

(Paper No. 4115.)

“Bristol Waterworks: Rainfall-Statistics and Notes on
Wet and Dry Cycles.”

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STATISTICS of annual rainfall and of average rainfall for the longest periods obtainable are of the first importance in considering the value of any scheme for waterworks which depends upon the water-resources of determinable drainage-areas.

The Bristol Waterworks Company have a number of rainfall-stations in the neighbourhood of their springs and wells and gathering-grounds, and in Bristol. The annual rainfalls since these rain-gauges were established are given in the accompanying Table.

The rain-gauges (*Fig. 1*, p. 424) have been established for various periods, and averages are given in the Table over a period of 22 years common to all the gauges, as well as for the longer periods during which some of the gauges have been in existence. It will be noticed that the averages for the longer periods at the Litton and Barrow rainfall-stations are 4 per cent. higher than for the 22 years. These differences are not great, but if similar comparisons had been made 4 years ago, the differences between the averages for the longer and shorter periods would then have been much more marked, Litton then being 11 per cent. higher and Barrow 7 per cent. higher for the longer period of 54 years than for the 22 years ending 1908. These differences show the desirability of records of the longest possible periods.

Periods of Maximum and Minimum Rainfall.—Particulars of periods of excessive rainfall or prolonged drought are of the utmost importance in considering the resources of a water-supply, and in regard to the question of storage.

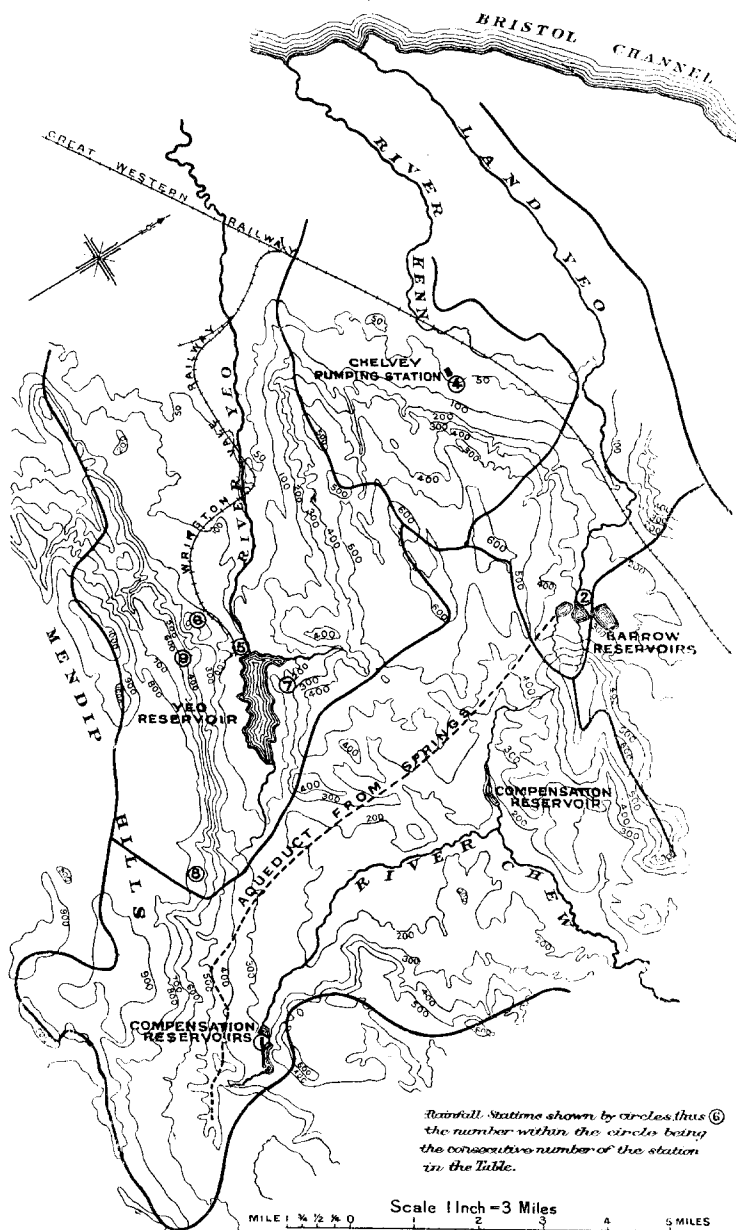
The maximum and minimum rainfalls for various periods, as

ANNUAL RAINFALL AT BRISTOL WATERWORKS RAINFALL-STATIONS.

Year	Litton.	Barrow.	Bristol.	Chelvey.	Blagdon.	Coombe Lodge.	West Town.	Hartree Hill.	Blagdon Hill.
Feet above O.D.	340	300	80	60	112	388	263	784	550
1855	35.15	26.20	24.43	..	..	..	..	..	..
1856	43.22	34.06	31.07	..	..	..	..	..	..
1857	35.97	25.75	24.61	..	..	..	..	..	..
1858	32.73	26.56	22.70	..	..	..	..	..	..
1859	41.50	35.67	33.20	..	..	..	..	..	..
1860	45.56	44.02	34.63	..	..	..	..	..	..
1861	30.82	37.15	26.66	..	..	..	..	..	..
1862	39.55	31.07	29.05	..	..	..	..	..	..
1863	36.97	35.92	28.69	..	..	..	..	..	..
1864	28.49	24.80	18.43	..	..	..	..	..	..
1865	41.96	39.30	34.16	..	..	..	..	..	..
1866	52.09	44.63	37.70	..	..	..	..	..	..
1867	44.99	37.80	31.12	..	..	..	..	..	..
1868	51.13	40.68	30.69	..	..	..	..	..	..
1869	49.41	40.81	34.36	..	..	..	..	..	..
1870	36.35	28.05	21.41	..	..	..	..	..	..
1871	40.52	33.07	26.31	..	..	..	..	..	..
1872	62.50	48.22	38.29	..	..	..	..	..	..
1873	38.63	35.99	30.09	..	..	..	..	..	..
1874	50.03	37.40	30.57	..	..	..	..	..	..
1875	57.34	45.65	40.46	..	..	..	..	..	..
1876	54.29	47.29	37.52	..	..	..	..	..	..
1877	46.70	46.40	34.98	..	..	..	..	..	..
1878	42.39	41.99	35.78	..	..	..	..	..	..
1879	44.83	44.41	35.11	..	..	..	..	..	..
1880	38.93	38.27	36.39	..	..	..	..	..	..
1881	42.84	36.81	30.06	29.54	..	..	..	..	..
1882	50.96	52.76	43.12	41.04	..	..	..	..	..
1883	40.82	37.02	29.47	28.32	..	..	..	..	..

[illegible]

Fig. 1.



recorded at the Bristol Waterworks rainfall-station at Litton are set forth below, together with the averages for the same periods.

Period.	Maximum.	Minimum.	Average.
	Inches.	Inches.	Inches.
1 month	10·09	Nil	3·43
3 months	23·23	1·62	10·27
6 „	38·31	8·58	20·55
9 „	47·71	15·43	30·82
12 „	63·09	26·11	41·10

Abnormal Rainfalls.—Particulars as to abnormal rainfalls are also highly important in considering the relief necessary for sudden and heavy floods in connection with impounding-reservoirs and other works. The following are instances of abnormal rainfalls in connection with the Bristol Waterworks records.

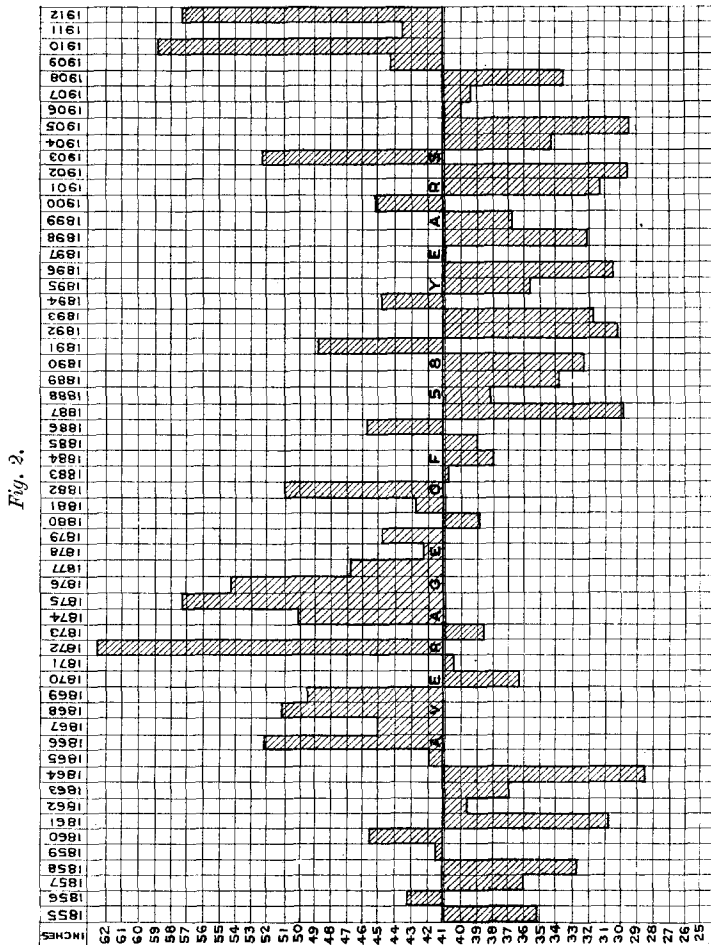
The heaviest rainfall in a given time was registered on the 16th July, 1892, at Chelvey, when 3·52 inches fell within 2¼ hours, the actual time during which the rain was falling not exceeding 1½ hour. The rain, accompanied by a heavy thunderstorm, commenced at about 12.30 p.m. and reached its height at 1 p.m.; it then ceased and the storm passing eastward, but a little before 2 p.m. it returned as severely as before, and lasted a further ¾ hour. The Author has not heard of any rainfall in the West of England approximating to this quantity in so short a time.

The nearest approach to the foregoing in the Bristol records was 3·25 inches at Bristol during 17 hours on the 30th August, 1897; and the heaviest 48 hours' record was 3·89 inches, on the 28th and 29th August, 1910. But the recorded rainfall which had the greatest effect in the Bristol Waterworks area and caused the heaviest floods in the district occurred during the three days 6th–8th March, 1889, when 4·24 inches were recorded at the rainfall-station at Chelvey—the effect in this case being greater on account of a heavy snow-fall two days previously, which in melting added its volume to the rainfall.

Wet and Dry Cycles.—The consideration of wet and dry cycles is extremely interesting, and although no positive conclusions can be arrived at, it is without doubt of advantage to investigate the subject.

The Author has given some attention to the question of regularity in the recurrence of wet and dry cycles, and for that purpose he has studied the rainfall records of the Bristol Waterworks, extending

over 58 years; but although these show well-defined wet and dry cycles, there does not appear to be any regularity in their recurrence or duration. It is noticeable, however, that during a wet cycle there are rarely found two consecutive years in which the rainfall



was below the average, and during a dry cycle it is equally rarely found that any two consecutive years' rainfall exceeded the average.

It will be seen from *Fig. 2*, which is a diagram of the records for 58 years at Litton, that the first 10 years (1855-64) was a

portion of a dry cycle, the average rainfall being 36·99 inches. The next 18 years (1865–82) was a wet cycle, the average rainfall being 46·99 inches. The next 26 years (1883–1908) was a dry cycle with an average yearly rainfall of 37·08 inches. The difference between the average rainfall of these periods will be seen to be practically 10 inches in each cycle; such a wide difference is remarkable, having regard to the lengths of the cycles.

The diagram also shows clearly the characteristic rarity or absence of two consecutive wet or dry years, as the case may be, particularly in the 26-year dry cycle (1883–1908) in which there was no instance of two consecutive years' rainfall being above the average.

In February, 1911, the Author drew attention to the characteristics named, and referred to the 2 years' rainfall, 1909 and 1910, as being the first two consecutive years' rainfall to exceed the average since 1881 and 1882; and he remarked that if anything was to be inferred from the deduction, then 1909 and 1910 constituted the beginning of a wet cycle. So far this has proved to be the case, as in all the four years since 1908 the rainfall has exceeded the average.

It would be unsafe to conclude that these are the invariable characteristics of the cycles: the facts are, however, interesting and worth noting, and the Author was interested to observe that Dr. H. R. Mill, in an address on Rainfall in connection with the British Association at Portsmouth in May, 1911, followed a very similar line of thought, and came to the conclusion that "we are probably entering upon a series of years the greater number of which may be expected to be wet."

The Paper is accompanied by one tracing and one drawing, from which the Figures in the text have been prepared.