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Bermuda Meteorological Station

No. 1 ← also see No. 8

The Rainfall and Water Supply of Bermuda

By

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CONTENTS

1. INTRODUCTION

Bermuda is situated near latitude 32° N longitude 65° W at a distance of 570 miles East-South-East of the nearest land, Cape Hatteras, North Carolina.

A majority of the cold fronts which move South and East off the American coast reach Bermuda during the winter and although modified by the Gulf Stream are often quite intense in all their frontal characteristics. During the summer fewer reach Bermuda as many are stopped by the Westward extension of the Azores-Bermuda anticyclone, and those which do reach the colony are often much more clearly marked by rain and cloud than by pressure changes or strong winds.

At all seasons of the year most of the rain which falls is associated with these frontal systems, although Tropical Disturbances and local thunder-storms occasionally give heavy falls. Extended wet periods are usually due to fronts lying almost stationary over Bermuda, often with a succession of waves forming to the South-West and moving across the Islands.

The Islands average less than one mile wide and are nowhere more than two miles across. Most of the land lies at less than 100 feet above M.S.L. with the highest points at less than 300 feet. There is therefore no large scale orographic effect on rainfall, and the results for Bermuda may be considered as fairly representative of the surrounding ocean.

The soil and subsurface layers are both extremely porous and rain water rapidly soaks back to sea level. There are consequently no fresh water streams or lakes, although a brackish water is obtained in places by sinking wells to tap the top layers of ground water. For this reason all fresh water must be obtained by collecting rain in special catchments, usually on the roof, and storing it in tanks. An essential feature in any building scheme therefore is the installation of adequate catchments and storage tanks, for the design of which an exact knowledge of the amount and distribution of rainfall is necessary.

With the end of 1942, ten years of rainfall records at the Meteorological Office, Fort George, were completed, and the records for the previous official station extend back to 1891, so that a total of 52 years of records is available. It is the purpose of this paper to present and discuss all the data available for this period.

2. SOURCES OF DATA

After considering all the records available, it was decided to use only those taken under some form of official supervision. The data given in this paper is therefore based on the following two sets of observations which cover the fifty-two years from 1891 to 1942:

(a) At Prospect Camp from January 1891 to 30th April 1932.
(b) At Fort George from 1st May 1932 to 31st December 1942.

Before 1890 no regular official records were kept, except occasionally by army and navy authorities. Different private persons made observations mainly for short periods, and some of the figures were published in Bermuda Blue Books and elsewhere.

It has not been possible to obtain any of these original records and only general information about the sites. In view of the unreliability detected in later Blue Book records it seemed better to use only original records and consequently none of these earlier observations have been used in calculating mean values.

Observations at Prospect Camp were begun by the R.A.M.C. during November 1890, at the request of the Canadian Meteorological Service, to whom the observer's original daily reports were forwarded. These original records have been returned to this office by courtesy of Dr. J. Patterson, Controller of the Canadian Meteorological Service, and are the source for the period 1891-1932, except for the two years 1920 and 1921. The original records for these two years are missing and the summarised figures published in the Canadian Meteorological records were used. The original records give the actual amounts recorded at two observations per day. The times of observation were usually twelve hours apart, being mainly 8 a.m. and 8 p.m., but at different periods other times, between 7.30 and 9 o'clock, were used. From these figures daily totals have been recalculated as sum of evening reading on date and morning reading on following day. In the summarised records available for 1920 and 1921 only one daily value is given for the twenty-four hours up to 8 p.m. on the day in question.

The Meteorological Station at Fort George was opened early in 1932 and rainfall observations were begun on 1st May. The Prospect observations were continued for another twelve months for the purpose of comparison, but from 1st May 1932 all the official records have been made at Fort George.

The original station records give hourly values from an automatic recorder and check observations at 8 a.m. and 8 p.m. Daily totals are counted from 8 a.m. on date to 8 a.m. the following day.

These observations are all made in millimetres, and for the purpose of this paper, the necessary conversions were made to inches.

Other records which are available, but have not been used in calculating means are:

(1) Observations stated to be for Ireland Island for the years 1852 to 1862 and published in the Bermuda Almanac, which gives monthly totals only. Nothing whatever is known of the conditions under which these records were taken, but they are assumed to give some indication of the variations through these years, and are used in section 15.

(2) Observations made at "Highwood," Paget, by Mr. William Gosling from 1870 to 1896 and continued by someone else until the end of 1899. This gauge is understood to have been located some fifty feet to the West of the house on the slope of a hill which is now covered with cedar trees. I am told that making these observations was Mr. Gosling's main hobby, and we may assume they were carefully made and are consistent, unless the growth of cedars was gradually changing the exposure. The original records have not been found, but summaries of monthly values were published in the Bermuda Almanac. The annual totals from 1870 to 1890 have been used in section 15.

(3) Observations published in Bermuda Blue Books for the period from 1886 onwards, for a station "Hamilton" until 1908 and for Prospect thereafter. So far as can be ascertained, the Hamilton station was in the grounds of the Colonial Secretariat, but was badly equipped, and the readings were taken by untrained persons without supervision, so that the figures are quite unreliable. The Blue Book figures for Prospect were also found to have many mistakes when compared with the original records. It appears therefore that all of the records in the Blue Books prior to 1932 must be regarded as suspect, and no use whatever has been made of them in this paper.

3. SITES AND INSTRUMENTS

Prospect military camp is a mile North-East of Hamilton and covers a number of ridges from 100 to 150 feet above Sea Level. The observations were made by R.A.M.C. personnel and it is believed that the instruments were for most of the period installed near Observatory Cottage at the Southern end of the camp but were later moved to a site adjacent to the hospital at the northern end. No photograph or sketch of the instrument enclosures is available and no information as to the size and location of gauge used or when the move was made from one site to the other. Both Observatory Cottage and the Hospital are on the crest of a ridge and at the Hospital site the gauge was apparently somewhat shielded by buildings to the South-East.

The instrument enclosure at St. George is on the Western slope of Fort George Hill, some ten feet below the crest of the hill and twenty-five feet below the parapet of the fort, which is 100 feet from the enclosure. The gauges are at a height of 164 feet above Sea Level and, except on the side towards the Fort, the ground outside the enclosure falls away rapidly to sea level. The site is rather an exposed one, especially to the North and West, and a windbreak of cedars outside the enclosure is kept cut to about six or seven feet high. The standard gauge is 8 inches in diameter and of the Official British Meteorological Office pattern. The recording gauge is a Casella natural siphon with 8 inch opening.

4. ANNUAL FALL

Table 1 gives some of the chief data relative to the annual fall.

Average Fall	58.10 inches	–
Maximum Fall	87.64 inches, =	151% of average. Recorded in 1902
Minimum Fall	39.54 inches, =	68% of average. Recorded in 1911
Range of Fluctuation	83% of average	
Mean Deviation	6.67 inches	
Percentage Variability	11%	

TABLE 1. ANNUAL FALL.

The average of 58.10 inches is a considerable rainfall, and is approximately equal to that of the wettest places on the Eastern Seaboard of the United States.

The fluctuation of 83 per cent of the average between the recorded extremes is also noteworthy in view of the extent of the average fall, but even the absolute minimum of 39.54 inches provides ample water for any normal purpose and is, for instance, much greater than the average falls over most of England.

Table 2 gives the percentage of years in which the fall lay between specified limits, while the diagram, Figure 1, shows by means of a graduation curve the number of occasions on which the annual fall equalled or exceeded various amounts.

Fall	Percentage Frequency	Fall	Percentage Frequency	Fall	Percentage Frequency	Fall	Percentage Frequency
39<40	2	51<52	4	59<60	8	67<68	–
40<45	–	52<53	6	60<61	4	68<69	2
45<46	4	53<54	6	61<62	8	69<70	–
46<47	2	54<55	6	62<63	4	70<71	2
47<48	–	55<56	–	63<64	4	73<74	2
48<49	2	56<57	4	64<65	4	74<75	–
49<50	8	57<58	4	65<66	–	75<76	2
50<51	4	58<59	2	66<67	8	87<88	2

TABLE 2. Percentage frequency of years with total falls between different limits.

Both these show that the recorded absolute extremes are well separated from the main body of the observations, the maximum being especially well marked. We may reasonably assume, therefore, that these extremes will be rarely exceeded in the future. It can also be noted that exactly half the observations were less than, and half greater than, the mean. From the figures we may deduce the close approximation given in Table 3.

1 year in 10 has a fall less than 48 inches
3 years in 10 have a fall less than 54 inches
5 years in 10 have a fall less than 58 inches
7 years in 10 have a fall between 50 and 65 inches
9 years in 10 have a fall between 45 and 70 inches
5 years in 10 have a fall greater than 58 inches
3 years in 10 have a fall greater than 62 inches
1 year in 10 has a fall greater than 68 inches

TABLE 3. Frequency of occurrence of specified annual falls.

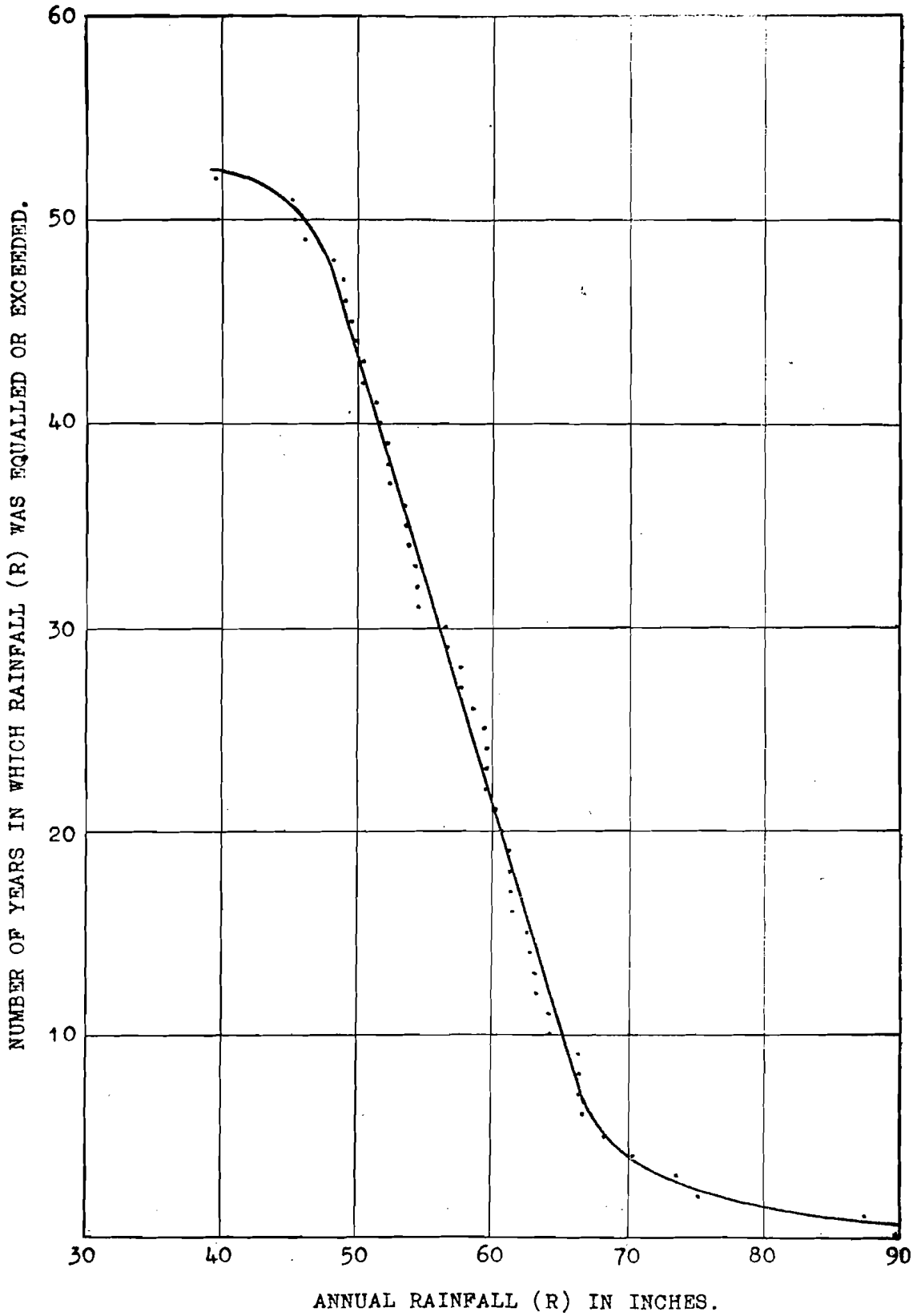

Fig.1. GRADUATION CURVE OF ANNUAL RAINFALL.

4.1 EXTREME FALLS IN SERIES OF CONSECUTIVE YEARS

The driest and wettest series of one to ten consecutive years are given in Table 4, and Figure 2 shows the percentage of normal which fell in the wettest and driest periods of from 1 to 50 years.

PERIOD	MAXIMUM			MINIMUM		
	Average Per Year	Per cent. of Normal	Occasion	Average Per Year	Per cent. of Normal	Occasion
1 year	87.64	151	1902	39.54	68	1911
2 years	75.15	129	1901-02	45.46	78	1911-12
3 years	72.35	125	1900-02	46.97	81	1911-13
4 years	69.59	120	1900-03	48.25	83	1910-13
5 years	67.24	116	1899-03	50.91	88	1910-14
6 years	65.49	113	1900-05	51.88	89	1907-12
7 years	64.89	112	1900-06	51.61	89	1907-13
8 years	64.01	110	1899-06	52.81	91	1906-13
9 years	62.96	108	1895-03	53.68	92	1905-13
10 years	62.78	108	1893-02	53.42	92	1907-16

TABLE 4. Extreme falls recorded in series of consecutive years.

As was noted earlier the extreme wettest and driest single years with 151% and 68% of normal had falls which are considerably larger and smaller respectively than the next most extreme years. Consequently the averages in the two wettest consecutive years and in the two driest consecutive years are much nearer the normal than the extreme single year, and as the length of the period increases the average rapidly approaches normal until for 9 year periods the averages are about 108% and 92% of normal respectively. After 9 years the approach to the normal becomes much slower and the wet periods tend to the average value sooner than the dry periods.

In every case the extreme periods are grouped about the absolute driest or wettest single years which is further indication of the exceptional nature of these two extremes.

The driest three years had 81% of normal fall which is very close to the value found over a large part of Great Britain.

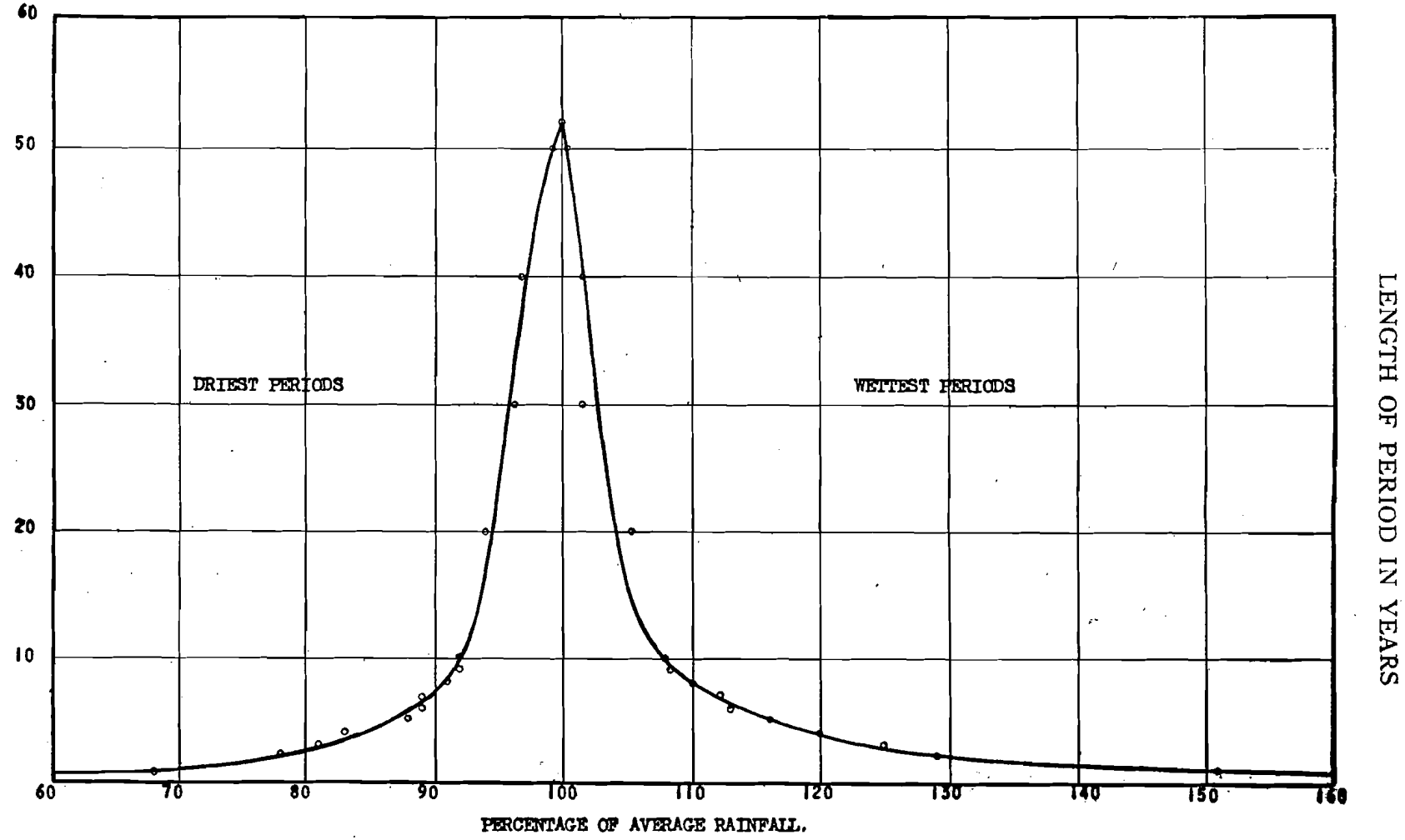

FIG. 2 Percentage of average rainfall which fell in driest and wettest periods of 1 to 50 consecutive years.

5. MONTHLY RAINFALL

The main data for each month of the year are summarised in Table 5.

Month	Average Fall	Extreme Maximum			Extreme Minimum			Mean Departure	Per cent. variability
		Fall	Per cent. of Average	Year	Fall	Per cent. of Average	Year		
Jan.	4.70	10.42	222	1901	1.08	23	1937	1.65	35
Feb.	4.67	10.40	225	1914	1.34	29	1918	1.72	37
Mar.	4.71	10.05	213	1920	1.20	26	1898	1.94	41
Apr.	4.37	13.17	301	1902	0.73	17	1931	1.98	45
May	4.38	12.03	274	1893	0.80	18	1918	2.12	48
June	4.40	11.02	250	1915	0.78	18	1941	2.07	47
July	3.86	11.24	291	1912	0.84	22	1919	1.75	45
Aug.	5.86	21.33	364	1902	0.64	11	1910	2.28	39
Sept.	5.33	16.30	306	1915	1.60	30	1904	2.42	45
Oct.	6.14	17.73	289	1892	1.34	22	1915	2.69	44
Nov.	4.92	11.54	235	1918	0.99	20	1940	1.82	37
Dec.	4.76	12.11	254	1930	0.55	12	1932	1.89	40

TABLE 5. Monthly rainfall in inches.

July, with 3.86 inches, has the smallest average total, and October, with 6.14 inches, the greatest. There is a sudden increase of two inches, or more than 50%, from July to August, and despite a decrease of half an inch in September, before a rise of 0.8 inch to the October maximum, these three months August to October, mark the quarter with markedly greatest fall. The other months fall into three rough groups. November and December, with 4.92 and 4.76 inches respectively, mark a period where the fall is decreasing from the October maximum to about 4.7 inches in each of January, February and March, after which there is another drop, and April, May and June have each approximately 4.4 inches, followed by a drop of half an inch to the Minimum in July.

July, the driest month, is also the month with the highest average pressure an indication that at this time the Azores-Bermuda anticyclone has its maximum western extension and therefore is most effective in stopping many fronts from the north before they reach Bermuda.

August is the hottest month of the year and consequently the high average rainfall may be due to the hot moist air together with a maximum of convection giving both local showers and increased precipitation at fronts.

Maxima of tropical depressions may be a factor in August and October but we have insufficient data definitely to confirm this.

October, the wettest month, has also the lowest average pressure of the year. Both are possibly due in part to tropical depressions but mainly to the fact that this is the average time when the first severe cold fronts of autumn push south as far as Bermuda and well developed storm centres affect the colony.

The absolute monthly extremes vary from the maximum of 21.33 inches in August 1902, to the minimum of 0.55 inches in December 1932. In every month a maximum exceeding ten inches has occurred, while no month has had less than half an inch and the five months January, February, March, September and October, have never been below one inch.

From the Percentage Variability, which is the ratio to the average of the mean departure from average ignoring sign, it is seen that the period November to March, that is, the winter, has the steadiest rainfall, while the remaining seven months of the year are appreciably more variable, except for August which, although it has the greatest range of absolute extremes, has a markedly smaller average variability than the months on each side of it.

The variability of the fall in each month is also shown in Table 6, which gives as percentages the number of occasions on which each month's fall lay between various limits during the fifty-two-year period under discussion. It may be noted here that, in this table and other later ones, which also give frequency of occurrence as percentages, the individual values are given to the nearest whole number. Since with all occurrences of 12% or less, this figure is above the exact value, it will be found therefore in some cases that the total number of occurrences as given exceeds 100%.

Inches	Jan.	Feb.	Mar	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
0.50 < 1.00				2	4	6	2	2			2	4
1.00 < 2.00	12	12	12	13	13	12	17		10	10	8	4
2.00 < 3.00	6	8	21	21	25	21	21	12	17	10	6	13
3.00 < 4.00	23	27	12	17	10	13	19	15	13	6	29	21
4.00 < 5.00	21	13	13	15	6	17	12	23	12	15	15	17
5.00 < 6.00	15	19	13	13	12	6	12	12	12	17	12	12
6.00 < 7.00	13	6	10	2	15	6	10	12	10	10	10	15
7.00 < 8.00	6	6	8	4	8	10	4	10	12	10	10	4
8.00 < 9.00		4	6	4	4	4		8	6	4	2	2
9.00 < 10.00		4	4	4	2	2	2		6	8	2	6
10.00 < 12.00	4	2	2	2		4	2	2		6	6	
12.00 < 14.00				2	2			2		2		2
14.00 < 16.00								2	2			
16.00 < 18.00									2	4		
18.00 < 20.00												
20.00 < 22.00								2				

TABLE 6. Percentage frequency of months with total falls between limits stated

5.1 DRIEST AND WETTEST SERIES OF CONSECUTIVE MONTHS

The extreme falls which have been recorded in series of consecutive months are given in Table 7.

DRIEST SERIES

Number of Months	Fall	Percentage of Average	Occasion
1	0.55	11.4	December 1932
2	1.72	17.8	July to August 1910
3	2.64	18.2	June to August 1910
4	6.55	33.8	April to July 1941
5	9.85	40.7	April to August 1941
6	13.24	45.6	January to June 1939
7	17.66	52.1	November 1910 to May 1911
8	22.08	57.0	December 1910 to July 1911 October 1912 to May 1913
9	24.06	55.2	September 1912 to May 1913
10	27.08	55.9	June 1910 to March 1911
11	28.80	54.1	June 1910 to April 1911
12	31.74	54.6	June 1910 to May 1911
18	58.00	66.6	June 1910 to November 1911
24	81.28	69.9	June 1910 to May 1912
36	127.36	73.1	June 1910 to May 1913
48	189.20	81.4	February 1910 to January 1914
60	241.38	83.1	June 1910 to May 1915

WETTEST SERIES

Number of Months	Fall	Percentage of Average	Occasion
1	21.33	441	August 1902
2	25.36	262	September to October 1917
3	36.57	252	August to October 1902
4	38.71	200	August to November 1902
5	47.64	197	April to August 1902
6	52.11	179	March to August 1902
7	62.88	186	April to October 1902
8	67.35	174	March to October 1902
9	75.44	173	February to October 1902
10	78.62	162	January to October 1902
11	84.46	159	February to December 1902
12	89.77	155	November 1901 to October 1902
18	119.19	137	October 1901 to March 1903
24	153.47	132	November 1900 to October 1902
36	217.88	125	November 1899 to October 1902
48	278.53	120	February 1900 to January 1904
60	339.59	117	August 1899 to July 1904

TABLE 7. Driest and wettest series of consecutive months.

It will be noticed that, with one exception, the greatest falls all occurred during the wet period of 1900 to 1902, while the smallest falls are, with four exceptions, in the dry period from 1910 to 1913.

On the driest occasion on record less than an average year's fall was recorded in eighteen months, while on the wettest occasion the year's average fell in less than seven months.

It is of interest to note that 1900 to 1902, the maximum wet period in Bermuda, coincides with the three driest years observed in England at the Radcliffe Observatory.

The fall of 31.74 inches in the driest twelve months is 7.8 inches or 20 per cent less than the fall in the driest calendar year but the wettest 12 months with 89.77 inches gave only 2.13 inches or 2½ per cent more than the wettest calendar year.

From 3-year periods onwards there is no change in the maximum whether periods are selected by months or calendar years, but there are still appreciable differences between the minima. Thus the driest 36 months have 4.5 inches per year or almost 10 per cent less than in the driest three calendar years, and the driest 60 months have 5 per cent less than the driest 5 years.

6. QUARTER MONTHLY RAINFALLS

To determine the falls in periods close to a week, each month was divided into quarters as follows:

Months with 31 days—1st-8th; 9th-16th; 17th-23rd; 24th-31st.
Months with 30 days—1st-8th; 9th-15th; 16th-23rd; 24th-30th.
February —1st-7th; 8th-14th; 15th-21st; 22nd-29th.

The average fall in each of these periods is given in Table 8, and the middle graph of Figure 3. Because of the varying length of the periods the average falls are given as the amount per day.

	Jan.	Feb.	Mar	Apr.	May	June	July	Aug	Sep.	Oct.	Nov.	Dec.
First Quarter....	.137	.144	.199	.111	.099	.125	.121	.172	.186	.170	.178	.161
Second Quarter....	.178	.146	.126	.141	.119	.157	.124	.166	.172	.255	.201	.137
Third Quarter....	.134	.170	.128	.179	.146	.187	.113	.257	.187	.191	.141	.143
Fourth Quarter....	.154	.201	.151	.152	.204	.116	.138	.172	.162	.160	.141	.172

TABLE 8. Average fall in inches per day in each quarter month.

The driest period of the year is the first quarter of May, where the average fall of 0.099 inch per day is only 62 per cent of the daily average for the whole year. The period from the last quarter of June to the third quarter of July inclusive, is consistently dry, with falls of from 71 per cent to 78 per cent of the average. The two wettest periods are sharply marked, the third quarter of August with 162 per cent and the second quarter of October with 160 per cent of the average.

As stated earlier the low fall in July is due to a minimum of frontal activity over Bermuda under the influence of the Azores-Bermuda anti-cyclone.

The heavy falls in August and October are due to several factors and there is no clear reason why the two quarters in question had so much more rain than those alongside them. It is seen from the lowest curve of Figure 3 that the third quarter of August is also a maximum in number of rain days which is further indication of a high frequency of convection showers at this time. The second quarter of October on the other hand has a relatively low number of rain days.

7. AVERAGE NUMBER OF RAIN DAYS

A rain day is defined as one on which at least 0.01 inch or 0.2 millimetres is recorded, depending on the units of measurement used. On this basis we have the data in Table 9.

	NUMBER OF RAIN DAYS			AVERAGE PERCENTAGE OF RAIN DAYS DAYS IN PERIODS				
	Average	Maximum and Year	Minimum and Year	Whole Month	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
January	16.7	24 in 1901	10 in 1907, 1911, 1916	54	56	56	47	56
February	15.8	25 in 1942	6 in 1903	56	60	51	56	58
March	14.5	24 in 1915, 1931	7 in 1921	47	52	45	44	47
April	11.3	19 in 1901	4 in 1931	38	37	39	36	39
May	10.5	17 in 1899, 1923	4 in 1918	34	34	32	30	39
June	11.0	21 in 1897	5 in 1920	37	36	35	40	34
July	13.1	23 in 1904	6 in 1919, 1921	42	41	38	39	50
August	15.2	28 in 1902	7 in 1910	49	44	50	57	47
September	13.4	19 in 1909	7 in 1941	45	46	42	48	43
October	15.0	25 in 1930	7 in 1911, 1916	48	50	49	47	47
November	15.0	22 in 1935	9 in 1906, 1912, 1914, 1927	50	49	47	51	54
December	16.2	24 in 1935	9 in 1891, 1908	52	55	49	54	53
Year	168	210 in 1930	133 in 1921	46				

TABLE 9. Number of rain days.

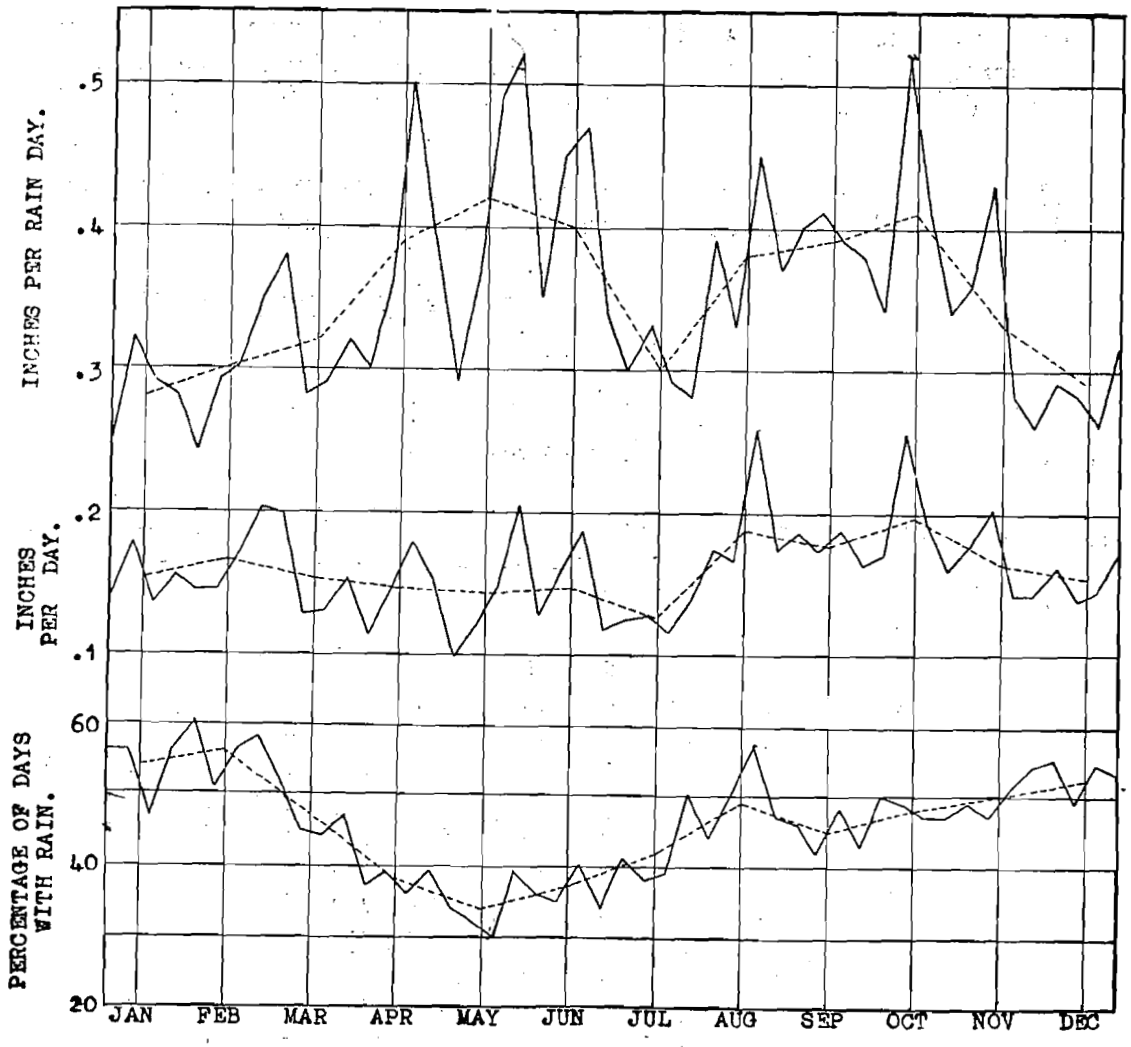

FIG. 3. Average Percentage of rain days and fall per day and per rain day in each month, and quarter month.

This gives the average, maximum and minimum number of days with rain in each month and also the average percentage of rain days in each quarter-monthly period and in the entire month.

In regard to the number of rain days, February is the wettest month with rain on 56 per cent of the days, while the first week of February is the wettest of the year with rain on 60 per cent of the days. October, which is the wettest month as regards amount of rain, has in all weeks an appreciably smaller number of rain days than February. The wet period in the third quarter of August has, however, rain on 57 per cent of the days and, as it also has the greatest fall per day, it might be regarded as the wettest week of the year.

The first three quarters of May are the driest in the year with rain on one day in three. The third quarter is the absolute driest with rain on 3 days in 10 and May is the driest month with rain on 34 per cent of the days.

The average percentage of days with rain in each month and quarter month are also plotted in the bottom graphs of Figure 3.

7.1 FREQUENCY OF MONTHS WITH A GIVEN NUMBER OF RAIN DAYS

In Table 10 is given a detailed analysis of the frequency of occurrence of a given number of rain days in each month.

No. days	Jan.	Feb.	Mar	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
4				2	2							
5					2	2						
6		2			8	6	4					
7		2	2	6	6	10	6	2	2	4		
8			2	10	10	13	2		4	4		
9			8	15	17	8	8	2	2	8	8	4
10	6	4	6	12	4	6	8	8	10	6	6	
11	2	4	6	15	13	12	15	4	6	2	6	4
12	8	6	10	10	12	12	4	8	15	8	8	10
13	2	10	12	8	8	13	8	12	17	10	6	8
14	8	10	6	2	8	8	6	12	12	8	12	13
15	8	6	10	10	4	4	13	13	6	4	10	8
16	12	19	8	4	4		4	6	8	4	10	8
17	15	6	8	6	4	2	10	12	6	10	8	12
18	6	13	10			2	10	4	12	6	13	12
19	10	4	8	2		2		6	2	12	4	
20	12	4	4					4		13	6	10
21	10	4				2	2	2			4	2
22	2	2						4			2	4
23		2					2	2		2		6
24	2	2	4									2
25		2								2		
26												
27												
28								2				

TABLE 10. Percentage frequency of occurrence of months with a given number of rain days (Days with 0.01 inch or more).

It is seen that there has never been a month with fewer than four rain days which minimum has been recorded in April and May. In each of the three months of November, December and January there have never been fewer than nine rain days, but all the other nine months have had seven days or less.

At the other end of the scale May has the smallest maximum number with seventeen days, but April exceeded this only once when there were nineteen days. The extreme number ever recorded was in August 1902 which had 28 rain days. In addition to the four months December to March, only August and October have ever exceeded 23 rain days, and in the whole fifty-two years under review there have been only 8 such occasions.

7.2 AVERAGE FALL PER RAIN DAY

It is of interest to combine the data given above on total monthly falls and number of rain days to determine for each month the average fall per day on the days when it does rain.

The average values for each month and quarter-month are given in Table 11 and plotted in the centre graphs of Figure 3.

	Whole Month	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
January	.28	.24	.32	.29	.28
February	.30	.24	.29	.30	.35
March	.32	.38	.28	.29	.32
April	.39	.30	.36	.50	.39
May	.42	.29	.37	.49	.52
June	.40	.35	.45	.47	.34
July	.30	.30	.33	.29	.28
August	.38	.39	.33	.45	.37
September	.39	.40	.41	.39	.38
October	.41	.34	.52	.41	.34
November	.33	.36	.43	.28	.26
December	.29	.29	.28	.26	.32
Year	.35				

TABLE 11. Average fall per rain day in inches.

It is seen that the months fall into two classes, the five months from November to March, together with July, in which the fall per rain day is near 0.30 inch (0.28 to 0.33 inch) and the other six months where the fall is near 0.40 inch (0.38 to 0.42). The general reason for this difference is that from April to October much of the rain is due to convection showers which produce heavy falls in a short period, while during the winter the weather is more unsettled, with considerable frontal activity; and particularly with a frontal zone lying to the South and East, light or moderate rain may occur at intervals for several successive days.

July appears in the same class as the winter months because, although its total fall is the smallest in the year, its percentage of rain days is appreciably more than in the three spring months, which have the smallest number in the year.

7.3 PERCENTAGE OF DAYS IN EACH MONTH WITH FALLS EXCEEDING VARIOUS LIMITS

Table 12 gives for each month the percentage frequency of days with total rainfalls equalling or exceeding various amounts from 0.04 inches to 12 inches. The figure of 0.04 is that used to specify a "Wet Day." The data for five major amounts are plotted in Figure 4.

Ins.	Jan.	Feb.	Mar	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
.04	43.2	45.2	39.2	29.3	27.2	29.2	32.8	40.7	36.1	38.9	39.4	40.9	36.8
.10	31.8	32.1	29.3	22.8	20.4	21.9	24.3	31.6	27.8	29.0	29.7	30.1	27.5
.20	20.8	21.9	20.7	16.5	14.7	16.5	16.4	22.6	20.2	21.7	20.0	21.0	19.4
.30	15.5	17.0	15.4	13.1	11.5	13.3	11.9	18.1	15.7	16.7	15.7	15.0	14.9
.40	11.4	12.3	11.4	10.5	9.4	10.6	10.1	14.8	12.2	13.2	12.6	12.0	11.7
.50	8.93	10.15	9.18	8.59	8.00	8.78	7.88	11.97	10.13	10.86	10.13	9.12	9.47
.60	7.57	8.65	7.13	7.18	7.13	7.69	6.02	9.99	8.65	9.18	8.46	7.75	7.95
.80	4.34	5.52	4.96	5.38	5.46	5.58	3.91	6.88	6.47	6.45	5.71	5.21	5.49
1.00	3.04	3.27	3.35	4.36	3.91	4.10	2.85	5.08	4.62	5.21	4.04	3.04	3.91
1.20	2.05	2.52	2.23	3.14	3.29	3.08	1.74	4.09	3.72	4.59	3.01	2.48	3.03
1.60	1.24	1.23	1.49	1.73	2.36	1.73	1.05	2.05	1.99	2.91	1.67	1.36	1.74
2.00	0.74	0.61	0.68	0.90	1.24	0.90	0.62	1.24	1.41	1.98	1.03	0.74	1.01
3.00	0.06	0.27	0.19	0.32	0.50	0.45	0.19	0.25	0.58	0.93	0.38	0.12	0.35
4.00	0.00	0.07	0.12	0.13	0.25	0.19	0.06	0.19	0.45	0.37	0.00	0.12	0.16
5.00		0.00	0.12	0.06	0.12	0.13	0.00	0.12	0.13	0.06		0.00	0.06
6.00			0.00	0.06	0.00	0.06		0.00	0.13	0.00			0.02
7.00				0.06		0.06			0.00				0.01
8.00				0.06		0.06							0.01
9.00				0.06		0.00							0.005
10 00				0.06									0.005
11.00				0.06									0.005
12.00				0.00									0.000

TABLE 12. Percentage of days with falls equalling or exceeding values stated.

The data show that the number of wet days varies from month to month in the same manner as the number of rain days given earlier and has maximum frequency in February. There is a rapid decline of frequency in March and April, and the minimum frequency is reached in May, whereafter the frequency increases again steadily to the February maximum, except for August which has a higher value than the smooth curve.

As we consider falls exceeding progressively higher values, the form of this distribution curve gradually changes until, when the limit is 2.00 inches the February maximum has become a minimum, and the May minimum a subsidiary maximum, after which the frequency falls to another minimum in July, rising to the chief maximum in October.

The actual change from month to month in the frequency of different falls is such that the frequency of wet days, i.e. falls of 0.04 inch, is two-thirds more in February, the month with the greatest frequency, than in May, the month with the smallest frequency. The ratio of the greatest to the smallest monthly frequency decreases as greater falls are considered, and reaches a minimum with falls of a half inch or more. Falls of this amount in August, which has the highest frequency, are

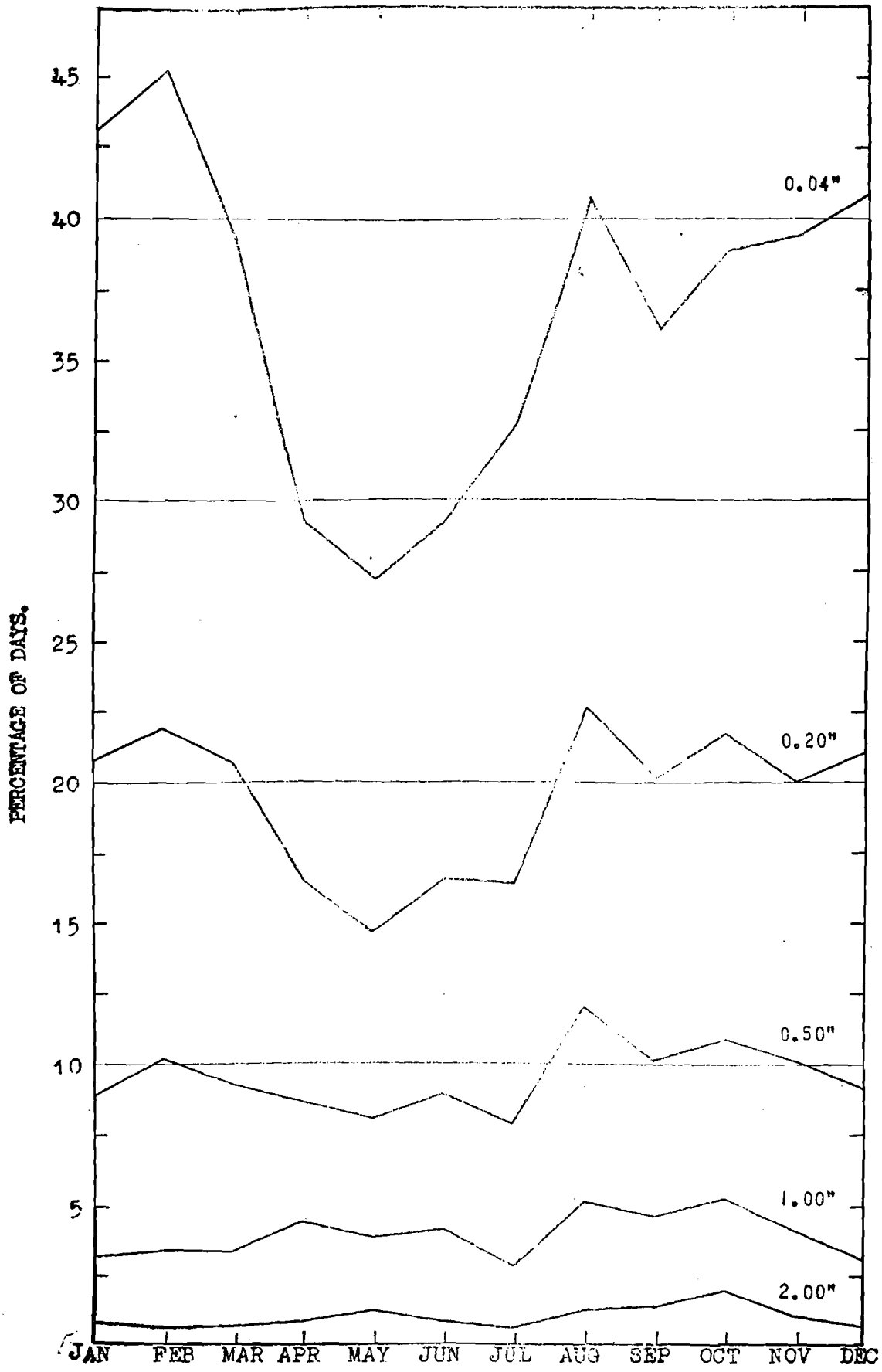

Fig.4. PERCENTAGE OF DAYS WITH RAIN EQUALLING OR EXCEEDING VARIOUS AMOUNTS.

only half again as frequent as in July, which has the lowest. The difference between maximum and minimum frequency then increases rapidly with the amount of fall, so that falls of 2.00 inches or more are over three times as frequent in October as in February.

It is of interest to compare the figures for the yearly distribution in Bermuda with those given for British stations in "Bilham's Climate of the British Isles." No station is given with a yearly fall close to that of Bermuda the nearest being Stonyhurst with 46 inches, and Strontian with 78 inches. Both these stations have a greater frequency than Bermuda of the days with lower limits to rainfall, but the frequency of days with heavier falls is greater at Bermuda. Thus Stonyhurst has a greater frequency of days up to 0.20 inch and Strontian of days up to 0.80 inch, but above these limits the frequency is increasingly greater at Bermuda. which has falls of 2.00 inches five times as frequently as Strontian and fourteen times as frequently as Stonyhurst.

7.4 MAXIMUM DAILY FALLS RECORDED

It will be seen from Table 12 that rainfall of 5.00 inches or more has been recorded on only twelve days in the fifty-two years under discussion. None of these days fell in the driest month of July or in the four winter months of November to February. Because of their special interest the exact falls and the dates are given below:

11.38 inches on 20th April, 1902
8.81 inches on 14th June, 1922
6.20 inches on 8th September, 1909
6.12 inches on 3rd September, 1915
5.88 inches on 25th August, 1902
5.70 inches on 13th October, 1892
5.64 inches on 20th August, 1891
5.50 inches on 27th May, 1921
5.40 inches on 23rd June, 1902
5.32 inches on 3rd March, 1908
5.09 inches on 23rd May, 1920
5.08 inches on 2nd March, 1901

8. VARIATION OF FALL WITH HOUR OF DAY

The percentage of the total rain which fell in each hour of the day was worked out from the St. George observations but as the period is short, percentages for two-hour periods are given in Table 13.

Hrs.	Jan.	Feb.	Mar	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
0- 2	11.7	4.9	7.5	8.9	4.1	3.8	12.4	9.5	5.3	7.2	9.8	10.1	8.0
2- 4	8.9	7.7	9.8	10.0	5.6	8.7	9.0	9.6	8.9	10.0	14.3	9.7	9.4
4- 6	6.3	10.3	7.7	18.0	11.7	10.0	13.8	6.6	11.1	8.2	8.2	10.5	10.2
6- 8	7.3	9.5	12.8	10.7	8.8	19.8	7.7	11.8	7.3	5.6	6.6	9.9	9.6
8-10	5.5	10.1	11.7	6.7	15.8	11.0	8.2	8.9	7.4	8.2	8.3	8.9	9.2
10-12	9.2	5.7	5.9	8.0	7.2	11.9	9.9	7.5	9.9	12.7	6.3	7.8	8.5
12-14	7.8	6.1	4.4	5.8	8.4	12.4	10.2	8.1	10.5	11.5	11.0	9.9	8.8
14-16	5.3	11.0	5.2	5.2	13.1	5.0	8.3	14.9	8.1	8.9	11.2	7.6	8.7
16-18	6.7	10.6	8.0	3.9	7.8	3.4	5.5	8.0	5.6	9.2	6.9	6.2	6.9
18-20	10.1	9.3	8.4	11.0	9.0	3.9	5.3	5.9	9.9	7.3	4.1	7.9	7.8
20-22	12.0	8.2	8.9	6.1	4.0	7.1	5.0	6.1	9.5	6.2	6.8	6.1	7.2
22-24	9.6	6.6	9.6	5.7	4.4	2.7	4.8	3.1	6.3	5.2	6.6	5.4	5.9

TABLE 13. Average percentage of monthly fall which occurred in each two hours.

The figures for the whole year show a minimum rate of fall from 10 p.m. to 12 p.m., followed by a steady rise to nearly twice the minimum at from 4 a.m. to 6 a.m. From the early morning maximum the rate decreases erratically but definitely throughout the day to the night minimum.

This same general variation is seen in the figures for individual months. Thus the highest percentage falls between 4 a.m. and 6 a.m. in April, July, September and December, and between 4 a.m. and 12 a.m. in a total of 9 months. Only in January, February and August does the maximum occur during the afternoon.

In all months the minimum occurred between noon and 2 a.m. In the three summer months June, July, August and in October and December the minimum lay between 10 p.m. and midnight. Also in February, May and September it fell between 8 p.m. and 2 p.m. making a total of eight months within these limits.

9. DURATION OF RAIN

The total duration of rain in hours each month is given in Table 14. These figures have been deduced from records of the automatic gauge, the duration of each rain period being measured to the nearest tenth of an hour. The duration is defined as the period during which rain fell at a rate of 0.1 m.m. per hour or more. This is the lowest rate which can be read on the automatic record.

	Total per Month			Average Per Day	Average Per Rain Day
	Average	Maximum	Minimum		
January	44.7	66.1	22.9	1.4	2.6
February	41.7	84.1	13.2	1.5	2.4
March	38.1	68.5	9.9	1.2	2.9
April	34.1	68.1	6.9	1.1	2.8
May	32.0	57.6	11.5	1.0	2.9
June	21.5	35.4	9.2	0.7	2.0
July	19.6	35.7	3.3	0.6	1.5
August	25.8	62.1	7.9	0.8	1.7
September	24.3	44.2	12.6	0.8	1.7
October	32.9	66.1	15.9	1.1	1.9
November	30.2	43.5	14.8	1.0	2.2
December	38.1	58.7	20.7	1.2	2.1
Year	383.1	480.4	293.2	1.05	2.2

TABLE 14. Duration of rain in hours.

There is a well marked seasonal variation with maximum duration in January and February, and minimum in June and July. February has the greatest average duration of 1.5 hours per day, which is two and a half times the minimum of 0.6 hours in July.

When the duration per rainday is considered, we find that the maximum has shifted to the Spring months of March, April and May, but the minimum is still in July, the Maximum value of 2.9 being not quite twice the July Minimum of 1.5 hours.

It is interesting to note that in each of the months of January, February, April and May, the average total duration is slightly greater than in London for the same months.

9.1 FREQUENCY OF DAYS WITH VARIOUS DURATIONS OF RAIN

In Table 15 are given the average number of days in each month on which rain fell for certain specified times. These figures are available only for St. George, and the shortness of the period is the cause of the irregularity from month to month. In Figure 5, which gives the percentage frequency in each month, the data of Table 15 is compressed into five curves for the more significant intervals. The curves show that days with rain which lasts less than an hour are most frequent in September and October where almost one day in three has this fall. The winter months have almost as high a percentage, but there is then a rapid decrease to a minimum in March with only half the frequency of the October maximum.

All the other four curves for longer durations show the general effect of a maximum frequency in January or February and a minimum in summer.

The minimum comes later in the summer for the longer durations than for the small, and the ratio of maximum to minimum monthly frequency increases from the factor of two for the shortest durations to four or five in the case of the longest.

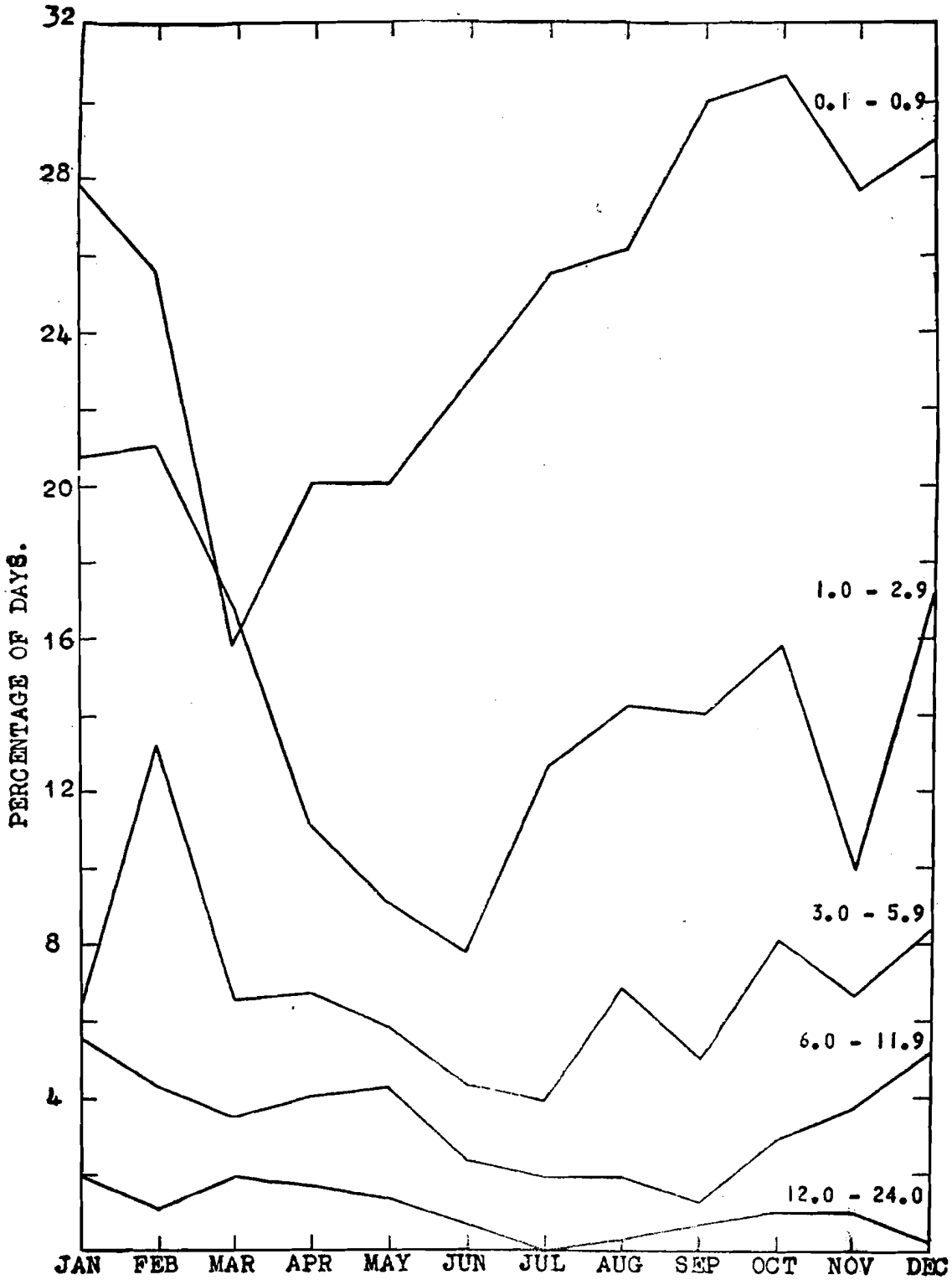

FIG. 5. Percentage of days in each month with duration of rain between stated limits in hours.

Duration Hours	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
0.0	11.7	9.9	17.2	17.0	18.5	18.7	17.4	15.7	14.7	12.9	15.3	12.4	181.4
0.1- 0.2	3.4	2.1	2.1	2.5	2.7	2.8	3.5	3.4	3.8	4.5	2.9	2.8	36.5
0.3- 0.4	1.3	1.4	1.1	1.4	1.4	1.4	1.7	1.3	2.7	2.7	1.8	2.2	20.4
0.5- 0.9	3.9	3.7	1.7	2.1	2.1	2.6	2.7	3.4	2.5	2.3	3.6	4.0	34.6
1.0- 1.4	2.8	2.2	1.5	1.5	0.9	1.0	1.3	1.6	1.6	2.1	0.9	1.9	19.3
1.5- 1.9	1.4	1.6	1.4	0.6	0.8	0.5	1.1	1.0	1.1	1.6	0.9	1.5	13.5
2.0- 2.9	2.2	2.1	2.3	1.2	1.1	0.8	1.5	1.8	1.5	1.2	1.2	1.9	18.8
3.0- 3.9	0.8	1.4	1.1	0.7	0.6	0.4	0.5	1.0	0.5	1.6	0.9	1.4	10.9
4.0- 4.9	0.7	1.6	0.6	0.6	0.5	0.5	0.6	0.4	0.6	0.4	0.7	0.6	7.8
5.0- 5.9	0.5	0.7	0.3	0.7	0.7	0.4	0.1	0.7	0.4	0.5	0.4	0.6	6.0
6.0- 6.9	0.7	0.6	0.3	0.2	0.4	0.1	0.2	0.1	0.1	0.4	0.3	0.4	3.8
7.0- 7.9	0.5	0.2	0.2	0.3	0.1	0.2	0.2	0.3	0.0	0.2	0.4	0.3	2.9
8.0- 8.9	0.1	0.3	0.2	0.2	0.4	0.1	0.0	0.0	0.0	0.0	0.2	0.6	2.1
9.0- 9.9	0.2	0.0	0.0	0.1	0.2	0.0	0.1	0.2	0.2	0.0	0.1	0.2	1.3
10.0-11.9	0.2	0.1	0.4	0.4	0.2	0.3	0.1	0.0	0.1	0.3	0.1	0.1	2.3
12.0-13.9	0.1	0.3	0.2	0.2	0.1	0.1		0.0	0.0	0.1	0.0	0.0	1.1
14.0-15.9	0.3		0.1	0.3	0.1	0.0		0.1	0.1	0.1	0.2	0.1	1.4
16.0-17.9	0.2		0.2		0.1	0.1			0.0	0.0	0.0		0.6
18.0-19.9			0.1		0.1				0.0	0.1	0.1		0.4
20.0-24.0									0.1				0.1

TABLE 15. Average number of days with duration of rain between certain limits.

9.2 MAXIMUM DURATION OF RAIN ON SINGLE OCCASIONS

Table 16 gives data on the maximum duration of rain on single occasions as observed over the 10 years at St. George. The figures for consecutive hours with rain are taken from the tabulation of hourly values and give the maximum number of consecutive hours for which rain is entered. There is no account taken of whether the rain lasted for all or only part of the hour. The figures for continuous rainfall were determined directly from the records of the Automatic Gauge, and give the duration of continuous recordable falls. The limit of 0.1 millimetres per hour is the lowest rate which can be detected on the record.

	Consecutive hours with rain recorded in each		Period of Continuous Rainfall > 0.1 mm. per hour	
Month	Average Maximum	Extreme Maximum	Average Maximum	Extreme Maximum
January	12.9	21	6.8	12.1
February	10.6	18	5.7	8.9
March	13.2	23	8.6	22.3
April	11.2	19	6'5	10.3
May	10.1	15	6.2	14.5
June	10.8	20	5.2	18.5
July	6.2	9	3.7	7.2
August	9.9	21	4.1	7.5
September	11.8	46	6.9	22.9
October	12.9	33	5.9	10.2
November	10.5	20	5.2	13.6
December	9.3	13	5.4	9.0
Year	22.7	46	14.8	22.9

TABLE 16. Maximum duration of rainfall on separate occasions.

In both tabulations July has the lowest average value and March the greatest. An everage March has one period of 8.6 hours of continuous rain and one of thirteen consecutive hours in which rain falls, while in July the periods of 3.7 and 6.2 hours are less than half as long. In general, periods of rainfall are shortest in midsummer and longest in early spring and early autumn.

There is every year one period with almost 15 hours of continuous rain, and one of 23 consecutive hours with rain recorded in each hour. The extreme values recorded were in September 1941, when there was one period of 23 hours with continuous rain, while for 46 hours rain fell at some time in each hour.

9.3 LONGEST RAIN PERIODS

Figures on the maximum duration of rain periods, that is consecutive days each with recordable rainfall, are given in Table 17 which gives the longest and shortest maxima ever recorded in each month and also the average maximum.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Average Maximum	6.0	5.1	5.0	3.9	3.9	4.2	5.0	6.0	5.1	5.3	5.2	5.3	10.1
Longest Maximum....	12	22	12	11	10	9	12	28	13	13	12	14	28
Shortest Maximum..	2	2	2	2	2	2	2	2	2	1	2	2	5

TABLE 17. Duration of longest rain periods; consecutive days each with 0.01 inch or more.

With the exception of one occasion in the record dry year 1911, when throughout October there were not two consecutive rain days, every month had at least two consecutive days with rain. The average maximum varies from under four days in spring and early summer to six and over in the two winter months of January and February, and also in August. All months have had at least nine consecutive days of rain on some occasion, and the two greatest were 28 days in August (from August 3rd to August 30th, 1902,) and 22 days in February and March (from February 11th to March 4th, 1942).

In any whole year the average maximum is over ten days, while the smallest on record is five.

10 MAXIMUM FALLS IN PERIODS FROM 12 HOURS TO 28 DAYS

The maximum falls in periods from twelve hours to twenty-eight days in the fifty-two-year period are given in Tables 18 and 19. The figures for 12, 24 and 48 hours are based on the twice daily observations, while the values for 7, 14, 21 and 28 days are determined from daily rainfall totals only.

Table 18 gives the average maximum in each month for the three short periods while Table 19 gives the absolute extremes ever recorded in each month.

	12 hours	24 hours	48 hours
January	1.14	1.46	1.74
February	1.25	1.51	1.73
March	1.21	1.54	1.75
April	1.65	1.84	2.03
May	1.32	1.97	2.22
June	1.55	1.92	2.22
July	1.17	1.37	1.65
August	1.48	1.82	2.33
September	1.69	2.05	2.45
October	1.71	2.25	2.71
November	1.30	1.59	1.89
December	1.23	1.65	1.73
Year	3.30	4.18	4.95

TABLE 18. Average maximum falls in periods of twelve to forty-eight hours.

The values given in Table 18 indicate that in every month there is, on the average, one occasion with at least 1.14 inches in 12 hours. 1.37 inches in 24 hours and 1.65 inches in 48 hours, while in the average year there is one occasion with 3.30, 4.18 and 4.95 inches respectively in 12, 24 and 48 hours. For all the three intervals the highest average values occur in October; the lowest fall in July, except for the 12-hour maximum which was slightly lower in January than in July. In each case value in October was some 50 to 60 per cent greater than in July or January.

The absolute extremes given in Table 19 are due to very exceptional conditions. Thus the maxima in 12, 24, and 48 hours are all due to a thunderstorm on the early morning of April 21st, 1902, when in a period of only eight hours a total of 11.36 inches of rain was recorded. On this same occasion a total of 12.50 inches was recorded by a private observer in Paget.

Month	12 hours	24 hours	48 hours	7 days	14 days	21 days	28 days
January	2.80	3.84	7.10	8.10	9.12	10.12	11.66
February	4.34	5.44	5.80	7.62	12.16	13.76	14.42
March	3.66	5.86	7.66	8.24	10.32	12.02	12.92
April	11.36	11.44	11.54	12.36	13.16	13.51	14.31
May	3.46	5.50	5.65	7.38	8.37	10.67	12.03
June	8.00	8.81	9.51	9.75	10.02	12.78	13.44
July	3.12	4.07	6.06	7.00	9.16	10.40	14.22
August	5.78	6.88	9.24	14.09	18.16	19.76	21.33
September	6.12	6.58	8.56	14.64	14.90	17.44	18.12
October	4.32	6.18	7.50	11.44	16.02	17.73	18.25
November	3.53	4.28	5.10	9.26	10.00	13.10	14.92
December	4.64	4.74	5.06	6.42	8.10	10.30	12.00
Year	11.36	11.44	11.54	14.64	18.16	19.76	21.33

TABLE 19: Absolute maximum falls in inches in period of twelve hours and more.

Also the extreme falls in 14, 21 and 28 days all occurred in the exceptional month of August 1902 which had rain on 28 consecutive days and in the second half of the month one day with over 5 inches, 3 days with over 2 inches, 2 over 1 inch and 3 over .7 inch.

For the periods up to 48 hours June has the next highest values after April. With these exceptions the highest values occurred in August, September and October.

In every case the lowest values are in December or January, but in most periods July has very little more.

10.1 MAXIMUM FALLS IN PERIODS OF ONE TO TWELVE HOURS

For data on falls in periods of less than twelve hours we are dependent on the ten years of autographic records from St. George. The maximum falls in 1, 3, 6, 12, and 24 hours have been extracted from these records and the figures for the first four are given in Table 20. The periods do not necessarily begin and end at exact hours, but at such intermediate times as would include the maximum fall in the period.

Month	AVERAGE MAXIMUM IN				ABSOLUTE MAXIMUM IN			
	1 Hour	3 Hours	6 Hours	12 Hours	1 Hour	3 Hours	6 Hours	12 Hours
January	0.57	0.91	1.12	1.33	1.13	1.37	2.00	2.28
February	0.56	0.93	1.07	1.13	0.87	1.95	2.68	2.84
March	0.69	1.04	1.22	1.53	1.28	2.26	2.51	3.46
April	0.89	1.39	1.65	1.88	1.29	2.07	2.47	3.03
May	0.73	1.13	1.38	1.63	1.07	1.92	2.15	2.83
June	0.79	1.06	1.19	1.39	1.63	2.16	2.65	2.98
July	0.80	1.02	1.15	1.35	1.65	2.18	2.58	2.84
August	0.96	1.13	1.29	1.42	1.52	1.81	1.81	2.19
September	0.97	1.20	1.43	1.65	2.09	2.43	3.30	4.57
October	0.81	1.09	1.31	1.54	1.55	1.88	2.12	3.65
November	0.75	0.93	1.20	1.45	1.74	2.03	3.01	4.09
December	0.80	1.17	1.33	1.49	1.50	2.11	2.39	2.61
Year	1.45	2.05	2.57	3.02	2.09	2.43	3.30	4.57

TABLE 20: Maximum falls in short periods, 1933 to 1942.

The data for 12 hour falls are included in the table because one figure, the absolute maximum for November, is greater than the maximum for the whole fifty-two-year period as given in Table 19, and is therefore a significant extreme. The 24-hour falls are not given because none of the absolute extremes exceeded the values already given in Table 19.

The table shows that in every month except February there has been at least one hour with 1.00 inch of rain, and on one occasion—September 30th, 1942—a total of 2.09 inches fell in one hour.

The average year has maximum falls of 1.45 inches in one hour, 2.05 in three hours, and 2.57 in six hours, while the absolute extremes, all of which occurred in September, are 2.09, 2.43 and 3.30 inches respectively.

January and February have, on the average, the smallest maxima, while September and April have the greatest, with values 50 per cent to 70 per cent greater than in January and February.

10.2 COMPARISON OF 12 AND 24-HOUR MAXIMA DETERMINED FROM TWICE-DAILY OBSERVATIONS WITH THOSE FROM CONTINUOUS RECORDS

As was stated above, the fifty-two-year extremes given in Tables 18 and 19 are based on two observations per day only, and it is probable therefore that somewhat larger values would have been obtained for at least the shorter periods if records from autographic instruments had been available.

To get some measure of this difference a comparison was made of the 12 and 24-hour maxima 1933 to 1942, as in Table 20, with the 12 and 24-hour maxima for the same years determined from the 8 a.m. and 8 p.m. readings only. The figures obtained from continuous records were expressed as a percentage of those obtained from twice-daily readings.

Appreciable variation in the ratio was found from month to month, especially in the 12-hourly figures. However, the mean of all monthly ratios indicated that for the 12-hour period the average maximum is 13 per cent greater and the absolute maximum 19 per cent greater when the values are obtained from continuous records. The difference in 24-hourly figures is much smaller, the values obtained from continuous records being greater by 4 per cent for average and 3 per cent for absolute values.

10.3 FALLS IN PERIODS OF ONE HOUR AND LESS

The falls on twenty occasions with the greatest falls in sixty minutes have been analysed as fully as the time-scale of the rain gauge will permit, and the results are given in Table 21.

Owing to the narrowness of the time-scale on the record, it is not possible to determine accurately the figures for the shorter periods, and there could well be a scale error of about 10 per cent in the 10 minute-values and 20 per cent in the 5-minute figures.

Date	Duration Rainfall in Hours	Total Fall Inches	Maximum Falls in Inches in Number of Minutes Stated						
			60	45	30	20	15	10	5
30 Sept., 1942	3.2	2.44	2.09	1.65	1.11	0.95	0.83	0.59	0.40
14 Nov., 1937	4.2	2.19	1.74	1.49	1.32	0.96	0.89	0.68	0.40
18 June, 1940	0.9	1.63	1.63	1.62	1.44	1.04	0.89	0.75	0.40
28 Oct., 1942	6.1	1.98	1.55	1.20	0.83	0.59	0.49	0.37	0.20
30 Aug., 1940	1.7	1.67	1.52	1.33	0.98	0.93	0.91	0.66	0.40
3 Dec., 1937	4.5	2.19	1.50	1.20	0.73	0.61	0.47	0.38	0.20
13 July, 1934	2.8	2.18	1.42	1.26	1.07	0.99	0.87	0.85	0.45
8 Aug., 1934	2.0	1.46	1.40	1.39	1.17	0.74	0.64	0.59	0.30
24 Aug., 1934	2.0	1.81	1.34	1.16	0.95	0.69	0.62	0.50	0.30
8 Sept., 1936	0.5	1.33	1.33	1.33	1.33	1.00	0.87	0.76	0.50
18 Aug., 1937	0.5	1.32	1.32	1.32	1.32	1.18	1.04	0.83	0.55
10 Aug., 1939	0.9	1.32	1.32	1.28	0.95	0.65	0.57	0.43	0.25
26 June, 1935	8.7	2.91	1.32	1.08	0.93	0.60	0.55	0.46	0.30
19 April, 1942	8.3	2.37	1.29	1.04	0.70	0.51	0.38	0.31	0.20
21 March, 1936	2.3	2.21	1.28	1.11	0.90	0.74	0.67	0.59	0.35
6 Nov., 1939	1.0	1.26	1.26	1.24	0.95	0.62	0.50	0.35	0.30
16 April, 1937	9.9	3.01	1.21	1.18	0.90	0.67	0.60	0.43	0.25
8 Oct., 1935	0.8	1.19	1.19	1.17	0.98	0.72	0.57	0.39	0.25
24 June, 1937	3.3	1.43	1.17	1.13	1.07	0.91	0.85	0.71	0.35
28 April, 1934	4.4	1.80	1.13	1.04	0.79	0.51	0.45	0.35	0.20
2 June, 1937	1.2	1.14	1.09	1.05	0.96	0.85	0.77	0.61	0.45
	MAXIMA		2.09	1.65	1.44	1.18	1.04	0.85	0.55

TABLE 21. Analysis of twenty greatest sixty-minute rainfalls at St. George, 1933-1942.

As is to be expected, these heavy falls occur mainly in the summer months, with greatest frequency in June and August. None of the cases given occurred in January or February, and there was only one case each in December and March.

From the figures of Table 21 we can deduce the maximum falls to be expected in one to ten years and these are given in Table 22.

Frequency	Interval in Minutes						
	60	45	30	20	15	10	5
1 in 10 years	2.09	1.65	1.44	1.18	1.04	0.85	0.55
1 in 5 years	1.74	1.62	1.33	1.04	0.91	0.83	0.50
1 in 2 years	1.55	1.39	1.32	0.99	0.89	0.75	0.45
1 in 1 year	1.33	1.20	0.98	0.74	0.67	0.59	0.35
2 in 1 year	1.09	1.04	0.70	0.51	0.38	0.31	0.20

TABLE 22: Maximum falls to be expected in stated periods.

10.4 MAXIMUM FALL IN ONE MINUTE

The rates of fall in inches per hour for the maxima recorded in Table 21 are:

Interval (minutes)	60	45	30	20	15	10	5
Rate of Fall in Inches per hour	2.1	2.2	2.3	3.5	4.2	5.1	6.6

The figures indicate that below thirty minutes, as the interval concerned is halved the rate of fall increased by less than half, the ratio of the 15-minute rate to the 30-minute rate, and of the 10-minute rate to the 20-minute rate, being both 1.45. The ratio of the 5-minute to the 10-minute rate is 10 per cent less than this, but as was stated above there is a possible error of twice this amount in the scaled figures. If, therefore, we assume that the rate increases by this factor of 1.45, and work from the 15 and 10-minute figures, we find that for an interval of one minute the maximum rate would be nearly 18 inches per hour, giving a fall in one minute of 0.3 inches.

11. DRY PERIODS

The figures already given in Tables 5 and 9 show that there has never been a calendar month without any rain. Nevertheless, marked dry periods occur and data on these are given in Table 23. The figures are given for each month, but in every case the maximum period was measured, and when it extended over two months it was credited to the one which it covered the more. On the left is given the length of the average and extreme monthly maxima of consecutive days without any recordable rainfall (less than 0.01 inch), and on the right the average and extreme length of the maximum periods in which less than 1.00 inch fell.

Month	MAXIMUM PERIODS WITH TOTAL FALLS LESS THAN—			
	0.01 inch		1.00 inch	
	Average	Extreme	Average	Extreme
January	4.6	10	17.0	39
February	4.1	9	16.1	30
March	6.0	17	16.6	37
April	6.9	17	20.2	38
May	8.5	22	22.0	39
June	7.4	14	22.2	50
July	7.5	15	23.6	54
August	6.4	21	18.3	50
September	6.8	15	18.4	58
October	6.0	12	18.3	37
November	5.1	13	17.2	33
December	4.7	11	17.7	38
Year	12.2	22	33.0	58

TABLE 23: Length of longest dry periods in days.

The longest rainless period which has been observed is 22 days in May, 1908, while an interval of 58 days ending in September, 1910, had a total fall of less than 1.00 inch.

There is every year, on the average, one rainless period of 12 days, and one period of 33 days in which less than one inch of rain falls.

The months from May to July have on the average the longest dry periods, and February has the shortest. While in February there is normally a maximum interval of only 4.1 days between rain, in May the interval is 8.5 days. In February 16.1 days is the average longest period with less than one inch, but in July the average is 23.6 days.

The longest dry period ever recorded in February, 9 days, is little greater than the average Maximum for May and is only 40 per cent of the extreme May value of 22 days. Also the longest period of 30 days in February with less than one inch, is only half as long as the corresponding period in September.

The 4 months June to September have each had periods covering the month when less than an inch fell in 50 days while in none of the remaining months has the period lasted as long as 40 days.

12. DROUGHTS

As was shown above, Twenty-Two days is the longest period which has ever been recorded with no measurable rain. There have, however, been numbers of periods considerably longer than this during which, although some rain fell, the total was so much less than normal that in effect a state of drought existed.

Various criteria of a drought might be selected. Owing to the dependence of water supply on rainfall collected and stored in tanks, the average of 58.1 inches per year, or 0.16 inches per day, is the maximum

which can be used over an extended period. Whenever the fall gets below average the reserve must be drawn upon, and the longer the deficit continues the greater the drain on the accumulated supply. Consequently, droughts will be marked as the periods with the greatest cumulative deficit and reduction in the water reserve. The extent of this reduction in the water reserve is probably the most useful criterion of a Bermuda drought and has been adopted here.

To detect these periods, the average falls in periods of 28 to 31 days were first determined from the year's average of 58.10 inches, and then the excess or deficit of each month's actual rainfall from the average for a month of that length. The cumulative value of the excesses or deficits from January 1891, onwards was then plotted month by month. Figure 6 gives this curve but shows only the values at each two-monthly interval as the actual working chart was on a bigger scale and too large for reproduction.

This curve could be considered as giving the water level in a tank which received and retained all the rain which fell, and from which the average rainfall was withdrawn each month.

It will be seen that in earlier years water was accumulated until a maximum of 83 inches was reached in 1906. From this point the accumulated supply decreased, but with occasional peaks, notably in 1910 and 1931, until zero line was crossed early in 1941 and a deficit of 10 inches, the minimum for the period, was reached later in the same year.

The drought periods-as, for instance, in 1901, 1911 and 1941—show up by continual decreases in the accumulated rain from month to month. The rainy periods, such as 1902 and the latter half of 1909, are marked by rises in the curve.

The greatest accumulated deficit is the approximate 93 inches from the 1906 maximum to the 1941 minimum, but it is obvious that for practical purposes this cannot be classed as a drought. It is necessary therefore to consider not only the absolute value, but also the intensity of any reduction in accumulated supply. The intensity of drought in a given period is best expressed by the percentage ratio of the actual deficit to the normal average for that length of period. On this basis, the drought intensity from 1906 to 1941 was less than 5 per cent.

The period with the greatest deficit, and with intensity such that it may be considered a drought, is from May 1910 to July 1913, where the total deficit was 53.62 inches and the intensity 29 per cent.

There were, however, many months during this period with normal fall, and some with considerably greater than normal fall, so that for most purposes this should not be regarded as a single period.

There are other cases where a series of months each with a deficit is interrupted by one or more months with above normal fall, but nevertheless the available water supply at the end of the whole period is considerably less than at the beginning.

The convention was therefore adopted that a single month with above normal rainfall does not end a dry spell, but two or more consecutive months do so.

With this criterion, the periods with the greatest accumulated deficits were taken from the graph. In each case the daily records were then examined to determine the exact length and intensity of each drought.

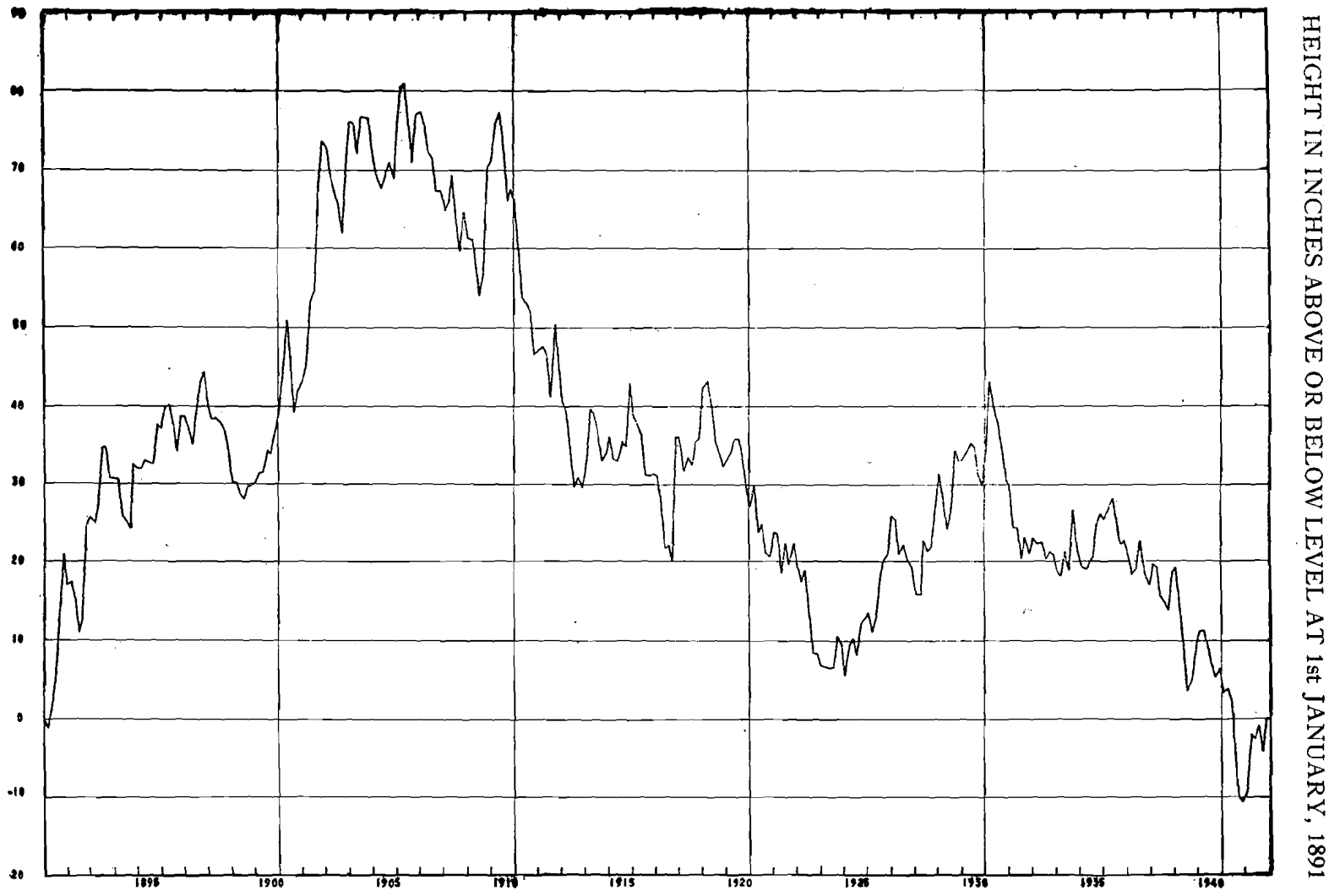

FIG. 6. Water level at two monthly intervals from 1st January, 1891, in a tank which received all the rain which fell and from which water was withdrawn steadily at a rate of 58.1 inches per year.

Total Deficit Inches	No. Days Supply	Duration in Days	Intensity	Dates
25.96	163	361	45	14th August, 1912-9th August, 1913
25.17	158	487	33	13th March, 1931-11th July, 1932
18.10	114	185	62	18th March, 1941-18th September, 1941
17.32	109	227	48	17th October, 1910-1st June, 1911
17.08	107	192	56	31st December, 1938-10th July, 1939
16.35	103	248	42	20th November, 1916-25th July, 1917
15.08	95	116	82	16th May, 1910-8th September, 1910
14.97	94	157	60	29th April, 1901-2nd October, 1901
14.38	90	190	47	4th April, 1906-10th October, 1906
13.82	87	158	55	9th September, 1915-13th February, 1916
13.72	86	338	25	31st December, 1906-3rd December, 1907
13.49	85	334	25	17th January, 1927-16th December, 1927
13.34	84	213	39	26th May, 1920-24th December, 1920
13.27	83	198	42	16th January, 1919-1st August, 1919
12.29	77	237	33	28th December, 1902-21st August, 1903
11.85	74	157	47	31st October, 1904-5th April, 1905
11.47	72	151	48	7th May, 1923-4th October, 1923
11.34	71	117	61	10th May, 1908-3rd September, 1908
11.32	71	215	33	26th November, 1908-28th June, 1909
11.29	71	230	31	15th August, 1897-1st April, 1898
10.97	69	129	53	31st January, 1929-21st May, 1929
10.59	67	369	18	28th November, 1939-30th November, 1940
10.55	66	226	29	26th August, 1898-8th April, 1899
10.19	64	130	49	20th January, 1938-29th May, 1938
9.80	62	108	57	4th February, 1922-22nd May, 1922
9.50	60	117	51	28th January, 1894-24th May, 1894

TABLE 24. Most intense droughts.

Table 24 gives figures for the twenty-six greatest deficits, while Table 25 gives all the cases not included in Table 24, but which have an intensity of 50 per cent or more and a total deficit of at least five inches.

Total Deficit Inches	No. Days Supply	Duration in days	Intensity	Dates
9.33	59	87	68	May to August, 1914
9.27	58	80	73	March to May, 1921
8.70	55	98	56	September to December, 1934
8.16	51	94	54	January to April, 1918
8.09	51	73	70	March to June, 1892
7.18	45	89	51	November, 1936 to February, 1937
6.96	44	76	58	February to April, 1897
6.60	41	55	75	April to May, 1915
5.84	37	52	71	November, 1891 to January, 1892
5.03	32	56	57	June to August, 1926

TABLE 25: Droughts with intensity greater than 50 per cent but not included in Table 24.

The greatest deficit which began in August, 1912, consists of two smaller periods separated by a month with more than normal rainfall, and during the whole period of almost a year, the total rainfall recorded was only 55 per cent of the average. The second maximum given is also made of two portions, and as it extends over sixteen months the actual intensity was not so great.

The third greatest deficit, which occurred from March to September, 1941, was possibly the worst drought ever experienced, as its intensity was considerably greater than in the above two. Only 38 per cent of the normal average rain fell over the six months; and beginning early in spring, when gardens were in great need of water, and continuing through summer, this drought was felt more than any other by farmers and the community generally.

The most intense drought occurred from May to September, 1910, when for a period of four months only 18 per cent of the normal rain fell. Coming as it did in the heat of summer, this drought was felt particularly by its effect on water supply, and a great many houses were entirely without fresh water in the latter part of the period.

From the point of view of water supply it is important to know the frequency with which various deficits of rainfall occur. In Figure 7 the value of deficit is plotted against the total number of occurrences equalling or exceeding the deficit. From this the figures in Table 26 were deduced.

Frequency	Deficit in Inches
Once in 1 year.....	5.3
Once in 2 years.....	9.8
Once in 3 years.....	11.7
Once in 5 years.....	13.9
Once in 10 years.....	16.5
Once in 20 years.....	20.0
Once in 30 years.....	24.0

TABLE 26: Maximum deficit to be expected in a number of years.

This might be expressed in a different form as in Table 27 which gives the intervals at which deficits equal to one to five months' rainfall may be expected.

Deficit equal to 1 month's average rainfall occurs once in	1 year.
Deficit equal to 2 months' average rainfall occurs once in	2 years.
Deficit equal to 3 months' average rainfall occurs once in	6 years.
Deficit equal to 4 months' average rainfall occurs once in	18 years.
Deficit equal to 5 months' average rainfall occurs once in	30 years.

TABLE 27: Minimum length of period in which various deficits are expected.

13. WATER SUPPLY

Using the data given above, we may now deduce the requirements of a water supply system in Bermuda as regards catchment and storage capacity.

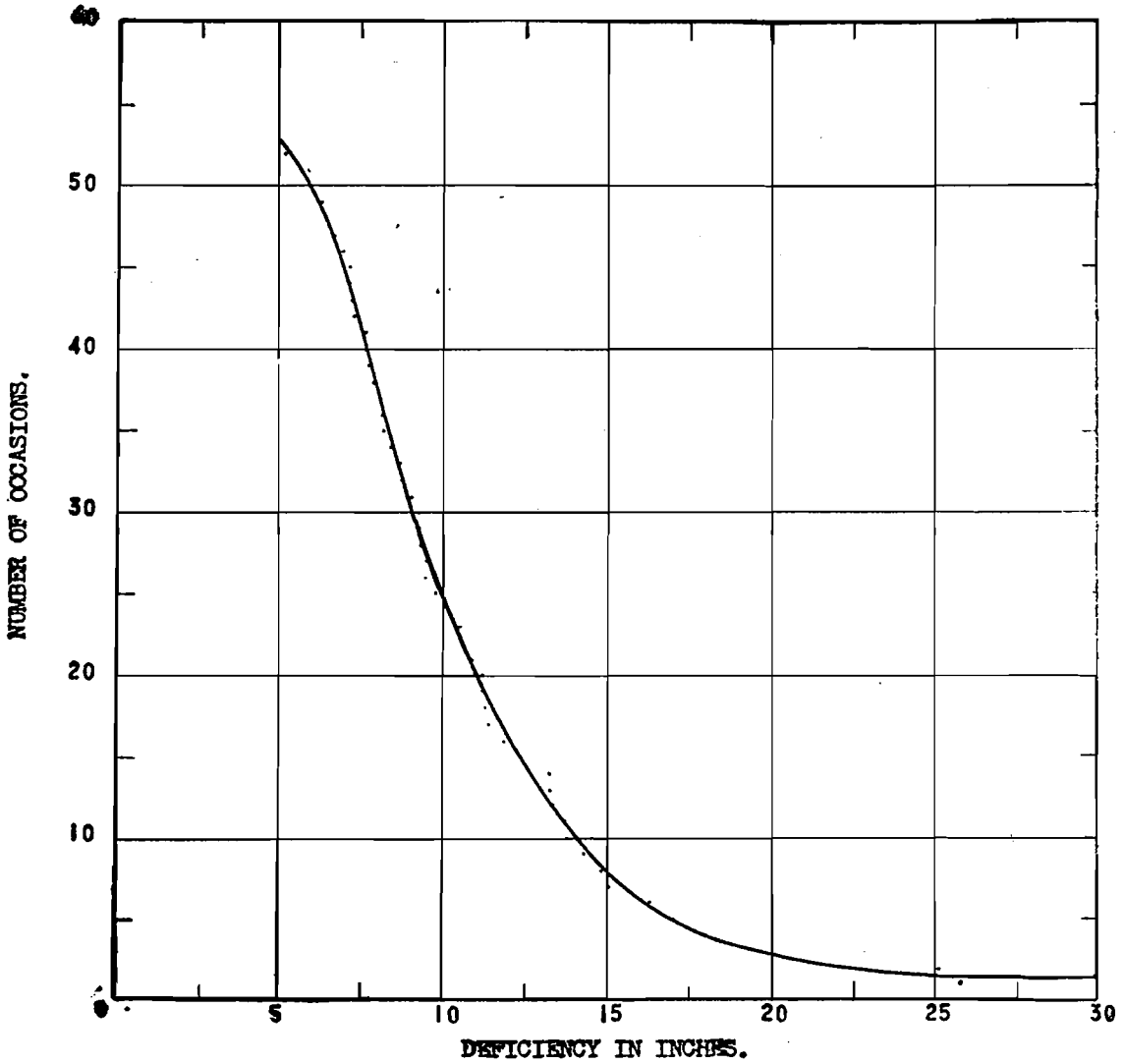

FIG. 7. Distribution Curve of Deficits recorded in 52 years.

The volume of water required daily is, of course, not a meteorological question, and will be determined by the needs of the particular user. For our purposes here it is most convenient to consider as a unit the needs of one individual living in a normal home. This will be a variable quantity depending upon the particular person, but after enquiry from the various bodies concerned in such matters it is concluded that twenty gallons per person per day is a reasonable allowance in Bermuda.

The following discussion is, therefore, directed to a determination of the catchment and storage required to give twenty gallons per day. For any amount different from this, and for a number of persons, the catchment and storage will vary in direct proportion to the total daily consumption desired.

The catchment and storage required are interdependent, for the greater the catchment area the smaller the storage necessary, so long as the catchment is large enough to collect the required total volume with the average rainfall expected. The catchment required will be directly proportional to the annual rainfall which it is considered desirable to rely on, while the storage necessary will depend upon the maximum deficit to be guarded against and the area of catchment. This deficit will itself depend upon the rainfall for which calculations are made, decreasing as the estimated rainfall decreases.

The long period average annual fall of 58.1 inches is the greatest amount which it can be planned to use, and to do so provision must be made for the deficits discussed in the previous section. In most cases it will be more convenient and economical to assume a smaller amount of annual rain. To enable comparisons to determine the most suitable rate of use, the deficits for the droughts in Table 24 were recalculated on the basis of using water at rates from 36 to 64 inches per year. A distribution curve similar to Figure 7 was then drawn for each rate of use, and from it frequency figures as in Table 26 were read off. Figure 8 was then drawn; it gives the maximum deficit to be expected in any number of years with the different rates of use.

The curves are extended only to cover periods up to thirty years, as it is felt that it would not be economical to provide against a drought which occurs less frequently than once in thirty years. The curves show that the maximum deficit to be expected increases rapidly at first with the length of the period involved, but the rate of increase per year decreases and after about ten years remains fairly steady. It appears therefore that for many purposes it would be satisfactory to design the water system to cope with the maximum deficit to be experienced in ten years.

If we consider as example a case where this ten-year limit has been decided on, we find from the curves that the maximum deficit to be expected is 3.8 inches if 36 inches is used per year, increasing to 16.7 inches if 58.1 inches is used, and to over 20 inches if an attempt is made to use 64 inches per year. To give our specified figure of 20 gallons per day, or 7,300 per year, it is easily calculated that a catchment of 391 square feet is needed with 36 inches of rain and 242 square feet with 58.1 inches.

Now, the maximum deficit of 3.8 inches to be expected with an annual use of 36 inches would mean a volume of 770 gallons on the necessary 391 square feet, and the deficit of 16.7 inches with the use of 58.1 inches means 2,100 gallons on the necessary 242 square feet. These figures of 770 and 2,100 gallons are therefore the volumes of storage which are necessary in the two cases.

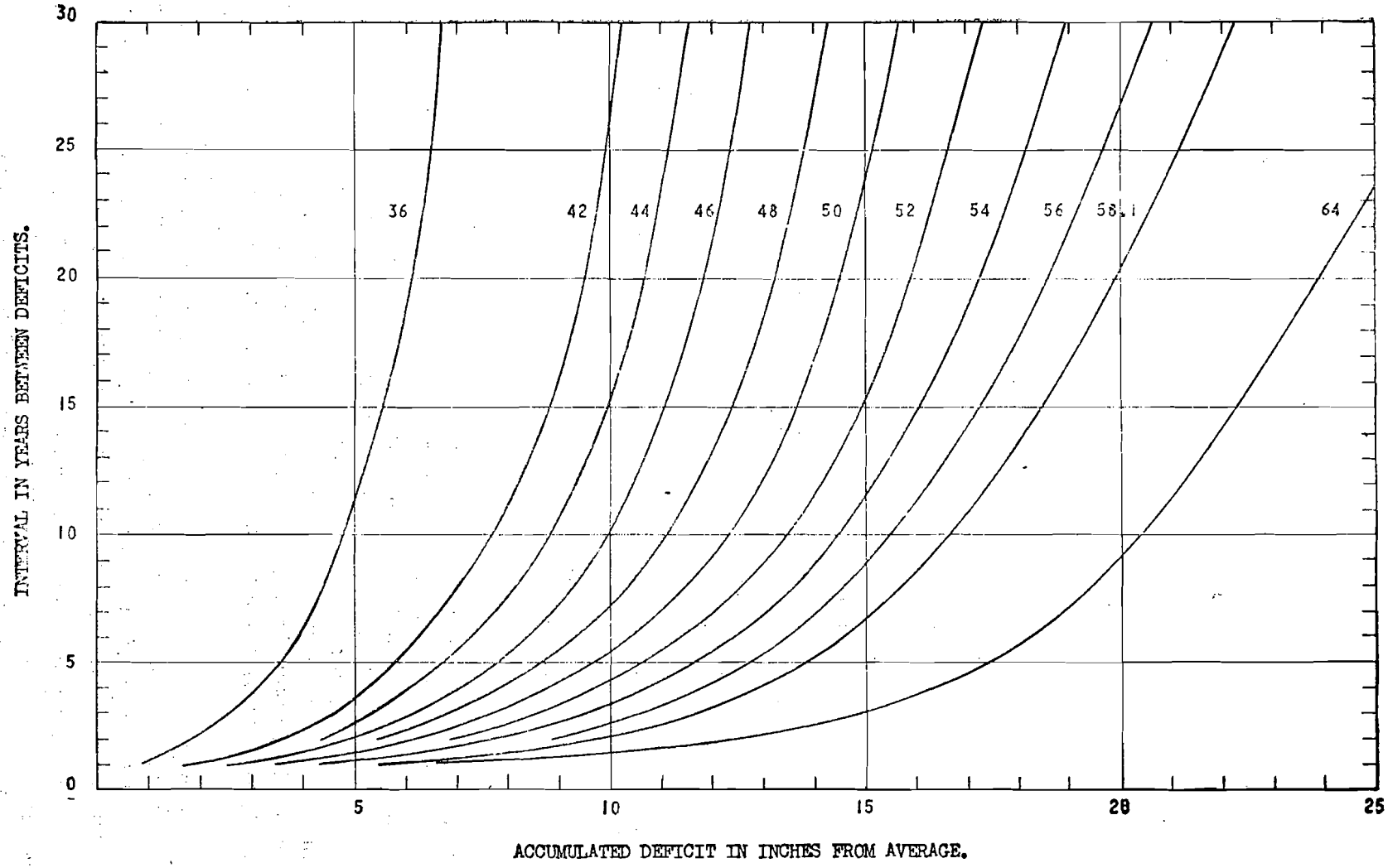

FIG. 8. Maximum deficits to be expected in periods up to thirty years with different rates of use.

Consequently, to meet the desired conditions the water system requires from 391 square feet catchment with 770 gallons storage to 242 square feet catchment with 2,100 gallons storage. Normally some intermediate values will be chosen, depending upon the relative costs of providing catchment and storage.

Figure 9 has been drawn to enable the catchment and storage to be determined directly. The curves running from top right to bottom left are similar to the curves of Figure 8, but instead of being drawn for given rates of annual use with the corresponding irregular areas of catchment they are drawn for evenly spaced catchment areas. The curves running from top left to bottom right give the storage volume required with specified catchment and inches deficit of rain. They eliminate the necessity for calculations as given in the preceding paragraph.

Using the diagram we can determine for any desired interval between deficits the catchments and corresponding storages necessary.

Also if either catchment or storage are fixed by other circumstances we can obtain directly the value of the other necessary to obviate deficits in any number of years.

Although the diagram allows for catchments from 200 to 400 square feet, in most practical cases the possible variations will be less than this. Thus it will not normally be intended to use more than the average long period rainfall of 58.1 inches and this means that 242 square feet would be the smallest possible catchment.

Also water engineers frequently aim to provide against the three driest years and we showed above that 42.45 inches per year was the fall in the driest 36 months. With this latter fall a catchment of 330 square feet would be needed.

To give 20 gallons per day therefore and have deficits less frequently than say once in ten years would normally mean between 242 square feet catchment with 2,100 gallons storage and 330 square feet catchment with 1,390 gallons storage.

It is probable that an average household will consist of 5 persons and require 100 gallons of water per day. Table 28 gives the volume of storage required with catchment of 1,000, 1,500 and 2,000 square feet in order to provide this quantity without shortages in specified periods.

Interval Years between Shortages	Storage capacity in Gallons required with catchments equal to		
	1,000 Square feet	1,500 Square feet	2,000 Square feet
2	7,900	3,950	1,750
5	10,750	6,250	3,350
10	12,450	8,050	4,700
15	13,500	9,050	5,400
20	14,400	9,700	5,900
25	15,200	10,150	6,300

TABLE 28: Storage capacity and catchment required to avoid shortages when 100 gallons used per day.

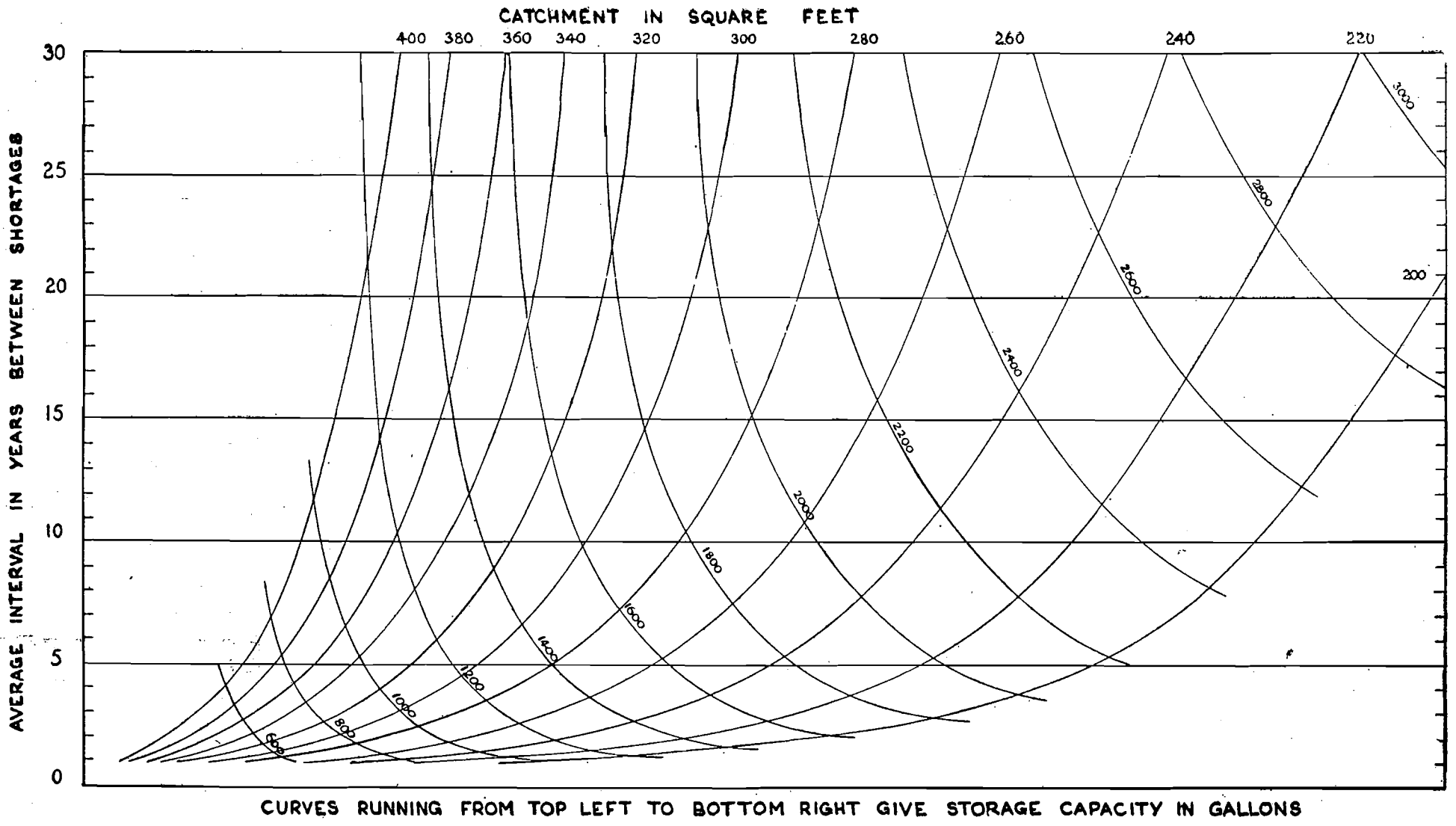

FIG. 9. Rain catchment and water storage needed to meet the maximum rain shortages expected in periods of 1-30 years.

As there are numerous occasions when rain falls in one part of the Islands and not at others the question arises whether there is any local variation in the normal average rainfall.

There are no records of two comparable stations at different ends of the Islands extending over sufficient numbers of years to give reliable comparisons between the two sites but three short series of simultaneous observations are discussed below.

There was a 13 months' comparison between Prospect and St. George after the latter was opened. Prospect recorded more rain in 9 months and less in 4, but the differences were not great. In May 1932 Prospect recorded more while in May 1933 St. George had the greater, the falls being of the same order in the two years. There were also individual days when a fall of an inch or more was recorded at one station and very little at the other, with sometimes the heavy fall at St. George and sometimes at Prospect.

There was also a comparison in 1934 to 1935 between Fort George and a site some 10 to 11 miles to the West near the South Shore in Paget Parish, where records were kept by Mr. C. B. A. Melville. These records also showed slight irregular differences from month to month but the yearly totals at the two sites agreed within ½ inch in each year and the monthly totals were as often greater at one site as at the other.

A third comparison extending over two years 1942 to 1943 is available between Fort George and the Meteorological Station at Belmont, Warwick. These figures also show no regular differences. The yearly totals differed by 0.83 inch and 1.45 inches, with the greatest fall at Fort George in each year. The figures for the two Julys illustrate an extreme case of the type of differences found in all these comparisons. In the first year Fort George with 3.19 inches had little more than half the 5.93 inches at Belmont, while in the following July, the Fort George fall of 10.12 inches was more than 2½ times the 3.80 inches at Belmont.

It has to be concluded therefore that the available records do not give any evidence of systematic differences between the long period average falls at different parts of the Islands.

15. LONG PERIOD VARIATIONS IN THE ANNUAL FALL

The suggestion that the climate is not what it once was and especially that there is more or less rain is met with in Bermuda as frequently as elsewhere. It is of interest therefore to study the figures available to see if any systematic change is detectable in the relatively short period under review and Figures 10 and 11 have been drawn for this purpose.

Figure 10 gives the excess or deficit in each year with reference to the accepted average of 58.10 inches, while Figure 11 gives the average annual fall and number of rain days in every 10 year period, expressed as a percentage of the 1891 to 1942 averages.

The annual totals for 1852 to 1862 and 1870 to 1890 are taken from the Bermuda Almanac and are for Ireland Island and Paget North respectively. As has been stated earlier insufficient is known about these records to justify their use in calculating averages but they can be expected to give some indication of the variations throughout these years.

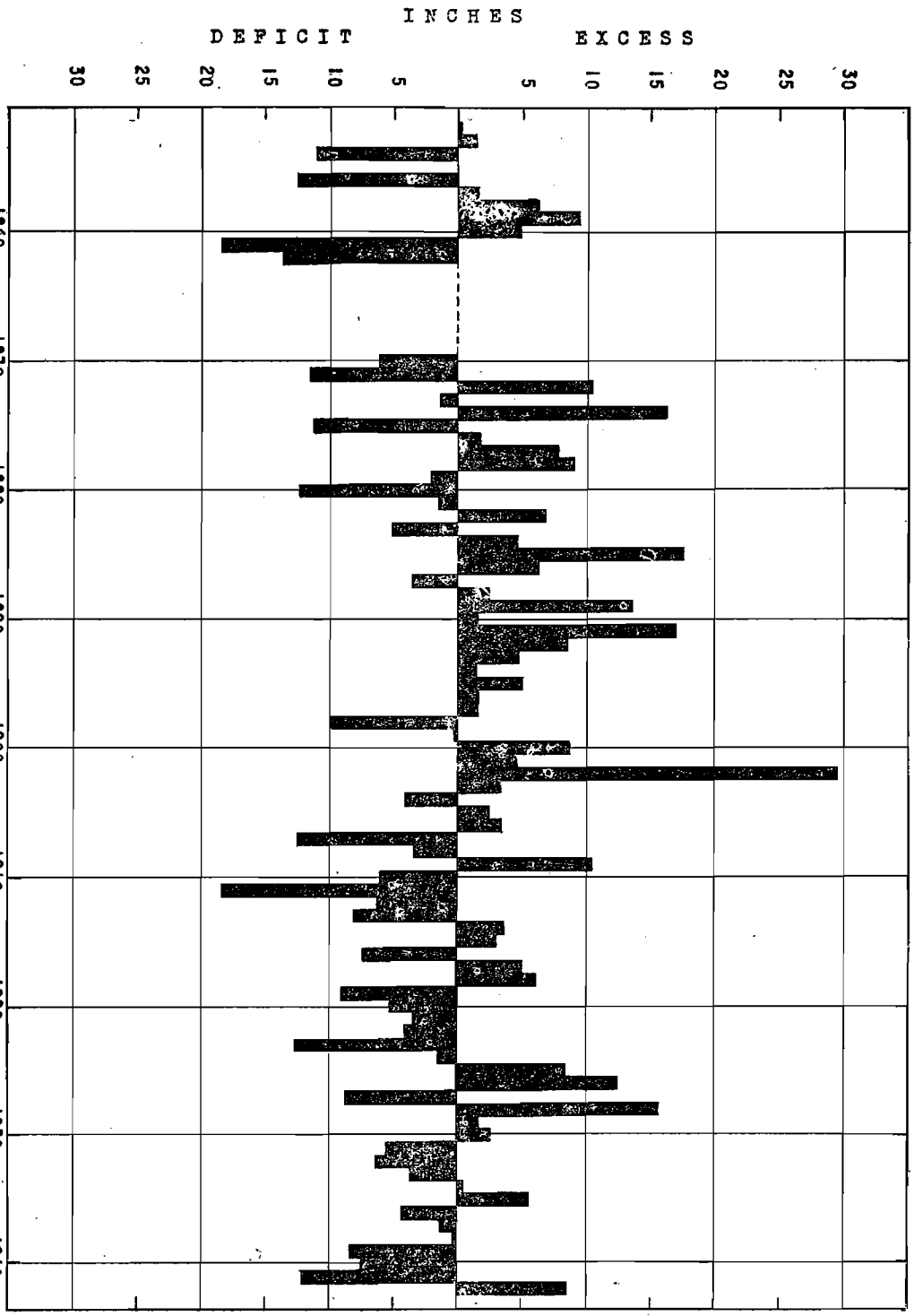

FIG. 10. Years rainfall as excess or deficit with reference to normal 58.10 inches.

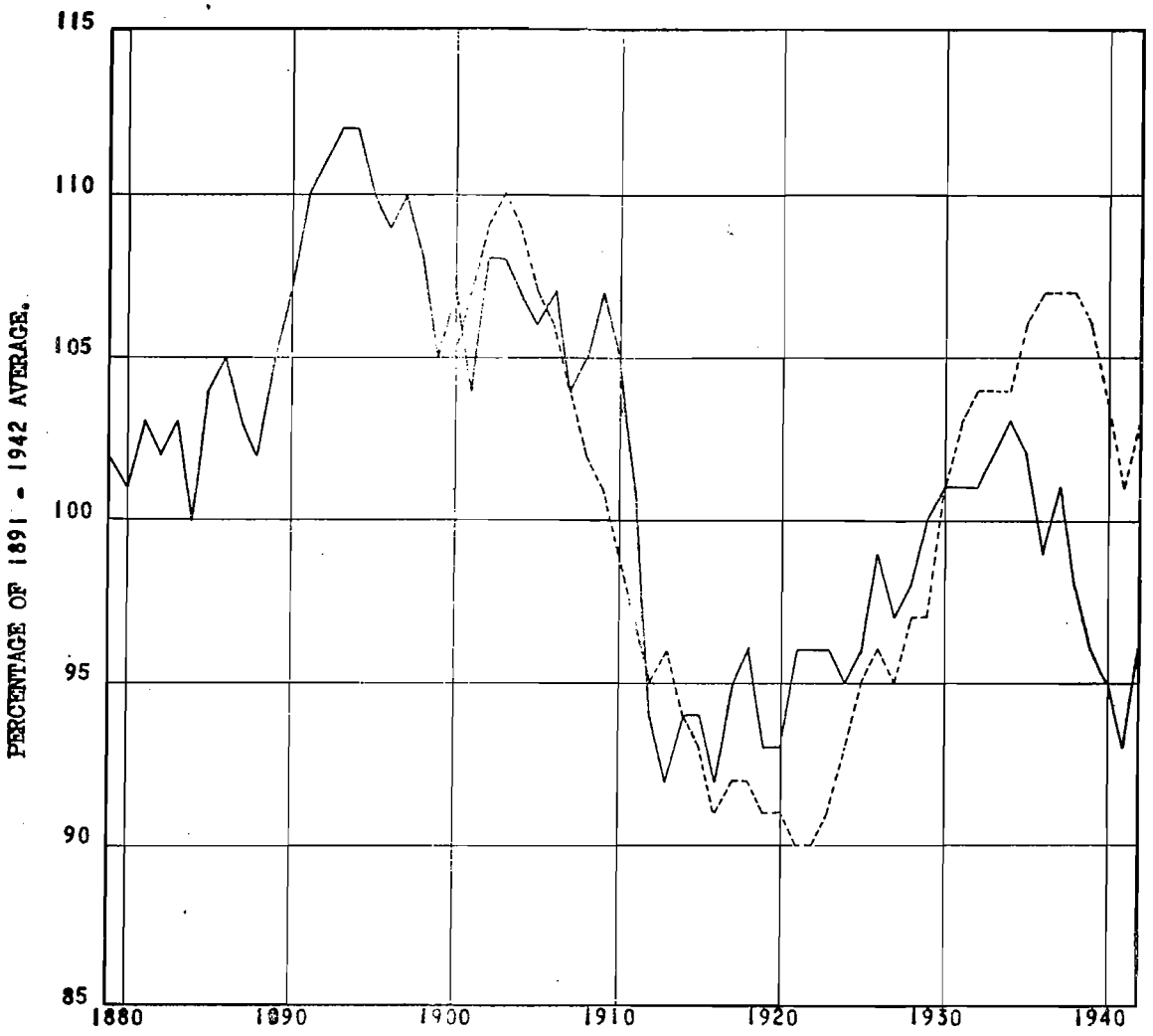

Fig. 11. AVERAGE YEARLY FALL (SOLID LINES) AND YEARLY RAINDAYS (DOTTED LINES) IN TEN YEAR PERIODS ENDING WITH YEARS STATED AND EXPRESSED AS PERCENTAGES OF 1891 - 1942 AVERAGES.

Figure 10 shows that the earliest records gave a mean fall very nearly the same as the accepted standard although 1861 had a fall very little greater than the record minimum in 1911. The average for 1870 to 1880 was also very near the 58.1 inch normal although individual years showed considerable departures. In 1884 a wet period set in and in the next 23 years until 1906 only 4 years had less than the standard fall. This was followed by a dry period lasting for 18 years with only 5 years in which above standard fall was recorded. Four of these years were, however, grouped together near the centre of the period. The 6 years 1925 to 1930 had an average considerably above standard and the following 10 years were markedly below.

Figure 11 shows that the 10 year mean number of rain days has changed steadily with a maximum of 110 per cent for the period ending 1903, declining to a minimum of 90 per cent in 1921 to 1922 and rising to another apparent maximum of 107 per cent in 1936 to 1938. There is, therefore, some indication of a 35-year periodicity. The mean annual falls show a variation similar to that of the number of rain days but with less regularity. The extremes occurred in 1894, 1913 to 1916 and 1934, some 4 to 10 years earlier than the corresponding extremes in number of rain days, and giving an interval of 40 years between the maxima. From the general agreement between the two curves it seems likely that another and higher maximum in number of rain days would be shown between 1903 and 1893 if we had the data covering the earlier period. In this case the interval between maxima would agree more closely with the 40 year interval in rainfall amounts.

It is not possible to be at all definite when a single period extends as here over almost the whole set of data available and all that can be suggested is that there has been an oscillation with an amplitude of about 10 per cent of the mean and with a period of 35 to 40 years. A peak being passed about 1934 to 1938 we will, if the oscillation continues, have a reduction in 10 year mean continuing during the next 10 years reaching the minimum about 1955 to 1960.

APPENDIX 1.

AVERAGES FOR 30 YEARS 1901 TO 1930			
	AVERAGE FALL		AVERAGE NUMBER RAIN DAYS
	Inches	mms	
January	4.58	116.3	15.8
February	4.78	121.4	15.1
March	4.63	117.6	14.3
April	4.41	112.0	10.9
May	4.07	103.4	10.3
June	4.50	114.3	10.6
July	3.56	90.4	12.6
August	5.96	151.4	15.2
September	5.23	132.8	13.4
October	6.20	157.5	14.2
November	5.11	129.8	14.5
December	4.97	126.2	15.9
Year	58.00	1,473.2	164.8

APPENDIX 2.

Extremes in 1943

During 1943 some falls occurred at Fort George which exceeded the extremes recorded above in Tables 5, 9, 14, 19 and 20. These new extremes are given below.

June

Total Fall —0.43 inches
Total Number of Rain Days—4
Total Duration Rain —1.3 hours

The values of total fall and duration are the lowest ever recorded in any month.

The number of rain days is the lowest for June and equals the lowest for any month as previously recorded in April and May.

July

An exceptionally heavy but local thunderstorm affected the St. George area on 27th and the rain recorded at the meteorological station in periods up to 24 hours exceeded the previous extremes for July.

The falls in 3 and 6 hours were also greater than recorded for these intervals in any month from 1933 to 1942.

The extremes for this occasion were

Maximum fall in 1 hour —1.99 inch
" 3 hours—4.62 "
" 6 hours—5.30 "
" 12 hours—5.47 "
" 24 hours—5.51 "