average										
1895-1929	263	60	91	21	39	9	28	6	17	4
1930-1965	276	61	88	19	56	12	21	5	14	3
Feb 1, 1895 - Jan 31, 1965	539	60	179	20	95	11	49	5	31	4

Figure 2 - (pages 7 & 8) Total number of individual snowfalls with indicated depths that occurred during semi-monthly periods of the snow seasons from February 1, 1895 through January 31, 1965. The first 35 years of record is compared with the second 35 years.

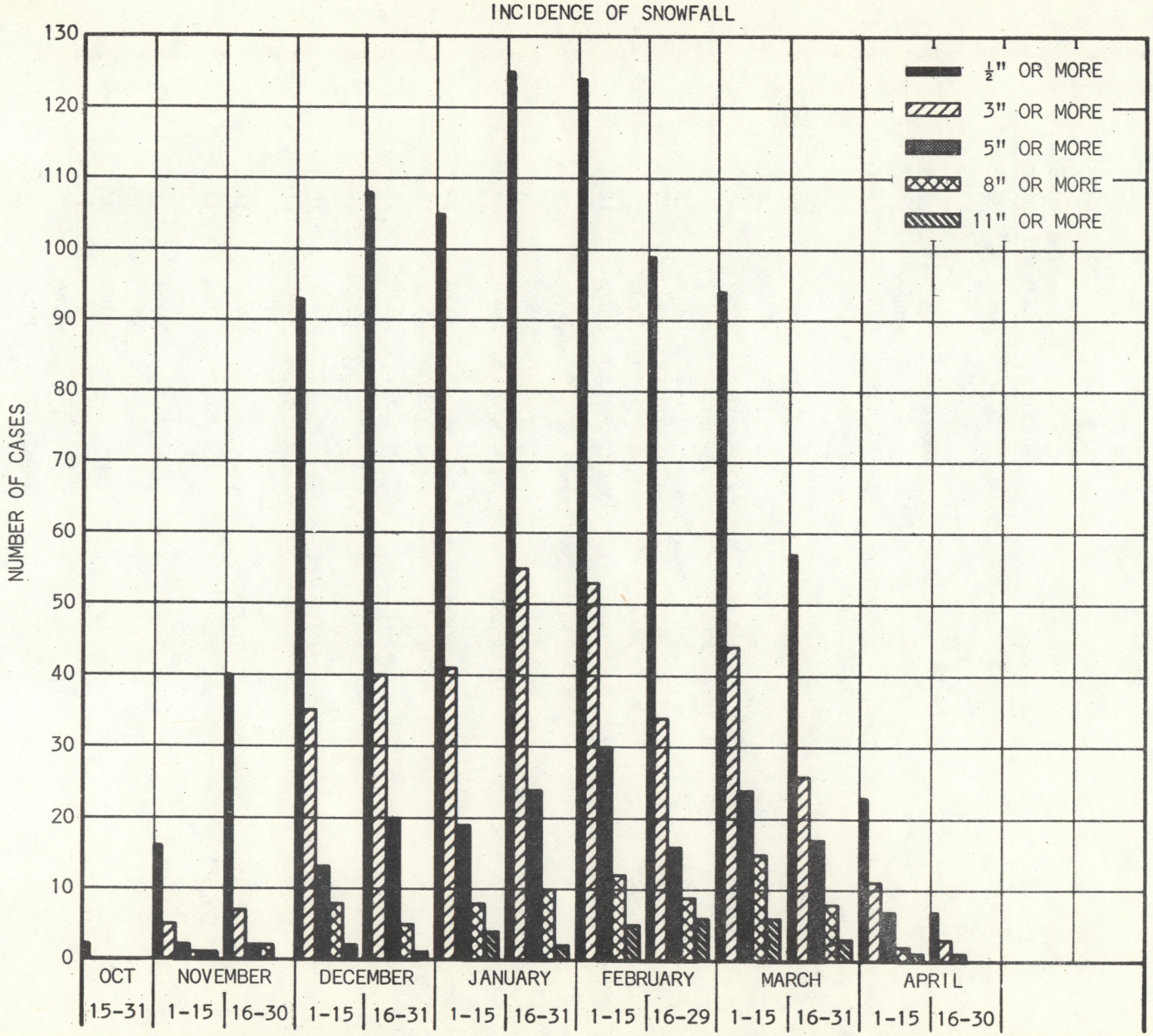

Figure 3. Incidence of Snowfall by Semi-Monthly Periods for the 70 Years, February 1, 1895 Through January 31, 1965

Incidence Of Severe Snowfalls *
(Accumulations of over 10 inches)

By Depth

Accumulation (inches)	Date of occurrence
24.1	Jan. 12-13, 1964
23.0	Feb. 22, 1902
17.0	Feb. 14-15, 1914
17.0	Feb. 4-5, 1926
17.0	Feb. 14-15, 1940
16.5	Feb. 18-19, 1964
16.0	Jan. 11-12, 1922
15.0	Mar. 8-9, 1941
14.8	Mar. 6, 1902
14.8	Feb. 3-4 1961
14.5	Mar. 4-5 1917
14.5	Jan. 30, 1925
14.5	Feb. 19-20, 1927
14.0	Jan. 7, 1908
14.0	Dec. 19-20, 1945
13.7	Mar. 3-4, 1960
13.1	Nov. 6-7, 1953
13.0	Feb. 20, 1921
13.0	Mar. 18-19, 1928
13.0	Jan. 19-20, 1936
12.6	Jan. 29-30, 1966
11.9	Mar. 22-23, 1950
11.5	Mar. 21, 1912
11.4	Jan. 22-23, 1966
11.1	Dec. 14, 1914
11.0	Feb. 12, 1910
11.0	Apr. 2, 1924
11.0	Feb. 26-27, 1934
11.0	Mar. 8, 1957
10.5	Mar. 15-16, 1916
10.5	Jan. 9, 1926
10.5	Feb. 22-23, 1935
10.5	Dec. 12-13, 1944

By Month

Date of occurrence	Accumulation (inches)
Nov. 6-7, 1953	13.1
Dec. 14, 1914	11.1
Dec. 12-13, 1944	10.5
Dec. 19-20, 1945	14.0
Jan. 7, 1908	14.0
Jan. 11-12, 1922	16.0
Jan. 30, 1925	14.5
Jan. 9, 1926	10.5
Jan. 19-20, 1936	13.0
Jan. 12-13, 1964	24.1
Jan. 22-23, 1966	11.4
Jan. 29-30, 1966	12.6
Feb. 22, 1902	23.0
Feb. 12, 1910	11.0
Feb. 14-15, 1914	17.0
Feb. 20, 1921	13.0
Feb. 4-5, 1926	17.0
Feb. 19-20, 1927	14.5
Feb. 26-27, 1934	11.0
Feb. 22-23, 1935	10.5
Feb. 14-15, 1940	17.0
Feb. 3-4, 1961	14.8
Feb. 18-19, 1964	16.5
Mar. 6, 1902	14.8
Mar. 21, 1912	11.5
Mar. 15-16, 1916	10.5
Mar. 4-5, 1917	14.5
Mar. 18-19, 1928	13.0
Mar. 8-9, 1941	15.0
Mar. 22-23, 1950	11.9
Mar. 8, 1957	11.0
Mar. 3-4, 1960	13.7
Apr. 2, 1924	11.0

Figure 4 - Incidence of severe snowfalls from a single snowstorm for the period February 1, 1895 to June 1, 1966. (* Events that occurred between Feb. 1, 1966 and Jun.1, 1966 are included in this summary but do not appear elsewhere in this report.)

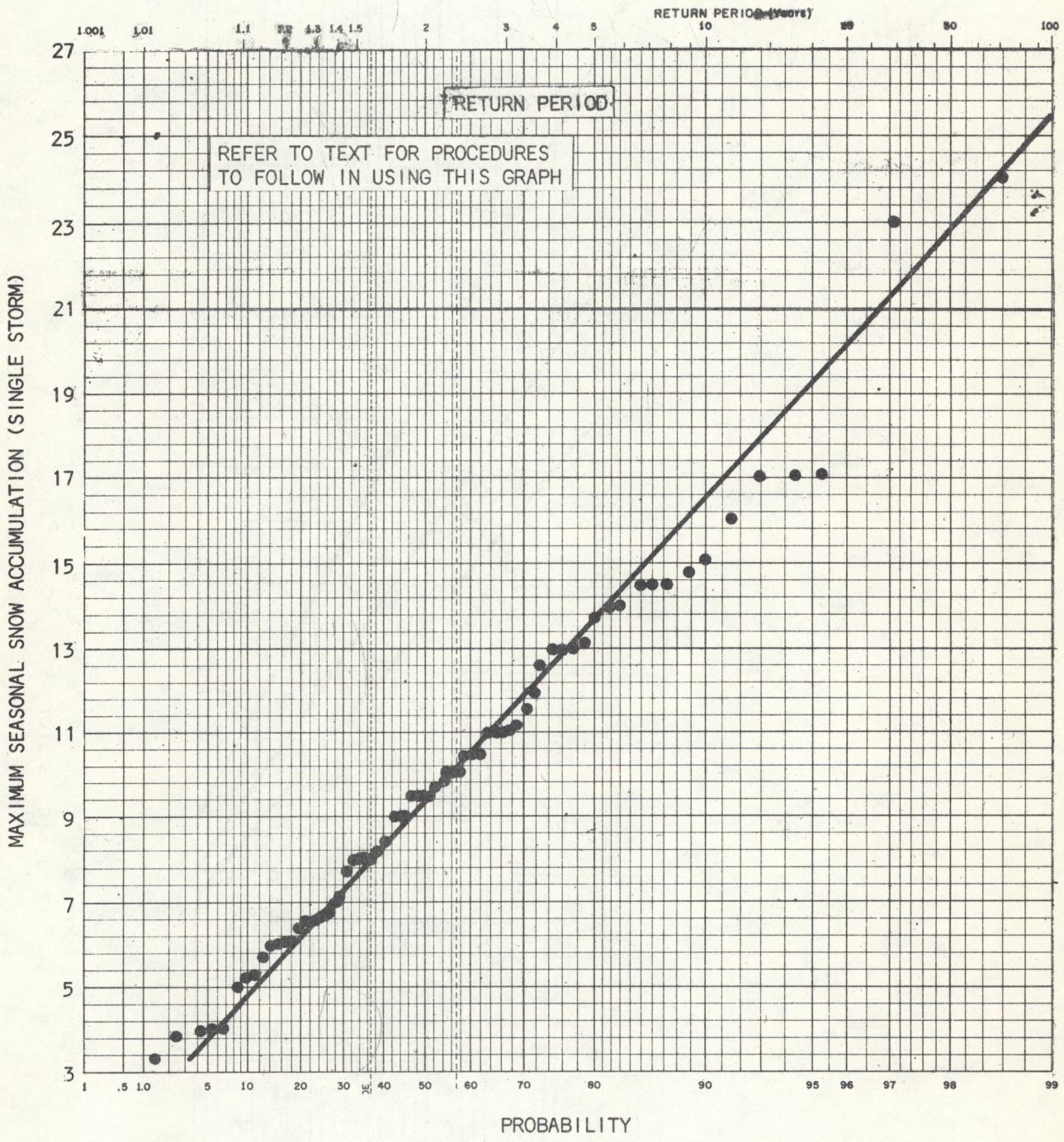

Figure 5. Return Period Determination

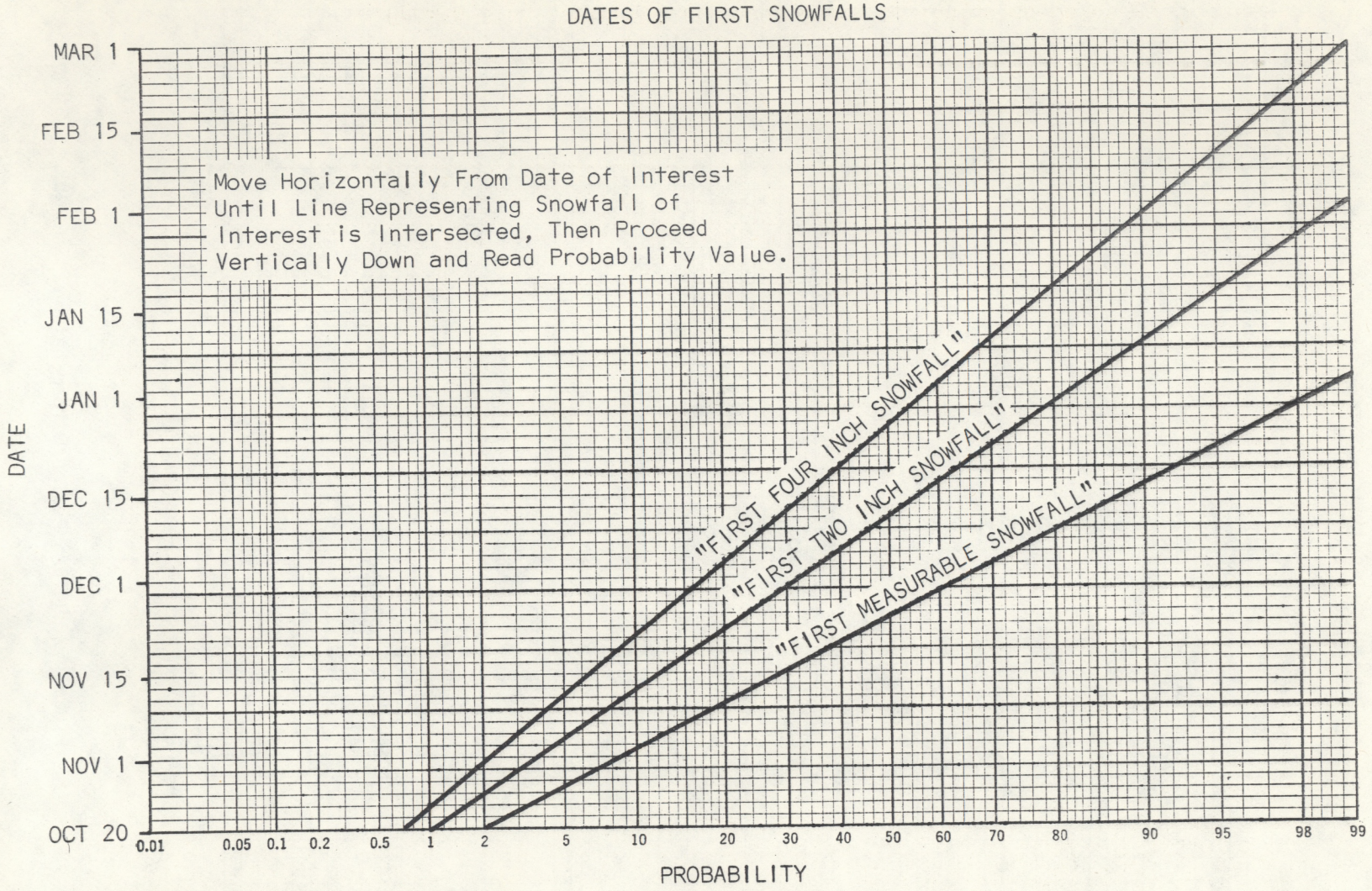

Figure 6. Probability First Measurable, Two Inch and Four Inch Snowfall From a Single Storm Will Occur Prior to Indicated Dates

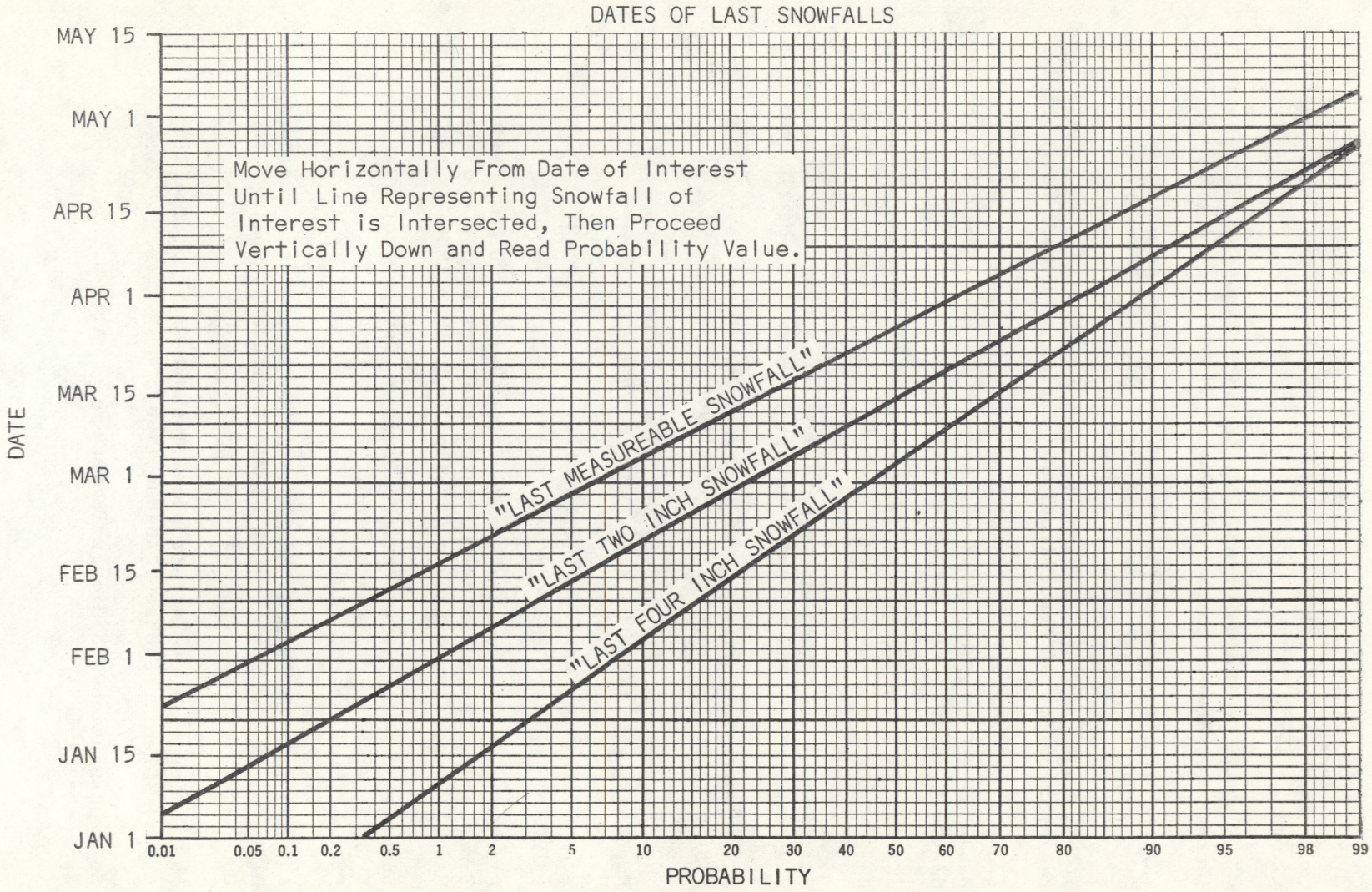

Figure 7. Probability Last Measurable, Two Inch and Four Inch Snowfall From a Single Storm Will Occur Prior to Indicated Dates

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