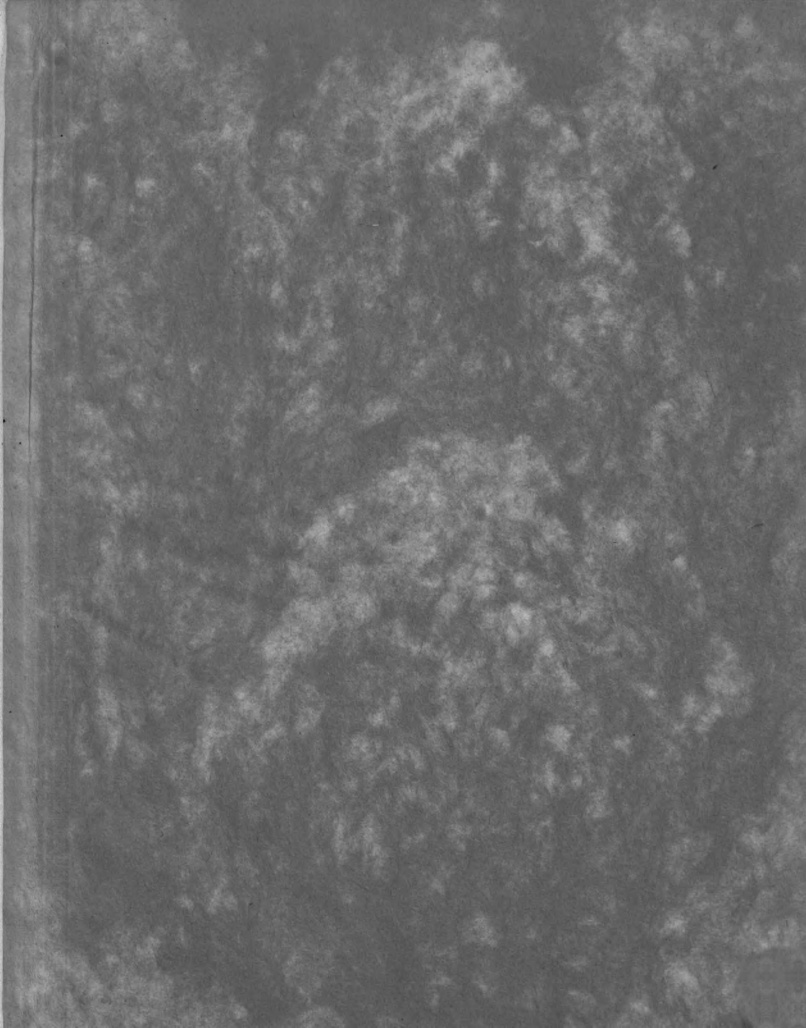


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Rainfall in Southern Mexican

A Thesis Submitted to

the Faculty of

HONORS OF THE COLLEGE

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by

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Candidate for the degree of

Master of Science

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THESIS

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Bibliography

Chronological Records of Intense Storms - U. S. Weather Bureau
at Detroit, East Lansing,
Grand Rapids, and Grand Haven

Maximum Rates of Precipitation at Each Station (Arrangement) -
See Table III - U. S. D. A. Bulletin #204

Tabulation of Most Intense Storms at Each Station (Arrangement) -
See Table I - U. S. D. A. Bulletin #204

Probability Chart - see Fig. 3, E. N. R.; Vol. 83, p. 870

Probability Table - Table VI, E. N. R.; Vol. 80, p. 870

Curve of Expected Storm Intensities - Fig. 4, E. N. R.; Vol. 80, p. 870

Summary of Maximum Average - see Table III, p. 9 of Horton's Reprint Article
Rain Intensities

Rainfall in Southern Michigan

The object of this paper is to aid in establishing a more scientific method of correlating intense rainfall data so that such data may be used to predict the frequency of occurrence for rainfall intensities of any given amount. The data contained herein covers a period of from seven to twenty years and any and every prediction accordingly should contain that observation. Any theoretical curves or values found herein should serve only as a guide in the study of rainfall records. Theory that does not conform to existing data is obviously of little practical value. It is a well known fact rainfall distribution follows rather a finite law. The absolute proof of this depends on the amount of available data. It is not so easy, however, to state factors controlling such laws.

Rainfall, like other natural phenomena, does not follow necessarily the normal law of chance which states that, "positive and negative variations are equally frequent," but generally indicates that there are more years during which the rainfall is less than the arithmetic mean.

Table 1.

Table 1, is a chronological record of accumulated values of intense rainfall for intervals of from 5 to 15 minutes from U.S. Weather Bureau record at four southern Michigan cities Detroit, East Lansing, Grand Haven, and Grand Haven. These stations appear to be in very nearly a straight line. By intense rainfall is meant only that amount in which the rate is inches per hour $\sum \frac{.01}{.05} + .01$ time in minutes.

For instance rain must come down at the rate of at least .01 inches per hour for five minutes in order to be considered an active amount.

Records accumulated at Detroit from the year 1811 to 1910 inclusive (period of 99 years) was taken as the basis of data. Data from East Lansing covers the period from 1811-1910 inclusive or a period of 99 years. Data for Grand Haven is rather limited *owing* to the fact that the recording station there was removed in 1910. Data covers the period from 1811-1910 inclusive or a period of 99 years.

Title 2.

The exact amount of rainfall that can be collected over a time interval of four to 12 minutes for any one storm - order rate of down pour is of great value for a single purpose alone: the values recorded in order of time occurrence during a storm can be rearranged to give the maximum amount of rain that fell in any five minute period and the corresponding rate in inches per hour, any ten minute period etc., up to 12 minutes.

For instance:- On September 14, 1911 the greatest amount of rain that fell in any 5 minute period fell at the rate of 8.75 inches per hour for that period and the total amount of rain that fell in any ten minute period three times that - but the same storm fell at the rate of 4.4 inches per hour. From this and subsequent data we see that rain falls at a greater rate for a 5 minute period than for a longer period say 10 minute period and we may say that the greater this period the slower the rate of rainfall. The rate of rainfall inches per hour is computed by multiplying the accumulated rainfall since the beginning of the storm by 60 and dividing by the time since the beginning of the storm. Being the same we can therefore give the rate of rainfall $\frac{.52 \times 60}{5} = 6.24$ inches per hour.

Table 3.

The intense rainfall records for each station were arranged according to the magnitude of their intensities, from the highest down to the lowest over a period of time. The number of storms which occurred with the same intensity over the period of record are shown in the left hand column.

For example: Detroit had two storms occurring between the years of 1931 - and 1946 which accumulated a rainfall of .86 inches in 5 minutes time or during which the rain fell at the rate of 4.68 inches per hour. We can say, therefore, that since two storms occur in a period of 17 years of the same magnitude that the apparent frequency of any storm of that magnitude is once in every 13.5 years. However such rare storms are extremes which are likely to lead to erratic predictions and may not follow the general laws of these storms of a more frequent occurrence and so the problem of the generalization becomes more involved.

Figure 1.

Rainfall intensity curves (in pocket in back of book) or curves showing the average precipitation values for each of the four stations of record as determined in table 53. The ordinates are measured in terms of the rate of rainfall in inches per hour. The abscissae are measured in terms of the duration intervals up to storms of 5 minute duration. The ordinates of each curve for a given frequency of occurrence was found by dividing the total recurrence interval by the given period and consulting the table that number of storms as plotted and observing the rate appearing opposite the value.

For example:- The maximum storm occurring with a frequency of say once in a nine year period at Detroit will then accumulate not less than .6 inches of rainfall in 5 minutes or at the rate of at least 5.1 inches per hour. From a perusal of curves for each of the four stations of record it appears that rain falls at the rate of 5.1 inches per hour for a five minute interval only once every 17.5 years at Detroit while at least 1 inch of rain falls at the same rate once about every 3 years, an event which is about once in 3 years, and at Grand Haven about once in 10 years. Most of these occur at Detroit as well as the other 5 minute intervals with a frequency of about once in 9 years.

Table 4.

This table shows the recorded maximum precipitation for each year for short time intervals with the values selected from table.

For example - The maximum rainfall for Detroit during the year 1911 fell at the rate of 4.2 inches per hour for a five minute interval. It is assumed in later discussion and computation that such storms occur in the middle of the year. An year is taken as basis of frequency measurements on the time of year during which occurrence is taken as mid-year or summer.

Table A.

Records of the most the intense storm at each of four stations for the period of record show that at Lansing and the largest 24-hour for a five minute interval had that rain fall at the Grand Rapids and Detroit at a greater rate for longer time intervals. The amounts are accumulated inches of rainfall.

Table B.

This table is conversion of accumulated inches of rainfall in table A into their corresponding rate in inches per hour.

Up to the fact that the maximum occurred at each Lansing we can say that the rain falls at a greater rate for longer time intervals at we move westward to Grand Rapids.

Figure 1.

probability chart based on table 1. The ordinates are measured in inches of rainfall per hour for time intervals of from 5 minute to 30 minute duration. The abscissae are measured in years of original duration of rainfall at any given rate and has been so indicated - and will not be exceeded. It is at once apparent that the best curve that can be drawn thru the plotted values approaches a linear function for the lower rates of rainfall and, further, for durations up to around 10 minutes the curves parallel each other in direction at a uniform slope.

Illustration:- What's the probability that a rainfall of 3.7 inches per hour for a five minute period at Detroit Michigan will be exceeded.

From the chart we see that 50% of the time (1916-1936) the given storm has not been exceeded or 50% of the time it has been exceeded and the probable occurrence of such a happening is $1/2$. The slopes of curves for the stations of record seem to be all approximately the same. Furthermore we see that the same amount of rainfall (3.7 inches per hour for a five minute period, will not be exceeded more than 50% of the time or will be exceeded 50% of the time with a probability of exceedance equal to $1/1000000$.

Figure 1., (cont'd.)

It has been found that the time at Grand Rapids, Michigan, of the time at Grand Haven.

Table 7.

From Figure 1., we see that a rate of rainfall of 3.7 inches per hour for a five minute interval at Detroit is not exceeded 1% of the time or it is exceeded 1% of the time or 18.5 years out of 17 years or 1 year out of every 17 years. Likewise we see that a rainfall of 3.1 inches per hour for any five minute period is not exceeded more than 1% of the time or once every two years. Also a rainfall of 4.0 inches per hour for any five minute interval at Detroit will not be exceeded more than 1% of the time or will ~~in other~~ be exceeded ^{out} 1% of the time or once ^{out} every three years.

Figure 3.

The values taken from the probability chart (Figure 1.) and from table 7 are plotted on logarithmic paper. The ordinate or the vertical is graduated along a logarithmic scale inches of rainfall per hour. The abscissa or horizontal scale is a logarithmic scale showing the period of return in minutes for storms occurring once in 1 year, 2 years, 5 years, 10 years, and 15 years.

A logarithmic scale flattens the curve to a straight line and does not magnify erratic errors.

Table 11

This table shows the ten highest rates of rainfall at each station for the intervals from 5 to 15 minute duration in order of their magnitude. The ten highest points are to serve as illustration as they represent extreme conditions and consequently may be most unreliable. The exceedence interval is found by dividing the per cent of record by the total number years during which the rainfall intensities are equalled or exceeded the given amount.

For example;- The period of record at Detroit was 17 years and the number of years during which the intensities are equalled or exceeded .15 inches per hour or 1.5 minute interval, .05 inches per hour for a 10 minute interval, etc., was 8 years there are the exceedence interval was

$= 17/8 = 2.125$ years. By computing the mean for each group of ~~the~~ five values arranged in order of their magnitude

it is possible to illustrate these extremes resulting

from the use of all tabular values. Thus the mean of the

first 5 values we will call number 1 mean with a mean ex-

$$\text{ceedence interval equal to 2 years} = \frac{(0.50 + 0.25 + 0.15 + 0.10 + 0.05)}{5} = 0.21 \text{ inches per hour}$$

and with a mean intensity rate per 5 minute

$$0.105 \text{ inches per hour} = \frac{(0.50 + 0.15 + 0.10 + 0.05 + 0.00)}{5}$$

Figure 4.

Values computed in table 3 were plotted on a uniform scale with inches of rainfall per hour as the ordinate and the exceedence interval in years as abscissa for the intervals from 1 to 5 minutes. Curves 1, 2, and 3 are functions of a parabolic trend with their apex at the origin.

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According to the normal curve of error there are many years during which the rainfall will be less than mean as there will be years during which the rainfall will be greater than the mean and 2% of all storms will occur within or closer to deviation from the mean. The normal curve is, therefore, 'symmetrical'. If, however there are more items above the mean than below the mean the curve of distribution will skew to the right and the mean of the new distribution will have moved to the right and also, from the mean of the normal curve of error distribution. Also the curve will be somewhat "flattened" out so that fewer than 2% of the items occur within one deviation from the mean. An average coefficient of skew for any one locality measures the intensity of rainfall that is not theoretically expected to exceed the mean. And the average coefficient variation for a locality ~~is~~ measures the amount of distribution above the mean. Generally rainfall does not conform to a normal distribution but is skewed to the right in the sense that there are more items above the mean than below the mean. Thus we. The standard variation is not equal to the variation by stating the amounts in terms of the mean as in table 2., and finding the sum of the squares variations from the mean. Thus we have not been aware of all variations from the mean without regard to sign(s) or-

Table 9 (cont'd.)

in the term values that have a positive sign, we have a measure of the flatness of the curve as the sum of the squares of the variations to be 1. greater for the normal curve than for a flatter curve. indicating that the individual items are spread out from the mean. If the distribution of items were a normal distribution, the coefficient of skew would be equal to zero.

[illegible]

Detroit

[illegible]

Detroit

Date	Ppt. before excess Rate	(Minutes)												Total
		5	10	15	20	25	30	35	40	45	50	60	80	
7-18-51	.01	.21	.42	.54	.60	.63								.66
5-26-52	.01	.16	.52	.64										1.04
7-15-52	.01	.25	.37											0.40
7-21-52	.01	.09	.32											0.57
8- 2-52	.04	.19	.30	.35										0.76
8-29-52	.40	.10	.25	.30	.37	.45	.60	.72	.75	.78	.85	1.06	1.39	2.38
9- 4-52	.06	.24	.31											0.40
8- 5-53	1.25	.05	.11	.21	.34	.45	.51	.53	.54	.55	.56	.56	.57	1.83
7- 6-54	.12	.18	.31	.41	.47	.52	.58	.58	.58	.59	.59	.60	.62	0.76
8- 2-54	.01	.11	.34	.46	.57	.66	.76	.83	.86	.86	.86	.86	.86	0.87
7-14-55	.03	.32	.43	.43	.43	.43	.43	.43	.43	.43	.43	.43	.43	0.46
7-19-55	.03	.34	.57	.85	1.11	1.32	1.51	1.73	2.01	2.20	2.29	2.37	2.59	2.42
8-10-55		.18	.26											
8- 6-55							.42					.58		
9-14-55		.04												
9- 5-55			.07				.10					.13		
10-14-55		.09	.10											
10-10-55							.13					.20		
4-28-56		.24	.40				.54					.96		
5- 2-56		.12	.25				.47					.52		
6- 1-56		.16	.33				.45					.51		
7-27-56		.06	.08				.17					.27		
8-16-56		.09	.13				.16					.16		
9- 7-56		.28	.43				.66					1.07		
10-6-56		.08	.10				.12					.22		

East Lansing

Date	Ppt. before excess Rate	(Minutes)												Total
		5	10	15	20	25	30	35	40	45	50	60	80	
6-25-10	.01	.15	.43	.54										.76
7- 6-10	.01	.18	.33											.35
5-20-11	.04	.37	.57	.67	.76									1.09
6- 4-11	.02	.06	.23	.57	.96	1.06	1.10	1.14	1.20	1.28	1.32	1.40		1.44
7- 6-11	.14	.12	.37	.57										.71
9-28-11	.34	.05	.15	.27	.40	.68	.79							1.46
10-1-11	1.22	.11	.29	.36	.40									1.92
11-11-11	.20	.34	.36											1.25
5-11-12	.69	.27	.38											2.21
5-21-12	.02	.35	.41											.69
7-24-12	.06	.05	.09	.23	.38	.46	.59							1.57
7-24-12	.88	.09	.34	.45	.50									1.57
7-28-12	.01	.23	.50	.59										.63
9-11-12	.09	.24	.52	.61	.68									.86
7- 5-13	.01	.11	.32	.34										.45
7-16-13	.01	.20	.35	.42										.53
7-16-13	.08	.21	.44	.55	.61									.75
8- 8-13	.16	.10	.33	.52	.70	.96	.96							1.15
8- 9-13	.02	.26	.67	.70	.71	.82	.94	1.08	1.29	1.37				1.40
8-16-13	.01			gage failed to record							1.47			1.49
8-21-13	.02	.20	.28	.29	.44									.56
4-27-14	.28	.19	.39	.45										.77
5-27-14	.01	.14	.45	.52										.65
5-29-14	.01	.25	.36	.42										.45
6-26-14	.01	.22	.32	.36										.47
7-13-14	.01	.13	.17	.19	.36	.58								.61

East Lansing

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East Lansing

Date	Ppt.	(Minutes)												Total
	before excess Rate	5	10	15	20	25	30	35	40	45	50	60	80	
6-18-21	.55	.15	.20	.30	.41	.48	.55							1.12
6-27-21	.02	.17	.44	.56										.60
8-17-21	.01	.66	.90											.92
8-19-21	.01	.06	.18	.29	.40									.63
8-27-21	.07	.11	.14	.16	.22	.45	.59							.70
7- 6-21	.04	.11	.25	.38	.39	.40	.43	.64	.74	.90	.95			1.00
7-14-21	.00	.40	.76											.76
4-11-22	1.08	.12	.19	.26	.39	.46								1.74
4-17-22	.15	.10	.31	.35										.49
7-10-22	.05	.35	.55	.67										.84
8- 5-22	.01	.07	.35	.61										.75
7- 7-23	.01	.05	.16	.36	.41	.45	.65	.96	1.33	1.65	1.92	2.06		2.33
9- 6-23	.07	.07	.28	.42										.50
6-20-24	.03	.22	.46											.77
6-26-24	.05	.06	.15	.20	.26	.42	.58	.60	.65	.70	.74	1.10		1.16
8- 5-24	.01	.16	.36	.45										.47
7-15-25	.09	.16	.27	.36	.42	.57	.68							1.06
9- 5-26	.08	.26												.36
6-14-26	.05	.10	.25	.48										.72
4-19-27	.01	.19	.36	.45	.49	.55								.90
5-25-27	.02	.15	.32	.38										.56
7-21-27	.06	.11	.31	.37										.67
9-12-27	.01	.13	.34											.57
5-18-28	.12	.06	.22	.39										.69
7-22-28	.02	.12	.24	.40	.53	.61								.71
8-30-28	.04	.26	.36	.39	.45	.56	.68	.78						.84

Date	Ppt. before excess Rate	(Minutes)												Total
		5	10	15	20	25	30	35	40	45	50	60	80	
10-18-28	.05	.29												.39
7-18-29	.05	.25	.56	.62										.68
1930	No excessive precipitation for years.													
4-20-31	.01	.21	.32	.49	.57	.65	.67	.74	.89	.95				1.07
6-26-31	.02	.10	.40	.47										.52
7- 5-31	.00	.27	.44											.46
8- 4-31	.01	-	-	.20	.55	.57	.55	.62						.68
10-4-31	.01	.20	.34	.38										.40
12-24-31	.01	.18	.56	.66										1.15
5-26-32	.06	.06	.36	.67	.74									.91
5-26-32	.01	.12	.25	.38										.41
7-26-32	.01	.12	.22	.34	.42									.71
8-29-32	.25	.09	.18	.25	.27	.36	.44	.57	.84	1.00	1.05	1.09	1.50	2.56 (100 min. 2.04)
6-29-33	.32	.12	.20	.22	.28	.59	.62	.81	1.21	1.51				1.86
4- 5-34	.15	.33	.37	.40	.41	.43	.44	.45	.46	.46	.47	.47	.48	.61 (100 min. .48 and 120 min. .48)
7- 6-34	.04	.15	.15	.20	.43	.68	.81	.96	.98	.99	.99	1.51	1.46	1.64
6-26-35	.32	.30	.52	.71	.95	1.08	1.21	1.22	1.27	1.39	1.45	1.53	1.55	1.87 (100 min. 1.50 and 120 min. 1.55)
7-19-35	.03	.32	.62	.79	.87	.93	.95	.95	.96	.96	.96	.98	1.00	1.11 (100 min. 1.04 and 120 min. 1.06)
8-20-35	.09	.05	.22	.30	.35	.57	.48	.63	.65	.66	.69	.70	.70	.79 (100 min. .70 and 120 min. .70)

RECORDS OF INTENSE RAINFALL OF GRAND RAPIDS

Rate equal to or greater than .20 inches + .01 x time in min.

Date	Prec.Bef.	(Minutes)												Total
	Excess 5 Rate Began	10	15	20	25	30	35	40	45	50	55	60	120	
12-7-56	.01	.02	.02			.05						.08	.15	
4-27-56	.05	.07	.09			.11						.15	.24	
5-25-56	.04	.07	.08	.09	.11	.13	.14	.15	.16	.17	.18	.19	.22	
5-2-56	.14	.25	.33	.40	.48	.56	.56	.56	.56	.56	.56	.57	.65	
7-1-56	.15	.14	.15	.15		.16						.17	.19	
8-28-56	.21	.30	.35	.39	.43	.47	.49	.51	.53	.55	.57	.59	.75	
9-16-56	.38	.44	.45	.45	.46	.46	.49	.51	.53	.54	.58	.61	.92	
10-2-56	.03	.05	.06	.065	.07	.08	.85	.09	.095	.10	.105	.11	.17	
11-3-56	.29	.48	.60	.66	.72	.78	.81	.84	.86	.91	.94	.97	1.18	
12-7-56	.01	.02	.02	.03	.04	.05	.055	.06	.065	.07	.075	.08	.15	
1- 8-56	.03	.05	.07	.08	.10	.11	.13	.14	.15	.16	.17	.18	.22	
2- 8-56	.03	.05												
2-21-56	.03	.05	.07	.08	.09	.10	.11	.12	.125	.13	.135	.14	.22	
3- 4-56	.04	.045	.05	.07	.08	.09	.095	.10	.11	.12	.13	.14	.22	

Date	Ppt. before excess Rate	(Minutes)												Total
		5	10	15	20	25	30	35	40	45	50	60	80	
7-29-6	.55	.09	.14	.19	.32	.52	.65	.82	.87					2.02
7-29-6	1.52	.17	.39	.45										2.02
8- 9-6	.02	.25	.30											.34
8-19-6	.09	.12	.24	.37	.44	.48								.60
9-29-6	1.17	.11	.22	.39	.63	.66								2.52
7- 8-7	.02	.37	.47											0.49
7-21-7	.51	.17	.32											1.61
7-21-7	1.12	.12	.33	.43										1.61
7-24-7	.04	.18	.47	.52	.63									0.67
9- 1-7	.05	.32	.72											0.76
9-17-7	.33	.09	.30	.55	.71	.83	.96	1.06	1.24	1.45	1.52			1.97
5-18-8	.08	.13	.24	.35										0.62
8-15-8	.13	.05	.13	.25	.36	.50	.55	.56	.58	.71	.77			2.63
8-16-8	1.02	.08	.17	.21	.33	.51	.60							2.63
8-16-8	1.78	.10	.33	.45	.56	.63								2.63
5-31-9	.15	.08	.13	.20	.38	.47	.55	.68	.74	.77	.84			1.33
6-13-9	.21	.23	.36											0.59
6-26-9	.02	.17	.35	.38										2.78
6-26-9	.57	.36	.84	1.10	1.31	1.51	1.71	1.86	2.01	2.11	2.19			2.78
8- 1-9	.01	.13	.46	.73	.98	1.22	1.51	1.64						1.69
8-23-9	.01	.32	.57	.71	.74									0.76
8-22-10	.01	.14	.24	.30	.33	.36	.40	.48	.57	.65	.69			2.84
8-23-10	.95	.16	.24	.30	.41	.46	.51	.54	.62	.82	1.00	1.11		2.84
9-12-10	.01	.20	.32	.41										0.59
10-3-10	.02	.25	.36											0.43
5-20-11	.05	.06	.15	.20	.23	.30	.39	.45	.54	.59	.63			
		.65	.69	.72	.75	.81	.92	1.05	1.17	1.20	1.24			

Grand Rapids

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Grand Rapids

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Grand Rapids

[illegible]

Grand Rapids

[illegible]

Date	Ppt. before excess Rate	(Minutes)												Total
		5	10	15	20	25	30	35	40	45	50	60	80	
5-11-29	.19	.26	.33	.50	.66	.72	.75	.76	.78	.81	.86	1.13		1.40
7- 6-29	T	.25	.36											0.42
7-15-29	0	.30												.52
7-15-29	.05	.12	.53	.64	.66	.69	.84	.89						0.96
6- 8-30	T	.16	.36											0.63
6-26-30	.11	.14	.35	.41										0.62
9-15-30	.01	.20	.32											0.34
9-26-30	0	.15	.30	.36	.43									0.45
7- 2-31	0.27	.09	.16	.28	.43	.48								0.83
7-15-31	0.14	.18	.32											0.51
9- 4-31	T	.22	.30	.39										0.58
10-6-31	T	.30	.60	.64	.74									0.86
5- 7-32	.03	.07	.29	.41	.51	.82	.93	1.02	1.09					1.40
8- 2-32	.03	.14	.15	.40	.47									0.52
8-29-32	.T	.30	.43											1.01
4-10-33	0.49	.27	.35	.35	.35	.35	.35	.35	.35	.35	.35	.35	.41	.90
4-30-33	.01	.28	.45	.48	.49	.50	.51	.51	.51	.51	.51	.51	.51	.58
5-20-33	.06	.10	.49	.55	.55	.56	.57	.61	.64	.66	.67	.71	.77	.85
7-15-33	.02	.14	.21	.44	.49	.58	.58	.58	.63	.65	.70	.88	1.01	1.03
7-15-33	.01	.15	.34	.34	.34	.34	.34	.34	.34	.34	.34	.34	.34	0.35
9-30-33	.01	.10	.13	.36	.65	.70	.79	.84	.85	.86	.86	.87	.88	0.96
11-29-33	.72	.08	.25	.36	.36	.36	.36	.36	.36	.36	.36	.36	.36	1.08
6-26-34	.02	.21	.32	.35	.33	.39	.46	.50	.62	.73	.75	.90	1.13	1.35
9- 2-34	1.01	.07	.15	.25	.30	.37	.40	.54	.66	.69	.71	.74	.75	2.11

Date	Ppt. before excess Rate	(Minutes)												Total
		5	10	15	20	25	30	35	40	45	50	60	80	
9-11-34	0	.08	.29	.38	.38	.38	.38	.38	.38	.38	.38	.38	.38	.38
9-11-34	.06	.12	.36	.37	.38	.40	.41	.41	.41	.41	.41	.41	.41	.47
6-16-35	.01	.17	.49	.53	.53	.54	.54	.54	.54	.54	.54	.54	.54	.55
6-26-35	.01	.12	.21	.25	.38	.62	.75	.84	.90	1.02	1.23	1.36	1.37	2.06
7- 3-35	.09	.28	.46	.54	.71	1.02	1.12	1.19	1.23	1.31	1.42	1.49	1.55	1.90
7-24-35	.01	.11	.12	.15	.20	.26	.41	.56	.39	.60	.67	.80	.85	.90
7-28-35	.01	.18	.36	.39	.39	.40	.40	.40	.40	.40	.40	.40	5.40	.41
8- 6-35	.04	.20	.23	.25	.36	.49	.53	.56	.58	.58	.58	.58	.59	.63
9-16-35	.15	.38	.44	.45	.45	.46	.46	.46	.46	.46	.46	.47	.75	.94
11-3-35	1.39	.17	.51	.60	.73	.73	.73	.73	.73	.73	.73	.74	.74	2.15

RECORDS OF INTENSE RAINFALLS OF GRAND HAVEN

Rate equal to or greater than .20 inches + .01 x time in min.

[illegible]

Date	Prec. Before	(Minutes)														Total
	Excessive Rate began	5	10	15	20	25	30	35	40	45	50	55	60	80		
6-29-16	.19	.09	.12	.18	.22	.28	.34	.41	.44	.50	.57	.60	.62	1.18	1.54	
8- 3-16	.07	.07	.16	.25	.45	.66	.99	1.24							2.10	
8- 30-16	1.65	.19	.44												2.10	
8- 4-16	.01	.14	.31												.49	
8- 6-16	T	.26	.35												.35	
8-10-16	.02	.21	.47	.87	.95											
9- 4-16	T	.14	.36	.52	.74	.95	1.17	1.32	1.39	1.47						
6-30-18	.38	.09	.11	.26	.46	.53					(100 min. 2.40)				1.49	
7-24-18	.37	.16	.39	.94	.59										1.54	
8-15-18	.92	.27	.30												.32	
9- 5-17	.92	.09	.27	.79											1.33	
9-20-19	.32	.08	.18	.26	.46	.70	.89	.97	1.21	1.46					2.29	
9-20-19	1.89	.17	.30	.39											2.29	
10-3-19	T	.42	.68												.73	
6-15-20	.41	.09	.25	.36	.45	.48									1.07	
6-16-20	.06	.13	.30	.44	.50										.67	
6-30-22	.33	.14	.23	.34	.40	.49									.97	
7-10-22	.14	.14	.34	.36											.58	
7-12-22	.12	.26	.31												.55	
8-12-22	.01	.12	.33	.61	.84	.95	.98								1.00	
8-25-22	.01	.38	.53	.72	.74										.79	
8-28-22	.01	.33	.52	.58	.67	.69									.73	
6-19-23	.36	.08	.12	.35	.52	.78	.94	1.06							1.57	
7- 6-23	.02	.20	.33												.36	
8-21-23	.29	.06	.19	.43	.65	.72	.77	.83	1.02						1.65	
6-24-24	.05	.21	.49	.62	.71	.79	.85	.92	.97						1.02	
7-30-24	T	.20	.51	.63											.63	
8- 4-24	.76	.14	.26	.31	.38	.43	.48	.54	.65	.67					1.65	

Date	Prec. Before	5	10	15	20	25	(Minutes)				50	55	60	80	Total
	Excessive Rate began						30	35	40	45					
8-22-24	T	.24	.53	.56											.59
4-24-25	T	.21	.51	.55											.72
7- 9-25	T	.07	.23	.41	.65	.74	.77	.83							1.01
7-15-25	.34	.05	.14	.45	.65	.71	.81	.86	.98	1.12	1.32	1.53	1.84		1.69
9-11-25	.42	.13	.48	.53											1.00
5-31-26	T	.10	.21	.51	.57	.65	.86	1.07	1.23	1.28					1.33
7-17-26	.07	.20	.31	.42											.56
7-21-26	0	.41	.62	.65											.66
5-9- 27	.01	.09	.30	.43	.46	.56									.63
5-9- 27	.01	.21	.25	.31	.41	.45	.51	.60							.68
5-17-27	.37	.09	.24	.38	.52	.57									1.01
6- 9-27	.07	.18	.40	.44											.63
7-16-27	T	.02	.36	.53	.57	.66	.83	.91	1.00	1.05					1.07
8-22-27	.02	.18	.29	.37	.39	.47									.50
10-6-27	.37	.11	.15	.23	.39	.45	.50								.89

Table II

Detroit

RECORDS OF INTENSE STORMS

Rearranged to show Maximum for Each Period
(Minutes)

Date	5		10		15		20		30		45		60	
	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate
5-21-10	.29	3.48	.49	2.94	.57	2.28								
9-14-11	.25	2.76	.40	2.40	.54	2.16	.68	2.04	.82	1.64	.99	1.32		
6-23-12	.12	1.44	.23	1.38	.51	1.24	.57	1.11	.54	1.08				
9-5-12	.55	6.60	.62	3.72	.70	2.80	.77	2.31						
5-21-13	.19	2.28	.33	1.98	.44	1.76	.51	1.53	.70	1.40				
6-4-13	.22	2.64	.51	3.06	.73	2.92								
8-21-13	.21	2.52	.41	2.45	.58	2.32	.73	2.19						
4-25-14	.32	2.84	.33	1.98										
6-13-14	.16	1.92	.29	1.74	.37	1.48								
8-10-14	.27	3.24	.33	1.98	.42	1.68	.47	1.41						
8-10-14	.18	2.16	.32	1.92	.44	1.76	.46	1.38						
8-21-14	.47	2.04	.32	1.92	.37	1.48								
6-4-15	.28	3.36												
6-16-15	.43	5.16	.76	4.56	.81	3.24								
6-30-15	.26	3.12	.48	2.88	.67	2.68	.89	2.67	1.23	2.46	1.58	2.11		
8-5-15	.39	4.68	.50	3.00	.52	2.08	.60	1.80						
8-11-15	.17	2.04	.32	1.92	.47	1.88	.53	1.59						
9-7-15	.21	2.52	.34	2.04	.41	1.64								
9-10-15	.34	4.08	.44	2.04										
9-16-15	.12	1.44	.25	1.50	.33	1.32	.40	1.20	.53	1.06				
4-13-16	.20	2.40	.36	2.16										
5-14-16	.21	2.52	.51	1.86										
5-27-16	.25	3.00	.38	2.29	.50	2.00	.58	1.74						
6-8-16	.16	1.92	.27	1.62	.35	1.40								
7-2-16	.27	3.24	.37	2.22	.50	2.00	.60	1.80	.94	1.88				
8-7-16	.35	4.20	.60	3.60	.79	3.16	.91	2.73						
9-7-16	.38	4.56	.54	3.24	.61	2.44								

Detroit

[illegible]

Detroit

Date	(Minutes)													
	5	10	15	20	30	45	60	80						
	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate
7-21-32	.23	2.76	.32	1.92										
8-2-32	.19	2.28	.30	1.80	.35	1.40								
8-29-32	.15	1.80	.25	1.50	.35	1.40	.42	1.26	.62	1.24	.78	1.04	1.06	1.06
9-4-32	.24	2.88	.31	1.86										
8-3-33	.13	1.56	.16	.96	.29	1.16	.40	1.20	.51	1.02	.56	.73	.56	.56
7-6-34	.18	2.16	.31	1.86	.41	1.64	.47	1.41	.58	1.16	.59	.79	.60	.60
8-2-34	.23	2.76	.35	2.10	.46	1.84	.57	1.71	.76	1.52	.86	1.16	.86	.86
7-14-35	.32	3.84	.43	2.58	.43	1.72	.43	1.29	.43	.86	.43	.57	.43	.43
7-19-35	.34	4.08	.57	3.42	.85	3.40	1.11	3.33	1.51	3.02	2.20	2.93	2.37	2.37

RECORDS OF INTENSE STORMS OF DETROIT

Rearranged to show maximum for each period (rate)

Date	(Minutes)											
	5	10	15	20	25	30	35	40	45	50	60	80 100
8-10-55	.18	.26										
8-6-55						.42					.58	
9-14-55	.04											
9-5-55		.07				.10					.15	
10-14-55	.09	.10										
10-10-55						.13					.26	
4-28-56	.24	.40				.54					.96	
5-2-56	.13	.25				.47					.52	
6-1-56	.17	.53				.45					.51	
7-27-56	.06	.08				.17					.27	
8-16-56	.09	.13				.16					.16	
9-7-56	.28	.43				.86					1.07	
10-6-56	.08	.10				.12					.22	

East Lansing

Date	(Minutes)												
	5	10	15	20	25	30	35	40	45	50			
	Ant.	Rate	Ant.	Rate	Ant.	Rate	Ant.	Rate	Ant.	Rate	Ant.	Rate	Ant.
6-23-10	.28	3.36	.43	2.58	.64	2.16							
7-6-10	.18	2.16	.33	1.98									
5-20-11	.37	4.44	.57	3.42	.67	2.68	.76	2.28					
6-4-11	.39	4.68	.73	4.37	.90	3.60	1.00	3.00	1.06	2.54	1.10	2.20	1.14
													1.83
													1.22
													1.28
													1.71
													1.84
													1.61
													(80 min. - A.1.40 R. 1.40)
7-6-11	.29	3.48	.45	2.70									
9-28-11	.28	3.36	.39	2.34	.53	2.12	.64	1.92	.74	1.83	.79	1.58	
10-1-11	.18	2.16	.29	1.74	.36	1.44	.40	1.20					
11-11-11	.34	4.08	.36	2.16									
3-11-12	.27	3.24	.38	2.28									
5-21-12	.35	4.20	.41	2.46									
7-24-12	.15	1.80	.29	1.74	.37	1.48	.50	1.50	.50	1.25	.59	1.18	
7-24-12	.25	3.00	.36	2.16	.45	1.80	.50	1.50					
7-28-12	.27	3.24	.50	3.00	.59	2.36							
9-11-12	.28	3.36	.52	3.12	.61	2.44	.68	2.04					
7-5-13	.21	2.52	.32	1.92	.34	1.30							
7-16-13	.20	2.40	.35	2.10	.42	1.68							
7-16-13	.23	2.70	.44	2.64	.55	2.20	.61	1.85					
8-8-13	.26	3.42	.44	2.64	.63	2.50	.86	2.58	.96	2.40	.96	1.92	

1000

1000

1000

1000

(Minutes)

No excessive ppt. for year.

East Lansing

Date	(Minutes)									
	5	10	15	20	25	30	35	40	45	50
	Amt.	Rate Amt.	Rate Amt.	Rate Amt.	Rate Amt.	Rate Amt.	Rate Amt.	Rate Amt.	Rate Amt.	Rate Amt.
7-1-17	.17 2.04	.29 1.24	.56 1.44	.42 1.23						
9-5-17	.16 1.92	.52 1.92	.46 1.84	.52 1.56	.53 1.33	.55 1.10	.69 1.13	.78 1.17	.88 1.15	
9-5-17	.29 3.48	.57 3.42	.59 2.36	.59 1.77	.68 1.63	.77 1.54	1.01 1.73	1.05 1.58	1.13 1.51	1.26 1.75
						(60 m. A-1.54	R-1.54; 80 m. A- 1.61, R- 1.27			
6-30-18	.19 2.28	.80 1.80	.41 1.64							
7-26-18	.17 2.04	.29 1.74	.57 1.48	.59 1.17						
7-26-18	.24 2.88	.35 2.10	.45 1.80	.50 1.50						
6-18-19	.27 3.24	.53 3.18	.69 2.76	.73 2.19						
8-4-19	.16 1.92	.25 1.50	.56 1.44	.42 1.26	.53 1.33	.62 1.24				
8-29-19	.15 1.80	.25 1.50	.56 1.44	.58 1.14						
3-28-20	.23 2.76	.39 2.34	.47 1.88	.54 1.62						
7-13-20	.16 1.90	.58 2.28	.49 1.96	.54 1.62	.63 1.58	.71 1.42	.87 1.30	.90 1.20	.97 1.07	1.13 1.13
								(60 m. A- 1.28, R- .96		
9-15-20	.28 3.36	.42 2.52	.53 2.12	.54 1.62						
6-16-21	.28 3.36	.40 2.40	.43 1.72							
6-16-21	.13 1.56	.21 1.26	.50 1.20	.41 1.23	.48 1.20	.53 1.06				
6-27-21	.27 3.24	.44 2.64	.56 2.24							
8-17-21	.66 7.92	.90 5.40								
8-19-21	.12 1.44	.23 1.36	.34 1.36	.40 1.20						
8-27-21	.23 2.76	.37 2.22	.43 1.72	.45 1.35	.48 1.20	.59 1.16				

East Lansing

Date	(Minutes)									
	5	10	15	20	25	30	35	40	45	50
	Ant. Rate	Ant. Rate	Ant. Rate	Ant. Rate	Ant. Rate	Ant. Rate	Ant. Rate	Ant. Rate	Ant. Rate	Ant. Rate
7-6-21	.16 1.92	.31 1.86	.47 1.86	.52 1.56	.55 1.56	.56 1.12	.64 1.10	.74 1.11	.90 1.20	.95 1.14
7-14-21	.40 4.80	.76 4.56								
4-11-22	.15 1.56	.20 1.20	.27 1.06	.39 1.17	.46 1.15					
4-17-22	.21 2.52	.31 1.86	.35 1.40							
7-10-22	.35 4.20	.55 3.30	.67 2.68							
8-5-22	.28 3.36	.54 3.24	.61 2.44							
7-7-23	.37 4.44	.70 4.20	1.02 4.08	1.29 3.98	1.47 3.53	1.51 3.02	1.61 2.83	1.76 2.64	1.87 2.53	1.92 2.51
										(60 m. Amt.- 2.06, Rate- 2.06)
9-6-23	.21 7.52	.35 2.10	.42 1.68							
6-20-24	.24 2.88	.46 2.76								
6-23-24	.36 4.32	.40 2.40	.45 1.80	.50 1.50	.62 1.55	.63 1.36	.64 1.44	.90 1.35	.97 1.25	1.04 1.25
										(60 m. Amt.- 1.16, Rate- 1.10)
8-5-24	.20 2.40	.36 2.16	.45 1.80							
7-15-25	.16 1.92	.27 1.62	.36 1.44	.42 1.26	.57 1.43	.66 1.36				
9-5-26	.26 3.12									
6-14-26	.25 3.00	.38 2.28	.46 1.92							
4-19-27	.19 2.28	.36 2.16	.45 1.80	.49 1.47	.53 1.35					
5-25-27	.17 2.04	.32 1.92	.36 1.52							
7-21-27	.20 2.40	.31 1.86	.37 1.48							

(Witness)

Date	5	10	15	20	25	30	35	40	45	50
	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate
9-12-27	.21	2.52	.34	2.04						
5-18-28	.16	1.92	.53	1.98	.59	1.60				
7-22-28	.16	1.92	.29	1.74	.41	1.64	.53	1.59	.61	1.53
8-30-28	.26	3.12	.36	2.16	.39	1.60	.45	1.35	.56	1.40
10-18-28	.29	3.48					.68	1.36	.78	1.34
7-18-29	.31	3.72	.56	3.36	.62	2.48				
4-20-31	.21	2.52	.32	1.92	.49	1.96	.57	1.71	.65	1.65
6-26-31	.30	3.60	.40	2.40	.47	1.88				
7-5-31	.27	3.24	.44	2.64						
8-4-31			.35	1.40	.42	1.26	.57	.89	.55	1.10
10-4-31	.20	2.40	.34	2.04	.38	1.52				
12-24-31	.38	4.56	.56	3.36	.66	2.64				
5-26-32	.30	3.60	.61	3.66	.67	2.66	.68	2.04	.74	1.86
5-26-32	.13	1.56	.26	2.16	.38	1.52				
7-26-32	.12	1.44	.22	1.92	.34	1.36	.42	1.26		
8-29-32	.41	4.92	.47	2.82	.56	2.24	.64	1.92	.66	1.05
									.93	1.86
									1.06	1.62
									1.14	1.71
									1.23	1.64
									1.27	1.52
									(60 m. A- 1.32, B-	1.32)
									80 m. A- 1.50 B-	1.15

East Lansing

Date	(Minutes)																			
	5	10	15	20	25	30	35	40	45	50										
	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate				
6-29-33	.40	4.80	.70	4.80	.69	3.56	1.12	5.36	1.23	2.95	1.29	2.53	1.51	2.24	1.38	2.07	1.51	2.01		
4-3-34	.33	3.96	.37	2.22	.40	1.80	.41	1.23	.43	1.08	.44	.88	.45	.79	.46	.69	.61	.47	.56	
												(60 m. Amt.--.47, R-	.47;	80 m. Amt.--	.98.	R-	.36			
7-6-34	.32	3.84	.47	2.82	.47	1.88	.48	1.44	.68	1.70	.81	1.62	.96	1.65	1.11	1.67	1.26	1.68	1.81	1.37
												(60 m. Amt.--1.32, R-1.52;	80 m. Amt.1.46, R-1.10							
6-26-35	.30	3.60	.52	3.12	.71	2.84	.93	2.79	1.08	2.59	1.21	2.42	1.22	2.09	1.27	1.91	1.39	1.85	1.45	1.74
												(60 m. Amt.1-1.55, R-1.55;	80 m. Amt.-1.55, R-1.16							
7-19-35	.32	3.84	.62	3.72	.79	3.16	.87	2.61	.93	2.33	.95	1.90	.95	1.63	.96	1.44	.96	1.28	.96	1.15
												(80 m. Amt.--	.96, R-	.96;	80 m. A mt.-1.00, R-	.75				
8-20-35	.17	2.04	.22	1.52	.30	1.20	.33	.99	.37	.89	.48	.96	.63	1.08	.65	.96	.66	.88	.69	.85
												(60 m. Amt.--	.70, R-	.70;	80 m. Amt.--	.70, R-	.52			

Grand Rapids

Date	(Minutes)													
	5		10		15		20		30		45		60	
	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate
7-29-8	.20	2.4	.59	2.54	.46	1.84	.63	1.89	.73	1.46				
7-29-8	.22	2.54	.39	2.34	.45	1.80								
8-8-8	.25	3.00	.50	1.80										
8-19-8	.13	1.56	.25	1.50	.57	1.48	.44	1.32	.48	.96				
9-29-8	.24	2.88	.41	2.46	.52	2.08	.63	1.89						
7-8-7	.37	4.44	.47	2.82										
7-21-7	.17	2.04	.52	1.92										
7-21-7	.26	3.12	.58	2.28	.43	1.72								
7-24-7	.29	3.48	.47	2.82	.52	2.08	.63	1.89						
9-1-7	.40	4.80	.72	4.52										
9-17-7	.25	3.00	.46	2.76	.62	2.48	.74	2.22	.97	1.94	1.45	1.95		
5-18-7	.13	1.56	.24	1.44	.25	1.00								
8-15-8	.14	1.68	.25	1.50	.51	1.24	.45	1.55	.55	1.10	.72	.96		
8-16-8	.18	2.16	.27	1.62	.59	1.56	.43	1.29	.60	1.20				
8-16-8	.23	2.76	.55	2.10	.46	1.84	.56	1.68						
5-31-9	.18	2.16	.27	1.62	.55	1.40	.48	1.44	.61	1.22	.77	1.03		
6-13-9	.23	2.8	.56	2.16										
6-26-9	.18	2.16	.55	2.10	.58	1.52								
6-26-9	.48	5.76	.84	5.04	1.10	4.40	1.51	3.93	1.71	3.42	2.11	2.82		
8-1-9	.29	3.45	.46	2.76	.78	3.12	1.05	3.15	1.51	3.02				
8-28-9	.52	3.84	.57	3.42	.71	2.84	.74	2.22						
8-22-10	.14	1.68	.24	1.44	.50	1.20	.53	.99	.40	.80	.65	.87		
8-23-10	.20	2.40	.58	2.28	.49	1.96	.56	1.68	.65	1.50	.87	1.13	1.11	1.11
9-12-10	.20	2.40	.52	1.92	.41	1.64								
10-3-10	.25	3.00	.56	2.16										
5-20-11	.09	1.08	.16	.96	.24	.96	.51	.99	.40	.80	.59	.79		

Grand Rapids

Date	(Minutes)													
	5		10		15		20		30		45		60	
	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate
5-22-11	.15	1.8	.29	1.74	.30	1.20	.33	.99						
5-31-11	.19	2.28	.33	1.98	.38	1.52	.48	1.44						
6-4-11	.21	2.52	.32	1.92										
6-4-11	.19	2.28	.32	1.92	.38	1.52								
6-24-11	.29	3.48	.58	3.48	.83	3.32	.85	2.55						
6-25-11	.17	2.04	.29	1.74	.40	1.60	.51	1.63						
8-1-11	.23	2.76	.37	2.22										
8-14-11	.26	3.12	.49	2.94	.61	2.44								
9-14-11	.21	2.52	.38	2.28	.49	1.96	.58	1.74	.74	1.48				
9-18-11	.26	3.12	.38	2.28	.41	1.64								
9-27-11	.21	2.52	.31	1.86	.39	1.56	.51	1.53	.67	1.34				
9-28-11	.20	2.40	.32	1.92	.35	1.40								
5-21-12	.39	4.68	.62	3.72	.83	3.32	.85	2.55						
7-8-12	.23	2.76	.38	2.28	.47	1.88	.56	1.67	.65	1.30				
7-13-12	.44	5.78	.74	4.44	.87	3.48								
7-20-12	.16	1.92	.18	1.08	.36	1.44	.41	1.23	.54	1.08				
7-23-12	.25	3.00												
8-8-12	.35	4.20	.39	2.34										
9-15-12	.23	2.76	.34	2.04	.39	1.56	.42	1.26	.51	1.02				
10-11-12	.16	1.92	.30	1.80	.41	1.64	.52	1.56	.63	1.26				
9-15-12	.23	2.76	.34	2.04	.39	1.56	.42	1.26	.51	1.02				
10-11-12	.16	1.92	.30	1.80	.41	1.64	.52	1.56	.63	1.26				
6-25-13	.23	1.78	.39	2.34	.44	1.76								
8-17-13	.19	2.28	.34	2.04	.36	1.44								
11-18-13	.20	2.40	.31	1.86	.40	1.60	.46	1.38	.60	1.20	.81	1.08	1.07	1.07
6-21-14	.10	1.20	.19	1.14	.26	1.04	.34	1.02	.47	.94				

Grand Rapids

Date	(Minutes)													
	5		10		15		20		30		45		60	
	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate
6-21-14	.22	2.64	.34	2.04	.43	1.72	.56	1.68	.74	1.48	.99	1.51	1.29	1.29
6-27-14	.20	2.40	.35	2.10	.43	1.72								
8-16-14	.17	2.04	.32	1.92	.45	1.80	.59	1.77	.71	1.42	.89	1.19		
7-1-15	.27	3.24	.52	3.12	.80	3.20	.99	2.97	1.17	2.54				
8-16-15	.20	2.40	.36	2.16	.48	1.92	.53	1.59						
9-7-15	.24	2.88	.46	2.76	.51	2.04								
9-10-15	.48	5.76	.89	5.34	1.07	4.28	1.10	3.30	1.12	2.24	1.21	1.61	1.39	1.39
														(80 min. A- 1.64, R- 1.23)
9-12-15	.28	3.36	.29	1.74										
9-14-15	.17	2.04	.29	1.74	.38	1.52								
6-2-16	.16	1.92	.35	2.10	.44	1.76								
6-14-16	.28	3.36	.39	2.34										
7-8-16	.37	4.44	.49	2.94	.67	2.68	.69	2.07						
8-5-16	.29	3.48	.61	3.66	.72	2.88	.75	2.25	.82	1.64	1.00	1.33	1.18	1.18
														(80 min. A- 1.51, R- .98)
8-4-16	.19	2.28	.35	1.98	.43	1.72	.54	1.62						
8-10-16	.42	5.04	.79	4.74	1.01	4.04	1.18	3.04	1.29	2.58				
9-4-16	.20	2.40	.34	2.04	.47	1.88	.50	1.50						
5-19-17	.39	4.68	.49	2.94										
7-6-17	.23	2.76	.45	2.70	.51	2.04	.53	1.59	.59	1.18	.77	1.03	1.02	1.02
														(80 min. A- 1.16, R- .87)
7-16-17	.20	2.40	.31	1.86	.40	1.60	.48	1.44						
7-22-17	.39	4.68	.67	4.02	.82	3.28	.87	2.61	1.14	2.28				
7-23-17	.26	3.12	.46	2.76	.62	2.48	.82	2.46						
9-5-17	.40	4.80	.50	3.00	.86	3.44	.95	2.85						
10-18-17	.16	1.92	.29	2.34	.35	1.40								
5-19-18	.16	1.92	.25	1.50	.34	1.36	.44	1.32	.52	1.04	.69	.92		
5-25-18	.26	3.12	.34	2.04	.35	1.40	.59	1.17	.55	1.10				
6-11-19	.29	3.48	.55	3.18	.61	2.44	.73	2.19						

Grand Rapids

[illegible]

Grand Rapids

[illegible]

Grand Rapids

Date	(Minutes)													
	5		10		15		20		30		45		60	
	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate
6-26-30	.21	2.52	.35	2.10	.41	1.64								
9-13-30	.20	2.40	.32	1.92										
9-26-30	.15	1.80	.30	1.80	.36	1.44	.43	1.29						
7-2-31	.15	1.80	.27	1.62	.34	1.36	.43	1.29						
7-13-31	.18	2.16	.32	1.92										
9-4-31	.22	2.64	.30	1.80	.39	1.56								
10-6-31	.30	3.60	.60	3.60	.64	2.56	.74	2.22						
5-7-32	.31	3.72	.42	2.52	.52	2.08	.65	1.95	.95	1.90				
8-2-32	.25	3.00	.32	1.92	.40	1.60	.47	1.41						
8-29-32	.30	3.60	.43	2.58										
4-10-33	.27	3.24	.35	1.10	.35	1.40	.35	1.05	.35	.70	.35	.47	.38	.38
													(80 min. A-	.41, R- .31
4-30-33	.28	3.36	.45	2.70	.48	1.92	.49	1.47	.51	1.02	.51	.68	.51	.51
													(80 min. A-	.51, R- .38
5-20-33	.39	4.68	.49	2.94	.55	2.20	.55	1.65	.57	1.14	.66	.88	.71	.71
													(80 min. A-	.77, R- .58
7-15-33	.23	2.76	.30	1.80	.44	1.26	.49	1.47	.58	1.16	.65	.87	.88	.88
													(80 min. A-	1.01, R- .76
7-15-33	.19	2.28	.34	2.04	.34	1.36	.34	1.02	.34	.68	.34	.45	.34	.34
													(80 min. A-	.34, R- .25
9-31-33	.29	3.45	.52	3.12	.57	2.28	.66	1.98	.79	1.58	.86	1.15	.87	.87
													(80 min. A-	.88, R- .66
11-29-33	.17	2.04	.25	1.50	.36	1.44	.36	1.08	.36	.72	.36	.48	.36	.36
													(80 min. A-	.36, R- .27
6-26-34	.21	2.52	.32	1.92	.35	1.40	.38	1.14	.46	.92	.73	.97	.90	.90
													(80 min. A-	1.15, R- .85
9-2-34	.14	1.68	.26	1.56	.29	1.16	.31	.93	.51	1.02	.69	.92	.74	.74
													(80 min. A-	.75, R- .56
9-11-34	.21	2.52	.30	1.80	.38	1.52	.38	1.14	.38	.76	.38	.51	.38	.38
													(80 min. A-	.38, R- .28
9-11-34	.24	2.88	.36	2.16	.37	1.48	.38	1.14	.41	.82	.41	.55	.41	.41
													(80 min. A-	.41, R- .31

Grand Rapids

Date	(Minutes)															
	5		10		15		20		30		45		60		80	
	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate	Amt.	Rate
6-18-35	.32	3.84	.49	2.94	.53	2.12	.53	1.59	.54	1.08	.54	.72	.54	.54	.54	.40
6-26-35	.24	2.88	.37	2.22	.50	2.00	.59	1.77	.77	1.54	1.15	1.15	1.53	1.53	1.37	1.03
7-3-35	.51	3.72	.46	2.76	.58	2.32	.74	2.22	1.12	2.24	1.51	1.75	1.49	1.49	1.53	1.14
7-24-35	.15	1.80	.30	1.80	.36	1.44	.41	1.23	.47	.94	.68	.91	.80	.80	.85	.64
7-28-35	.18	2.16	.36	2.16	.39	1.56	.39	1.17	.40	.80	.40	.53	.40	.40	.40	.30
8-6-35	.20	2.40	.23	1.38	.25	1.00	.36	1.08	.53	1.06	.58	.77	.59	.59	.59	.44
9-16-35	.33	4.56	.44	2.64	.45	1.80	.45	1.35	.46	.92	.46	.61	.47	.47	.75	.50
11-3-35	.29	3.48	.43	2.58	.60	2.40	.73	2.19	.73	1.46	.73	.97	.74	.74	.74	.53

Rearranged to show maximum for each

Date	(Minutes)												
	5	10	15	20	25	30	35	40	45	50	55	60	120
12-7-35	.01	.02	.03	.03	.04	.05						.08	.15
4-27-36	.05	.07	.09	.09	.10	.11	.11+	.12+	.13	.13+	.14	.15	.16
5-23-36	.04	.07	.08	.09	.11	.13	.14	.15	.16	.17	.18	.19	.22
6-2-36	.14	.25	.35	.40	.48	.56	.56+	.56++	.56+++	.56+	.56+	.57	.65
7-1-36	.13	.14	.15	.15+	.16=	.16	.16+	.16+	.16+	.16+	.16+	.17	.19
8-28-36	.21	.30	.35	.39	.43	.47	.49	.51	.53	.55	.57	.59	.75
9-16-36	.38	.44	.45	.45+	.46-	.46	.49	.51	.53	.55	.58	.61	.92
10-2-36	.03	.05	.06	.065	.07	.08	.085	.09	.095	.105	.105	.11	.17
11-3-36	.29	.48	.60	.66	.72	.78	.81	.84	.88	.91	.94	.97	1.18
12-7-36	.01	.02	.02	.03	.04	.05	.05	.06	.065	.07	.075	.08	.15
1-8-36	.03	.05	.07	.08	.10	.11	.13	.14	.15	.16	.17	.18	.22
2-8-36	.03	.05											
2-21-36	.03	.05	.07	.08	.09	.10	.11	.12	.12+	.13	.135	.14	.22
3-4-36	.04	.04	.05	.07	.08	.09	.095	.10	.11	.12	.13	.14	.22

Records of Intense Rainfall of Grand Haven

(Rearranged to show maximum for each period)

Date	(Minutes)												
	5	10	15	20	25	30	35	40	45	50	55	60	100
4-29-11	.10	.21	.30	.39	.51	.60	.69	.77	.84	.90	.95	1.00	
9-14-11	.14	.25	.33	.40	.47	.55	.62						
9-27-11	.24	.39	.46	.53	.62	.75							
9-30-11	.09	.18	.27	.35	.42	.47	.56	.61	.65	.70	.78	.82	.96
10-16-11	.16	.32	.42	.58	.62								
11-11-11	.25	.40	.52	.63	.77	.93	1.02	1.18	1.30				
4-27-14	.21	.29	.29	.42									
6-3-14	.28	.54	.76	.86									
6-4-14	.18	.35											
6-21-14	.32	.59	.74	.88	1.14	1.43	1.54						
6-21-14	.16	.31	.40	.48	.55								
6-22-14	.23	.41	.49	.55	.60	.64	.70						
7-27-14	.27	.44	.49										
8-16-14	.42	.59	.64	.65	.67	.68	.81	.93	1.10	1.25			
8-30-14	.28	.43	.50	.56									
8-30-14	.24	.39	.44										
6-18-15	.24	.44	.50										
8-2-15	.23	.43	.57	.68	.84	.94	1.01	1.05	1.21	1.29			
8-2-15	.14	.28	.35										
8-2-15	.25	.49	.62	.74	.82	.86	1.00	1.08	1.15				
8-3-15	.13	.22	.33	.39	.52	.57	.64	.77	.81	.90			
8-23-15	.22	.41	.61	.80	.94	1.01							
9-7-15	.18	.32	.38										
9-10-15	.25	.44	.60	.71	.82	.89							
9-10-15	.14	.27	.37	.46	.57	.60	.67	.75					
9-12-15	.27	.46	.67	.86	1.02								

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840.

Grand Haven

| Date | (Minutes) | | | | | | | | | | | | | |
|---------|-----------|-----|-----|-----|------|------|------|------|------|-----|-----|-----|------|-----|
| | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 80 | 100 |
| 6-29-16 | .09 | .13 | .18 | .22 | .28 | .34 | .41 | .44 | .50 | .57 | .60 | .62 | 1.15 | |
| 8-5-16 | .33 | .58 | .79 | .99 | 1.08 | 1.17 | 1.24 | | | | | | | |
| 8-5-16 | .25 | .44 | | | | | | | | | | | | |
| 8-4-16 | .17 | .31 | | | | | | | | | | | | |
| 8-6-16 | .26 | .35 | | | | | | | | | | | | |
| 8-10-16 | .40 | .66 | .87 | .95 | | | | | | | | | | |
| 9-4-16 | .22 | .43 | .65 | .81 | 1.03 | 1.18 | 1.32 | 1.39 | 1.47 | | | | | |
| 6-30-18 | .15 | .35 | .42 | .44 | .53 | | | | | | | | | |
| 7-24-18 | .23 | .39 | .54 | .59 | | | | | | | | | | |
| 8-15-18 | .27 | .30 | | | | | | | | | | | | |
| 9-5-17 | .18 | .30 | .39 | | | | | | | | | | | |
| 9-20-19 | .25 | .49 | .63 | .71 | 1.20 | 1.30 | 1.38 | 1.46 | | | | | | |
| 9-20-19 | .17 | .30 | .39 | | | | | | | | | | | |
| 10-5-19 | .42 | .68 | | | | | | | | | | | | |
| 6-15-20 | .16 | .27 | .36 | .45 | .48 | | | | | | | | | |
| 6-16-20 | .17 | .30 | .44 | .50 | | | | | | | | | | |
| 6-30-22 | .14 | .23 | .34 | .40 | .49 | | | | | | | | | |
| 7-10-22 | .20 | .34 | .36 | | | | | | | | | | | |
| 7-12-22 | .26 | .31 | | | | | | | | | | | | |
| 8-24-22 | .28 | .51 | .72 | .84 | .95 | .98 | | | | | | | | |
| 8-25-22 | .38 | .53 | .72 | .74 | | | | | | | | | | |
| 8-28-22 | .33 | .52 | .58 | .67 | .69 | | | | | | | | | |
| 6-19-23 | .26 | .43 | .66 | .82 | .94 | .98 | 1.06 | | | | | | | |
| 7-6-23 | .20 | .33 | | | | | | | | | | | | |
| 8-21-23 | .24 | .46 | .59 | .66 | .73 | .78 | .84 | 1.02 | | | | | | |
| 6-24-24 | .28 | .49 | .62 | .71 | .79 | .85 | .92 | .97 | | | | | | |

Grand Haven

| Date | (Minutes) | | | | | | | | | | | | | |
|---------|-----------|-----|-----|-----|-----|------|------|------|------|------|------|------|----|-----|
| | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 80 | 100 |
| 7-30-24 | .51 | .51 | .63 | | | | | | | | | | | |
| 8-4-24 | .14 | .26 | .31 | .38 | .43 | .48 | .54 | .65 | .67 | | | | | |
| 8-22-24 | .29 | .53 | .56 | | | | | | | | | | | |
| 4-24-25 | .50 | .51 | .55 | | | | | | | | | | | |
| 7-15-25 | .31 | .51 | .60 | .66 | .76 | .81 | .86 | .98 | 1.12 | 1.32 | 1.33 | 1.34 | | |
| 9-11-25 | .35 | .48 | .53 | | | | | | | | | | | |
| 5-31-26 | .50 | .42 | .58 | .66 | .72 | 1.02 | 1.13 | 1.23 | 1.28 | | | | | |
| 7-17-26 | .20 | .31 | .42 | | | | | | | | | | | |
| 7-21-26 | .42 | .62 | .65 | | | | | | | | | | | |
| 5-9-27 | .21 | .34 | .43 | .46 | .56 | | | | | | | | | |
| 5-9-27 | .21 | .25 | .31 | .41 | .45 | .51 | .60 | | | | | | | |
| 5-17-27 | .15 | .29 | .43 | .48 | .57 | | | | | | | | | |
| 6-9-27 | .22 | .40 | .44 | | | | | | | | | | | |
| 7-16-27 | .34 | .51 | .55 | .64 | .81 | .84 | .89 | .98 | 1.03 | 1.05 | | | | |
| 8-22-27 | .18 | .29 | .37 | .39 | .47 | | | | | | | | | |
| 10-6-27 | .16 | .24 | .30 | .35 | .39 | .50 | | | | | | | | |

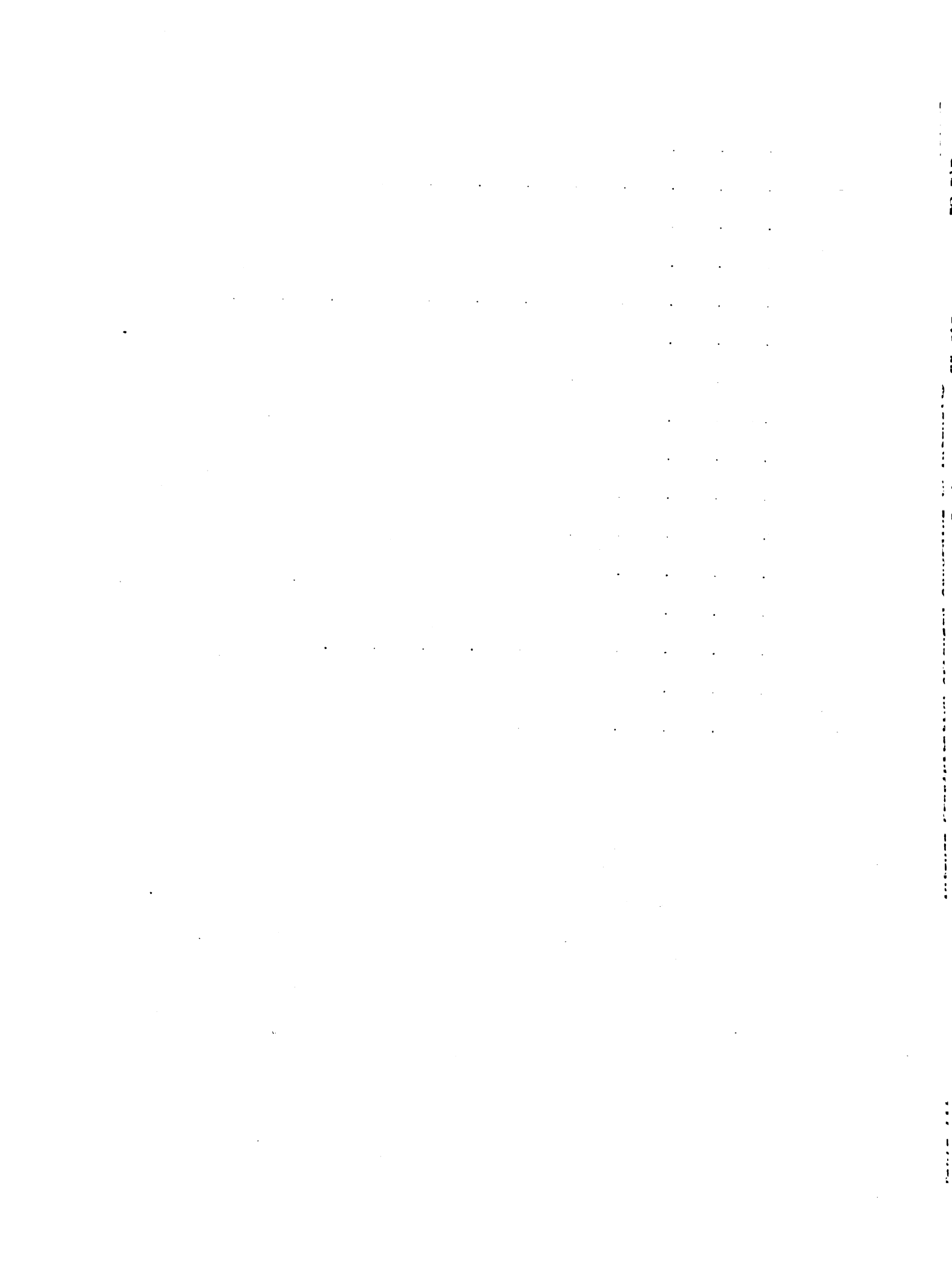


Table III Intense Precipitation Arranged According to Intensity

| 5 min. | | | | 10 min. | | | | 15 min. (cont) | | | | 20 min. | | | | 25 min. | | | | 30 min. | | | |
|--------|-------|------|------|---------|------|------|-------|----------------|------|-------|------|---------|-------|------|------|---------|------|------|-------|---------|------|-------|------|
| No. | In. | Rate | No. | In. | Rate | No. | In. | Rate | No. | In. | Rate | No. | In. | Rate | No. | In. | Rate | No. | In. | Rate | No. | In. | Rate |
| Sto- | Rain- | Rate | Sto- | Rain- | Rate | Sto- | Rain- | Rate | Sto- | Rain- | Rate | Sto- | Rain- | Rate | Sto- | Rain- | Rate | Sto- | Rain- | Rate | Sto- | Rain- | Rate |
| fall | fall | fall | fall | fall | fall | fall | fall | fall | fall | fall | fall | fall | fall | fall | fall | fall | fall | fall | fall | fall | fall | fall | fall |
| 1 | .44 | 5.28 | 1 | .90 | 5.40 | 1 | .15 | .90 | 1 | .97 | 5.88 | 1 | 1.15 | 5.45 | 1 | 1.45 | 5.48 | 1 | 2.04 | 4.08 | | | |
| 1 | .45 | 5.16 | 1 | .81 | 4.88 | 2 | .15 | .78 | 1 | .96 | 5.84 | 1 | 1.02 | 5.06 | 1 | 1.20 | 2.88 | 2 | 1.16 | 2.32 | | | |
| 1 | .40 | 4.80 | 1 | .76 | 4.56 | 1 | .12 | .72 | 1 | .95 | 5.80 | 1 | 1.01 | 5.05 | 1 | 1.08 | 2.59 | 1 | 1.15 | 2.30 | | | |
| 1 | .59 | 4.68 | 1 | .75 | 4.50 | 2 | .11 | .66 | 1 | .90 | 5.60 | 1 | .99 | 2.97 | 1 | 1.07 | 2.58 | 1 | 1.99 | 1.98 | | | |
| 2 | .54 | 4.08 | 1 | .61 | 5.66 | 3 | .10 | .60 | 1 | .81 | 5.24 | 1 | .95 | 2.79 | 1 | 1.01 | 2.42 | 1 | .98 | 1.96 | | | |
| 2 | .55 | 5.96 | 1 | .54 | 5.24 | 1 | .08 | .48 | 1 | .75 | 5.00 | 1 | .91 | 2.75 | 1 | 1.00 | 2.40 | 1 | .94 | 1.88 | | | |
| 1 | .52 | 5.84 | 1 | .53 | 5.18 | 1 | .07 | .42 | 1 | .72 | 2.88 | 1 | .82 | 2.48 | 1 | .95 | 2.28 | 1 | .90 | 1.80 | | | |
| 2 | .29 | 5.48 | 1 | .52 | 5.12 | | | | 1 | .70 | 2.80 | 1 | .77 | 2.51 | 1 | .85 | 2.04 | 1 | .86 | 1.77 | | | |
| | | | 1 | .50 | 5.00 | | | | 1 | .68 | 2.72 | 2 | .73 | 2.19 | 1 | .85 | 1.99 | 1 | .83 | 1.66 | | | |
| 2- | .28 | 5.56 | 1 | .49 | 2.94 | | | | 1 | .61 | 2.44 | 1 | .70 | 2.10 | 2 | .82 | 1.97 | 1 | .77 | 1.54 | | | |
| 1 | .27 | 5.24 | 1 | .44 | 2.64 | | | | 2 | .58 | 2.52 | 1 | .67 | 2.10 | 1 | .79 | 1.90 | 1 | .75 | 1.50 | | | |
| 2 | .25 | 5.00 | 1 | .45 | 2.58 | | | | 1 | .57 | 2.28 | 1 | .61 | 1.85 | 1 | .72 | 1.75 | 1 | .72 | 1.44 | | | |
| 3 | .24 | 2.88 | 1 | .41 | 2.46 | | | | 1 | .52 | 2.08 | 2 | .60 | 1.80 | 1 | .67 | 1.61 | 1 | .64 | 1.28 | | | |
| 3 | .21 | 2.52 | 1 | .40 | 2.40 | | | | 1 | .51 | 2.04 | 1 | .59 | 1.77 | 1 | .66 | 1.58 | 1 | .57 | 1.14 | | | |
| 1 | .18 | 2.16 | 2 | .39 | 2.34 | | | | 1 | .50 | 2.00 | 1 | .58 | 1.74 | 1 | .65 | 1.56 | 4 | .54 | 1.08 | | | |
| 4 | .17 | 2.04 | 4 | .37 | 2.22 | | | | 2 | .44 | 1.76 | 1 | .57 | 1.71 | 1 | .59 | 1.42 | 1 | .55 | 1.06 | | | |
| 2 | .16 | 1.92 | 1 | .36 | 2.16 | | | | 2 | .41 | 1.64 | 2 | .52 | 1.56 | 1 | .56 | 1.59 | 1 | .49 | .98 | | | |

Detroit

[illegible]

1

13

[illegible]

East Lansing

| 5 min. | | | | 10 min. | | | | 15 min. | | | | 20 min. | | | |
|--------|-------|---------------|--------|---------|-------|----------------|--------|---------|-------|----------------|--------|---------|-------|------|--------|
| No. of | | 5 min. (cont) | | 10 min. | | 10 min. (cont) | | 15 min. | | 15 min. (cont) | | 20 min. | | | |
| Stor. | Amt. | Rate | No. of | Stor. | Amt. | Rate | No. of | Stor. | Amt. | Rate | No. of | Stor. | Amt. | Rate | No. of |
| Rate | Stor. | Amt. | Rate | Rate | Stor. | Amt. | Rate | Rate | Stor. | Amt. | Rate | Rate | Stor. | Amt. | Rate |
| 1 .66 | 7.92 | 5 | .17 | 2.04 | 1 | .90 | 5.40 | 2 | .38 | 2.28 | 1 | 1.02 | 4.08 | 3 | .41 |
| 1 .42 | 5.04 | 6 | .15 | 1.92 | 1 | .82 | 4.92 | 6 | .36 | 2.16 | 1 | 1.00 | 4.00 | 1 | .40 |
| 2 .41 | 4.92 | 2 | .15 | 1.80 | 1 | .76 | 4.56 | 4 | .35 | 2.10 | 1 | .80 | 3.60 | 3 | .39 |
| 2 .40 | 4.80 | 1 | .14 | 1.68 | 1 | .73 | 4.38 | 2 | .34 | 2.04 | 1 | .88 | 3.56 | 4 | .38 |
| 1 .39 | 4.68 | 3 | .13 | 1.56 | 2 | .70 | 4.20 | 4 | .33 | 1.98 | 1 | .83 | 3.32 | 3 | .37 |
| 2 .38 | 4.56 | 2 | .12 | 1.44 | 1 | .67 | 4.02 | 7 | .32 | 1.92 | 2 | .79 | 3.28 | 6 | .36 |
| 2 .37 | 4.44 | | | | 2 | .62 | 3.72 | 2 | .31 | 1.86 | 2 | .71 | 2.94 | 3 | .35 |
| 1 .36 | 4.32 | | | | 1 | .61 | 3.66 | 1 | .30 | 1.80 | 1 | .70 | 2.80 | 3 | .34 |
| 2 .35 | 4.20 | | | | 1 | .57 | 3.42 | 5 | .29 | 1.74 | 1 | .69 | 2.76 | 3 | .30 |
| 1 .34 | 4.08 | | | | 2 | .56 | 3.36 | 1 | .28 | 1.68 | 3 | .67 | 2.68 | 1 | .29 |
| 1 .33 | 3.96 | | | | 1 | .53 | 3.30 | 2 | .27 | 1.62 | 1 | .66 | 2.64 | 1 | .27 |
| 2 .32 | 3.84 | | | | 1 | .54 | 3.24 | 1 | .26 | 1.56 | 1 | .63 | 2.52 | | |
| 2 .31 | 3.72 | | | | 1 | .53 | 3.18 | 3 | .25 | 1.50 | 1 | .62 | 2.48 | | |
| 3 .30 | 3.60 | | | | 3 | .52 | 3.12 | 1 | .23 | 1.38 | 1 | .61 | 2.44 | | |
| 4 .29 | 3.48 | | | | 1 | .50 | 3.00 | 2 | .22 | 1.32 | 2 | .59 | 2.36 | | |
| 5 .28 | 3.36 | | | | 1 | .49 | 2.94 | 1 | .21 | 1.26 | 2 | .58 | 2.24 | | |
| 7 .27 | 3.24 | | | | 3 | .47 | 2.82 | 2 | .20 | 1.20 | 1 | .55 | 2.20 | | |
| 3 .26 | 3.42 | | | | 1 | .46 | 2.76 | | | | 1 | .54 | 2.16 | | |

East Lansing

| 5 min. | | | 10 min. | | | 15 min. | | | 20 min. | | |
|--------|---------------|------|---------|----------------|------|---------|----------------|-------|---------|---------|------|
| No. of | 5 min. (cont) | | No. of | 10 min. (cont) | | No. of | 15 min. (cont) | | No. of | 20 min. | |
| Sto. | Rate | Sto. | Rate | Sto. | Rate | Sto. | Rate | Sto. | Rate | Sto. | Rate |
| 3 | .25 | 3.00 | 2 | .45 | 2.70 | 2 | .53 | 2.12 | 1 | .53 | 1.59 |
| 2 | .24 | 2.88 | 4 | .44 | 2.64 | 3 | .49 | 1.96 | 2 | .52 | 1.56 |
| 3 | .23 | 2.76 | 1 | .43 | 2.58 | 1 | .48 | 1.92 | 1 | .51 | 1.53 |
| 4 | .22 | 2.64 | 1 | .42 | 2.52 | 3 | .47 | 1.89 | 4 | .50 | 1.50 |
| 4 | .21 | 2.52 | 1 | .41 | 2.46 | 1 | .46 | 1.845 | 1 | .49 | 1.47 |
| 7 | .20 | 2.40 | 3 | .40 | 2.40 | 6 | .45 | 1.80 | 1 | .48 | 1.44 |
| 2 | .19 | 2.28 | 4 | .39 | 2.34 | 2 | .43 | 1.72 | 3 | .48 | 1.55 |
| 2 | .18 | 2.16 | | | | 4 | .42 | 1.68 | 1 | .44 | 1.52 |

East Lansing

[illegible]

Grand Rapids

| 5 min. | | | 10 min. | | | 15 min. | | | 20 min. | | | 25 min. | | |
|--------|------|-------|---------|------|------|---------|------|-------|---------|------|------|---------|------|-------|
| No. of | | | No. of | | | No. of | | | No. of | | | No. of | | |
| Sto. | Amt. | Rate | Sto. | Amt. | Rate | Sto. | Amt. | Rate | Sto. | Amt. | Rate | Sto. | Amt. | Rate |
| 1 | | 5 .14 | 1 | 1.68 | | 1 | | 7 .43 | 1 | 1.72 | | 1 | .50 | 1.50 |
| 1 | | 5 .13 | 1 | 1.56 | 5.34 | 1 | 1.44 | 4.96 | 4 | 1.64 | 1 | 1.61 | 4.83 | 4 .49 |
| 1 | .65 | 7.80 | 1 | 1.20 | 4.74 | 1 | 1.10 | 4.40 | 4 | 1.60 | 1 | 1.51 | 3.93 | 4 .48 |
| 2 | .48 | 5.76 | 1 | 1.08 | 4.32 | 1 | 1.07 | 4.28 | 7 | 1.56 | 1 | 1.10 | 3.50 | 2 .47 |
| 1 | .44 | 5.28 | 1 | .60 | 4.02 | 1 | .87 | 3.48 | 6 | 1.52 | 1 | 1.03 | 3.15 | 3 .46 |
| 1 | .42 | 5.04 | 2 | .48 | 3.72 | 1 | .86 | 3.44 | 4 | 1.48 | 1 | .99 | 2.97 | 4 .45 |
| 1 | .41 | 4.92 | 4 | .56 | 3.60 | 1 | .85 | 3.32 | 8 | 1.44 | 1 | .95 | 2.85 | 3 .44 |
| 2 | .40 | 4.80 | 2 | .12 | 3.36 | 1 | .82 | 3.28 | 7 | 1.40 | 1 | .91 | 2.73 | 4 .45 |
| 2 | .39 | 4.68 | 3 | | 3.12 | 1 | .80 | 3.20 | 1 | 1.36 | 1 | .87 | 2.61 | 1 .42 |
| 2 | .38 | 4.56 | 2 | | 2.94 | 1 | .78 | 3.12 | 1 | 1.28 | 2 | .85 | 2.55 | 2 .41 |
| 2 | .37 | 4.44 | 6 | | 2.76 | 1 | .72 | 2.88 | 1 | 1.24 | 1 | .82 | 2.46 | 1 .40 |
| 1 | .35 | 4.20 | 2 | | 2.64 | 1 | .71 | 2.84 | 2 | 1.20 | 1 | .78 | 2.34 | 2 .39 |
| 1 | .34 | 4.08 | 2 | | 2.52 | 1 | .67 | 2.68 | 1 | 1.16 | 1 | .76 | 2.28 | 3 .38 |
| 2 | .33 | 3.96 | 2 | | 2.46 | 1 | .63 | 2.64 | 2 | 1.00 | 3 | .75 | 2.25 | 2 .36 |
| 3 | .32 | 3.84 | 7 | | 2.34 | 1 | .65 | 2.60 | 1 | .90 | 4 | .74 | 2.22 | 1 .35 |
| 1 | .31 | 3.72 | 9 | | 2.16 | 2 | .64 | 2.56 | 1 | .86 | 2 | .73 | 2.19 | 1 .34 |
| 6 | .30 | 3.60 | 9 | | 2.04 | 3 | .62 | 2.48 | 1 | .82 | 1 | .69 | 2.07 | 2 .33 |
| 8 | .29 | 3.48 | 12 | | 1.92 | 1 | .61 | 2.44 | 2 | .87 | 2 | .66 | 1.98 | 2 .31 |

Grand Rapids

| 5 min. (cont) | | | 10 min. | | | 15 min. | | | 15 min. (cont.) | | | 20 min. | | | 20 min. (cont.) | | |
|---------------|------|------|---------|------|------|---------|------|------|-----------------|------|------|---------|------|------|-----------------|------|------|
| No of | Sto. | Rate | No.of | Sto. | Rate | No.of | Sto. | Rate | No.of | Sto. | Rate | No.of | Sto. | Rate | No.of | Sto. | Rate |
| 3 | .28 | 3.86 | 11 | .80 | 1.80 | 3 | .60 | 2.40 | 1 | .06 | .24 | 1 | .65 | 1.95 | 1 | .15 | .45 |
| | | | 5 | .29 | 1.74 | | | | | | | | | | | | |
| 1 | .27 | 3.24 | 2 | .28 | 1.68 | 1 | .58 | 2.32 | 1 | .05 | .20 | 1 | .64 | 1.92 | 2 | .09 | .27 |
| | | | 2 | .27 | 1.62 | | | | | | | | | | | | |
| 6 | .26 | 3.12 | 4 | .28 | 1.56 | 1 | .57 | 2.28 | 1 | .03 | .12 | 3 | .68 | 1.89 | 2 | .08 | .24 |
| | | | 5 | .25 | 1.50 | | | | | | | | | | | | |
| 13 | .25 | 3.00 | 2 | .24 | 1.44 | 1 | .55 | 2.20 | 1 | .02 | .08 | 1 | .61 | 1.83 | 1 | .07 | .21 |
| | | | 1 | .25 | 1.58 | | | | | | | | | | | | |
| 2 | .24 | 2.88 | 1 | .19 | 1.14 | 1 | .53 | 2.12 | | | | 4 | .60 | 1.80 | 1 | .06 | .18 |
| | | | 1 | .18 | 1.08 | | | | | | | | | | | | |
| 6 | .23 | 2.76 | 1 | .16 | .86 | 3 | .52 | 2.08 | | | | 2 | .60 | 1.80 | 1 | .06 | .18 |
| | | | 1 | .14 | .84 | | | | | | | | | | | | |
| 4 | .22 | 2.64 | 2 | .07 | .22 | 2 | .51 | 2.04 | | | | 1 | .58 | 1.74 | 1 | .02 | .06 |
| | | | | | | | | | | | | | | | | | |
| 7 | .21 | 2.52 | 4 | .05 | .20 | 5 | .50 | 2.00 | | | | 1 | .57 | 1.71 | | | |
| | | | | | | | | | | | | | | | | | |
| 17 | .20 | 2.40 | 1 | .04 | .24 | 2 | .49 | 1.96 | | | | 4 | .56 | 1.68 | | | |
| | | | | | | | | | | | | | | | | | |
| 8 | .19 | 2.28 | 2 | .02 | .12 | 2 | .48 | 1.92 | | | | 2 | .55 | 1.65 | | | |
| | | | | | | | | | | | | | | | | | |
| 10 | .18 | 2.16 | | | | 4 | .47 | 1.88 | | | | 1 | .54 | 1.62 | | | |
| | | | | | | | | | | | | | | | | | |
| 6 | .17 | 2.04 | | | | 3 | .46 | 1.84 | | | | 3 | .53 | 1.59 | | | |
| | | | | | | | | | | | | | | | | | |
| 6 | .16 | 1.92 | | | | 7 | .45 | 1.80 | | | | 1 | .52 | 1.56 | | | |
| | | | | | | | | | | | | | | | | | |
| 5 | .15 | 1.80 | | | | 4 | .44 | 1.76 | | | | 2 | .51 | 1.53 | | | |

Grand Rapids

| 30 min. | | | | 45 min. | | | | 60 min. | | | | 80 min. | | | | 120 min. | | | |
|---------|------|--------|------|---------|------|--------|------|---------|------|--------|------|---------|------|--------|------|----------|------|--|--|
| No. of | | No. of | | No. of | | No. of | | No. of | | No. of | | No. of | | No. of | | No. of | | | |
| Sto. | Amt. | Rate | Sto. | Amt. | Rate | Sto. | Amt. | Rate | Sto. | Amt. | Rate | Sto. | Amt. | Rate | Sto. | Amt. | Rate | | |
| 1 | 1.84 | 3.68 | 2 | .55 | 1.10 | 1 | 2.11 | 2.58 | 1 | 1.58 | 1.88 | 1 | 1.68 | 1.27 | 1 | 1.18 | .59 | | |
| 1 | 1.71 | 3.42 | 2 | .54 | 1.08 | 1 | 2.01 | 2.08 | 1 | 1.55 | 1.55 | 1 | 1.64 | 1.23 | 1 | .92 | .46 | | |
| 1 | 1.51 | 3.02 | 1 | .53 | 1.06 | 1 | 1.45 | 1.93 | 1 | 1.49 | 1.49 | 1 | 1.53 | 1.16 | 1 | .75 | .38 | | |
| 1 | 1.29 | 2.58 | 1 | .52 | 1.04 | 1 | 1.36 | 1.81 | 1 | 1.48 | 1.48 | 1 | 1.58 | 1.03 | 1 | .65 | .33 | | |
| 1 | 1.17 | 2.34 | 3 | .51 | 1.02 | 1 | 1.34 | 1.79 | 1 | 1.39 | 1.39 | 1 | 1.37 | 1.02 | 4 | .22 | .11 | | |
| 2 | 1.14 | 2.28 | 3 | .47 | .94 | 1 | 1.31 | 1.75 | 1 | 1.36 | 1.36 | 1 | 1.31 | .98 | 1 | .19 | .10 | | |
| 2 | 1.12 | 2.24 | 3 | .46 | .92 | 1 | 1.26 | 1.68 | 1 | 1.29 | 1.29 | 1 | 1.16 | .87 | 1 | .17 | .09 | | |
| 1 | 1.02 | 2.04 | 1 | .41 | .82 | 1 | 1.21 | 1.61 | 1 | 1.18 | 1.18 | 1 | 1.01 | .76 | 1 | .16 | .08 | | |
| 1 | 1.01 | 2.02 | 2 | .40 | .80 | 1 | 1.15 | 1.53 | 1 | 1.15 | 1.15 | 1 | .88 | .66 | 1 | .15 | .07 | | |
| 1 | .97 | 1.94 | 1 | .38 | .78 | 1 | 1.06 | 1.41 | 1 | 1.13 | 1.13 | 1 | .85 | .64 | | | | | |
| 1 | .95 | 1.90 | 1 | .36 | .72 | 1 | 1.00 | 1.33 | 1 | 1.11 | 1.11 | 1 | .77 | .58 | | | | | |
| 1 | .92 | 1.84 | 1 | .35 | .70 | 1 | .99 | 1.31 | 1 | 1.07 | 1.07 | 2 | .75 | .56 | | | | | |
| 1 | .88 | 1.72 | 1 | .34 | .68 | 1 | .89 | 1.19 | 1 | 1.02 | 1.02 | 1 | .74 | .55 | | | | | |
| 2 | .84 | 1.68 | 1 | .16 | .32 | 1 | .88 | 1.17 | 1 | .97 | .97 | 1 | .59 | .44 | | | | | |
| 1 | .83 | 1.66 | 1 | .13 | .26 | 1 | .87 | 1.16 | 1 | .95 | .95 | 1 | .54 | .40 | | | | | |
| 2 | .82 | 1.64 | 2 | .11 | .22 | 1 | .81 | 1.08 | 1 | .90 | .90 | 1 | .51 | .38 | | | | | |
| 1 | .79 | 1.58 | 1 | .10 | .20 | 2 | .77 | 1.03 | 1 | .88 | .88 | 2 | .41 | .31 | | | | | |
| 1 | .78 | 1.56 | 1 | .09 | .18 | 2 | .73 | .97 | 1 | .80 | .80 | 1 | .40 | .30 | | | | | |

Grand Rapids

| 30 min. | | | | 45 min. | | | | 60 min. | | | | 80 min. | | | | 120 min. | | | |
|---------|------|-----------|------|---------|------|------|------|---------|------|------|------|---------|------|------|------|----------|------|------|------|
| No. of | | Sto. Amt. | | No. of | | Rate | | No. of | | Rate | | No. of | | Rate | | No. of | | Rate | |
| No. of | Rate | Sto. | Amt. | No. of | Rate | Sto. | Amt. | No. of | Rate | Sto. | Amt. | No. of | Rate | Sto. | Amt. | No. of | Rate | Sto. | Amt. |
| 1 | .77 | 1.54 | 1 | .08 | .16 | 1 | .72 | .96 | 2 | .74 | .74 | 1 | .58 | .28 | | | | | |
| 1 | .75 | 1.50 | 2 | .05 | .10 | 2 | .69 | .92 | 1 | .71 | .71 | 1 | .56 | .27 | | | | | |
| 3 | .74 | 1.48 | | | | 1 | .68 | .91 | 1 | .61 | .61 | 1 | .54 | .25 | | | | | |
| 2 | .73 | 1.46 | | | | 2 | .66 | .88 | 2 | .59 | .59 | | | | | | | | |
| 2 | .72 | 1.44 | | | | 2 | .65 | .87 | 1 | .57 | .57 | | | | | | | | |
| 2 | .71 | 1.42 | | | | 1 | .59 | .79 | 1 | .54 | .54 | | | | | | | | |
| 1 | .67 | 1.34 | | | | 1 | .53 | .71 | 1 | .51 | .51 | | | | | | | | |
| 3 | .65 | 1.30 | | | | 1 | .51 | .68 | 1 | .47 | .47 | | | | | | | | |
| 1 | .63 | 1.26 | | | | 1 | .46 | .61 | 1 | .41 | .41 | | | | | | | | |
| 1 | .61 | 1.22 | | | | 1 | .40 | .53 | 1 | .40 | .40 | | | | | | | | |
| 2 | .60 | 1.20 | | | | 1 | .36 | .48 | 1 | .38 | .38 | | | | | | | | |
| 1 | .59 | 1.18 | | | | 1 | .35 | .47 | 1 | .36 | .36 | | | | | | | | |
| 1 | .58 | 1.16 | | | | 1 | .34 | .45 | 1 | .34 | .34 | | | | | | | | |
| 1 | .57 | 1.14 | | | | 2 | .16 | .21 | 1 | .19 | .19 | | | | | | | | |
| 1 | .56 | 1.12 | | | | 1 | .15 | .20 | 1 | .18 | .18 | | | | | | | | |
| | | | | | | 1 | .13 | .17 | 1 | .17 | .17 | | | | | | | | |
| | | | | | | 1 | .12 | .16 | 1 | .15 | .15 | | | | | | | | |
| | | | | | | 1 | .11 | .15 | 2 | .14 | .24 | | | | | | | | |
| | | | | | | 1 | .09 | .12 | 1 | .11 | .11 | | | | | | | | |
| | | | | | | 1 | .06 | .08 | 2 | .08 | .08 | | | | | | | | |

Grand Haven

| 5 min. | | | 10 min. | | | 15 min. | | | 20 min. | | | 25 min. | | | 30 min. | | | 35 min. | | |
|--------|------|------|---------|------|------|---------|------|------|---------|------|------|---------|------|------|---------|------|------|---------|------|------|
| No. of | | Rate | No. of | | Rate | No. of | | Rate | No. of | | Rate | No. of | | Rate | No. of | | Rate | No. of | | Rate |
| Sto. | Amt. | | Sto. | Amt. | | Sto. | Amt. | | Sto. | Amt. | | Sto. | Amt. | | Sto. | Amt. | | Sto. | Amt. | |
| 5 | .42 | 5.04 | 1 | .68 | 4.08 | 1 | .87 | 3.48 | 1 | .99 | 2.97 | 1 | 1.20 | 2.88 | 1 | 1.43 | 2.86 | 1 | 1.54 | 2.04 |
| 1 | .40 | 4.8 | 1 | .66 | 3.96 | 1 | .79 | 3.16 | 1 | .95 | 2.85 | 1 | 1.14 | 2.73 | 1 | 1.30 | 2.60 | 1 | 1.58 | 2.56 |
| 1 | .56 | 4.56 | 1 | .82 | 3.71 | 1 | .76 | 3.04 | 1 | .88 | 2.64 | 1 | 1.08 | 2.59 | 1 | 1.18 | 2.56 | 1 | 1.52 | 2.26 |
| 1 | .55 | 4.20 | 2 | .59 | 3.54 | 1 | .74 | 2.96 | 1 | .86 | 2.58 | 1 | 1.05 | 2.47 | 1 | 1.17 | 2.54 | 1 | 1.24 | 2.12 |
| 1 | .54 | 4.08 | 1 | .58 | 3.48 | 2 | .72 | 2.88 | 1 | .85 | 2.55 | 1 | 1.02 | 2.45 | 1 | 1.02 | 2.04 | 1 | 1.13 | 1.94 |
| 2 | .55 | 3.96 | 1 | .54 | 3.24 | 1 | .67 | 2.88 | 1 | .84 | 2.52 | 1 | .95 | 2.28 | 1 | 1.01 | 2.02 | 1 | 1.08 | 1.82 |
| 1 | .52 | 3.84 | 2 | .53 | 3.16 | 1 | .66 | 2.64 | 1 | .82 | 2.46 | 1 | .94 | 2.25 | 2 | .98 | 1.96 | 1 | 1.02 | 1.75 |
| 2 | .51 | 3.72 | 1 | .52 | 3.17 | 2 | .65 | 2.60 | 1 | .81 | 2.45 | 1 | .84 | 2.08 | 1 | .94 | 1.88 | 1 | 1.01 | 1.73 |
| 2 | .50 | 3.60 | 5 | .51 | 3.06 | 1 | .64 | 2.56 | 1 | .80 | 2.40 | 2 | .82 | 1.97 | 1 | .93 | 1.86 | 1 | 1.00 | 1.71 |
| 1 | .29 | 3.48 | 3 | .49 | 2.94 | 2 | .63 | 2.52 | 2 | .74 | 2.22 | 1 | .81 | 1.95 | 1 | .89 | 1.78 | 1 | .92 | 1.58 |
| 4 | .28 | 3.26 | 1 | .48 | 2.86 | 2 | .62 | 2.48 | 3 | .71 | 2.13 | 1 | .79 | 1.89 | 1 | .88 | 1.76 | 1 | .89 | 1.53 |
| 3 | .27 | 3.24 | 2 | .46 | 2.76 | 1 | .61 | 2.44 | 1 | .68 | 2.04 | 1 | .77 | 1.85 | 1 | .86 | 1.72 | 1 | .86 | 1.48 |
| 3 | .26 | 3.12 | 4 | .44 | 2.64 | 2 | .60 | 2.40 | 1 | .67 | 2.01 | 1 | .76 | 1.84 | 1 | .85 | 1.70 | 1 | .84 | 1.44 |
| 5 | .25 | 3.00 | 4 | .43 | 2.56 | 1 | .59 | 2.36 | 3 | .66 | 1.96 | 1 | .73 | 1.75 | 1 | .84 | 1.68 | 1 | .81 | 1.39 |
| 4 | .24 | 2.88 | 1 | .42 | 2.52 | 2 | .58 | 2.32 | 1 | .65 | 1.95 | 1 | .72 | 1.73 | 1 | .81 | 1.62 | 1 | .70 | 1.20 |
| 3 | .25 | 2.76 | 2 | .41 | 2.46 | 1 | .57 | 2.28 | 1 | .64 | 1.92 | 1 | .69 | 1.67 | 1 | .78 | 1.56 | 1 | .69 | 1.18 |
| 3 | .22 | 2.64 | 2 | .40 | 2.40 | 1 | .56 | 2.24 | 1 | .63 | 1.89 | 1 | .67 | 1.61 | 1 | .75 | 1.50 | 1 | .67 | 1.15 |



Grand Haven

[illegible]

Grand Haven

[illegible]

EXCESSIVE PRECIPITATION CURVES for Detroit, Mich.

1910-1936 (2.7 YRS) (MAX. AVERAGES)

Legend for Curve Numbers

① Frequency of once in 27 yrs.

② " " " " 18.5 yrs.

③ " " " " 9.0 yrs.

④ " " " " 3.0 yrs.

⑤ " " " " 1.0 yrs.

Precipitation in Inches Per Hour

DURATION INTERVAL - (MINUTES)

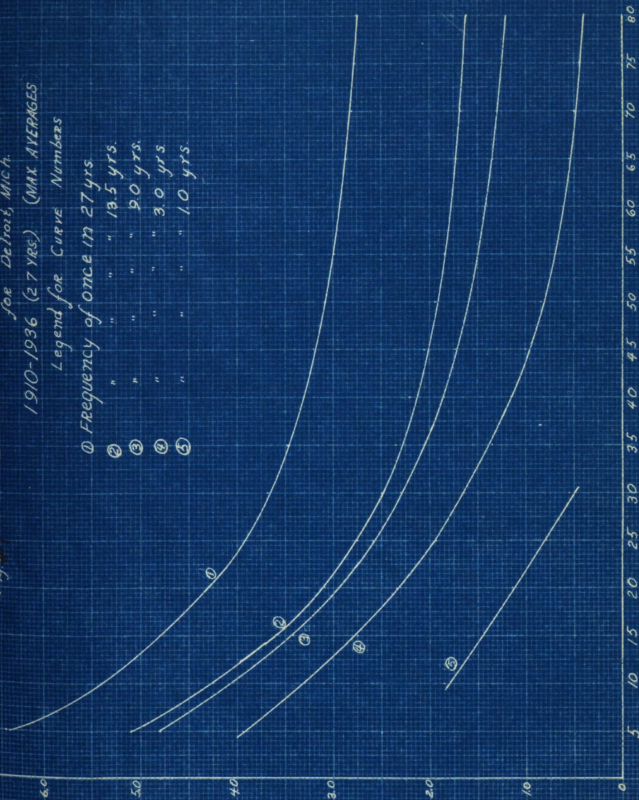


Fig. 1

EXCESSIVE PRECIPITATION CURVES
for East Lansing, Mich.

1910-1936 (27 yrs) - (MAX AVERAGES)

Legend for Curve Numbers

| | |
|---|-----------------------------|
| ① | Frequency of once in 27 yrs |
| ② | " " " 13.5 " |
| ③ | " " " 9.0 " |
| ④ | " " " 6.0 " |
| ⑤ | " " " 3.0 " |

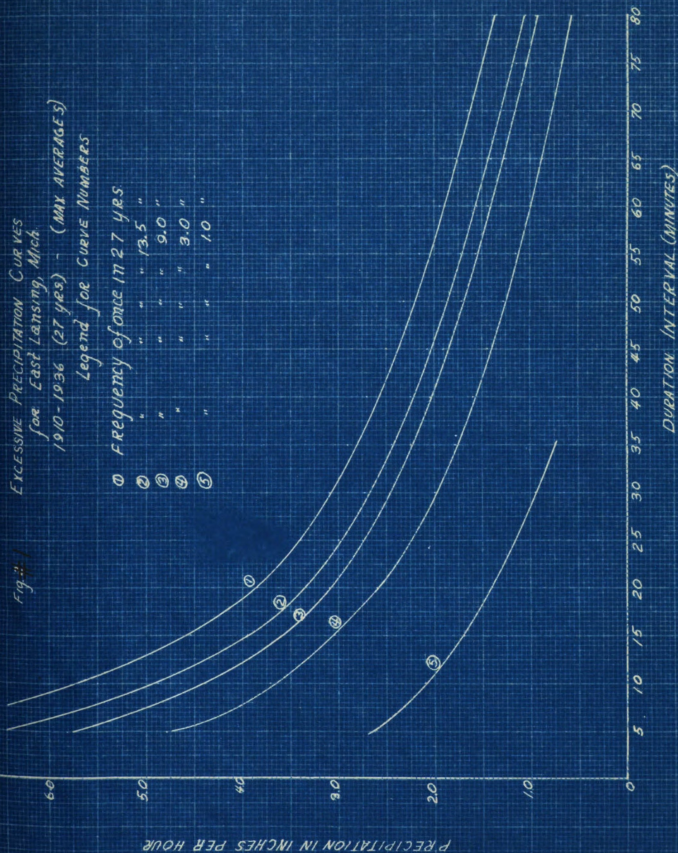


Fig. 1 EXCESSIVE PRECIPITATION CURVES
for GRAND RAPIDS, MICH.

1910-1936 (27 yrs)

(MAXIMUM AVERAGES)

Legend of Curve Numbers

① - Frequency of once in 27 yrs

② " " " 13.5 "

③ " " " 9.0 "

④ " " " 3.0 "

⑤ " " " 1.0 "

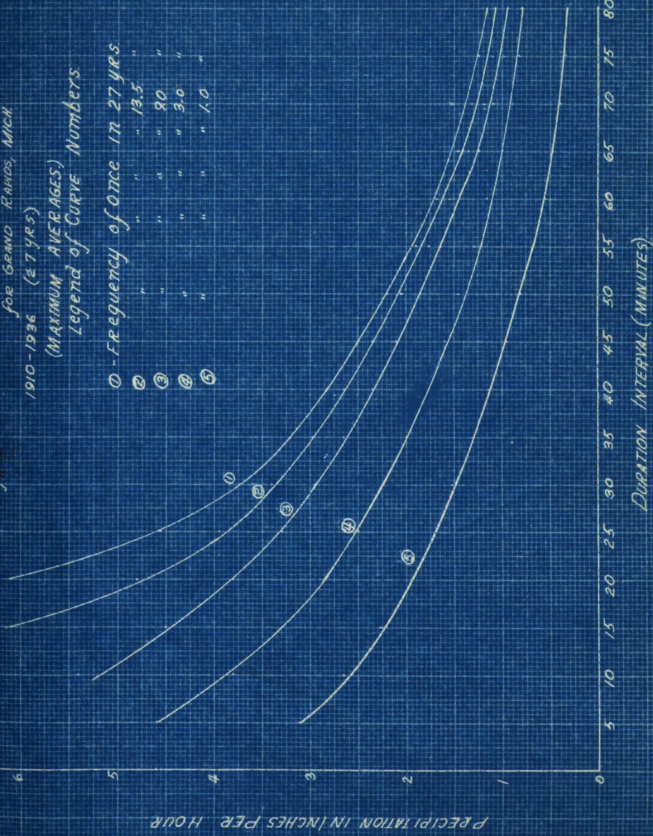


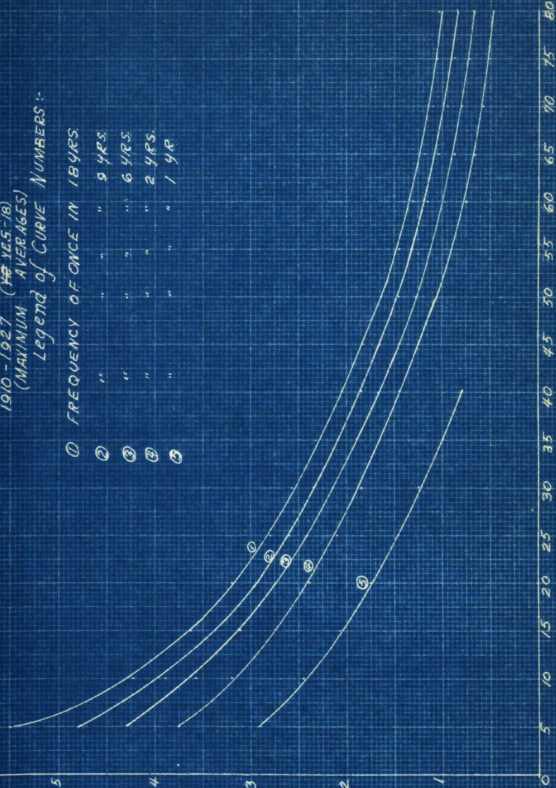
Fig. 1

EXCESSIVE PRECIPITATION CURVES for GRAND HAVEN, MICH.

1910-1927 (~~1910-1927~~ 1910-1927)
(MAXIMUM AVERAGES)

Legend of CURVE NUMBERS:-

- ① FREQUENCY OF ONCE IN 18 YRS.
- ② " " " 9 YRS.
- ③ " " " 6 YRS.
- ④ " " " 2 YRS.
- ⑤ " " " 1 YR.



DURATION INTERVAL - MINUTES

PRECIPITATION IN INCHES PER HOUR

Table IV

Records of Maximum Precipitation for Detroit

Each Year for short time Intervals (1910-1935)

| Year | 5 min.
Amt. Rate | 10 min.
Amt. Rate | 15 min.
Amt. Rate | 20 min.
Amt. Rate | 30 min.
Amt. Rate | 45 min.
Amt. Rate | 60 min.
Amt. Rate |
|------|---------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| 1910 | .29 | 5.46 | .49 | 2.94 | .57 | 2.28 | |
| 1911 | .23 | 2.76 | .402 | 2.40 | .54 | 2.16 | .68 |
| 1912 | .55 | 6.60 | .62 | 3.72 | .70 | 2.80 | .77 |
| 1913 | .22 | 2.64 | .51 | 3.06 | .73 | 2.92 | .73 |
| 1914 | .32 | 2.84 | .53 | 1.98 | .44 | 1.76 | .47 |
| 1915 | .43 | 5.16 | .76 | 4.56 | .81 | 3.24 | .89 |
| 1916 | .38 | 4.56 | .60 | 3.60 | .79 | 3.16 | .91 |
| 1917 | .43 | 5.10 | .61 | 3.66 | .38 | 1.52 | .44 |
| 1918 | .15 | 1.80 | .34 | 2.04 | .38 | 1.52 | .44 |
| 1919 | .40 | 4.80 | .75 | 4.50 | .90 | 3.60 | .99 |
| 1920 | .32 | 3.84 | .52 | 3.12 | .75 | 3.00 | .93 |
| 1921 | .47 | 5.64 | .90 | 5.40 | .97 | 3.88 | 1.07 |
| 1922 | .24 | 2.88 | .39 | 2.34 | .59 | 2.36 | .82 |
| 1923 | .34 | 4.08 | .63 | 3.75 | .68 | 2.64 | .85 |
| 1924 | .29 | 3.48 | .41 | 2.46 | | | |
| 1925 | .32 | 3.84 | .49 | 2.94 | .64 | 2.56 | .76 |
| 1926 | .78 | 9.36 | 1.57 | 8.22 | 1.61 | 7.24 | 2.06 |

2.28 1.84 .99 1.32 2.31 .54 1.08 2.19 .70 1.40 1.41 2.67 1.23 2.46 1.59 2.11 1.88 1.32 .54 1.08 .67 .89 .81 1.32 .75 1.50 .86 1.13 1.15 1.15 2.97 1.15 2.30 2.79 1.16 2.32 3.21 1.16 2.32 1.94 1.19 1.59 2.55 .98 1.96 2.28 1.01 2.02 1.51 1.75 1.70 1.70 1.98 1.48 6.18 2.56 4.72 2.59 3.45 3.18 3.41 2.56

Detroit

| Year | 5 min.
Amt. Rate | 10 min.
Amt. Rate | 15 min.
Amt. Rate | 20 min.
Amt. Rate | 25 min.
Amt. Rate | 30 min.
Amt. Rate | 45 min.
Amt. Rate | 60 min.
Amt. Rate | 80 min.
Amt. Rate |
|------|---------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| 1927 | .24 2.88 | .56 2.16 | .53 2.12 | .61 1.85 | .72 1.44 | | | | |
| 1928 | .42 5.04 | .74 4.44 | .95 3.80 | 1.15 3.45 | | | | | |
| 1929 | .13 1.56 | .21 1.88 | .51 1.24 | .56 1.08 | | | | | |
| 1930 | .25 3.00 | .36 2.28 | .49 1.96 | .45 1.35 | .49 .98 | .61 1.08 | .97 .97 | | |
| 1931 | .21 2.52 | .42 2.52 | .54 2.16 | .60 1.80 | .62 1.24 | .78 1.04 | 1.06 1.06 | 1.59 1.04 | |
| 1932 | .36 4.52 | .52 3.12 | .64 2.56 | | | | | | |
| 1933 | .13 1.56 | .16 .96 | .29 1.16 | .40 1.20 | .51 1.02 | .55 1.73 | .56 .56 | .57 .43 | |
| 1934 | .25 2.76 | .35 2.10 | .46 1.84 | .57 1.71 | .76 1.52 | .86 1.15 | .86 .86 | .86 .65 | |
| 1935 | .34 4.08 | .57 3.42 | .85 3.40 | 1.11 3.33 | 1.51 3.02 | 2.20 2.93 | 2.37 2.37 | 2.39 1.79 | |
| 1936 | .23 3.36 | .43 2.075 | | | .12 .24 | .22 .22 | | | |

Grand Rapids

| Year | 5 min. | | 10 min. | | 15 min. | | 20 min. | | 30 min. | | 45 min. | | 60 min. | |
|------|--------|------|---------|------|---------|------|---------|------|---------|------|---------|------|---------|------|
| | Rate | Ant. | Rate | Ant. | Rate | Ant. | Rate | Ant. | Rate | Ant. | Rate | Ant. | Rate | Ant. |
| 1910 | .25 | 5.00 | .38 | 2.28 | .49 | 1.96 | .56 | 1.68 | .65 | 1.58 | .87 | 1.16 | 1.11 | 1.11 |
| 1911 | .29 | 5.48 | .58 | 5.48 | .85 | 5.52 | .85 | 2.55 | | | | | | |
| 1912 | .39 | 4.68 | .62 | 5.72 | .87 | 5.48 | .85 | 2.55 | .65 | 1.50 | | | | |
| 1913 | .25 | 1.78 | .39 | 2.34 | .44 | 1.76 | .46 | 1.58 | .60 | 1.20 | .61 | 1.08 | 1.07 | 1.07 |
| 1914 | .22 | 2.64 | .35 | 2.10 | .45 | 1.80 | .59 | 1.77 | .74 | 1.48 | .99 | 1.51 | 1.29 | 1.29 |
| 1915 | .48 | 5.76 | .89 | 5.34 | 1.07 | 4.28 | 1.10 | 5.00 | 1.12 | 2.24 | 1.21 | 1.61 | 1.59 | 1.64 |
| 1916 | .42 | 5.04 | .79 | 4.74 | 1.01 | 4.04 | 1.18 | 5.04 | 1.29 | 2.58 | | | | 1.23 |
| 1917 | .40 | 4.80 | .67 | 4.02 | .68 | 5.44 | .95 | 2.85 | 1.14 | 2.28 | | | | |
| 1918 | .26 | 5.12 | .54 | 2.04 | .55 | 1.40 | .44 | 1.52 | .55 | 1.10 | .69 | .92 | | |
| 1919 | .29 | 5.48 | .53 | 5.18 | .61 | 2.44 | .75 | 2.19 | .71 | 1.42 | | | | |
| 1920 | .35 | 4.20 | .40 | 2.40 | .50 | 2.00 | .60 | 1.80 | .74 | 1.48 | .66 | .88 | .95 | 1.01 |
| 1921 | .35 | 5.96 | .65 | 5.78 | .65 | 2.60 | .75 | 2.25 | 1.01 | 2.02 | 1.56 | 1.61 | 1.55 | 1.55 |
| 1922 | .46 | 5.52 | .55 | 5.18 | .62 | 2.48 | .76 | 2.28 | 1.14 | 2.28 | 1.28 | 1.68 | 1.48 | 1.68 |
| 1923 | .25 | 5.00 | .29 | 1.74 | | | | | | | | | | |
| 1924 | .35 | 5.96 | .59 | 2.34 | .45 | 1.72 | .49 | 1.47 | | | | | | |
| 1925 | .25 | 5.00 | | | | | | | | | | | | |
| 1926 | .50 | 5.60 | .52 | 5.12 | .60 | 2.40 | .68 | 2.04 | | | | | | |
| 1927 | .52 | 5.64 | .58 | 2.28 | .45 | 1.72 | | | | | | | | |

Grand Rapids

| Year | 5 min. | | 10 min. | | 15 min. | | 20 min. | | 30 min. | | 45 min. | | 60 min. | | 80 min. | |
|------|--------|------|---------|------|---------|------|---------|------|---------|------|---------|------|---------|------|---------|------|
| | Amt. | Rate | Amt. | Rate | Amt. | Rate | Amt. | Rate | Amt. | Rate | Amt. | Rate | Amt. | Rate | Amt. | Rate |
| 1928 | .30 | 5.60 | .56 | 5.56 | .72 | 2.88 | .91 | 2.78 | 1.02 | 2.04 | 1.54 | 1.79 | 1.58 | 1.58 | | |
| 1929 | .41 | 4.92 | .53 | 5.18 | .64 | 2.56 | .66 | 1.98 | .64 | 1.68 | | | | | | |
| 1930 | .21 | 2.52 | .36 | 2.16 | .41 | 1.64 | .43 | 1.29 | | | | | | | | |
| 1931 | .30 | 3.60 | .60 | 3.60 | .64 | 2.56 | .74 | 2.22 | | | | | | | | |
| 1932 | .51 | 3.72 | .45 | 2.58 | .52 | 2.08 | .65 | 1.95 | .95 | 1.90 | | | | | | |
| 1933 | .39 | 4.68 | .49 | 2.94 | .55 | 2.20 | .56 | 1.65 | .57 | 1.14 | .66 | .88 | .71 | .71 | .77 | .58 |
| 1934 | .24 | 2.88 | .36 | 2.16 | .37 | 1.48 | .38 | 1.14 | .51 | 1.02 | .75 | .97 | .90 | 1.13 | .85 | |
| 1935 | .38 | 4.56 | .44 | 1.64 | .60 | 2.40 | .74 | 2.22 | 1.12 | 2.24 | 1.81 | 1.75 | 1.49 | 1.55 | 1.16 | |

East Lansing

| Year | 5 min. | 10 min. | 15 min. | 20 min. | 25 min. | 30 min. | 35 min. | 40 min. | 45 min. | 50 min. | 60 min |
|---|--------|---------|---------|---------|---------|---------|---------|---------|---------|---------|--------|
| | Ant. | Rate | Ant. | Rate | Ant. | Rate | Ant. | Rate | Ant. | Rate | Ant. |
| <u>Ant. Rate Ant. Rate Ant. Rate Ant. Rate Ant. Rate Ant. Rate Ant. Rate Ant.</u> | | | | | | | | | | | |
| 1910 | .28 | 3.86 | .45 | 2.58 | .54 | 2.16 | | | | | |
| 1911 | .39 | 4.68 | .75 | 4.58 | .90 | 3.60 | 1.00 | 3.00 | 1.06 | 2.54 | 1.10 |
| | | | | | | | | | 1.22 | 1.85 | 1.28 |
| 1912 | .55 | 4.20 | .52 | 3.12 | .61 | 2.44 | .68 | 2.04 | .50 | 1.25 | .59 |
| | | | | | | | | | | | 1.18 |
| 1913 | .41 | 4.92 | .67 | 4.02 | .70 | 2.80 | .86 | 2.58 | .96 | 2.40 | .96 |
| | | | | | | | | | 1.92 | 1.08 | 1.85 |
| 1914 | .51 | 3.72 | .45 | 2.70 | .52 | 2.08 | .45 | 1.35 | .58 | 1.45 | 1.29 |
| | | | | | | | | | | | 1.93 |
| 1915 | .42 | 5.04 | .82 | 4.92 | 1.02 | 4.00 | 1.04 | 3.12 | 1.10 | 2.64 | 1.87 |
| | | | | | | | | | | | 1.85 |
| 1916 | None | | | | | | | | | | |
| 1917 | .29 | 3.48 | .57 | 3.42 | .59 | 2.86 | .59 | 1.77 | .68 | 1.65 | .77 |
| | | | | | | | | | | | 1.54 |
| 1918 | .124 | 2.98 | .55 | 2.10 | .45 | 1.80 | .50 | 1.50 | | | 1.01 |
| | | | | | | | | | | | 1.73 |
| 1919 | .27 | 3.24 | .55 | 3.18 | .69 | 2.76 | .73 | 2.19 | .53 | 1.35 | .62 |
| | | | | | | | | | | | 1.24 |
| 1920 | .28 | 3.86 | .42 | 2.52 | .55 | 2.12 | .54 | 1.62 | .65 | 1.58 | .71 |
| | | | | | | | | | | | 1.42 |
| 1921 | .66 | 7.92 | .90 | 5.40 | .47 | 1.88 | .52 | 1.56 | .55 | 1.38 | .59 |
| | | | | | | | | | | | 1.13 |
| 1922 | .55 | 4.20 | .55 | 3.50 | .67 | 2.68 | .59 | 1.17 | .46 | 1.15 | .64 |
| | | | | | | | | | | | 1.10 |
| 1923 | .57 | 4.44 | .70 | 4.20 | 1.02 | 4.08 | 1.29 | 3.67 | 1.47 | 3.52 | 1.51 |
| | | | | | | | | | | | 3.02 |
| 1924 | .56 | 4.32 | .46 | 2.76 | .45 | 1.80 | .50 | 1.50 | .62 | 1.55 | .68 |
| | | | | | | | | | | | 1.36 |
| 1925 | .16 | 1.92 | .27 | 1.62 | .36 | 1.44 | .42 | 1.26 | .57 | 1.43 | .68 |
| | | | | | | | | | | | 1.36 |
| 1926 | .26 | 3.12 | .58 | 2.28 | .48 | 1.92 | | | | | |
| | | | | | | | | | | | |
| 1927 | .21 | 2.52 | .54 | 2.04 | | | | | | | |

(Rate-1.54, 80 min. A-1.61, R-1.21)

(Rate-1.13, 80 min. A-1.28, R-.96)

(Rate-2.06)

(Rate-1.10)

[illegible]

| Year | 5 min. | 10 min. | 15 min. | 20 min. | 25 min. | 30 min. | 35 min. | 40 min. | 45 min. | 50 min. | 60 min. | | | |
|------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------|------|-------------------------------------|
| | Ant. Rate | Ant. Rate | Ant. Rate | Ant. Rate | Ant. Rate | Ant. Rate | Ant. Rate | Ant. Rate | Ant. Rate | Ant. Rate | Ant. Rate | | | |
| 1928 | .29 | 3.48 | .36 | 2.16 | .39 | 1.60 | .55 | 1.59 | .61 | 1.55 | .68 | 1.36 | .78 | 1.34 |
| 1929 | .31 | 3.72 | .56 | 3.36 | .62 | 2.48 | | | | | | | | |
| 1930 | None | | | | | | | | | | | | | |
| 1931 | .38 | 4.56 | .56 | 3.36 | .66 | 2.64 | .42 | 1.26 | .37 | .89 | .55 | 1.10 | .62 | ? |
| 1932 | .41 | 4.92 | .47 | 2.82 | .56 | 2.24 | .64 | 1.92 | .66 | 1.65 | .93 | 1.86 | 1.06 | 1.62 |
| | | | | | | | | | | | | | | (Rate-1.32, 80 min. A-1.50, R-1.13) |
| 1933 | .40 | 4.80 | .70 | 4.80 | .69 | 3.56 | 1.12 | 3.36 | 1.23 | 2.95 | 1.29 | 2.53 | 1.31 | 2.24 |
| | | | | | | | | | | | | | | 1.38 2.07 1.51 2.01 |
| 1934 | .33 | 3.96 | .37 | 2.22 | .47 | 1.88 | .48 | 1.44 | .68 | 1.70 | .61 | 1.62 | .96 | 1.65 |
| | | | | | | | | | | | | | | 1.11 1.37 1.26 1.68 1.31 1.57 1.32 |
| | | | | | | | | | | | | | | (Rate-1.32, 80 min. A-1.46, R-1.10) |
| 1935 | .32 | 3.84 | .62 | 3.72 | .79 | 3.16 | .93 | 2.79 | 1.08 | 2.59 | 1.21 | 2.42 | 1.22 | 2.09 |
| | | | | | | | | | | | | | | 1.37 1.31 1.59 1.85 1.45 1.74 1.55 |
| | | | | | | | | | | | | | | (Rate-1.55, 80 min. A-1.55, R-1.16) |

1936

Grand Haven

| Year | 5 min. | 10 min. | 15 min. | 20 min. | 25 min. | 30 min. | 35 min. | 40 min. | 45 min. | 50 min. | 55 min. |
|----------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Ant. Rate Amt. | Rate Amt. | Rate Amt. | Rate Amt. | Rate Amt. | Rate Amt. | Rate Amt. | Rate Amt. | Rate Amt. | Rate Amt. | Rate Amt. | Rate Amt. |

| | | | | | | | | | | | | | | | | | | |
|------|-----|-----|-----|------|-----|------|-----|------|-----|------|-----|------|------|------|------|------|------|------|
| 1911 | .25 | 3.0 | .40 | 2.40 | .52 | 2.08 | .03 | 1.89 | .77 | 1.85 | .93 | 1.88 | 1.02 | 1.75 | 1.18 | 1.77 | 1.30 | 1.73 |
|------|-----|-----|-----|------|-----|------|-----|------|-----|------|-----|------|------|------|------|------|------|------|

1912-13

| | | | | | | | | | | | | | | | | | | | | |
|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|------|------|------|------|------|------|
| 1914 | .42 | 5.04 | .59 | 3.54 | .64 | 2.53 | .65 | 1.95 | .67 | 1.61 | .68 | 1.36 | .81 | 1.59 | 1.93 | 1.53 | 1.10 | 1.47 | 1.25 | 1.50 |
|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|------|------|------|------|------|------|

| | | | | | | | | | | | | | | | | | | | | |
|------|-----|------|-----|------|-----|------|-----|------|------|------|------|------|-----|------|-----|------|-----|------|-----|------|
| 1915 | .27 | 3.25 | .46 | 2.76 | .67 | 2.68 | .93 | 2.58 | 1.02 | 2.45 | 1.01 | 2.02 | .67 | 1.15 | .77 | 1.15 | .81 | 1.08 | .90 | 1.08 |
|------|-----|------|-----|------|-----|------|-----|------|------|------|------|------|-----|------|-----|------|-----|------|-----|------|

| | | | | | | | | | | | | | | | | | | | | |
|------|-----|------|-----|------|-----|------|-----|------|------|------|------|------|------|------|------|------|------|------|--|--|
| 1916 | .40 | 4.80 | .68 | 3.95 | .87 | 3.48 | .95 | 2.85 | 1.03 | 2.47 | 1.18 | 2.36 | 1.32 | 2.26 | 1.39 | 2.08 | 1.47 | 1.96 | | |
|------|-----|------|-----|------|-----|------|-----|------|------|------|------|------|------|------|------|------|------|------|--|--|

| | | | | | | | | | | | | | | | | | | | | |
|------|-----|------|-----|------|-----|------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| 1917 | .18 | 2.18 | .30 | 1.80 | .59 | 1.56 | | | | | | | | | | | | | | |
|------|-----|------|-----|------|-----|------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|

| | | | | | | | | | | | | | | | | | | | | |
|------|-----|------|-----|------|-----|------|-----|------|-----|------|--|--|--|--|--|--|--|--|--|--|
| 1918 | .27 | 3.25 | .30 | 1.80 | .54 | 2.16 | .59 | 1.77 | .55 | 1.27 | | | | | | | | | | |
|------|-----|------|-----|------|-----|------|-----|------|-----|------|--|--|--|--|--|--|--|--|--|--|

| | | | | | | | | | | | | | | | | | | | | |
|------|-----|------|-----|------|-----|------|-----|------|------|------|------|------|------|------|------|------|--|--|--|--|
| 1919 | .42 | 5.04 | .68 | 4.08 | .63 | 2.52 | .71 | 2.13 | 1.20 | 2.88 | 1.30 | 2.60 | 1.13 | 2.37 | 1.48 | 2.19 | | | | |
|------|-----|------|-----|------|-----|------|-----|------|------|------|------|------|------|------|------|------|--|--|--|--|

| | | | | | | | | | | | | | | | | | | | | |
|------|-----|------|-----|------|-----|------|-----|------|--|--|--|--|--|--|--|--|--|--|--|--|
| 1920 | .17 | 2.04 | .30 | 1.80 | .44 | 1.76 | .50 | 1.50 | | | | | | | | | | | | |
|------|-----|------|-----|------|-----|------|-----|------|--|--|--|--|--|--|--|--|--|--|--|--|

1922

| | | | | | | | | | | | | | | | | | | | | |
|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|--|--|--|--|--|--|--|--|
| 1922 | .38 | 4.55 | .53 | 3.18 | .72 | 2.88 | .94 | 2.52 | .95 | 2.28 | .98 | 1.98 | | | | | | | | |
|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|--|--|--|--|--|--|--|--|

| | | | | | | | | | | | | | | | | | | | | |
|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|------|------|------|------|--|--|--|--|
| 1923 | .26 | 3.12 | .46 | 2.76 | .68 | 2.64 | .82 | 2.46 | .94 | 2.25 | .98 | 1.98 | 1.06 | 1.82 | 1.02 | 1.53 | | | | |
|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|------|------|------|------|--|--|--|--|

| | | | | | | | | | | | | | | | | | | | | |
|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|--|--|--|--|
| 1924 | .31 | 3.72 | .51 | 3.06 | .63 | 2.52 | .71 | 2.13 | .79 | 1.90 | .86 | 1.70 | .92 | 1.57 | .97 | 1.45 | | | | |
|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|--|--|--|--|

| | | | | | | | | | | | | | | | | | | | | | |
|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|------|------|------|------|------|
| 1925 | .35 | 4.20 | .51 | 3.06 | .60 | 2.40 | .66 | 1.98 | .76 | 1.83 | .81 | 1.62 | .86 | 1.47 | .98 | 1.47 | 1.12 | 1.49 | 1.33 | 1.60 | 1.34 |
|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|------|------|------|------|------|

| | | | | | | | | | | | | | | | | | | | | | |
|------|-----|------|-----|------|-----|------|-----|------|-----|------|------|------|------|------|------|------|------|------|--|--|--|
| 1926 | .42 | 5.04 | .62 | 3.72 | .65 | 2.60 | .66 | 1.98 | .72 | 1.73 | 1.02 | 2.04 | 1.15 | 1.94 | 1.23 | 1.84 | 1.28 | 1.70 | | | |
|------|-----|------|-----|------|-----|------|-----|------|-----|------|------|------|------|------|------|------|------|------|--|--|--|

| | | | | | | | | | | | | | | | | | | | | | |
|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|------|------|------|------|--|
| 1927 | .34 | 4.08 | .51 | 3.06 | .55 | 2.20 | .64 | 1.92 | .81 | 1.95 | .84 | 1.68 | .89 | 1.53 | .98 | 1.47 | 1.03 | 1.87 | 1.05 | 1.26 | |
|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|------|------|------|------|--|

Rate- 1.40

Table V

Most Intense Storm Recorded at each Sta. 1910-1986

(Amount)

| Station | 5 min. | 10 min. | 15 min. | 20 min. | 25 min. | 30 min. | 35 min. | 40 min. | 45 min. | 50 min. | 60 min. | 80 min. | 120 min. |
|--------------------------|--------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|
| Detroit | .44 | .80 | .97 | 1.15 | 1.45 | 2.04 | 2.29 | 2.44 | 2.59 | 2.60 | 2.61 | 3.41 | 3.86 |
| E.Lansing | .68 | .90 | 1.02 | 1.29 | | 1.51 | 1.87 | - | - | - | 2.06 | 1.61 | |
| Gr.Rapids | .48 | .89 | 1.07 | 1.10 | | 1.12 | | | | | | | |
| (1910-1987)
Gr. Haven | .42 | .68 | .87 | .99 | 1.20 | 1.43 | 1.54 | 1.46 | 1.47 | 1.32 | 1.34 | 1.34 | |

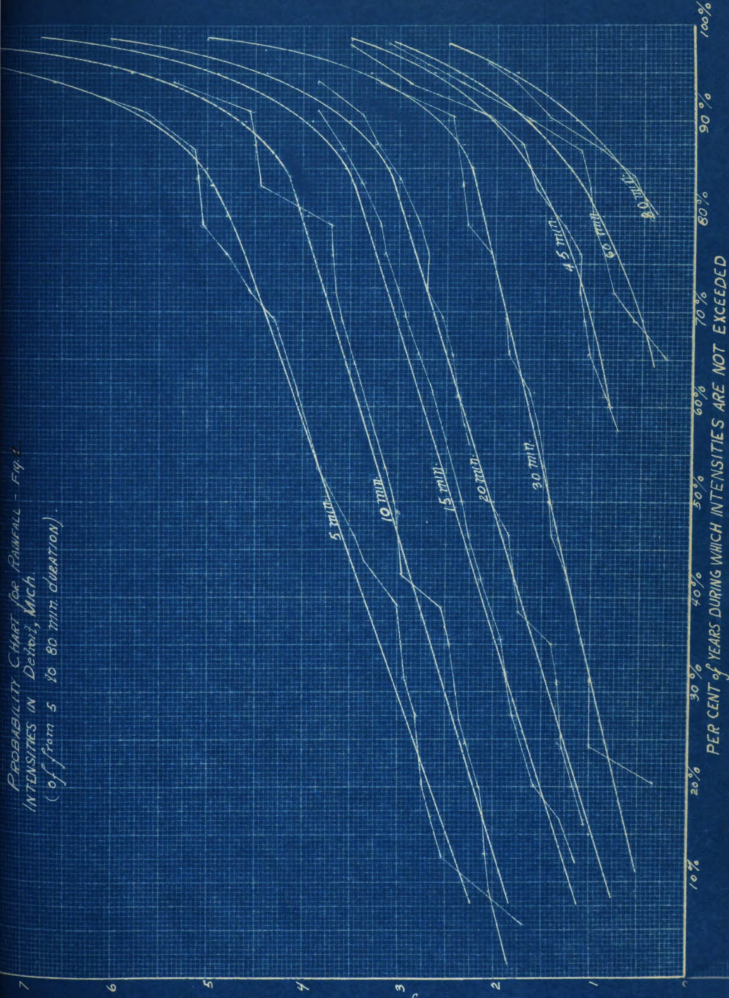
Table VI

Maximum Rates of Precipitation at each of the Four Stations

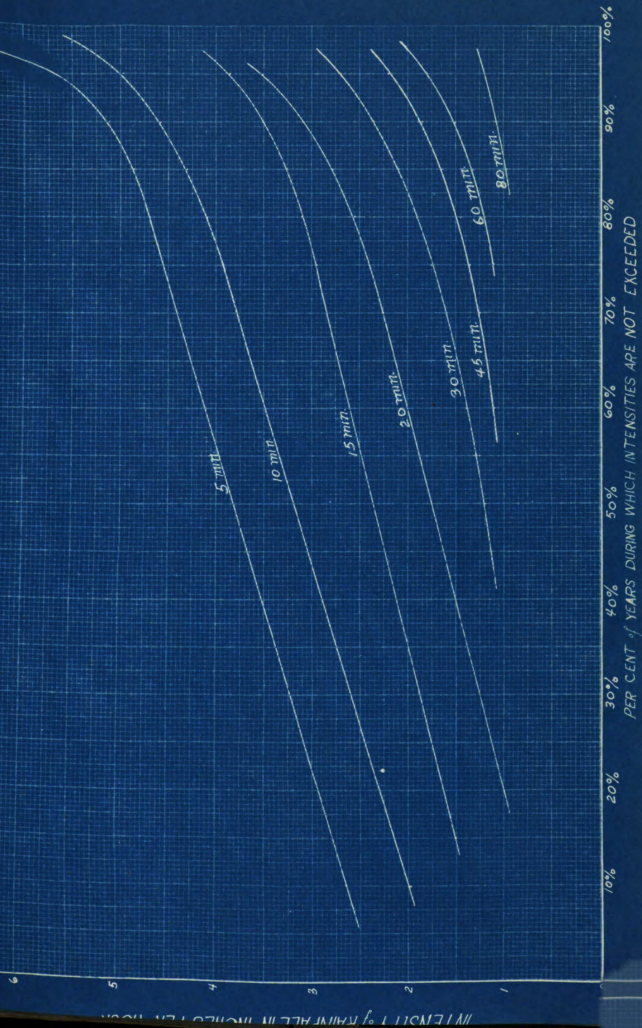
1910-1936

| Station | 5 min. | 10 min. | 15 min. | 20 min. | 25 min. | 30 min. | 35 min. | 40 min. | 45 min. | 50 min. | 60 min. | 90 min. | 120 min. |
|------------|--------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|
| Detroit | 5.28 | 5.40 | 5.88 | 5.45 | 5.48 | 4.08 | 3.92 | 3.66 | 3.44 | 2.61 | 2.56 | 1.93 | |
| E. Lansing | 7.92 | 5.40 | 4.08 | 3.67 | | 3.02 | | | 2.53 | 2.06 | 1.21 | | |
| Gr. Rapids | 5.52 | 5.34 | 4.28 | 3.30 | | 2.58 | | | 1.81 | 1.58 | 1.26 | | |
| Gr. Haven | 5.04 | 4.08 | 3.48 | 2.37 | 2.88 | 2.86 | 2.04 | 2.19 | 1.96 | 1.34 | 1.01 | | |

PROBABILITY CHART FOR HAWAII - Fig. 1
 INTENSITIES IN DETERMINED
 (of from 5 to 80 min duration).



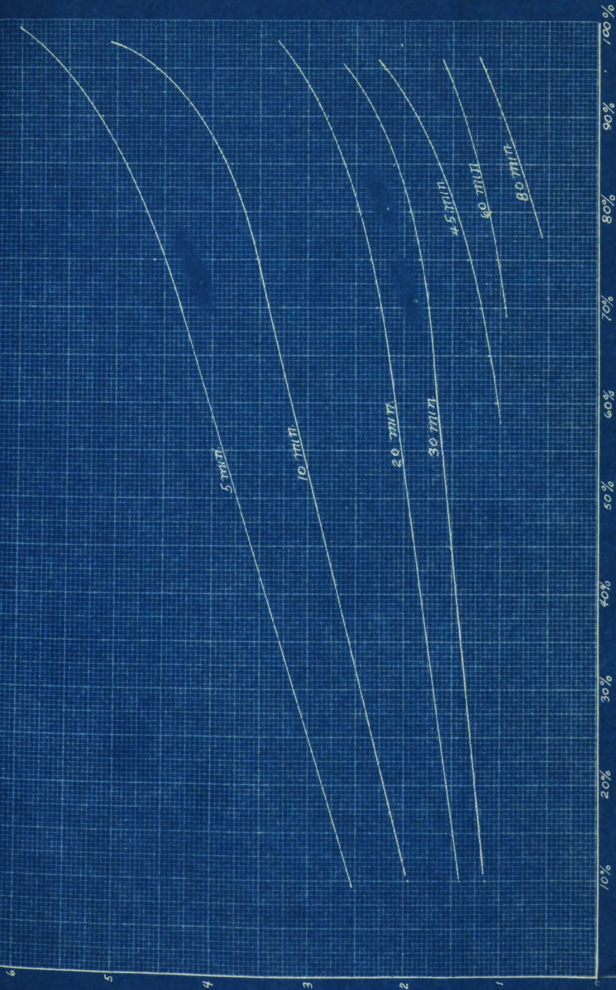
PROBABILITY CHART for RAINFALL INTENSITIES Fig. 8.2
in EAST LANSING, MICH.
(of from 5 to 80 mm duration)



PROBABILITY CHART FOR RAINFALL INTENSITIES - Fig. 1-2

IN Grand Rapids, Mich

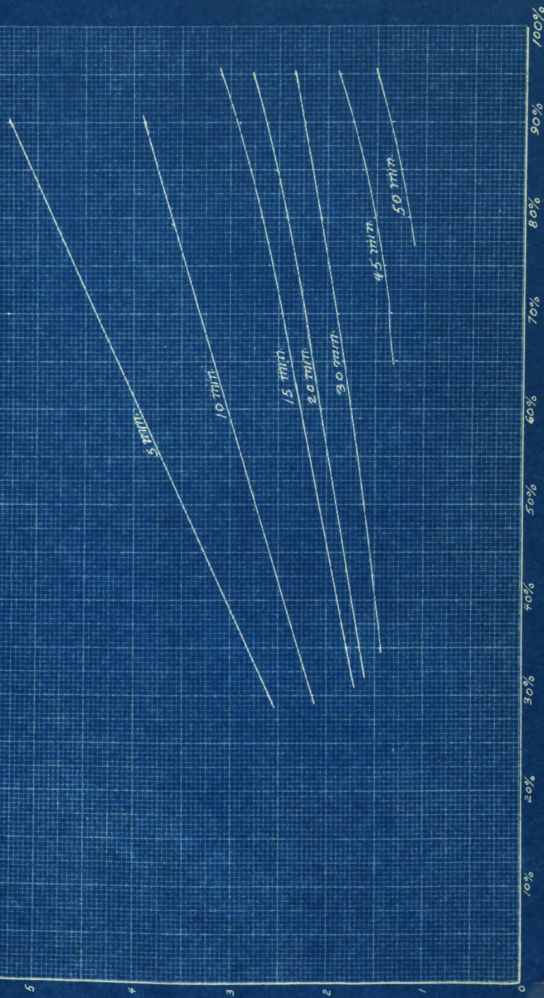
(of from 5 to 80 mm duration)



PER CENT OF YEARS DURING WHICH INTENSITIES ARE NOT EXCEEDED

PROBABILITY CHART for PINEALL INTENSITIES - Fig. 4-2
IN GRAND HAVEN, MICH.

(of from 5 to 80 mm duration)



PROBABILITY TABLE

Table VII

Precipitation in inches per hour to be equalled
or exceeded once in from 2 to 20 years

(Detroit, Mich)

| Period | 5 min. | 10 min. | 15 min. | 20 min. | 30 min. | 45 min. | 60 min. | 80 min. |
|--------|--------|---------|---------|---------|---------|---------|---------|---------|
| 2 | 3.7 | 3.1 | 2.45 | 2.05 | 1.45 | | | |
| 3 | 4.30 | 3.55 | 2.90 | 2.45 | 1.80 | .90 | | |
| 5 | 4.80 | 3.95 | 3.35 | 2.90 | 2.15 | 1.35 | .95 | .45 |
| 10 | 5.60 | 4.60 | 3.90 | 3.50 | 2.5 | 2.05 | 1.68 | 1.22 |
| 20 | 6.95 | 5.85 | 4.85 | 4.35 | 3.35 | 2.65 | 2.35 | 1.82 |

(East Lansing)

| Period | 5 min. | 10 min. | 15 min. | 20 min. | 30 min. | 45 min. | 60 min. | 80 min. |
|--------|--------|---------|---------|---------|---------|---------|---------|---------|
| 2 | 3.81 | 3.15 | 2.35 | 1.75 | 1.20 | | | |
| 3 | 4.32 | 3.68 | 2.78 | 2.15 | 1.50 | 1.20 | | |
| 5 | 4.71 | 4.10 | 3.10 | 2.55 | 1.90 | 1.45 | 1.20 | |
| 10 | 5.15 | 4.55 | 3.50 | 3.08 | 2.35 | 1.88 | 1.50 | 1.08 |
| 20 | 5.78 | 4.95 | 3.85 | 3.50 | 2.71 | 2.20 | 1.78 | 1.18 |

(Grand Rapids)

| Period | 5 min. | 10 min. | 15 min. | 20 min. | 30 min. | 45 min. | 60 min. | 80 min. |
|--------|--------|---------|---------|---------|---------|---------|---------|---------|
| 2 | 3.78 | 2.90 | 2.20 | 1.90 | 1.35 | | | |
| 3 | 4.30 | 3.30 | 2.58 | 2.20 | 1.68 | 1.05 | | |
| 5 | 4.72 | 3.65 | 2.92 | 2.48 | 2.00 | 1.35 | 1.1 | |
| 10 | 5.15 | 4.12 | 3.40 | 2.82 | 2.30 | 1.63 | 1.38 | .95 |
| 20 | 5.5 | 4.60 | 3.85 | 3.08 | 2.55 | 1.85 | 1.57 | 1.15 |

(Grand Haven)

| Period | 5 min. | 10 min. | 15 min. | 20 min. | 30 min. | 45 min. | 60 min. | 80 min. |
|--------|--------|---------|---------|---------|---------|---------|---------|---------|
| 2 | 3.5 | 2.72 | 2.10 | 1.90 | 1.62 | | | |
| 3 | 4.18 | 3.20 | 2.42 | 2.18 | 1.88 | 1.30 | | |
| 5 | 4.82 | 3.60 | 2.68 | 2.42 | 2.05 | 1.52 | | |
| 10 | 5.30 | 3.90 | 2.90 | 2.62 | 2.22 | 1.75 | | |
| 20 | 5.50 | 4.05 | 3.10 | 2.75 | 2.35 | 1.85 | | |

Fig. 5. EXPECTED STORM INTENSITIES (g) from 5 to 80 mph (g) duration
For Period Years as shown

Detroit, Mich.

INTENSITY IN INCHES PER HOUR

PERIOD OF YEARS IN MINUTES
DOWN PAUSE

20 YR

10 YR

5 YR

3 YR

1 YR

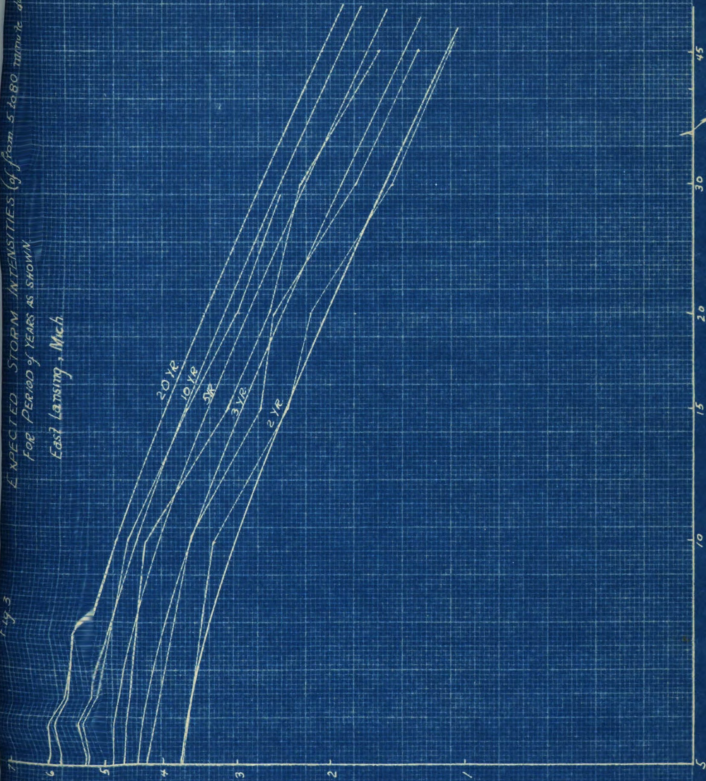
Fig 3

EXPECTED STORM INTENSITIES (of from 5 to 80 minutes duration)
FOR PERIODS OF YEARS AS SHOWN
East Lansing, Mich

INTENSITY IN INCHES PER HOUR

PERIOD OF DOWNPOUR IN MINUTES

20 yr
10 yr
5 yr
3 yr
2 yr



FN 193

EXPECTED STORM INTENSITIES (from 5.0 to 4.5 minute duration)
FOR PERIOD OF YEARS AS SHOWN
GRAND PRAIRIES, MICH.

INTENSITY IN INCHES PER HOUR

PERIOD of DOWNPOUR IN MINUTES

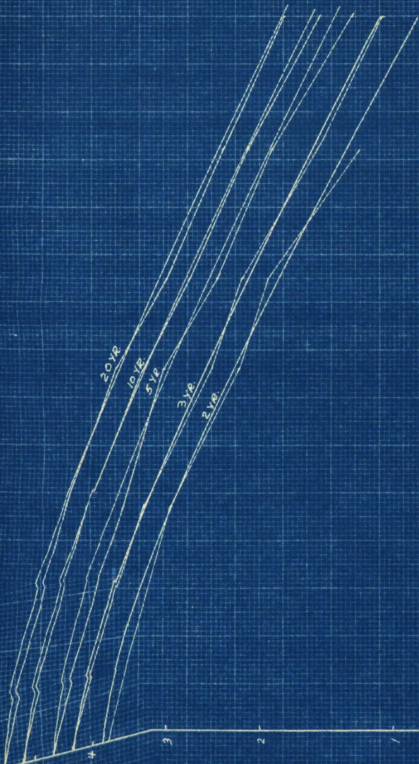


Fig. 5. 8 EXPECTED STORM INTENSITIES (of from 5 to 40 duration)
for Periods or Years as shown
Grand Haven, Mich.

INTENSITY IN INCHES PER HOUR

PERIOD of DOWNPOUR IN MINUTES

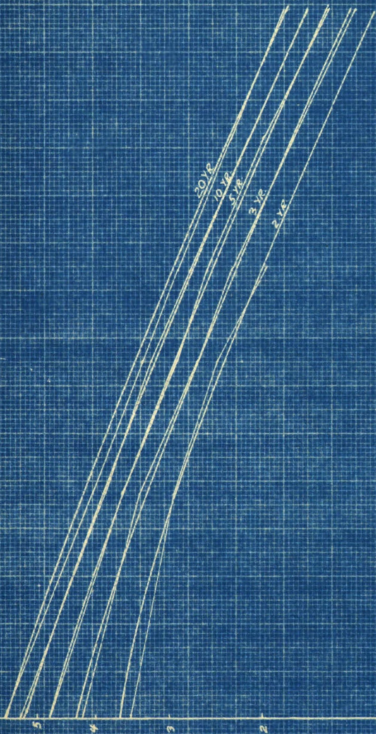


Table VIII

Summary of Maximum Average Rain Intensity

Detroit

No. Exceed-

ance 5 min. 10 min. 15 min. 20 min. 25 min. 30 min. 35 min. 40 min. 45 min. 50 min. 60 min. 80 min. 100 min. 120 min
Interval.

| | | | | | | | | | | | | | | | |
|----------|------|------|-------|-------|-------|------|-------|-------|------|-------|------|------|------|------|------|
| 1 | 27 | 5.28 | 5.40 | 5.66 | 5.45 | 5.48 | 4.08 | 5.92 | 5.66 | 5.44 | 5.12 | 2.61 | 2.56 | 2.27 | 1.95 |
| 2 | 15.5 | 5.16 | 4.86 | 5.84 | 5.06 | 2.88 | 2.52 | 2.21 | 2.90 | 2.10 | 2.06 | 1.70 | 1.49 | | |
| 3 | 9 | 4.80 | 4.56 | 5.80 | 5.05 | 2.59 | 2.50 | 2.14 | 2.09 | 1.74 | 1.67 | 1.15 | | | |
| 4 | 6.75 | 4.68 | 4.50 | 5.60 | 2.97 | 2.58 | 1.98 | 2.11 | 1.95 | 1.55 | 1.48 | 1.14 | | | |
| 5 | 5.4 | 4.08 | 5.66 | 5.24 | 2.79 | 2.42 | 1.96 | 1.85 | 1.85 | 1.52 | 1.25 | 1.07 | | | |
| 6 | 4.5 | 4.08 | 5.24 | 5.00 | 2.75 | 2.40 | 1.88 | 1.68 | 1.70 | 1.14 | 1.19 | 1.05 | | | |
| 7 | 3.8 | 5.96 | 5.18 | 2.86 | 2.46 | 2.28 | 1.80 | 1.42 | 1.41 | 1.10 | 1.07 | .97 | | | |
| 8 | 3.4 | 5.96 | 5.12 | 2.80 | 2.51 | 2.04 | 1.72 | 1.57 | 1.22 | 1.05 | 1.04 | .96 | | | |
| 9 | 3 | 5.84 | 5.00 | 2.72 | 2.19 | 1.99 | 1.66 | 1.57 | 1.16 | .88 | .90 | .81 | | | |
| 10 | 2.7 | 5.48 | 2.94 | 2.44 | 2.19 | 1.97 | 1.54 | 1.50 | 1.11 | | | .58 | | | |
| 5 mean 9 | 4.80 | 4.59 | 5.67 | 5.06 | 2.79 | 2.6 | 2.44 | 2.52 | 2.52 | 2.065 | 1.91 | 1.55 | 2.02 | 2.27 | 1.95 |
| 8 " | 5.4 | 5.86 | 5.10 | 2.77 | 2.57 | 2.15 | 1.804 | 1.42 | 1.32 | 1.044 | 1.05 | .87 | | | |
| 15 " | 2.07 | 5.28 | 2.48 | 2.208 | 1.908 | 1.76 | 1.58 | 1.067 | .895 | | | .54 | | | |
| 18 " | 1.5 | 2.6 | 2.24 | 1.76 | 1.67 | 1.57 | 1.076 | | | | | | | | |
| 25 " | 1.18 | 2.25 | 2.028 | 1.52 | 1.52 | 1.16 | .8 | | | | | | | | |
| 28 " | .968 | 1.94 | 1.88 | 1.59 | 1.02 | 1.00 | .24 | | | | | | | | |

Detroit

Exceed-

No. since 5 min. 10 min. 15 min. 20 min. 25 min. 30 min. 35 min. 40 min. 45 min. 50 min. 60 min. 80 min. 100 min. 120 min.
Interval

| | | | | | | |
|----|------|-----|-------|------|------|-----|
| 53 | mean | .82 | 1.62 | 1.76 | 1.18 | .75 |
| 58 | " | .71 | 1.32 | 1.48 | .808 | |
| 43 | " | .63 | 1.104 | 1.12 | | |
| 48 | " | .56 | .98 | .82 | | |
| 53 | " | .51 | .78 | .62 | | |
| 58 | " | .47 | .48 | .45 | | |

Exceed-

No. 5 min. 10 min. 15 min. 20 min. 25 min. 30 min. 35 min. 40 min. 45 min. 50 min. 55 min. 60 min. 65 min.

Interval

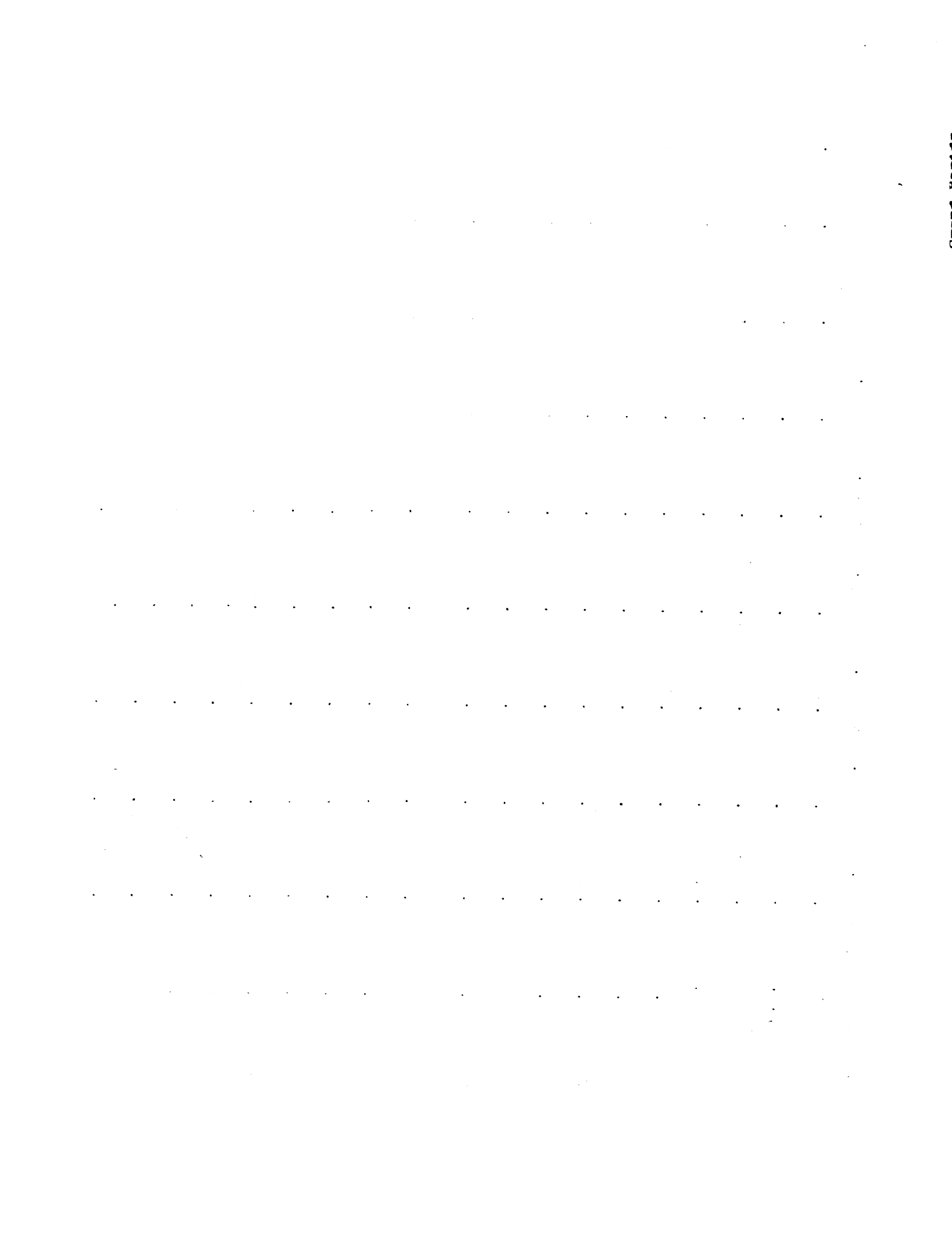
| | | | | | | | | | | | | |
|--------|------|------|-------|------|-------|-------|------|------|------|--|--|--|
| 1 | 26 | 7.92 | 5.40 | 4.08 | 3.87 | 3.02 | 2.53 | 2.06 | 1.21 | | | |
| 2 | 13 | 5.04 | 4.92 | 4.00 | 3.36 | 2.58 | 2.01 | 1.54 | 1.16 | | | |
| 3 | 8.66 | 4.92 | 4.56 | 3.60 | 3.12 | 2.42 | 1.85 | 1.53 | 1.16 | | | |
| 4 | 6.5 | 4.92 | 4.38 | 3.56 | 3.03 | 2.42 | 1.85 | 1.53 | 1.13 | | | |
| 5 | 5.2 | 4.80 | 4.20 | 3.32 | 3.00 | 2.20 | 1.83 | 1.47 | 1.10 | | | |
| 6 | 4.3 | 4.80 | 4.02 | 3.16 | 2.79 | 1.92 | 1.71 | 1.32 | .96 | | | |
| 7 | 3.7 | 4.68 | 3.72 | 3.16 | 2.79 | 1.90 | 1.68 | 1.32 | .80 | | | |
| 8 | 3.25 | 4.56 | 3.66 | 2.84 | 2.61 | 1.90 | 1.64 | 1.13 | .75 | | | |
| 9 | 2.90 | 4.56 | 3.42 | 2.84 | 2.61 | 1.88 | 1.51 | 1.04 | .74 | | | |
| 10 | 2.6 | 4.44 | 3.36 | 2.80 | 2.58 | 1.82 | 1.51 | .98 | .53 | | | |
| 3 mean | 6.66 | 3.52 | 4.69 | 3.71 | 3.27 | 2.52 | 2.01 | 1.62 | 1.15 | | | |
| 8 " | 3.25 | 4.6 | 3.66 | 2.96 | 2.67 | 2.26 | 1.57 | 1.15 | .75 | | | |
| 13 " | 2 | 4.24 | 3.33 | 2.68 | 2.13 | 1.504 | 1.24 | .68 | .44 | | | |
| 18 " | 1.44 | 3.8 | 3.104 | 2.43 | 1.85 | 1.29 | | | | | | |
| 23 " | 1.13 | 3.68 | 2.83 | 2.19 | 1.63 | 1.13 | | | | | | |
| 28 " | .93 | 3.4 | 2.66 | 1.98 | 1.53 | .97 | | | | | | |
| 33 " | .79 | 3.33 | 2.52 | 1.85 | 1.45 | .84 | | | | | | |
| 38 " | .68 | 3.24 | 2.36 | 1.80 | 1.308 | | | | | | | |

East Lansing

| No. | Exceed-
ance | Interval |
|-------|-----------------|-------------------------------|
| 48 m. | .60 | 3.07 2.28 1.69 1.24 |
| 48 " | .54 | 2.85 2.16 1.64 1.18 |
| 53 " | .49 | 2.68 2.088 1.55 1.04 |
| 45 " | .45 | 2.49 1.98 1.51 |
| 65 " | .41 | 2.40 1.92 1.46 |
| 68 " | .38 | 2.25 1.85 1.404 |
| 73 " | .35 | 2.04 1.72 1.26 |
| 78 " | .33 | 1.94 1.54 1.12 |
| 83 " | .31 | 1.82 1.35 |
| 88 " | .30 | 1.51 |
| 93 " | .28 | |
| 98 " | .26 | |
| 103 " | .25 | |

Grand Rapids

| Exceedance | | | | | | | | | | | |
|------------|----------|--------|---------|---------|---------|---------|---------|---------|---------|----------|--|
| No. | Interval | 5 min. | 10 min. | 15 min. | 20 min. | 30 min. | 45 min. | 60 min. | 80 min. | 120 min. | |
| 1 | 27 | 7.80 | 5.34 | 4.96 | 4.85 | 3.68 | 2.58 | 1.58 | 1.26 | 1.59 | |
| 2 | 13.5 | 5.76 | 5.04 | 4.40 | 3.93 | 3.42 | 2.38 | 1.55 | 1.23 | .46 | |
| 3 | 9 | 5.76 | 4.74 | 4.28 | 3.50 | 3.02 | 1.93 | 1.49 | 1.16 | .38 | |
| 4 | 6.75 | 5.28 | 4.44 | 3.48 | 3.15 | 2.58 | 1.81 | 1.48 | 1.03 | .33 | |
| 5 | 5.4 | 5.04 | 4.32 | 3.44 | 2.97 | 2.34 | 1.79 | 1.39 | 1.02 | .11 | |
| 6 | 4.5 | 4.92 | 4.14 | 3.32 | 2.85 | 2.28 | 1.75 | 1.36 | .98 | .10 | |
| 7 | 3.8 | 4.80 | 4.02 | 3.28 | 2.73 | 2.28 | 1.68 | 1.29 | .87 | .09 | |
| 8 | 3.4 | 4.80 | 3.78 | 3.20 | 2.61 | 2.24 | 1.61 | 1.18 | .76 | .08 | |
| 9 | 3 | 4.68 | 3.72 | 3.12 | 2.55 | 2.24 | 1.53 | 1.15 | .68 | .07 | |
| 10 | 2.7 | 4.68 | 3.60 | 2.88 | 2.55 | 2.04 | 1.41 | 1.13 | .64 | | |
| 3 Mean | 9 | 5.92 | 4.77 | 4.09 | 3.63 | 3.46 | 2.09 | 1.49 | 1.14 | .37 | |
| 8 " | 3.4 | 4.77 | 3.85 | 3.16 | 2.65 | 2.11 | 1.59 | 1.22 | .78 | .10 | |
| 13 " | 2.07 | 4.44 | 3.30 | 2.66 | 2.31 | 1.81 | 1.13 | 1.02 | .53 | .075 | |
| 18 " | 1.5 | 3.33 | 3.01 | 2.48 | 2.22 | 1.84 | 1.03 | .81 | .34 | | |
| 23 " | 1.18 | 3.67 | 2.89 | 2.36 | 2.08 | 1.51 | .93 | .61 | .26 | | |
| 28 " | .968 | 3.55 | 2.77 | 2.11 | 1.98 | 1.46 | .85 | .46 | | | |
| 33 " | .82 | 3.48 | 2.71 | 2.01 | 1.84 | 1.35 | .55 | .29 | | | |
| 38 " | .71 | 3.36 | 2.57 | 1.96 | 1.77 | 1.23 | .25 | .14 | | | |
| 43 " | .63 | 3.12 | 2.41 | 1.88 | 1.68 | 1.16 | .13 | .08 | | | |



Grand Rapids

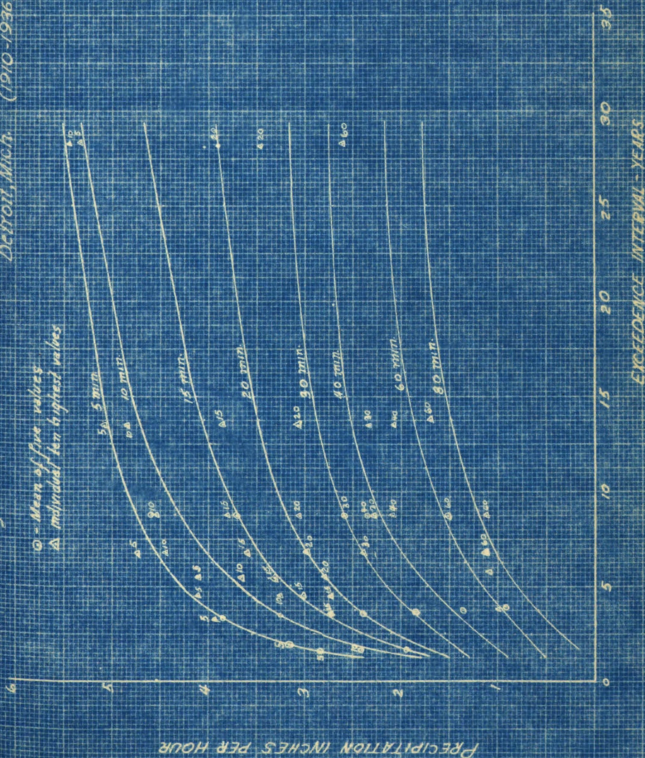
| No. | Exceedance | | Interval | | | | | | |
|---------|------------|---------|----------|---------|---------|---------|---------|---------|----------|
| | 5 min. | 10 min. | 15 min. | 20 min. | 30 min. | 45 min. | 60 min. | 80 min. | 120 min. |
| 48 mean | .56 | 3.02 | 2.54 | 1.82 | 1.62 | 1.08 | | | |
| 53 " | .51 | 3.00 | 2.29 | 1.80 | 1.54 | 1.01 | | | |
| 58 " | .47 | 2.97 | 2.28 | 1.75 | 1.47 | .95 | | | |
| 63 " | .43 | 2.78 | 2.28 | 1.72 | 1.43 | .78 | | | |
| 68 " | .40 | 2.69 | 2.18 | 1.64 | 1. | .43 | | | |
| 73 " | .37 | 2.54 | 2.18 | 1.59 | 1.38 | .17 | | | |
| 78 " | .35 | 2.47 | 2.11 | 1.56 | 1.33 | .10 | | | |
| 83 " | .33 | 2.40 | 2.06 | 1.53 | 1.29 | | | | |
| 88 " | .31 | 2.40 | 2.04 | 1.49 | 1.21 | | | | |
| 93 " | .29 | 2.40 | 1.99 | 1.45 | 1.13 | | | | |
| 98 " | .28 | 2.28 | 1.95 | 1.44 | 1.02 | | | | |
| 103 " | .26 | 2.23 | 1.92 | 1.43 | .57 | | | | |
| | | 2.16 | 1.82 | 1.40 | .19 | | | | |
| | | 2.11 | 1.86 | 1.32 | .075 | | | | |
| | | 2.01 | 1.80 | 1.16 | | | | | |
| | | 1.92 | 1.80 | .65 | | | | | |
| | | 1.80 | 1.73 | .22 | | | | | |
| | | 1.68 | 1.67 | .08 | | | | | |
| | | 1.39 | 1.55 | | | | | | |
| | .45 | 1.48 | 1.48 | | | | | | |
| | .28 | 1.2 | .45 | | | | | | |
| | | | .21 | | | | | | |

Exordance

Exceedance
No. Interval 5 min. 10 min. 15 min. 20 min. 25 min. 30 min. 35 min. 40 min. 45 min. 50 min. 55 min. 60 min.

| | | | | |
|---------|------|------|------|------|
| 48 Mean | .36 | 2.11 | 1.63 | 1.56 |
| 53 " | .52 | 1.69 | 1.77 | 1.17 |
| 56 " | .292 | 1.70 | 1.68 | .72 |
| 63 " | .270 | 1.51 | 1.52 | |
| 66 " | .250 | 1.08 | 1.26 | |
| 73 " | .232 | | | |
| 76 " | .216 | | | |
| 83 " | .205 | | | |
| 86 " | .194 | | | |
| 93 " | .176 | | | |
| 96 " | .169 | | | |
| 103 " | .165 | | | |

FIG. 4 FREQUENCY CURVES OF EXCESSIVE RAINFALLS
 Detroit, Mich. (1910-1936)



781016-19-20-21-22-23-24-25-26-27-28-29-30-31-32-33

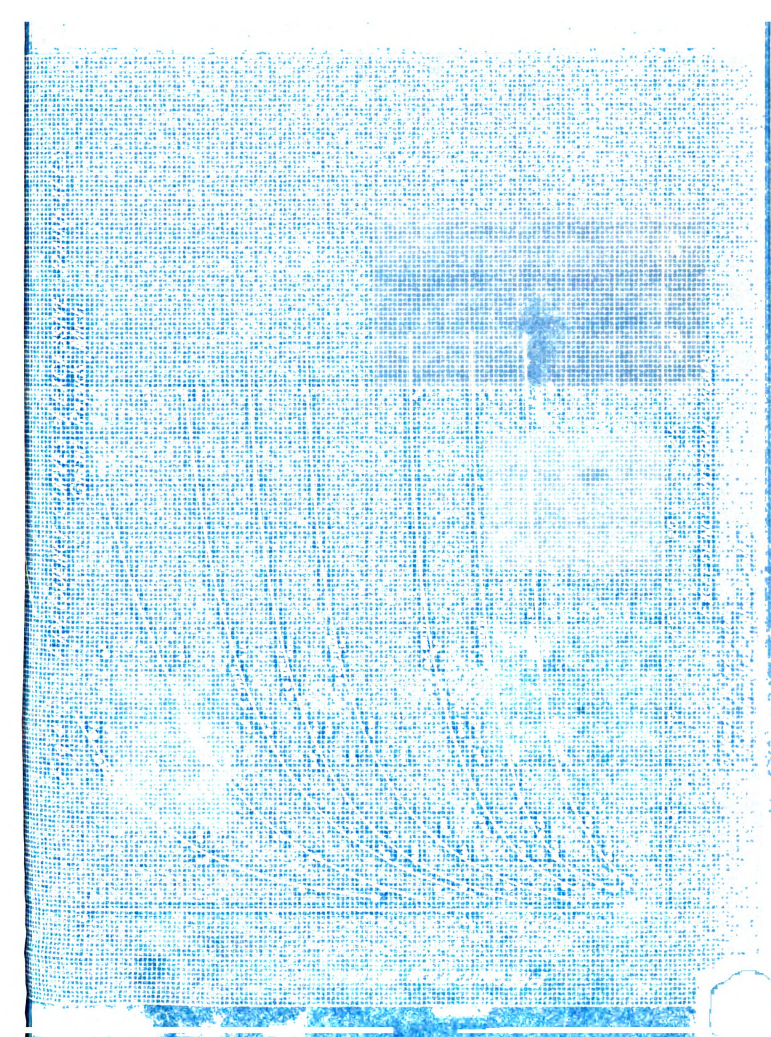
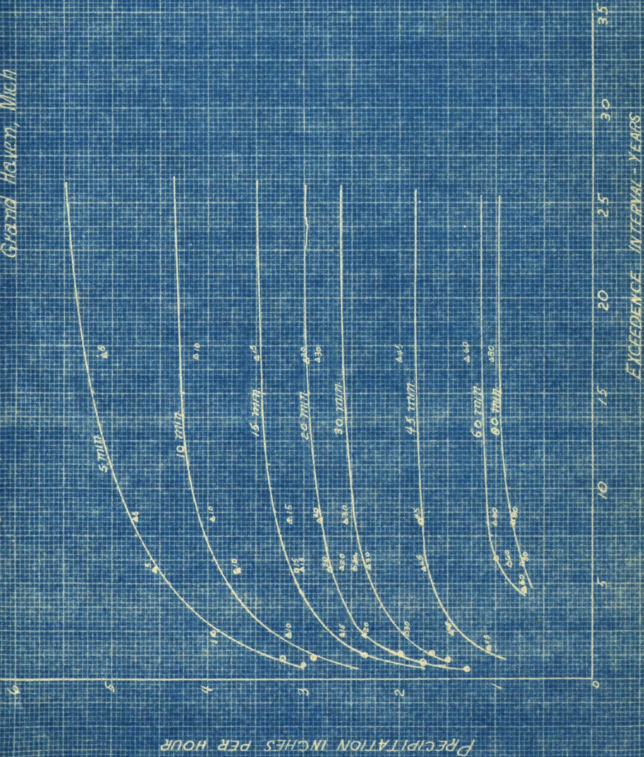


FIG 4 FREQUENCY CURVES OF EXCESSIVE RAINFALLS
Grand Haven, Mich



○ Mean of five values
△ Individual ten highest values

Table IX Annual Maximum Precipitation Rate Detroit
 Arranged According to Intensities

| 5 min. Rate
Inches | Rates in terms
of Mean | Variation
from Mean = V | V ² | V ³ |
|-----------------------|---------------------------|----------------------------|----------------|----------------|
| .78 | 2.50 | 1.50 | 2.25 | 3.39 |
| .55 | 1.77 | .77 | .59 | .46 |
| .47 | 1.51 | .51 | .26 | .33 |
| .43 | 1.38 | .38 | .144 | .055 |
| .43 | 1.38 | .38 | .144 | .055 |
| .42 | 1.35 | .35 | .122 | .043 |
| .40 | 1.28 | .28 | .0782 | .022 |
| .38 | 1.22 | .22 | .0484 | .0107 |
| .36 | 1.15 | .15 | .0225 | .00339 |
| .34 | 1.09 | .09 | .0081 | .000735 |
| .34 | 1.09 | .09 | .0081 | .000735 |
| .32 | 1.03 | .03 | .0009 | .000027 |
| .32 | 1.03 | .03 | .0009 | .000027 |
| .32 | 1.03 | .03 | .0009 | .000027 |
| .29 | .93 | .07 | .0049 | .000345 |
| .29 | .93 | .07 | .0049 | .000345 |
| .28 | .90 | .10 | .01 | .0010 |
| .25 | .81 | .19 | .0361 | .00685 |
| .24 | .77 | .23 | .053 | .0122 |
| .24 | .77 | .23 | .053 | .0122 |
| .23 | .74 | .26 | .0676 | .0176 |
| .23 | .74 | .26 | .0676 | .0176 |
| .22 | .71 | .29 | .0840 | .0245 |
| .21 | .68 | .32 | .102 | .0327 |
| .15 | .48 | .52 | .27 | .1410 |
| .13 | .42 | .58 | .336 | .195 |
| .13 | .42 | .58 | .336 | .195 |

$$\bar{x} = .311 \text{ rate} = 3.732''/\text{hr.} \quad +4.90 \quad -3.70 \quad \Sigma V^2 = 5.103 \quad \Sigma V^3 = 3.5176$$

$$CV = \sqrt{\frac{\Sigma V^2}{n-1}} = \sqrt{\frac{5.103}{26}} = .442 \quad CS = \frac{\Sigma V^3}{(n-1)(CV)^3} = \frac{3.5176}{26 \times .442^3} = 1.566$$

| 5 min.
Inches | Rate in terms
of Mean | Variation from
Mean = V | East Lansing | |
|------------------|--------------------------|----------------------------|----------------|----------------|
| | | | v ² | v ³ |
| .66 | .21 | 1.1 | 1.21 | 1.33 |
| .42 | 1.3 | .3 | .09 | .027 |
| .41 | 1.27 | .27 | .073 | .0197 |
| .41 | 1.27 | .27 | .073 | .0197 |
| .40 | 1.24 | .24 | .0575 | .0138 |
| .39 | 1.21 | .21 | .044 | .0093 |
| .38 | 1.18 | .18 | .0324 | .00585 |
| .37 | 1.15 | .15 | .0225 | .00338 |
| .36 | 1.12 | .12 | .0144 | .001728 |
| .35 | 1.08 | .08 | .0064 | .000516 |
| .35 | 1.08 | .08 | .0064 | .000516 |
| .33 | 1.02 | .02 | .0004 | .000008 |
| .32 | .995 | .005 | .000025 | .000000005 |
| .31 | .96 | .04 | .0016 | .000064 |
| .31 | .96 | .04 | .0016 | .000064 |
| .29 | .90 | .10 | .01 | .001 |
| .29 | .90 | .10 | .01 | .001 |
| .28 | .87 | .13 | .0169 | .0022 |
| .28 | .87 | .13 | .0169 | .0022 |
| .27 | .84 | .16 | .0256 | .0041 |
| .26 | .81 | .19 | .0361 | .0069 |
| .24 | .75 | .25 | .0625 | .015600 |
| .21 | .65 | .35 | .122 | .0430 |
| .16 | .50 | .50 | .250 | .125 |

$\bar{x} = .322$
Mean Rate/hr. = 3.864

+3.02 -1.9950 ~~EV~~² = 2.1832 ~~EV~~³ = 1.23039

$$C_v = \sqrt{\frac{\sum v^2}{n-1}} = \sqrt{\frac{2.1832}{23}} = .3807 \quad C_s = \frac{\sum v^3}{(n-1)(C_v)^3} = \frac{1.23039}{23 \times .0551} = .97$$

Grand Rapids

| 5 min.
Inches | Rate in Terms
of Mean | Variation from
Mean = V | v^2 | v^3 |
|------------------|--------------------------|----------------------------|-------|---------|
| .48 | 1.6 | .60 | .36 | .216 |
| .46 | 1.49 | .49 | .24 | .118 |
| .42 | 1.36 | .36 | .129 | .0469 |
| .41 | 1.33 | .33 | .109 | .0360 |
| .40 | 1.29 | .29 | .084 | .0245 |
| .39 | 1.26 | .26 | .0675 | .0176 |
| .39 | 1.26 | .26 | .0675 | .0176 |
| .38 | 1.23 | .23 | .0530 | .0122 |
| .35 | 1.13 | .13 | .0169 | .0022 |
| .33 | 1.07 | .07 | .0049 | .000344 |
| .33 | 1.07 | .07 | .0049 | .000344 |
| .32 | 1.03 | .03 | .0009 | .000027 |
| .31 | 1.0 | .00 | .00 | .00 |
| .30 | .97 | .03 | .0009 | .000027 |
| .30 | .97 | .03 | .0009 | .000027 |
| .30 | .97 | .03 | .0009 | .000027 |
| .29 | .94 | .06 | .0036 | .000216 |
| .29 | .94 | .06 | .0036 | .000216 |
| .26 | .84 | .16 | .0256 | .004100 |
| .25 | .81 | .19 | .0361 | .00688 |
| .25 | .81 | .19 | .0361 | .00688 |
| .25 | .81 | .19 | .0361 | .00688 |
| .24 | .78 | .22 | .0485 | .01065 |
| .23 | .74 | .26 | .0675 | .0177 |
| .22 | .71 | .29 | .084 | .0244 |
| .21 | .68 | .32 | .102 | .0327 |

$\bar{x} = 3.19$
Mean rate per hour = 3.828

+3.120 -2.03 $\sum v^2 = 1.5834$ $\sum v^3 = .3810$

$$C_v = \sqrt{\frac{\sum v^2}{n-1}} = \sqrt{\frac{1.5834}{25}} = .255$$

$$C_s = \frac{\sum v^3}{(n-1)(C_v)^3} = \frac{.3810}{25 \times .0166} = .919$$

Grand Haven

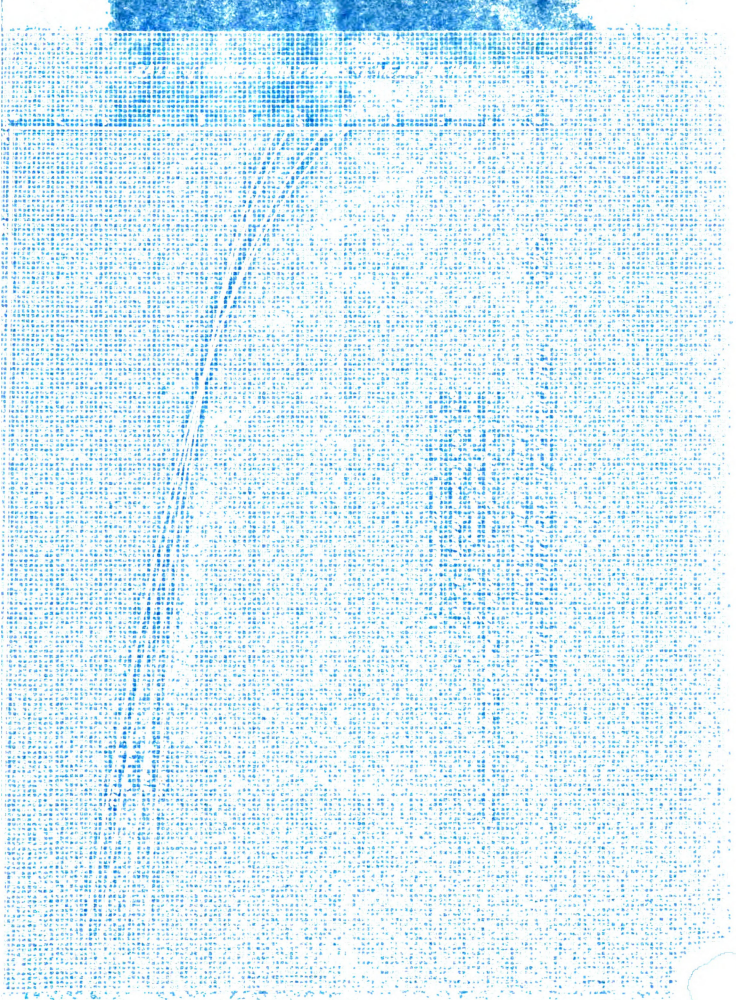
| 5 min.
Inches | Rate in Terms
of Mean | Variation from
Mean = V | V ² | V ³ |
|------------------|--------------------------|----------------------------|----------------|----------------|
| .42 | 1.41 | .41 | .168 | .069 |
| .42 | 1.41 | .41 | .168 | .069 |
| .42 | 1.41 | .41 | .168 | .069 |
| .40 | 1.35 | .35 | .122 | .043 |
| .38 | 1.28 | .28 | .0785 | .022 |
| .35 | 1.18 | .18 | .0325 | .00585 |
| .34 | 1.15 | .15 | .0225 | .00339 |
| .31 | 1.05 | .05 | .0025 | .000125 |
| .27 | .91 | .09 | .0081 | .00073 |
| .27 | .91 | .09 | .0081 | .00073 |
| .26 | .88 | .12 | .0144 | .001728 |
| .25 | .85 | .15 | .0225 | .003390 |
| .18 | .61 | .39 | .0152 | .0595 |
| .17 | .575 | .425 | .182 | .0770 |

$$\bar{X} = .296$$

Mean rate/hr. = 3.553 in.

$$+2.24 \quad -1.265 \quad \sum V^2 = 1.149 \quad \sum V^3 = .138287$$

$$C_v = \sqrt{\frac{\sum V^2}{n-1}} = \sqrt{\frac{1.149}{13}} = .297 \quad C_s = \frac{\sum V^3}{(n-1)(C_v)^3} = \frac{.138287}{13 \times .297^3} = .406$$



Acknowledgment

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Likewise, I wish to thank the operators of the U. S. Weather Bureau stations at Detroit, East Lansing, Grand Rapids, and Grand Haven, Michigan for their invaluable cooperation in supplying necessary data.

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at Detroit, East Lansing,
Grand Rapids, and Grand Haven

Maximum Rates of Precipitation at Each Station (Arrangement) -
See Table III - U. S. D. A. Bulletin #204

Tabulation of Most Intense Storms at Each Station (Arrangement) -
See Table I - U. S. D. A. Bulletin #204

Probability Chart - see Fig. 3, E. M. R.; Vol. 83, p. 870

Probability Table - Table VI, E. M. R.; Vol. 80, p. 870

Curve of Expected Storm Intensities - Fig. 4, E. M. R.; Vol. 80, p. 870

Summary of Maximum Average - see Table III, p. 9 of Horton's Reprint Article
Rain Intensities

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